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ARTICLE

Identification of Medical and Industrial Used Radioisotopes in Mining Sites of Nasarawa, Nasarawa State, Nigeria

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ABSTRACT

This research intends to unveil the presence of radioisotopes in the soil of some mining sites in Nasarawa of Nasarawa state using thermos-scientific interceptor (IdentiFINDER). The work aimed at detecting the presence, types and trust level of radioisotopes. The result showed that, ^{103}Pd and ^{125}I were found in 57% of the total points and the percentage abundance of the detector reached 50-65% indicating that, those radioisotopes are likely found in the area, ^{109}Cd was found in 15% of the total areas. The percentage abundance of the detector for ^{109}Cd shows 50% indicating that, those radioisotopes are likely to be found in the area, ^{241}Am was found in 7% of the total areas. The percentage abundance of the detector for ^{241}Am shows 81% indicating that, those radioisotopes are likely found in the area, ^{235}U was found in 7% of the total points. The percentage abundance of the detector for ^{235}U reaches 57% indicating that, those radioisotopes are likely found in the area, ^{75}Se was found in 7% of the total points. The percentage abundance of the detector for ^{75}Se was in abundance up to 57% indicating that, those radioisotopes are likely gotten in the area and ^{57}Co was gotten in 7% of the total areas. The percentage abundance of the detector for ^{57}Co was 54% indicating that, those radioisotopes are likely to be gotten in the area. Based on this high percentage abundance of the detector for these radioisotopes, they can be harnessed and applied appropriately in medicine and industry.

1. Introduction

Nuclear medicine is one of the specializations in medicine that uses the nuclear properties of radioisotopes in diagnostic, therapeutic and researches to evaluate metabolic, physiological and pathological situations of human parts. As an integral part of patient care, nuclear physics in medicine is currently applied to diagnose, treat and prevent many of serious problems in medicine [1]. In the present days, nuclear physics in medicine provides procedures which are vitally important over a wide range

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of medical sciences starting from oncology to cardiology up to psychiatry. Today physicists are equipped with a broad spectrum of nuclear imaging procedures and these differently supplies information about the working of virtually every major organ/tissue of the human parts. Nuclear medicine imaging procedures most times identify abnormalities at the initial stage of the growth of the disease, long before other alternative diagnostic modalities could detect them and this allows the disease to be arrested in its early course. However, the main strength of nuclear medicine depends on its ability to control both anatomical and physiological work in-vivo, which is impossible by the other contemporary imaging methods, like, computed tomography (CT) scanning, magnetic resonance imaging (MRI) and ultrasound imaging [1]. Though, these imaging techniques are able to depict anatomical features with a much quality resolution. Even though the field of nuclear medicine is filled with the diagnostic procedures, it also has valuable therapeutic applications, such as treatment of hyperthyroidism, rheumatoid arthritis, Hodgkin's disease and a wider range of cancers, such as breast cancers, ovary cancer, prostate cancer, liver cancer, colon cancer, lung cancer and endocrine glands cancer. Nuclear medicine has also been completely used to treat various heart problems, leukemia and for providing pain relief to the patients suffering from metastatic bone cancer. Nuclear medicine has always been maybe the most exciting area of investigation in medicine. Now-a-days, it is considered as one of the good diagnostic and therapeutic specialization in the armamentarium of medical sciences in spite of its modest beginning few centuries ago [2].

Nuclides with fixed atomic number but different mass number are known as isotopes. Almost 2500 known isotopes exist; even though, only 280 of them are stable. The remaining ones are not stable. The unstable ones are called Radioisotopes, because they emit some kinds of energetic rays and/or particles when they are trying to attain more stability [3].

Thus, radioisotopes used in nuclear medicine are vastly artificial and are originated from the soil. In most of our farm lands, the radioisotopes are embedded and whenever there is mining activities going on in these farm lands, the radioisotopes get excavated from beneath the soil surface to the top of the soil surface, and then when it rains, the water flushes it to our rivers or our farms where we consume them either through water or through crops [4].

These radioisotopes can be used in our various hospitals and our various industries for so many purposes if properly harnessed, instead of living these them after been excavated from beneath the soil to the soil surface to be flushed by rain water and later become harmful to us [5].

Applications of radioisotopes in human health care are extensively wide-spread and cover both the diagnostic and therapeutic domains. The diagnostic procedures could be performed either by in-vivo use of radiopharmaceuticals or by in-vitro use of radioimmunoassay. On the other hand, therapeutic procedures could be affected either by using the sealed sources or by the systematic administration of radiopharmaceuticals [6].

Even though there are few naturally occurring radioisotopes such as ^{131}I, ^{125}I, ^{123}I which are all isotopes of the same element. Their chemical and biological properties are expected to be the same [6]. The little variation in the weights, that they have, is because of the variation in the number of particles that they hold inside their nucleus. Some isotopes are disturbed by this kind of changes in their nuclear structure. They become not stable, and give out radiation till they reach their stable state. These elements are called radioisotopes [7]. Importance of radioisotopes in medicine is because they possessed two unique characteristics, which include the fact that their biological behavior is identical to their stable counterparts, and also because they are radioactive, so their emissions can be detected by suitable machines. Finding the percentage abundance of radioisotope spreading in our surroundings gives vital information on radiological sciences. Natural radioactivity originates from extraterrestrial sources as well as from radioactive elements in the earth crust [7]. About 340 nuclides have been found in nature, and more than 60 of these are radioactive [8]. All elements having an atomic number greater than 80 possess radioactive isotopes, and all isotopes of elements heavier than number 83 are radioactive [8]. The natural radio activities of the earth are categorized into primordial, secondary and Cosmo genic radioisotopes [9]. The primordial nuclides which now exist are those that have half-life at least comparable to the age of the universe. Radioisotopes with half-life greater than 1010 years have decayed very little up to the present time [10]. All isotopes of iodine will behave in the same way and will concentrate in the thyroid gland. There is no way of detecting the stable, natural iodine in the thyroid gland, but the presence of radioactive iodine can be detected externally in vivo by a detector. Thus, the radioactive iodine becomes a tracer, a sort of a spy, which mimics the behavior of natural iodine and relays information to a detector [10]. The radioactive tracers are popular because of the ease with which they can be detected in vivo and the fact that the measurement of their presence in the body can be in quantitative terms. The measurement can be very accurate and sensitive [11]. The radioisotopes are physical entities and their radiations and measurements are characterized by laws of physics. Hence, the knowledge of nuclear physics is needed for practicing Nuclear Medicine [12]. Radioisotopes are also used in 'Radiation joint lining removal' or 'Radio-surgery', where the radio labeled preparations are used to control and counteract immoderate propagation of synovial membrane in arthritis affected joints. This methodology has the advantage over other treatment modalities such as, chemical surgery and surgical intervention in terms of cost, side effects and need for hospitalization. Targeted radioisotope therapy in addition with other treatment techniques like, chemotherapy and surgical intervention have now become an integral part in the management of a wider variety of cancers such as, prostate cancer, colon cancer, breast cancer, ovary cancer and so on [13]. Nuclear Medicine is usually defined as a "clinical specialty devoted to diagnostic, therapeutic and research applications of internally administered radioisotopes." Diagnostic implies both in vivo and in vitro uses [13]. In modern times, there is hardly any medical research, where a radioactive tracer is not used in some form or other. Normally basic medical research is not considered as nuclear medicine, but clinical research applications of radioisotopes are considered as an integral part of this specialty. Same thing holds true for nuclear physics in relation to the practice of nuclear medicine. The approach in this work is also to give few salient facts, which one needs to know in actual day-to-day practice of nuclear medicine [14]. When we detect radioactivity, there is some component of it, which is arising from the background radiation. Most of these come from naturally occurring radioactivity in the soil. Procedures designed to answer these questions with the use of radioisotopes form the basis of Nuclear Medicine [15]. Radiation discovered more than a century ago has found many vital applications in medical and industrial spheres. Radiotracer technology has become an integrated part of multi-disciplinary investigation in oil fields for oil reservoir evaluation [16].

In medicine, ^{57}Co is used as marker to estimate organ size also used as a tracer to diagnose pernicious anemia [17], ^{75}Se is a radiotracer used in brain studies scinti graphy scanning study of the production of digestive enzymes [18], ^{103}Pd is used in brachy therapy for early prostate cancer [19], ^{109}Cd is used in cancer detection and pediatric imaging [20], ^{125}I is used in cancer brachy therapy (prostate and brain) filtration rate of kidneys, can also be used as a major diagnostic tool applied in clinical tests and to diagnose thyroid disorders [21]. Also used in biomedical research and ^{241}Am is used in osteoporosis detection and heart imaging [21]. While in industry, ^{57}Co is used to locate pipeline blockages in petroleum industries [22], ^{241}Am is applied in many smoke detectors for homes and businesses, to measure levels of toxic lead in dried paint samples, to ensure uniform thickness in rolling processes like steel and paper production and to help determine where oil wells should be drilled [23], ^{109}Cd is used to analyze metal alloys for checking stock and scrap sorting [24], ^{75}Se is used in protein studies in life science research [25] and ^{235}U is used a fuel for nuclear power plants and naval nuclear propulsion systems and used to produce fluorescent glassware, a variety of colored glazes and wall tiles in industries [26].Studies of the same kind have been conducted in different parts of Nigeria to assess the radioisotope spreading and their respective percentage abundance but there were never been any proof of such a kind of research to assess the radioisotope spreading and their respective percentage abundance in Lafia dumpsites. Therefore, this research unveils the presence of the above stated radioisotopes in soil from some mining sites as well as their trust level (which indicates their availability in the study area) in Nasarawa of Nasarawa State, using thermos-scientific interceptor (identiFINDER) obtained from Nigerian Nuclear Regulatory Authority (NNRA).

2. Materials and Methods

2.1 Materials

The materials which have been applied in the study area for the Identification of Medical and Industrial Used Radioisotopes in Mining Sites in Nasarawa, Nasarawa State, Nigeria can be shown in Table 1.

2.2 Method

To achieve the aim of this study, the stratified random data collection method was employed in which a grid was defined for the study area. The grids for the area under study have been defined within the area of meters. After defining the grid of the area under study, in each data point, the type of radioisotopes and their respective percentage abundance are obtained. The process have been made according to the recommendations of technical documents of some Regulatory authorities like International Atomic Energy Agency and Nigerian Nuclear Regulatory Authority that covers almost if not all the aspects of the uranium mining industry, from exploration to exploitation, decommissioning and the application of modalities in other non-uranium resource areas[27-29]. The data were taken using a portable hand held detector (i.e. thermo scientific interceptor), which is the most suitable detector for qualitative and quantitative analysis of gamma radiation that uses a Cadmium Zinc

Telluride (CZT) detector.

This research work centered on Nasarawa of Nasarawa State. The coordinates of the study area are tabulated in Table 2. Map of the study area is presented in Figure 1.

Table 1. Materials, their Specifications and uses

Materials	Specifications	(i) Uses
Thermo Scientific Interceptor (radiation identiFINDER)	(ii) A High-efficiency Cadmium Zinc Telluride (CZT) finder Detector, with dimension 122mm x 68mm x 30mm, resolution of 7mm x 7mm x 3.5mm (0.3in x 0.3in x 0.15in) CZT identification detector, with ^{3}He Neutron detection at 8atm., 13-mm diameter x 66m (0.5in dia x 2.6in) at 1.2 cps/nv. It has dose rate of High performance, 1024-channel DSP-based MCA with energy compensation dose rate algorithm on finder detectors and operating temperature range of -20^{0}C to +50^{0}C (-4^{0}F to +122^{0}F) at up to 95%RH at 95^{0}F with energy range of 25KeV to 3MeV and sensitivity of 1.5cps/µR/h, 1.2cps/nv.	(iii) This is used to detect the radioisotopes as well as their trust level
Map of the study area	Google map	This gives the names and locations of the area.
Tape Measure	Steel type	This is for measuring grid size.
Global Positioning System (GPS)	15m horizontal (50 ft)	Used to take coordinatesof sample points.

Table 2. Sample Points and their Locations

PointCode	Sample Coordinates	
	North	East
OP A	08^{0}21'24.9"	007^{0}54'29.6"
OP B	08^{0}21'19.8"	007^{0}54'24.5"
OP C	08^{0}21'15.5"	007^{0}54'20.2"
OK A	08^{0}24'04.1"	007^{0}52'10.6"
OK B	08^{0}24'01.2"	007^{0}52'07.7"
OK C	08^{0}23'99.8"	007^{0}52'04.8"
EY A	08^{0}24'38.2"	007^{0}52'59.2"
EY B	08^{0}24'33.1"	007^{0}52'54.1"
EY C	08^{0}24'28.0"	007^{0}52'49.0"
UM A	08^{0}25'56.3"	007^{0}53'49.3"
UM B	08^{0}25'51.2"	007^{0}53'44.2"
UM C	08^{0}25'46.9"	007^{0}53'39.9"

3. Results and Discussion

In this section, the results for both medical and industrial used radioisotopes as well as their respective trust level obtained from the field was presented and further discussion was made on the radioisotopes distribution in the study area.

3.1 Results

The results gotten from different mining areas like radioisotopes with their respective percentage abundance are presented in Table 3.

Table 3. Radioisotopes and Trust Level from the Study Area

Point Code	Radioisotope I	Trust Level (%)	Radioisotope II	Trust Level (%)
OP A	I-125 (Med)	61	Pd-103 (Med)	54
OP B	Pd-103 (Med)	53	Cd-109 (Ind)	50
OP C	U-235 (Med)	57	I-125 (Med)	52
OK A	I-125 (Med)	49	Pd-103 (Med)	46
OK B	Se-75 (Med)	57	Co-57 (Ind)	54
OK C	I-125 (Med)	49	Cd-109 (Ind)	42
EY A	Pd-103 (Med)	63	-	-
EY B	Am-241 (Ind)	81	-	-
EY C	I-125 (Med)	62	Pd-103 (Med)	50
UM A	I-125 (Med)	53	Pd-103 (Med)	45
UM B	I-125 (Med)	64	Pd-103 (Med)	51
UM C	I-125 (Med)	56	Pd-103 (Med)	52

OP = Opanda; OK = Okereku; EY = Eyenu; UM = Udege = Mbeki; A = Mining Point; B = 100 meter away from Mining Point; C = Water Way within the Mining Point.

Results Analysis

In this study, the results presented in Table 3 were used to plot chart in other to explain the radioisotopes percentage abundance per total area under investigation as presented in Figure 2.

3.2 Discussion

The results of the Identification of Medical and Industrial Used Radioisotopes in Mining Sites across Nasarawa Local Government using Thermo-Scientific Interceptor CTZ Radioisotope IdentiFINDER Detector were presented in Table 3. The analysis of the radioisotopes percentage abundance was done using a chart as presented in Figure 2. Seven (7) radioisotopes were found to be spread across the twelve points in the area under study. These radioisotopes and their respective atomic masses include Palladium-103, Iodine-125, Cadmium-109, Americium-241, Uranium-235, Selenium-75 and Cobalt-57. From the findings of this study as presented, it is possible to see that ^{103}Pd (Palladium-103) and ^{125}I (Iodine-125) were found to be in 57% of the areas in which the samples were taken and the percentage abundance of the detector reaches 50-65% which indicates that, those radioisotopes which may be used for either medical or industrial purpose are likely to be found in the area. Similarly, it is clearly seen that

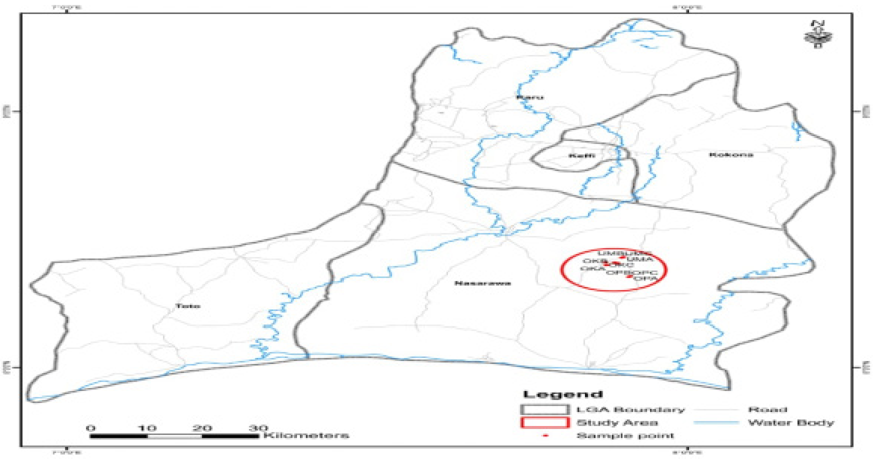

Figure 1. Map of the Sample Location in Nasarawa West

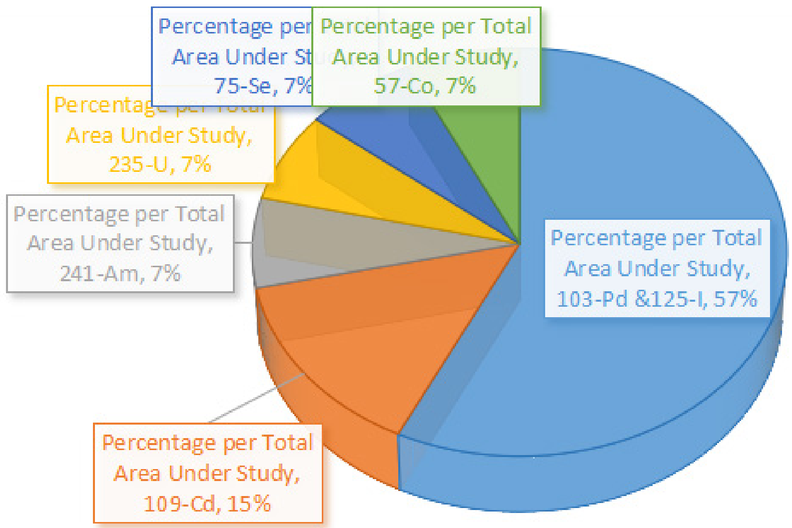

Figure 2. Radioisotopes and Percentage Abundance per Total Area under Study

^{109}Cd (Cadmium-109) was found to be in 15% of the total areas in which the samples were collected. The percentage abundance of the detector for ^{109}Cd (Cadmium-109) shows 50% which indicates that, those radioisotopes which may be used for either medical or industrial purpose are likely to be found in the area. It is also obviously seen that ^{241}Am (Americium-241) was found to be in 7% of the total areas in which the samples were taken. The percentage abundance of the detector for ^{241}Am shows 81% which indicates that, those radioisotopes which may be used for either medical or industrial purpose are likely found in the area. It is similarly possible to notice that ^{235}U (Uranium-235) was found to be in 7% of the total points in which the samples were collected. The percentage abundance of the detector for ^{235}U (Uranium-235) reaches 57% which indicates that, those radioisotopes which may be used for either medical or industrial purpose are likely gotten in the area. It is also possible to see that ^{75}Se (Selenium-75) was found to be in 7% of the total points in which the data were measured. The percentage abundance of the detector for ^{75}Se (Selenium-75) was in abundance up to 57% which indicates that, those radioisotopes which may be used for either medical or industrial purpose are likely gotten in the area. And lastly, it is also possible to see that ^{57}Co (Cobalt-57) was found to be in 7% of the total areas in which the data were taken. The percentage abundance of the detector for ^{57}Co (Cobalt-57) was 54% which indicates that, those radioisotopes which may be used for either medical or industrial purpose are likely to be gotten in the area. Based on this high percentage abundance of the detector of these radioisotopes, they can be harnessed and applied appropriately in medicine and industry.

4. Conclusions

Identification of Medical and Industrial Used Radioisotopes in Mining Sites of Nasarawa in Nasarawa State, Nigeria using thermos-scientific interceptor (radiation identiFINDER) was carried out and the findings of the study show that, the trust level of the radioisotopes distributed across all the areas under investigation for both Medical and Industrial uses found in most of the areas under investigation are high. This high trust level indicates that these radioisotopes are embedded in those areas and can be harnessed and put to appropriate use in their area of usage as stated in Table 3 since they are highly demanded in our various hospitals and industries. It is therefore recommended that, the government should look for a way of sponsoring researchers to enable them to engage in researches on the possible ways to extract these radioisotopes for use in our various hospitals and industries instead of importing them from foreign countries. It is also suggested that researches of the same kind should be conducted in the remaining parts of the country.

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