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Seasonal Variation of Radon Concentration in Water Sources using Smart RnDuo

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Abstract: ***Concentration of radon in water is measured in Champhai district and Serchhip District of Mizoram using Smart RnDuo, and the seasonal variation have been measured during winter, summer and monsoon seasons. The water samples have been collected from streams, springs, pumps, open well and government supplied water. Seasonal variation of radon concentration in water for Champhai district was found to be 7.85 Bq/L in winter, 16.25 Bq/L in summer and 10.17 Bq/L in monsoon. In Serchhip district, it was found to be 3.19 B/L in winter, 16.60 Bq/L in summer and 7.09 Bq/L in monsoon. The radon concentration measured was found to be well within the range which is considered safe [1].***
Keywords: RnDuo, seasonal variation, radon concentration.

I. INTRODUCTION

Radon is a naturally occurring radioactive gas from the decay of radium which in turn is derived from the decay of Uranium in rocks and minerals. Radon is colourless, odourless inert gas and it is the heaviest noble gas which is 7.5 times heavier than air. It is also the only gaseous decay product in uranium decay series. Hence its presence in drinking water is not felt during its consumption[2].

Natural water usually contains dissolved radon due to the presence of radium, a member of natural uranium decay series, in soils and rocks through which the water has filtered [3]. Statistically the global radiation dose to humans from natural sources is due to the radioactive radon gas [4]. Radon and its daughter products are a health concern since they are capable of causing lung cancer when inhaled over a long period [5]. Published reports show that one of the greatest risks associated with ingestion of water containing radon and radon progeny is stomach and colon cancer and other organ cancers [6]. Radon as a cause of leukemia has also been discussed [7].

Human beings are exposed to radon through inhalation or ingestion. Dissolved radon is released to air upon usage of water, which adds to the dose received from inhalation of airborne radon emanating from the ground itself. In 1991, the United States Environmental Protection Agency (EPA) proposed a National Primary Drinking Water Regulation (NPDWR) for radon with a maximum contaminant level of 11 Bq/L [8].

On the other hand, the European Union (EU) issued a non-binding recommendation in 2001 setting 100 Bq/L as a reference level; a concentration above this level warrants consideration of possible remedial actions. The EU recommendation also sets 1000 Bq/L as the upper bound above which remedial action is definitely required [9]. Therefore, proper assessment of radon is required considering its associattion with the public health. As such is the case, henceforth studies have been carried out in Champhai and Serchhip districts of Mizoram, India.

II. STUDY AREA

Fig. 1 shows the geographical sites where the water samples were collected. The state of Mizoram is a hilly area with an average elevation of about 500 meters to 800 meters from sea level. The soil types are of mainly sand-loamy and clay-loamy soil rich in organic carbon and rocks are mainly of sedimentary rocks.

It is a tropical region with moderate climate and the temperature varies from 11^{o}C to 24^{o}Cduring the winter season and 18^{o}C to 29^{o}C during summer with an average rainfall of 254 centimetres [10]. Water samples were collected from 49 different locations for three seasons, i.e. winter, summer and monsoon within the study area.

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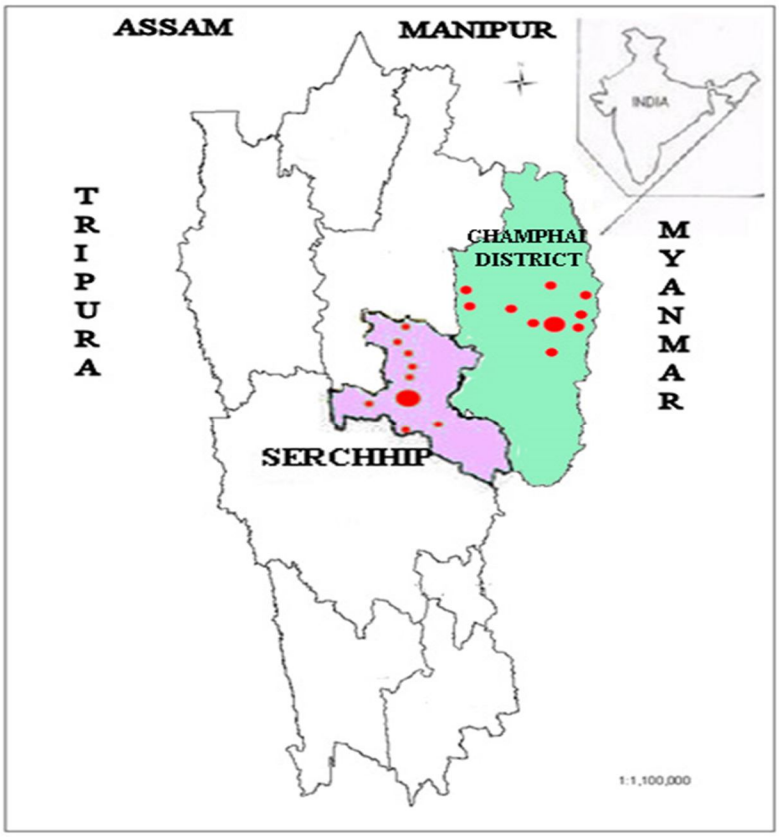

Fig.1: Locations of samples in Champhai and Serchhip districts of Mizoram.

III. MATERIAL AND METHODS

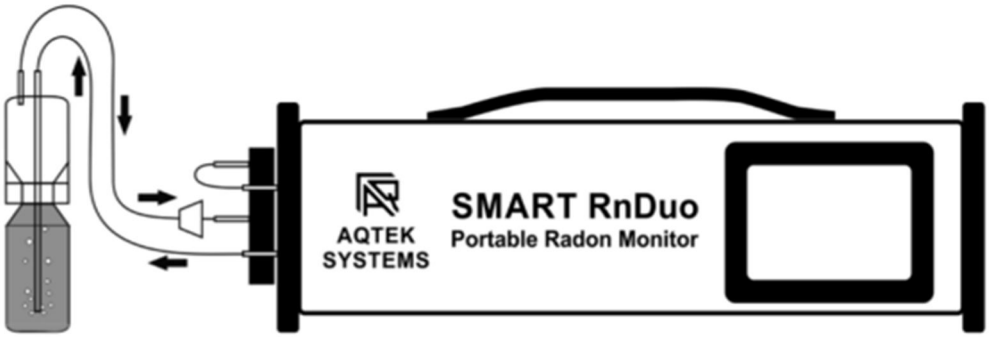

Fig. 2: Measurement of radon in water.

Radon content in water was obtained using Smart RnDuo which is a scintillation cell method. To measure radon content in water the radon gas in the setup is flushed for 5 minutes by using an inbuilt pump to eliminate any background. RnDuo monitor is connected with bubbler attached to the sampling bottle using flexible tubing as shown in Fig. 2.Then the pump is On again for 3 minutes so that the dissolve radon can escape into the tubing. Measurement is taken in 15 minutes cycle for 1 hour. The radon concentration in liquid (C_{liq}) (Bq/m3) is calculated from the concentration measured in air (C_{air}) by using the equation:

$$C_{liq} = C_{air}\left(K + \frac{V_{air}}{V_{liq}}\right) \quad (1)$$

Where K is partition coefficient of radon in liquid with respect to air, V_{air} is volume of air and V_{liq} is volume of liquid in sampling bottle.

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IV. RESULTS AND DISCUSSION

A total of 49 water samples were collected from two districts, 26 from Champhai district and 23 from Serchhip district. Among these, 35 water samples were taken are from surface water sources like springs, streams, ponds and government supplied water, 14 samples from ground water which are mostly borewells.

Table 1: Measurement of Radon concentration in water using RnDuo in Champhai district, Mizoram.

Code	Source	Winter (Bq/L)	Summer (Bq/L)	Monsoon (Bq/L)
C-1	Surface water	0.53	2.09	2.60
C-2	Surface water	0.56	2.79	3.27
C-3	Ground Water	4.38	3.54	8.83
C-4	Ground Water	2.88	4.06	4.44
C-5	Surface water	1.93	2.61	3.75
C-6	Surface water	12.12	2.92	2.70
C-7	Surface water	8.62	2.52	4.83
C-8	Surface water	4.21	1.37	1.52
C-9	Surface water	2.60	Dry	6.01
C-10	Surface water	3.76	4.51	1.94
C-11	Surface water	4.87	27.00	15.13
C-12	Surface water	8.57	14.60	25.53
C-13	Ground Water	15.21	12.64	5.73
C-14	Surface water	10.25	41.68	9.93
C-15	Enclosed Spring	17.67	16.15	22.90
C-16	Surface water	14.84	2.30	9.09
C-17	Ground Water	6.99	31.90	17.09
C-18	Surface water	15.46	14.88	16.62
C-19	Surface water	13.10	30.66	13.38
C-20	Surface water	6.91	26.17	7.71
C-21	Surface water	6.29	Dry	7.57
C-22	Ground Water	4.08	30.64	3.22
C-23	Surface water	12.95	34.57	15.72
C-24	Ground Water	5.66	30.40	11.53
C-25	Surface water	13.22	35.58	30.23
C-26	Ground Water	6.49	14.42	13.09

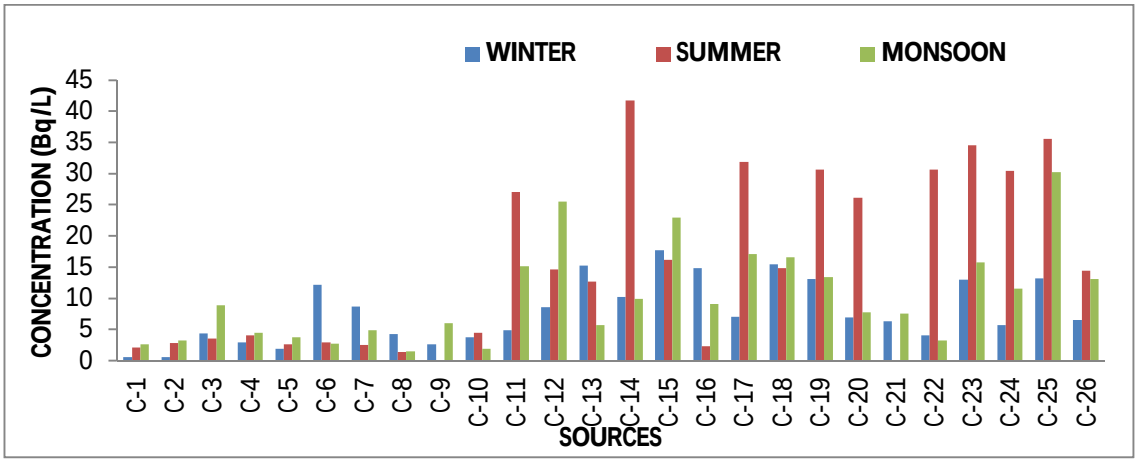

Fig. 3 : Graphical representation of seasonal variation of Radon concentration in water at Champhai district, Mizoram.

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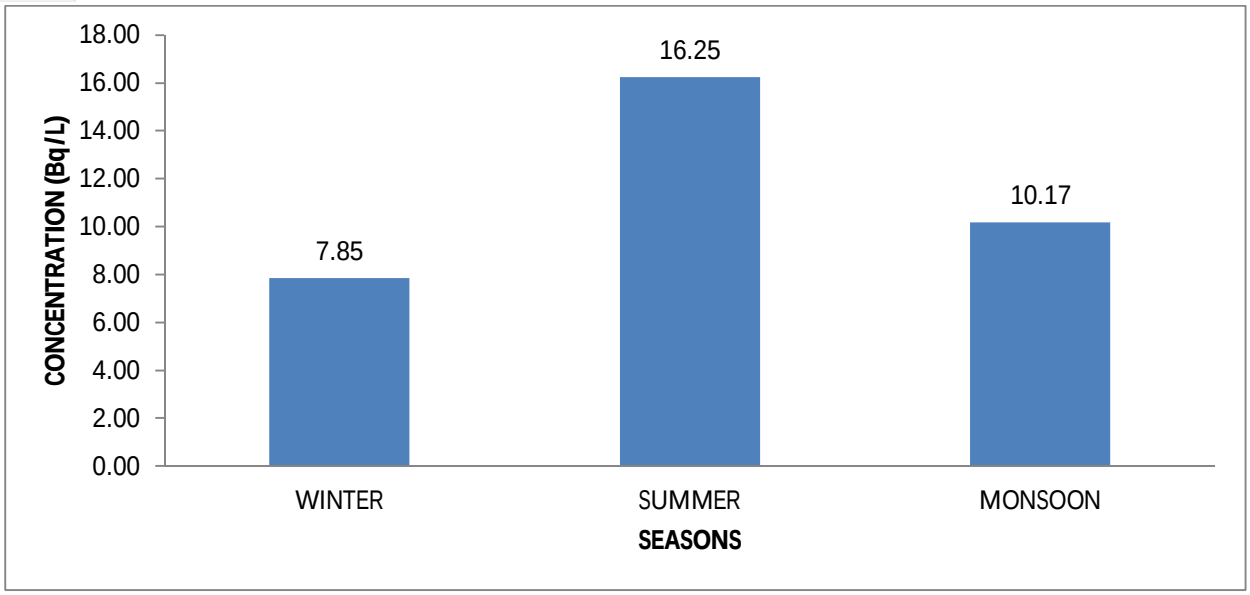

Fig.4 : Comparison of average seasonal variation of Radon concentration in water in at Champhai district, Mizoram

Table 2: Measurement of Radon concentration in water using RnDuo in Serchhip district, Mizoram.

Code	Source	Winter (Bq/L)	Summer (Bq/L)	Monsoon (Bq/L)
S-1	Surface water	0.40	11.85	0.53
S-2	Surface water	0.57	19.86	0.53
S-3	Surface water	0.86	28.33	8.94
S-4	Surface water	0.85	26.48	1.21
S-5	Surface water	0.66	11.34	7.18
S-6	Surface water	1.75	13.78	0.74
S-7	Surface water	2.90	13.76	1.83
S-8	Surface water	1.46	14.56	0.48
S-9	Surface water	1.46	19.18	1.81
S-10	Ground Water	9.16	18.91	Dry
S-11	Surface water	0.85	9.74	2.06
S-12	Surface water	2.36	8.84	0.57
S-13	Surface water	2.47	20.15	3.83
S-14	Surface water	1.42	14.94	1.01
S-15	Surface water	22.78	15.13	17.83
S-16	Ground Water	2.15	13.71	7.84
S-17	Surface water	0.92	10.86	21.02
S-18	Ground Water	2.14	25.99	4.59
S-19	Surface water	0.80	Dry	16.90
S-20	Ground Water	4.43	29.69	26.27
S-21	Ground Water	20.39	12.86	6.44
S-22	Ground Water	2.86	14.59	12.91
S-23	Ground Water	6.28	10.65	11.45

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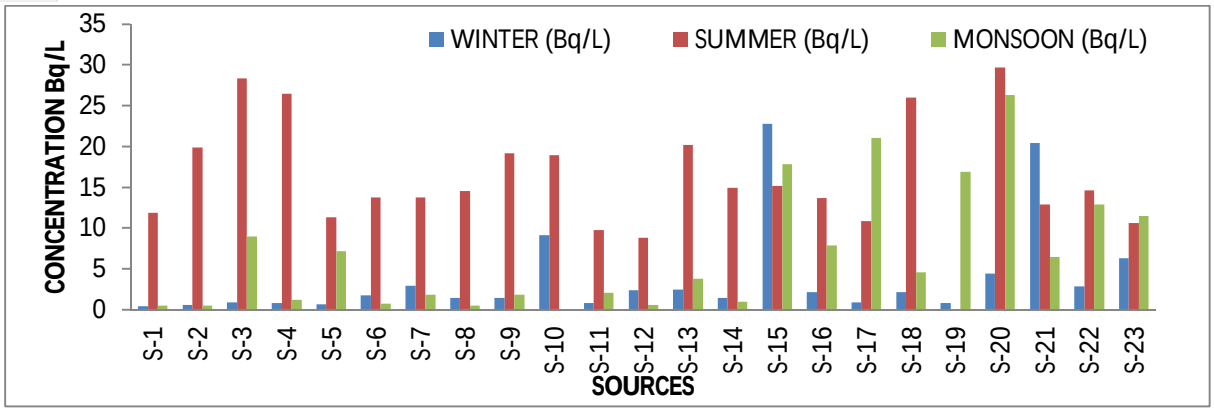

Fig. 5 : Graphical representation of seasonal variation of Radon concentration in water at Serchhip district, Mizoram.

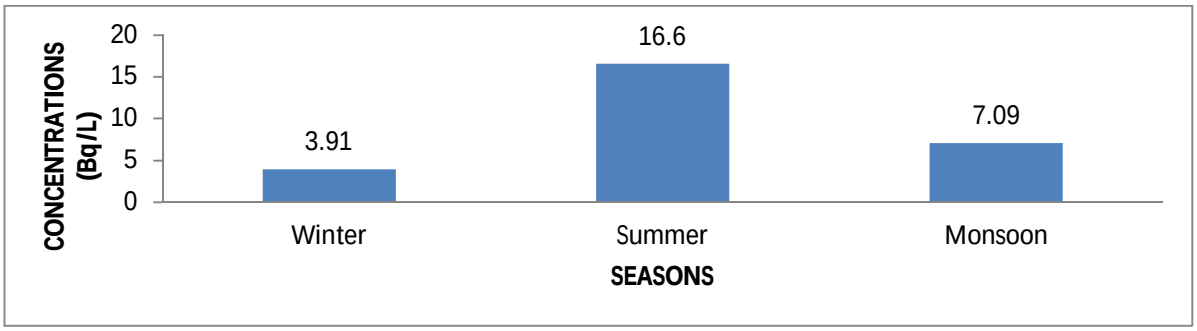

Fig. 6: Comparison of average Radon concentration in water at Serchhip district, Mizoram.

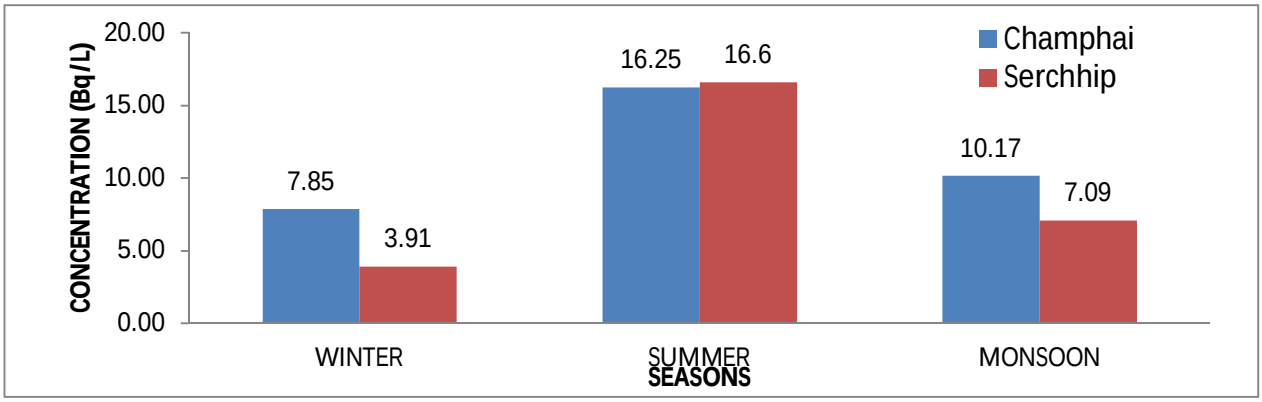

Fig. 7: Comparison of average Radon concentration in water between Champhai and Serchhip districts.

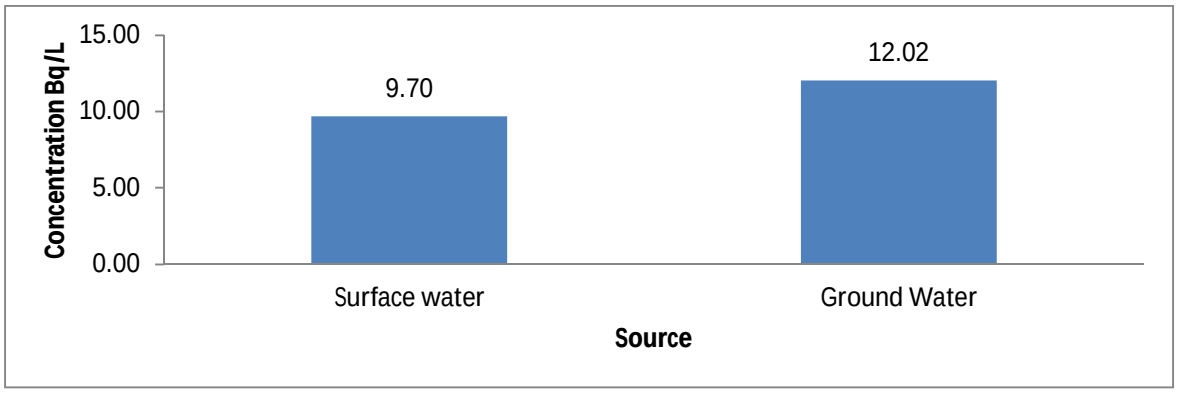

Fig. 8: Comparison of average Radon concentration in water between surface water and ground water.

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Fig. 3 represents the seasonal variation of Radon concentration in water at Champhai district and Fig. 4 is the comparison of average Radon concentration in water at Champhai district in different seasons. Fig. 5 represents the seasonal variation of Radon concentration in water at Serchhip district and Fig. 6 shows the comparison of average Radon concentration in water at Serchhip district at different seasons. From Figs. 4 and 6, the Radon concentration in water is found to be highest during summer followed by monsoon and winter for both districts of Mizoram. Fig. 7 represents the comparison of average Radon concentration in water between Champhai and Serchhip district and Fig. 8 shows the comparison of average radon concentration between surface water and ground water, and the average concentration is higher for ground water which is in accordance with WHO. The groundwater from wells and boreholes usually contains higher radon concentrations than surface waters[11], the reason being ground water are enclosed and the radon content are not released in to the ambient air. The result obtained was in accordance with guidelines provided by WHO as mentioned above.

V. CONCLUSION

Seasonal variation of radon concentration in water for Champhai district was found to be 7.85 Bq/L in winter, 16.25 Bq/L in summer and 10.17 Bq/L in monsoon. In Serchhip district, it was found to be 3.19 B/L in winter, 16.60 Bq/L in summer and 7.09 Bq/L in monsoon. The average of radon concentration is highest during summer followed by monsoon and lowest during winter. The average radon concentration is also found to be higher in the ground water sources than the surface water.

VI. ACKNOWLEDGEMENT

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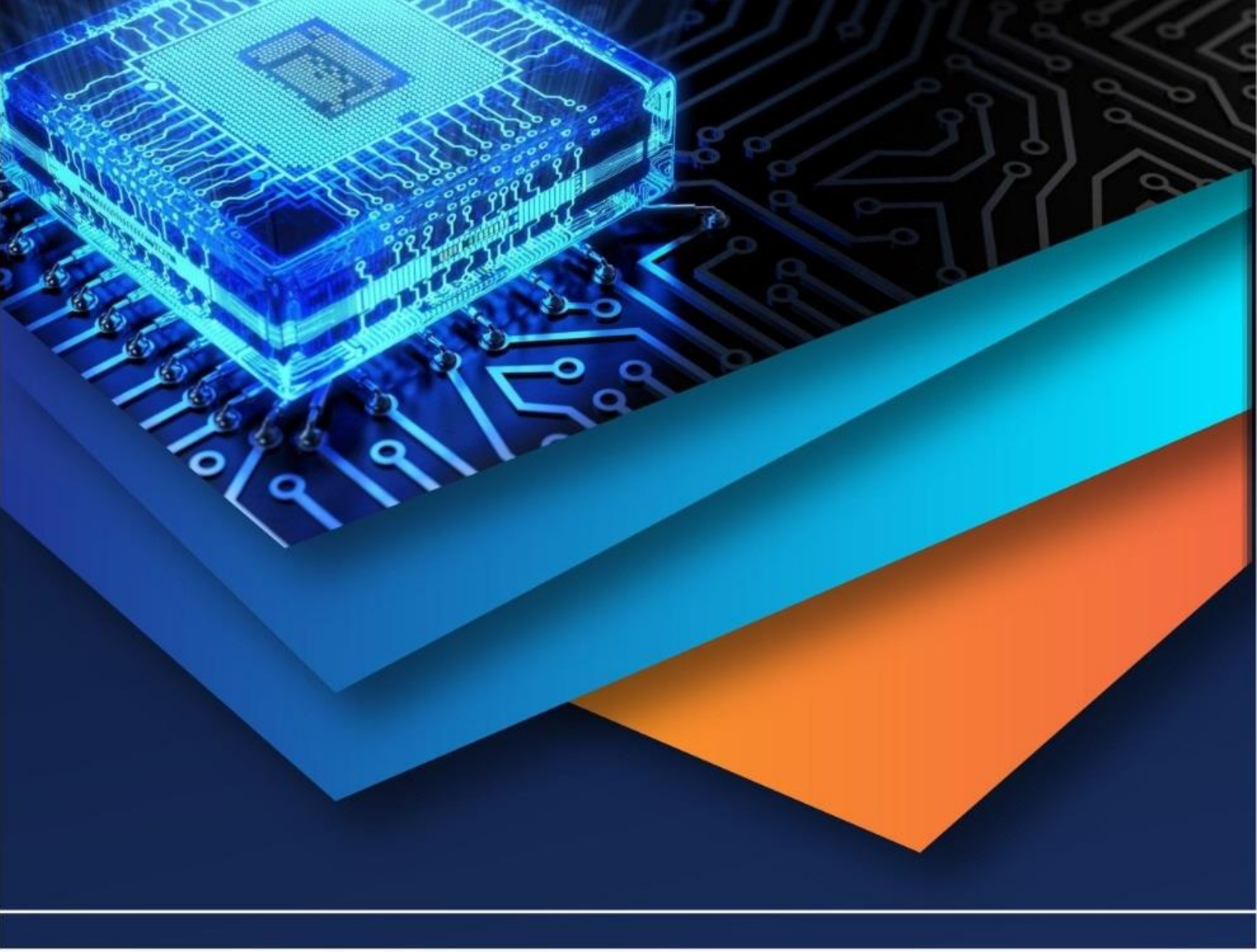

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