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Radiological Implication of Some Selected Dumpsites in Birnin Kebbi: Natural Background Ionizing Radiation Measurement and Excess Life Cancer Risks Estimation

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Abstract

This study was intended to ascertain the contribution of the wastes in some selected dumpsites in the Birnin Kebbi community setting to the exposure levels of the immediate environment and to compare its value to internationally acceptable dose limits. It is established that there is a direct correlation between the activity of radionuclide concentration in materials found at dumpsites and radiation levels, particularly gamma radiation. Over time, the population of Birnin Kebbi town has significantly increased. It is necessary to determine the background radiation level of certain of the town's dumpsites because residential, market, and medical trash are continuously disposed of there. The study's objective is to assess the background radiation exposure levels in a few chosen dumpsites in Birnin Kebbi and compare them to the results of previous research and the global average of 2.4 millisieverts per year that is advised for human health. An accurately calibrated International Digital Radiation Monitor (survey meter) was used to determine the background radiation levels in these dumpsites. This study used a cross-sectional survey as its method. As per the protocol, the radiation monitor was positioned 1.0 meters above the ground, five measurements were obtained at each site, and the average dose rate was noted. Calculations were performed to determine the organ doses, excess life cancer risk (ELCR), and annual equivalent dose rate (AEDR). The data were summarized using Word Excel and descriptive statistics. The dose rate findings of all visited 12 dumpsites was found to be 0.113μSv/hr with annual effective dose of 0.198mSv/yr and excess life cancer of 0.692×10^{-3}, While mean organ doses were 0.127 mSv/yr, 0.115 mSv/yr, 0.137 mSv/yr, 0.162 mSv/yr, 0.091 mSv/yr and 0.135 mSv/yr with average organ cancer risks of 0.443×10^{-3}, 0.402×10-3, 0.478×10^{-3}, 0.568×10^{-3}, 0.319×10^{-3} and 0.471×10^{-3} for Lung, Ovaries, Bone Marrow, Tests, Kidney and Whole Body respectively. The findings of the annual effective dose were remarkably below the threshold limit of 1.0mSv/yr set by NNRA and the world average of 2.4mSv/yr for the public. The probability of future cancer risk is not in line with the 0.29×10^{-3} world average. Both people who work on dumpsites and those who live nearby have a comparatively significant risk of developing cancer. If the sites are not adequately monitored in a timely manner, this could result in an epidemic outbreak.

Keywords: cancer risk; background radiation; organ doses; dumpsites; birnin kebbi

Introduction

Waste is a serious global concern that has existed since the dawn of humankind and continues to rise. The incapacity of people to properly dispose of wastes like scrap metal, electronic waste from homes and markets due to the widespread use of electronics in this information era, animal waste from slaughterhouses, domestic waste from residential areas, chemical waste from manufacturing industries, and human and animal excrement is becoming more and more prevalent in all developing countries' expanding cities. The management and disposal of municipal solid waste (MSW) is one of the main issues that city planners worldwide must deal with. Poor waste management has resulted in a variety of environmental concerns for the world. Sludges, slags, fluids, cement, and scrap metals that caused a radiation disaster in the Mayapuri scrap market in West Delhi are the waste streams that contain technologically enhanced radioactive materials, or TERNORM (Faweya et al., 2018 and Samaila et al., 2021a). Due to their putrid odor, poisonous fumes inhaled, contaminated soil and water, disease-causing microorganisms present, potential radiation from ashes, smoke, dust from dumpsites, and lead from e-wastes, waste dumpsites pose serious health and safety risks to the environment and the people who live nearby (Samaila et al., 2021b). It is crucial to measure the radiation exposure dose rates coming from trash dumpsites since workers and nearby residents may receive different intermittent radiation doses based on how close they are to the source and how long they are exposed. The two organizations tasked with keeping an eye on radiation levels in Nigeria are the

Nigerian Nuclear Regulatory Authority (NNRA, 1995) and the Nigerian Atomic Energy Commission (NAEC, 1976). Not every state in the union has easy access to these bodies. Therefore, Nigeria lacks sufficient routine monitoring mechanisms, effective regulations to verify radiation levels in different dumpsites, and data on the radiological state of these dumpsites. Workers who collect scrap metals and refuse from landfills are doing so to sell salvage auto parts and use the metal for foundry purposes. Some Nigerian cities have established systems for burning rubbish and using it to make compost and fertilizer, which is how scavengers make a living from waste from dumpsites. Without regard for their health or the environment, trash workers and recyclers burn waste.

Natural background ionizing radiation levels in dumpsites have been evaluated in several studies. In Nigeria, the radiation levels in scrap metal dumpsites were found to be below the standard values, indicating that people living and working in the area are safe from high doses of radiation (Dan-Bi et al., 2022). However, in another study, the background ionization radiation levels in selected dumpsites exceeded the normal world average levels, suggesting potential long-term health effects on workers and residents (Gregory et al., 2014). In Kathmandu Valley, the average dose rates and annual effective doses were measured, with values ranging from 0.391 mSv/yr to 0.661 mSv/yr, which were compared to worldwide average values and legal dose limits (Parkash et al., 2018). Studies have shown that the detection of the risk of cancer from exposure to natural background ionizing radiation can be challenging due to large variations in risk from other causes, but specific types of cancer, such as childhood leukemia, may have a relatively strong signal against background radiation (Shweikan et al., 2009; Richard et al., 2009). This research is required to prevent another radiation accident like the one that occurred in Mayapuri, Delhi, India. The two possible ways that humans may be exposed to radiation are internally through inhaling radon and its daughters in dust and fumes from waste disposal sites, or externally through activity concentrations of 40K, 238U, and 232Th in soil. If site workers' and nearby residents' doses are discovered to be higher than the global average, preventive actions must be taken. This involves measuring the activity concentration caused by gamma rays from the dumpsite soil and determining the dose rate as a result. Environmental monitoring in these cities is necessary due to the likelihood of radon build-up in soil and trash that could affect nearby workers and residents. However, some of the crucial variables that are typically taken into account in radiation risk assessment include the population involved as well as the location and timing of exposure. This investigation was motivated by the current lack of adequate understanding regarding radiation exposure levels owing to time and the radiological implications for the population living in garbage dump sites. A baseline database on natural background radiation in Birnin Kebbi will be established by the research.

Materia and Method

Study Area

Northwest Nigeria is home to the city of Birnin Kebbi. It serves as both the Gwandu Emirate's and Kebbi State's capital city. The Fulani ethnic group resides in the city, which is situated on the Sokoto River and has road connections to Argungu (45 km northeast), Jega (35 km southeast), and Bunza (45 km southwest). The latitude and longitude coordinates of the city are: 12.466078 and 4.199524.

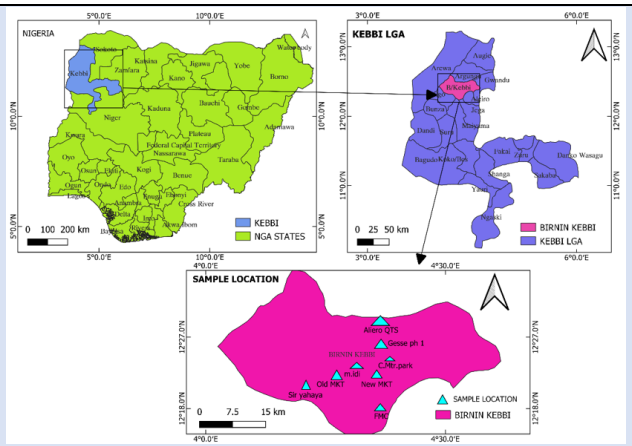

Figure 1: Location map showing various sampled areas.

The summary of physical composition of all visited dumpsites comprised of; expired dry cells, rotten fruits, waste clothes, rusted horns, fresh cow horns, animal dungs. Empty medical bottle, dry leaves e.g., neem. Sugar cane bagasse, kennels of maize and sand, rotten banana, syringes with wastes medicines, hand gloves, leathers, Cannulas, plastics, empty hydration drops, empty packages of soft drink, pampers, takeaways, egg shells, bandages, pieces of mosquito coils, human faces, rotten food, pieces of mattress, leathers, empty packages of milk, soaps, and biscuit. Dry leaves. empty packages of drugs and syrups, plastics, cars and motorcycle tiers. empty packets of biscuit, magi and milk, Human hairs, broken bottles, sugarcane bagasse, empty wasted television components, wasted drugs, empty packages of magi, banana stem, rat killer, broken glasses, nylon, takeaway, charcoal, deadly chicken, dry vegetable, raw onions, attachment hairs, herbs. and pieces of cigarettes. The rotting process that these items undergo could have been responsible for the radiation values recorded at the dumpsites. Below are figures showing different physical compositions of Birnin Kebbi dumpsites.

Figure 2: Gesse Phase I, **Figure 3:** Aliero Q. PDP, **Figure 4:** Aliero Q. Primary Sch, **Figure 5:** Central Motor, **Figure 6:** Federal Medical Center.

Figure 7: Aliero Quarter Nursery, **Figure 8:** Sir Yahaya Hospital. **Figure 9:** Masallachin IDI, **Figure 10:** Aliero Q. Opp INEC. **Figure 11:** Old Market.

Figure 12: New Market.

Method of Natural Background Radiation Measurement

The study used a cross-sectional survey design and was carried out in 12 significant dumpsites located in Birnin Kebbi. A single-stage cluster sampling method was employed to choose these dumpsites. An International Digital Radiation Monitor with proper calibration was used to determine the background

radiation levels at the designated dumpsites. Alpha, beta, gamma, and X-ray radiation can all be measured using the BR-6, a general-purpose Geiger counter radiation detector. It features a liquid crystal display (LCD) panel that indicates the radiation intensity that users are now exposed to in micro-sieverts per hour (μSv/hr). In accordance with the accepted practice outlined in the literature, an in-situ background radiation measurement approach was used. The radiation monitor was positioned 1.0 meters above the ground, and the average of five readings (such as north, south, east, west, and middle of the dumpsite) obtained at each site was noted. For best results, the readings were obtained between 1 and 1999μSv/hr, as this radiation meter responds to external radiation at its maximum during these hours.

Data Analysis

The obtained data were analyzed using MS Word and Excel spread sheet. The dose rate was first obtained from the radiation detector in (μSv/hr). The dose rate was then converted to annual effective dose rate (AED) and subsequently the AED converted to ELCR using mathematical equations incorporated into excel spread sheets. To convert the dose rate from μSv/hr to mSv/yr for Outdoors, the following equation was used

$$AEDR\ \left(\frac{mSv}{yr}\right) = \left(\mu\frac{Sv}{hr}\right) \times 8760\ \left(\frac{hr}{yr}\right) \times O.F \div 1000$$

Where AEDR- annual effective dose rate, (μSv/hr)- micro sievert per hour, O.F- occupancy factor (0.2). The annual equivalent dose rate in mSv/yr was calculated using the recommended outdoor occupancy factors of 0.2 (Samaila et al., 2020 Samaila et al., 2022). The values of readings obtained for each dumpsite were tabulated.

ELCR was estimated using mathematical equation below:

$$ELCR = AEDR\ \left(\frac{mSv}{yr}\right) x\ DL\ x\ RF$$

Where ELCR- excess lifetime cancer risk, DL- average duration of life (70 years) and RF- risk factor (0.05 Sv-1).

The following methodological chart was adopted in this research.

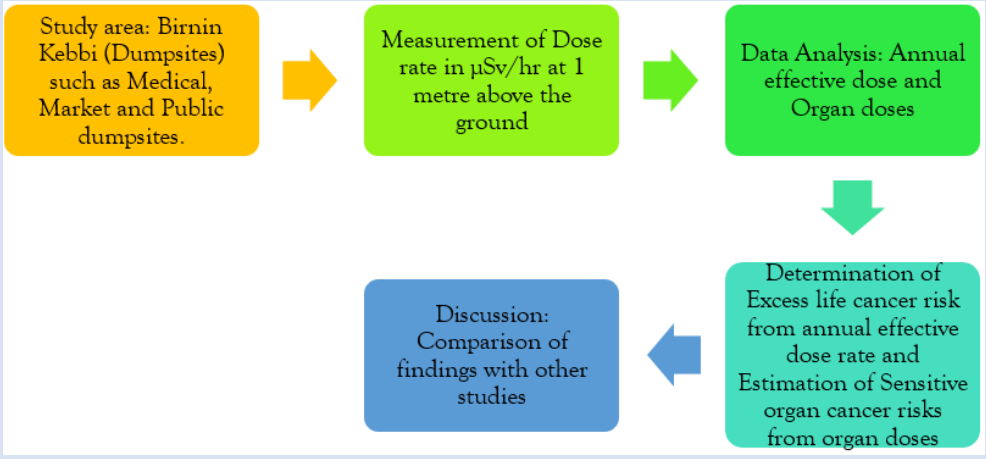

Chart 1: Methodological flow chart.

Results

Radiation exposure rates were obtained from 12 locations at zero distances. Five different measurements were obtained at each dumpsite and the mean values were calculated. Calculated values of annual effective dose rate (AEDR), Dose rate (DR), and excess life cancer risks are presented in Tables 1-4.

Table 1: Locations, Coordinates, Dumpsites and Mean Exposure dose rate.

S/N	Location	Coordinates	Dumpsite type	N	S	E	W	M	Mean μSv/hr
1	Old Market	12^0 27' 01"N4^0 12' 00" E	Market	0.120	0.130	0.120	0.120	0.120	0.122
2	SYMH	120 27' 19" N40 12' 03" E	Medical	0.110	0.120	0.100	0.110	0.100	0.108
3	Gesse phase 1A	12^0 27' 19"N4^0 12' 11" E	Public	0.110	0.110	0.100	0.100	0.120	0.108
4	Gesse phase 1B	12^0 27' 16"N4^0 12' 55" E	Public	0.100	0.120	0.100	0.110	0.100	0.106
5	Masallachin Idi	12^0 26' 47" N4^0 12' 16" E	Public	0.110	0.120	0.110	0.120	0.120	0.116

6	New market at Kazako	12^0 26' 28"N4^0 12' 24" E	Market	0.130	0.080	0.110	0.110	0.130	0.112
7	Aliero quarters Opp INEC	12^0 28' 07" N4^0 15' 19" E	public	0.110	0.110	0.110	0.130	0.120	0.116
8	Aliero quarters PDP forum	12^0 28' 07" N4^0 15' 19" E	Public	0.110	0.080	0.110	0.100	0.100	0.100
9	Aliero quarters nursery and primary A	12^0 28' 20"N4^0 15' 42" E	Public	0.110	0.090	0.110	0.110	0.100	0.104
10	Adamu Aliero model primary school B	12^0 28' 14"N4^0 15' 27" E	Public	0.130	0.110	0.110	0.120	0.130	0.120
11	Central motor park	12^0 26' 26" N4^0 12' 38" E	public	0.130	0.110	0.120	0.130	0.130	0.124
12	Federal medical center	12^0 26' 18"N4^0 11' 24" E	Medical	0.100	0.120	0.130	0.130	0.120	0.120
Average value									0.113

N= North; S= South; E= East; W= West; M= Middle.

Based on the data presented in Table 1, the mean dose rate for old and new market dumpsites was found to be 0.122 μSv/hr and 0.112 μSv/hr, which shows that, the old market dumpsite is higher than that of the new market. For public dumpsite, the central motor park has the highest Dose rate with a mean value of 0.124μSv/hr followed by Adamu Aliero model primary school with a mean value of 0.120 μSv/hr, while for medical dumpsite, the dose rate measured at FMC with a mean value of 0.120 μSv/hr is higher than that of Sir Yahaya memorial hospital as shown in the Table 1. The lowest dose rate value was obtained at Aliero quarters PDP forum Dumpsite with a mean value of 0.100 μSv/hr.

Table 2: Annual Effective Dose and Excess Live Cancer Risks.

Locations	Dumpsites	AEDR (mSV/Year)	ELCR (10^{-3})
Old Market	Market	0.214	0.749
SYMH	Medical	0.189	0.6615
Gesse Phase 1	Public	0.189	0.6615
Gesse Phase 1	Public	0.186	0.651
Masallachin Idi	Public	0.203	0.7105
New Market at Kazako	Market	0.196	0.686
Aliero Quarters Opp INEC	Public	0.203	0.7105
Aliero Quarters PDP Forum	Public	0.175	0.6125
Aliero Quarters Nursery and Primary	Public	0.182	0.637
Adamu Aliero Model Primary School	Public	0.21	0.735
Central Motor Park	Public	0.217	0.7595
Federal Medical Center	Medical	0.21	0.735
Average Values		0.198	0.692

The mean background radiation measured at twelve dumpsites was 0.198 mSv/year, central motor park having the highest value of 0.217 mSv/year, followed by the old market with a mean value of 0.214 mSv/year. The lowest value obtained was in Aliero quarters PDP forum with a mean value of 0.175 mSv/year. The estimated cancer risk was $0.692x10^{-3}$ with the central motor park having the highest excess life cancer risks, followed by the old market dumpsite with a mean ELCR of $0.749x10^{-3}$.

Table 3: Organ Doses (mSv/Year).

Locations	Dumpsites	Lung	Ovaries	Bone Marrow	Tests	Kidney	Whole Body
Old Market	Market	0.137	0.124	0.148	0.175	0.098	0.146
SYMH	Medical	0.121	0.110	0.130	0.155	0.087	0.129
Gesse Phase 1	Public	0.121	0.110	0.130	0.155	0.087	0.129
Gesse Phase 1	Public	0.119	0.108	0.128	0.153	0.086	0.126
Masallachin Idi	Public	0.130	0.118	0.140	0.166	0.093	0.138
New Market at Kazako	Market	0.125	0.114	0.135	0.161	0.090	0.133
Aliero Quarters Opp INEC	Public	0.130	0.118	0.140	0.166	0.093	0.138
Aliero Quarters PDP Forum	Public	0.112	0.102	0.121	0.144	0.081	0.119
Aliero Quarters Nursery and Primary	Public	0.116	0.106	0.126	0.149	0.084	0.124
Adamu Aliero Model Primary School	Public	0.134	0.122	0.145	0.172	0.097	0.143
Central Motor Park	Public	0.139	0.126	0.150	0.178	0.100	0.148

Federal Medical Centre	Medical	0.134	0.122	0.145	0.172	0.097	0.143
Average Values		0.127	0.115	0.137	0.162	0.091	0.135

Based on the findings presented in Table 3, the mean organ dose is 0.127, 0.115, 0.137, 0.162, 0.091, and 0.135 for Lung, Ovaries, Bone Marrow, Tests, Kidney, and Whole Body. The test organ has the highest mean value of 0.162 compared to other organs. The order of magnitude is Test > Bone Marrow > Whole body >Lung > Overy > Kidney. All the organ doses were below the world average value of 2.4 mSv/y.

Table 4: Organ Cancer Risks.

Locations	Dumpsites	Lung	Overy	BM	Tests	Kidney	WB
Old Market	Market	0.479	0.434	0.517	0.614	0.345	0.509
SYMH	Medical	0.423	0.384	0.456	0.542	0.304	0.450
Gesse Phase 1	Public	0.423	0.384	0.456	0.542	0.304	0.450
Gesse Phase 1	Public	0.417	0.378	0.449	0.534	0.299	0.443
Masallachin Idi	Public	0.455	0.412	0.490	0.583	0.327	0.483
New Market at Kazako	Market	0.439	0.398	0.473	0.563	0.316	0.466
Aliero Quarters Opp INEC	Public	0.455	0.412	0.490	0.583	0.327	0.483
Aliero Quarters PDP Forum	Public	0.392	0.355	0.423	0.502	0.282	0.417
Aliero Quarters Nursery and Primary	Public	0.408	0.369	0.440	0.522	0.293	0.433
Adamu Aliero Model Primary School	Public	0.470	0.426	0.507	0.603	0.338	0.500
Central Motor Park	Public	0.486	0.441	0.524	0.623	0.349	0.516
Federal Medical Centre	Medical	0.470	0.426	0.507	0.603	0.338	0.500
Average Values		**0.443**	**0.402**	**0.478**	**0.568**	**0.319**	**0.471**

The organ cancer risk presented in Table 4, indicated that the test organ has the highest value of 0.568 x10-3, followed by Bone Marrow with a mean value of 0.478 $x10^{-3}$.

Table 5: Comparison of the results with other works.

S/N	This work and other related studies	Mean ADR	AEDR	ELCR
1	This work	0.113	0.198	0.693 x 10^{-3}
2	Bassey and Ndubuisi (2020)	0.0178	0.0312	0.109 $x10^{-3}$
3	Ugwuanyi (2021)	0.106	0.186	0.651 x 10^{-3}
4	Ademola et al., 2014	0.113	0.47	-
5	Mojisola et al., 2017	0.150 (Indoor)	2.28 (Indoor)	-
		0.280 (Outdoor)	1.31 (Outdoor)	-

Discussion

This study assessed the levels of natural background ionizing radiations in landfills. The findings demonstrated that, for the most part, the radiation levels released from the dumpsites fell within audience-acceptable bounds. It was discovered that the average exposure dose rates and absorbed dose rates were below the guidelines suggested by global bodies like the International Commission on Radiological Protection (ICRP). The goal of this study was to compare the results to internationally acceptable dose limits in order to determine the extent to which the wastes at a few designated dumpsites in the Birnin Kebbi community context contribute to human and environmental exposure levels. According to Samaia et al. (2023), there exists a direct correlation between the content of radionuclides in materials found at dumpsites and the levels of radiation, particularly gamma radiation. The center motor pack's dumpsite was where the exposures were maximum, according to the data displayed in both tables. Despite the fact that conventional radiation intensities decrease with distance, this implies that people conducting business in the area and travelers are more vulnerable to radiation risks. This is consistent with a study (Olubosede et al., 2012) that found that the distance from the dump site increased in an inverse connection with exposure and absorbed dose rate. The annual effective dose estimated from all the 12 dumpsites was found to be below 2.4 mSv/y of the world average, NNRA (1.0 mSv/y) and also below the value obtained by Ugwuanyi et al. (2021), Ademola et al. (2014) and Mojisola et al. (2017). The ELCR was

found to be higher than the world average of 0.29×10^{-3} for each dumpsite as indicated in Table 3-4. Therefore, individuals within these areas are at risk of developing cancer at a later time.

Conclusion

The results showed that the radiation levels emitted from the dumpsites were generally within permissible limits for the general population. The mean exposure dose rates and annual effective dose rates were found to be below the recommended limits set by international organizations such as the International Commission on Radiological Protection (ICRP) and the Nigerian Nuclear Regulatory Agency (NNRA). However, the calculated mean excess life cancer risk of each dumpsite marginally exceeded the maximum permissible limit recommended for the public. It was concluded that the dumpsites may have been impacted radiologically and could pose long-term health side effects on workers and residents. Therefore, Continuous monitoring of background radiation in dumpsites was recommended.

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