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ASSESSMENT OF BACKGROUND IONIZING RADIATION LEVEL OF SCRAP METAL DUMPSITES IN DUTSE TOWN, JIGAWA STATE, NIGERIA.

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ABSTRACT

The level of awareness of the radiation hazards from indiscriminate dumping of scrap metals is very low in developing countries. In this study, the background ionizing radiation level of scrap metal dumpsites in Dutse Town, Jigawa State, Nigeria was assessed. A hand-held Radiation Alert Inspector (RAI) was used and a total of Ten (10) scrap metal dumpsites were randomly selected. Four readings were taken in Counts Per Minute (CPM) and micro Sievert per hour(µSv/hr) at four (4) different selected points on each of the dumpsites. The value of exposure dose rate (in µSv/hr) was used to estimate the Absorbed Dose D (in nGy/hr), Annual Effective Dose (in mSvy^{-1}) and Excess Lifetime Cancer Risk respectively. The results show that the mean exposure dose rate range from 0.01225 to 0.02125 µSv/hr. All the values of exposure dose rate were found to be below the standard value of 0.133 µSv/h. The mean value of the Absorbed Dose D varies from 12.25 to 21.25 nGy/hr respectively. The calculated mean Annual Effective Dose was found to be in the range of 0.015023 to 0.026061 mSvy^{-1}. These values are below 1.0 mSvy^{-1} dose limit recommended by the International Commission on Radiological Protection (ICRP). The mean Excess Lifetime Cancer Risk range from 0.052582 to 0.091214 and are lower than the world limit of 0.29×10^{-3}. The study indicates that the people working and living within the study area are safe and are not exposed to high doses of radiation as result of activities in the dumpsite. However, continuous monitoring of background radiation in the dumpsites is recommended.

Keyword: Radiation, Excess lifetime cancer risk, Dumpsites, Absorbed Dose, Annual Effective Dose.

INTRODUCTION

Many forms of radiation are present in our natural environment of which some are produced by modern technology. Most of them have the potential to trigger both beneficial and harmful effects. Even the sunlight, the most important radiation of all, can be harmful in excessive amounts. In our daily life, we are exposed to various types of naturally occurring radiation from cosmic rays, radioactive substances in the earth, and from naturally occurring radiation from our bodies. (James *et al.*, 2014 and Neopane *et al.*, 2021).). The adverse health effect when persons are over exposed to ionizing radiation is a cause for concern. The earth's atmosphere especially the human populace is exposed to both non-ionizing and ionizing radiation from different sources, which include natural and artificial sources. Prominent among the natural sources are the primordial radionuclides (^{328}U and ^{232}Th and their progenies, and ^{40}K), while the artificial sources include, anthropogenic radionuclide such as ^{137}Cs, ^{90}Sr, etc. (Oyeyinka *et al*., 2012 and El-Arabi *et al*., 2007). Everything living on earth is bathed throughout life with low-level ionizing radiation from natural sources. There are several categories of ionizing radiation of natural origin, also called background radiation, that affect life on Earth. (Dankawu *et al.,* 2021).

Ionizing radiation has the ability to affect the chemical state of a material and so cause changes which are biologically important. Exposure to ionizing radiation can cause injuries and clinical symptoms; which may include a chromosomal transformation, cancer induction, free radical formation, bone necrosis and radiation catractogenesis. The injuries and clinical symptoms could be caused by both chronic and acute dose exposure. (Jwanbot *et al*., 2013). There have been several documentations on the accumulation of NORM to TENORM due to human activities; this concentration poses radiation risks not only to the human population within the affected area but also to the flora and fauna within such area. Some of these radionuclides have been found to accumulate in earthworms within such areas. The enhanced radiation due to NORM has become an issue of importance in radiological protection of humans and biota. (Jelena *et al*., 2012).

The environment is the totality of biological and non-biological factors that affects an organism's life, making up the abiotic and biotic components. That is, the environment describes all plants and animals (living or dead), land, water and air and also there are various changes which occur in the environment, due to natural or artificial causes. (Chijioke *et al.,* 2021). Major factors contributing to environmental problems include human population increase, industrial development and urbanization, unsustainable use of resources and local changes. Pollution is defined as the introduction, by man, into the environment, substances or energy, liable to cause hazard to human health, harm to living resources and ecological systems, damage to structures or amenity or interference with legitimate uses of the environment. (Bayero, 2004).

Environmental Radiation Monitoring is a systematic collection and analysis of certain environmental media such as air, milk and water to determine the level of radioactivity present. Various levels of radioactivity are compared with safety standards to ensure a safe environment. This is introduced so as to protect the public and the environment from hazards associated with ionizing radiation (MDH 2008). Human body is permanently irradiated from two ionizing radiation sources: external and internal. External radiation sources can either be natural (cosmic, terrestrial) or artificial (medical, commercial and industrial sources), both of equal risk to man. Small traces of many naturally occurring radioactive materials are present inside the human body. These come mainly from naturally occurring radioactive nuclides present in the food we eat and, in the air, we breathe. These isotopes include tritium (3H), carbon-14 (14C), and potassium-40 (40K) (James *et.al.,* 2014). The level of the natural radioactivity in the soil and in the surrounding environment as well as the associated external exposure due to the gamma radiation depends primarily on the geological and geographical conditions of the region (UNSCEAR, 2000). Environmental pollution is the unfavorable alteration of our environment as a result of wastes from man's activities, changes in radiation levels, physicochemical characteristics and abundance of organisms in a harmful way (Miller, 1988). Thus, a pollutant is a substance that occurs in the environment, at least in part, as a result of human activities, and which has deleterious effect on the environment (Adewoyin *et al*., 2013).

Different studies have been carried out to evaluate the level of background radiation in the environment in some areas of Nigeria. However, there is still little data recorded in the study area. In this article, the background ionizing radiation level in scrap metal dumpsites in Dutse, Jigawa State, Nigeria is measured. The absorbed dose rate, annual effective dose and excess lifetime cancer risk from the background radiation is calculated.

MATERIALS AND METHODS

Study Area

The study Area is Dutse Town, the Capital City of Jigawa State, Nigeria. Dutse is one of the twenty-seven Local Government Areas of Jigawa State. It is located between Latitudes 11^{o} 38' 31"N and 11^{o} 46' 16"N and longitudes 9^{o} 18' 33"E and 9^{o} 24' 24"E. (Dankawu *et al*., 2021). The climate of Dutse is tropical wet dry climate and the temperature is warm to hot almost throughout the year, with exceptions of November to February with slightly lower temperatures.

Sampling

A total of ten (10) scrap metal dumpsites were selected randomly across scrap metal dumpsites in Dutse Town of Jigawa State, Nigeria. Four readings were taken in CPM and µSv/hr at four (4) different selected points on each of the selected scrap metal dumpsites. An area monitoring survey was carried out using a well calibrated hand-held dosimeter (Radiation Alert Inspector), to measure the radiation exposure level from the selected dumpsites. The calibration was established at the reference conditions. The study was carried out during dry (March to April season and readings were taken in the afternoon (between 12: 00noon and 3: 00noon).

Method of Data Collection

A total of forty (40) sample points were taken across ten (10) metal scrap dumpsites. The selected metal scrap dumpsites were divided into several parts and four (4) points were randomly selected from each metal scrap dumpsite and each point 10 m away from the waste dumpsite. Radiation Alert Inspector (RAI) was used to measure the ambient radiation that is emitted. The instrument was switched on and was kept on the metal scrap dump site points (U1 to U4) on the randomly selected points in each of the scrap dumpsite. The Gamma Activity level was recorded for each point. Also, GPS was used to measure the coordinates (latitude and longitude) of each sample area.

Radiological Impact Parameters

The measured raw data (results) obtained from the metal scrap dumpsites in the selected samples areas were analyzed using Microsoft excel and compared with regulatory standards.

The Absorbed Dose D (nGy/hr), Annual Effective Dose Equivalent (mSvy^{-1}) and Excess Lifetime Cancer Risk was estimated using equations (1), (2) and (3) respectively.

$$1\ \mu Sv/hr = 10^{3}\ nGy/hr \qquad (1)$$

$$E\ (mSvy^{-1}) = D \times T \times OF \times CC \times 10^{-6} \qquad (2)$$

$$ELCR = E \times DL \times RF \qquad (3)$$

where, E (mSvy^{-1}) is the Annual Effective Dose, D (nGy/hr) is the Absorbed Dose, T is the Working Hours per Year = 8760 hours, OF is the Occupancy Factor = 0.2 (Outdoor), CC is the Conversion Coefficient = 0.7

Sv/Gy, DL is the Duration of Life = 70 years and RF are the Risk Factor = 0.05 Sv^{-1}. For stochastic effects ICRP 60 recommend RF is the 0.05 for the public

RESULTS AND DISCUSSION

The radiation parameters measured and calculated for each sampling point are shown in Table 1.

Table 1: Measured and Calculated Radiation Parameters

SAMPLE ID	LATITUDE	LONGITUDE	Exposure rate (µSv/hr)	D (nGy/hr)	AEDE ($mSvy^{-1}$)	ELCR 10^{-3}
BMD 01	11^0 42"57.47	9^0 21"25.21	0.014	14	0.017	0.060
			0.012	12	0.015	0.052
			0.012	12	0.015	0.052
			0.013	13	0.016	0.056
BMD 02	11^0 42"45.12	9^0 21"33.08	0.009	9	0.011	0.039
			0.011	11	0.013	0.047
			0.013	13	0.016	0.056
			0.016	16	0.020	0.069
BMD 03	11^0 41"25.19	9^0 21"41.68	0.036	36	0.044	0.155
			0.015	15	0.019	0.064
			0.015	15	0.018	0.064
			0,017	17	0.021	0.073
BMD 04	11^0 41"35.66	9^0 20"35.70	0.013	13	0.016	0.056
			0.013	13	0.016	0.056
			0.008	8	0.010	0.034
			0.017	17	0.021	0.073
BMD 05	11^0 41"44.14	9^0 20"23.22	0.021	21	0.026	0.090
			0.007	7	0.009	0.030
			0.018	18	0.022	0.077
			0.014	14	0.017	0.060
BMD 06	11^0 43"14.64	9^0 20"10.11	0.018	18	0.022	0.077
			0.009	9	0.011	0.039
			0.015	15	0.018	0.064
			0.015	15	0.018	0.064
BMD 07	11^0 43"12.17	9^0 20"58.62	0.018	19	0.023	0.082
			0.022	22	0.027	0.094
			0.014	14	0.017	0.060
			0.020	20	0.025	0.086
BMD 08	11^0 45"12.5	9^0 22"52.02	0.018	18	0.022	0.077
			0.016	16	0.020	0.069
			0.015	15	0.018	0.064
			0.020	20	0.025	0.086
BMD 09	11^0 44"33.01	9^0 22"56.34	0.011	11	0.013	0.047
			0.014	14	0.017	0.060
			0.012	12	0.015	0.052
			0.015	15	0.018	0.064
BMD 10	11^0 44"28.20	9^0 22"50.22	0.020	20	0.025	0.086
			0.022	22	0.027	0.094
			0.019	19	0.023	0.082
			0.024	24	0.029	0.103

From Table 1 and Figure 1. the results show that the Mean Exposure Rate (μSv/hr) range from 0.01225 μSv/hr as the minimum value obtained from BMD02 to 0.2125 μSv/hr as the maximum value obtained from BMD10. These values were not in accordance with the findings of Abah, (2014) who found the exposure rate to be higher than the result of this study and also not in accordance with Ogundare and Nwankwo, (2015) and also by Hyacienth *et al*., (2022), who found the exposure rate to be in the range of 3.28 to 188.64 μSv/hr. However, this study agreed with study carried out by James *et al*., (2014) and also, slightly in accordance with findings of Kerinja *et al*., (2020); Echeweozo *et al*., (2020). Also, the result shows that the entire Exposure dose rates of all the locations were below the value of the Standard Background Radiation of 0.133 μSv/hr (James *et al*., 2014). From Table 1 and figure 2, the Estimated Mean Absorbed Dose was found to be in the range of 12.25 nGy/hr as the lowest value observed from BMD02 to 21.25 nGy/hr as the highest value observed from BMD10. All these obtained values were three times lower than the world average value of 57 nGy/hr. This finding was not in accordance with research carried out by Kerinja *et al*., (2020) and Abah (2014) who found the absorbed dose rate to be above the world average value. The main contributor of the absorbed dose rate in air is from the Exposure rate generated from the radionuclides in the scrap metal dumpsite investigated. Hence, the absorbed dose rate depends on some specific radionuclide concentrations observed during the study. Its well-known that the absorbed dose rate will always be high, If the of radionuclide concentration for the study area is high, (Kerinja *et al*., 2020).

From Table 1. and Fig. 3 the Estimated Mean Annual Effective Dose ($mSvy^{-1}$) revealed that the 0.015023 $mSvy^{-1}$ was the lowest value of annual effective dose observed on location BMD02, while the highest value of annual effective dose of 0.026061 $mSvy^{-1}$ was recorded on locations BMD10. All the values from metal scrap dumpsites were found to be below 1 $mSvy^{-1}$ limit as set by the public exposure, and also lower than the occupational dose limit of 20 $mSvy^{-1}$ which are not high enough to warrant regulatory control and this may not cause any radiological health hazards on people living around and workers of scrap metal dumpsites. All the estimated samples of annual effective dose were found to be within the ICRP dose limit of 1 $mSvy^{-1}$ for public exposure. This result is not in line with study carried out by Abah, (2014); Oluwafisoye, *et al*., (2009) and Kerinja *et al*., (2020) who got results above the current study. The analyzed results of Excess Lifetime Cancer Risk (ELCR) presented in table 1 and Fig. 4 shows that the value of ELCR range from 0.052582 as the lowest value recorded from BMD02 to 0.091214 as the highest value recorded from BMD10. All the values in the study area were found to be lower than the world average value of 0.29×10^{-3} (Taskin *et al.,* 2009). The result for this study was not in accordance with study carried out by Kerinja *et al*., (2020); whose findings gave the value of excess lifetime cancer risk to be 0.7585×10^{-3} which is more than double of the result obtained from this result and world average value of 0.29×10^{-3}. Also, with study carried out by Godwin *et al*., (2019). Based on the result obtained in this study there is very low risk of developing cancer by the workers, scavengers and the people living closer to the metal scrap dumpsites, this implies that location of settlements and processing activities in the metal scrap dumpsite will not pose severe health risk. The obtained results are also presented in Figures 1 to 4 for clarity.

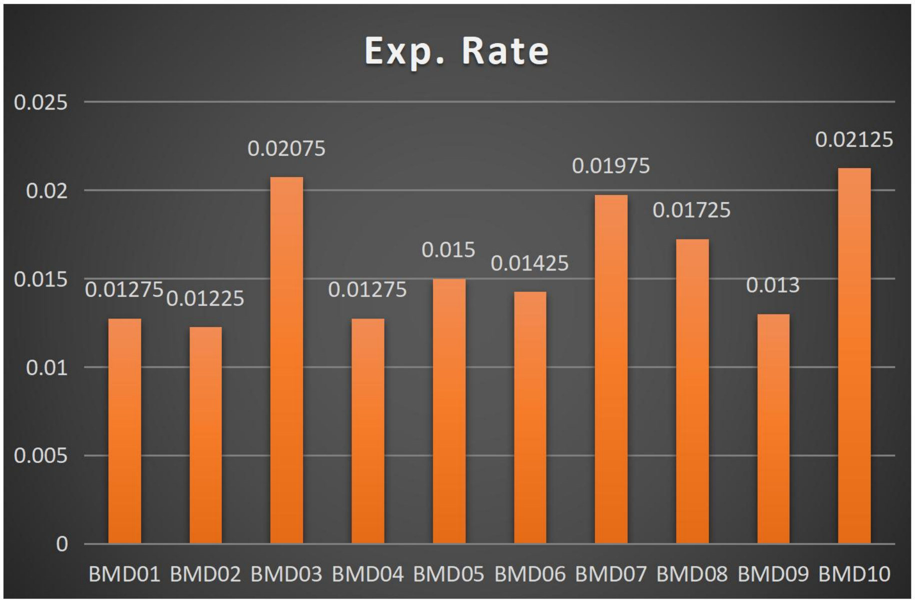

Figure1: Chart of Exposure Rate

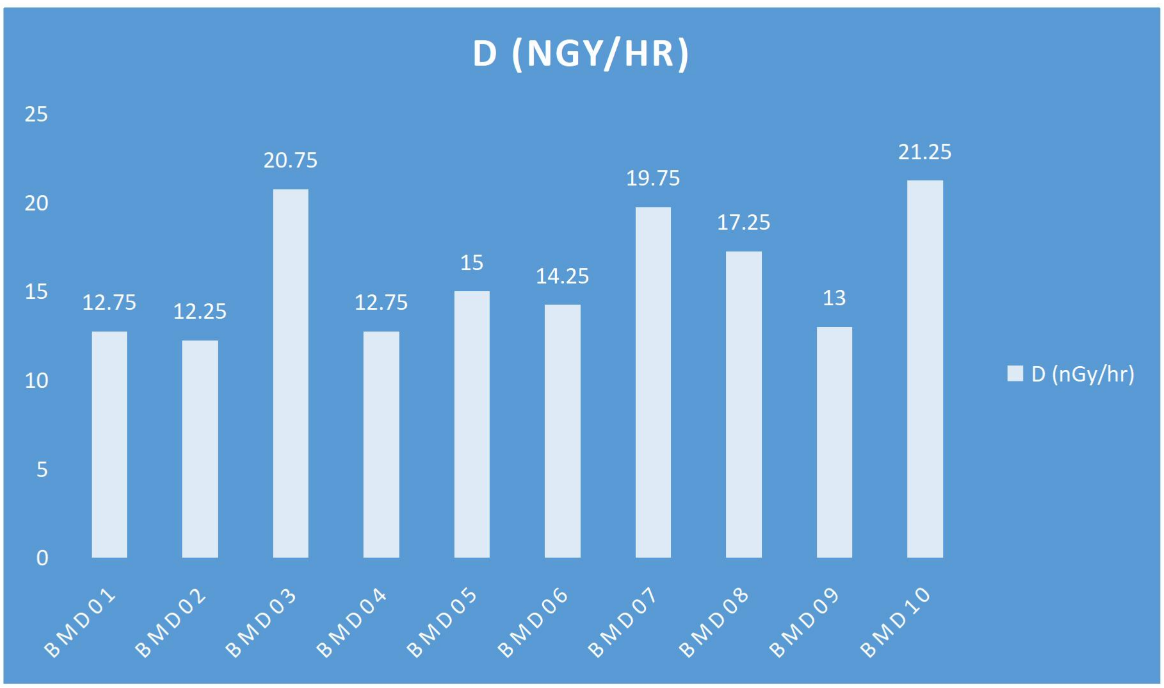

Figure 2: Chart of Mean Absorbed dose D (nGy/hr)

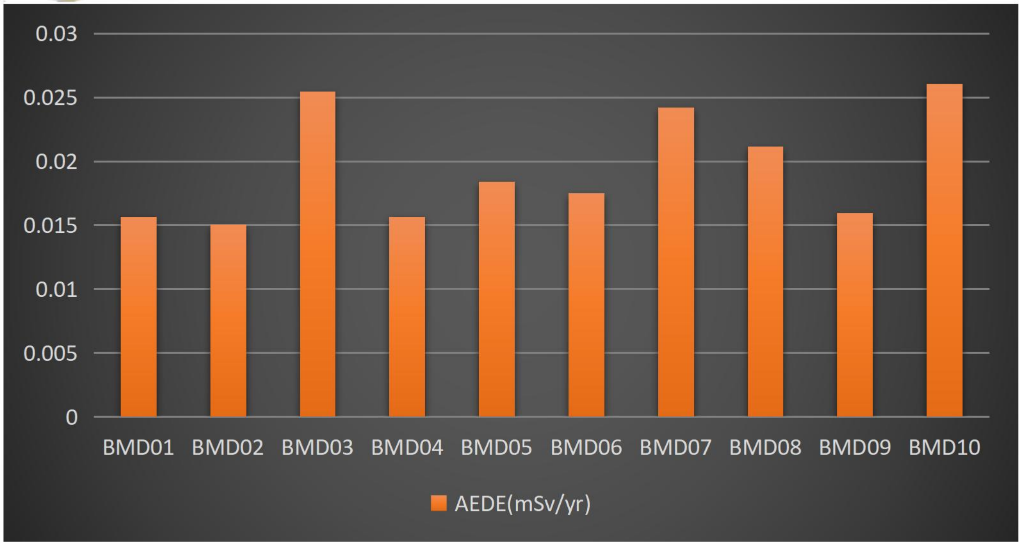

Figure 3: chart of Mean Annual Effective Dose in ($mSvy^{-1}$)

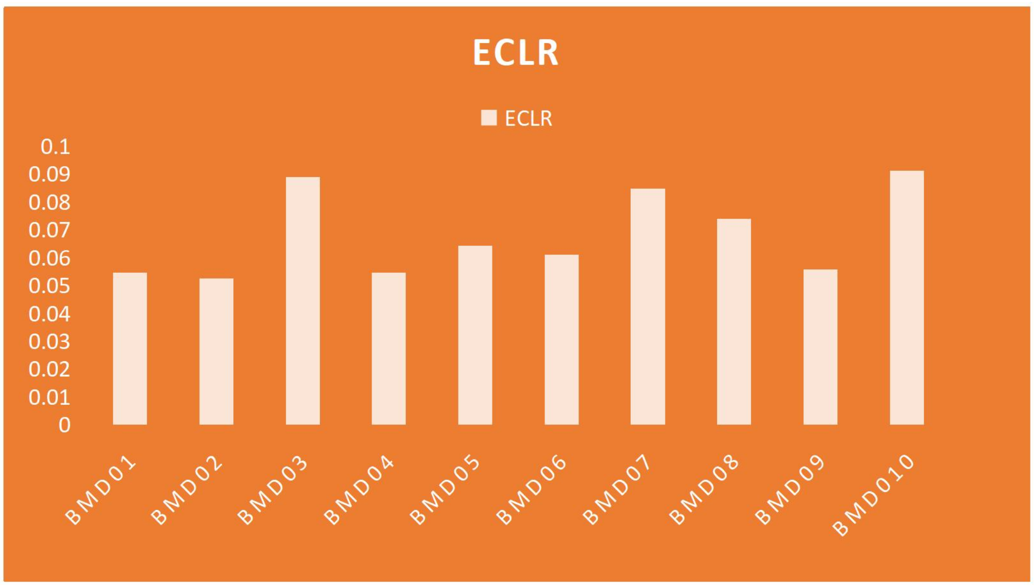

Figure 4: Chart of Mean Excess Lifetime Cancer Risk

Table 3: Comparison of Estimated Radiological Parameters of this Study with Other Part of Nigeria.

Study Area	E.R (µSv/h)	AED ($mSvy^{-1}$)	ELCR	References
Akwa Ibom	0.042 ± 002	0.35	0.05×10^{-3}	Godwin *et al.*, 2019
Gwagwalada	0.109±0.013	0.192±0.005	-	James *et al.*, 2014
Ebonyi	0.15±0.01	0.27±0.03	0.94×10^{-3}	Echeweozo *et al.*, 2020
Abuja	0.10± 0.03	0.20±0.06	-	James *et al.*, 2014
Jigawa	0.144	-	-	Eke and Emelue, 2020
Current Study	0.0159	0.0195	0.068249×10^{-3}	

CONCLUSION

This study was carried out to assess the background ionizing radiation level from metal scrap dumpsites in Dutse Town, the Capital City of Jigawa State, Nigeria. A total of ten (10) scrap metal Dumpsites were Selected randomly across various scrap metal dumpsites. Four readings were taken in CPM and µSv/hr at four (4) different selected points on each of the selected scrap metal dumpsites. The exposure rate µSv/hr recorded from the scrap metal dumpsite was use to estimate absorbed dose D (nGy/hr), Annual Effective Dose ($mSvy^{-1}$) and Excess Lifetime Cancer Risk (ELCR). And the results of the absorbed dose show that all the values are within the world average value of 57 nGy/hr. Also, the estimated mean value of annual effective dose $mSvy^{-1}$ were below the 1 $mSvy^{-1}$ dose limit that people of the public should not exceed, as recommended by the ICRP. The resulted mean value of Excess Lifetime Cancer Risk (ELCR) were also found to be within world average value of 0.29×10^{-3}. Based on the result obtained in this study there is very low risk of developing cancer by the workers, scavengers and the people living closer to the metal scrap dumpsites, this implies that location of settlements and processing activities in the metal scrap dumpsite will not pose severe health risk or any significant radiation hazard to the scrap metal workers and the public around the dumpsites.

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