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Evaluation of the Radioactive Waste Management in nuclear medicine department at Royal Care International Hospital

تقويم إدارة التخلص من النفايات المشعة فى قسم الطب النووي بمستشفي رويال كير

A thesis submitted for partial fulfillment of the requirements of Master degree in Medical Physics

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الاية

قال تعالى:

(وقل اعملو فسيرى الله عملكم و رسوله و المؤمنون و ستردون الى
عالم الغيب و الشهادة فينبئكم بما كنتم تعملون)

صدق الله العظيم

سورة التوبة الاية (105)

Dedication

To those who offered me a moment of happiness

To my parents

To my family

To my friends

I dedicate this study…

Acknowledgements

First thanks to Allah. Secondly I would like to express my special appreciation and thanks to my supervisor Dr. Awad Abdalla Adlan for his unlimited help and encouragement .

Also I would like to thank the members of Royal Care Hospital Nuclear Medicine department and all those who have been there to support me .

Abstract

The study was done in Royal Care International Hospital Nuclear Medicine Department, using two types of Radionuclide Tc^{99m} and I^{131} , during the period from March to September 2018,the main objective of this study to assess waste management in nuclear medicine department, and provide practical guidance on the management of radioactive waste from nuclear medicine department.

Data was collected using Analog Radiation Detector,I'm take eight sample of Tc^{99m} waste and read activity before storage and before disposal , activity reading before disposal almost in range from 0.03 KBq/cm^2 to 0.1 KBq/ cm^2, I'm take four sample of I^{131} waste and read activity before storage and before disposal , activity reading before disposal almost in range 0.1 KBq/cm^2 to 1 KBq/ cm^2.

The results of this study revealed that discharge of the radioactive waste to the environment was done after 10^{th}half-lives of radioactive materials in Royal Care International Hospital.

In concluded the waste management in Royal Care International Hospital nuclear medicine department use optimum way to manage the Radioactive waste.

ملخص البحث

التخلص من النفايات المشعة من أهم الاهداف فى ادارة النفايات المشعة و يجب ان يكون بالطرق الصحيحة ويجب التأكد من عدم تعرض الأفراد فى المستشفي للاشعاع المنبعث من النفايات المشعة و الهدف من هذه الدراسة توضيح كيفية التعامل مع النفايات الاشعاعية لحماية الانسان و البيئة وهذه الدراسة تمت في مستشفي رويال كير قسم الطب النووي وذلك بأستخدام نوعين من النويدات المشعة , نظير اليود ونظيرالتكنشيوم , في الفترة من مارس الى سبتمبر 2018.

أخذت ثمانية قراءات للنشاط الاشعاعي لنفايات التكنشيوم قبل التخزين وقبل التخلص منها و كان النشاط الاشعاعي قبل التخلص منها تقريبا فى المدى من 0.03 KBq/cm^2 الى 0.1 KBq/ cm^2, أخذت أربعة قراءات للنشاط الاشعاعي لنفايات اليود قبل التخذين و قبل التخلص منها وكان النشاط الاشعاعي قبل التخلص منها تقريبا فى المدى من 0.1 KBq/cm^2 الى .1 KBq/ cm^2.

أظهرت النتائج المتحصل عليها من مستشفي رويال كير قسم الطب النووي ان النفايات المشعة يتم التخلص منها بعد مرور عشرة اعمار نصف للمادة المشعة .

وفي النهاية ادارة النفايات فى مستشفي رويال كير تستخدم طرق جيدة لادارة النفايات في قسم الطب النووي.

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Abbreviation

Bq	Becquerel
ESTRO	European Society for Therapeutic Radiology and oncology
EU	European Union
FDG	Flurodeoxy Glucose
GTRI	Global Threat Reduction Initiative
GY	Gray
IAEA	International Atomic Energy Agency
ICRU	International Commission on Radiological Units and Measurements
MV	Mega volt
NCR	National Cancer Registry
OSRP	Offsite Source Recovery Project
PET	Positron Emition Tomography
QA	Quality Assurance
QC	Quality control
RIA	Radio immune analysis
RPO	Radiation Protection Officer
SPECT	Single Photon Emition Computed Tomography
TC	Technetium

Chapter One

Introduction:

Nuclear medicine is a branch of medicine which uses radioactive materials in diagnosis and therapy for many diseases. Radionuclides are compounded with radiopharmaceuticals based on metabolic activity of thetargeted organ . Unlike MRI and CT, nuclear medicine uniquely provides information about both the function and structure of organ systems within the body. (Cherry et al 2003) While the introduction ofI^{131} for treating thyroid disease in 1946, followed a few years later by I^{131}thyroid imaging , marks the beginning of Nuclear Medicine, it was the discovery of 99mTechnetium in 1937 and the subsequent development of the first commercial Tc^{99m} generator in 1964 that lead to the tremendous growth of nuclear medicine . For nuclear imaging,

Tc^{99m} has become the isotope because of its virtually ideal physical characteristics for scintigraphic applications (i.e., generator produced , 6-half-life, 140kev gamma radiations) and its versatile chemistry that can be manipulated to label a variety of legends. The Mo/Tc generator can be shipped to laboratories for the production of single Tc^{99m} dose radiopharmaceuticals on site making Tc^{99m} , by far, the most utilized radioisotope in nuclear medicine. Other isotopes require cyclotron or reactor generation, which is more costly, and less available for emergency or rapid administration. Today, there are nearly 100 nuclear medicine imaging procedures available using various single photon emission isotopes and positron emission isotopes. The availability of 18F and specificallyF^{18} , -fluorodeoxy-D glucose (FDG) has allowed for the practical application of PET.Gamma emission imaging has been successfully applied to almost every organ of the body (brain , bone , heart, kidney, lung and neuroreceptors) as well as sites of inflammation , atherosclerosis, thrombosis and cancer. The molecular nature of nuclear medicine imaging leads to unique non-invasive pharmacokinetics modeling application. The future of nuclear medicine imaging radiopharmaceutical lies primarily in the development of new legends for Tc^{99m} (for SPECT) and F^{18} (for PET) to carry the radioisotope to the site of application without compromising the

biological activity of the legend molecule rather than in the development or discovery of new radioisotopes (Cherry et al 2003).

Problem of the study:

Safe handling of radioactive waste was not carried out properly in most Nuclear medicine departments in Sudan .

Objectives of the study:

General objective:

To assess waste management in nuclear medicine department , and provide practical guidance on the management of radioactive waste in nuclear medicine departments.

Specific objectives:

1. To measure the activity of the waste before storage.
2. To measure the activity of waste before disposal.
3. To check the waste type and the half life of radioactive nuclei.

Chapter Two

LITRITURE REVIW

2.1 Theoretical Background

2.1.1 Radioactive waste:

The radioactive waste in a nuclear medicine facility comprises many different type of waste. It may be of high activity, such as a technetium generator , or of low activity , such as form biomedical procedures or research (IAEA 2005).

In addition , it may have a long or short half life and it may be in a solid , liquid or gaseous from. Radioactive waste needs to be safely managed it is potentially .

Hazardous to human health and the environment . through good practices in the use of radionuclide's, the amount of waste cane be significantly reduced but not eliminated (IAEA2005).

It is important that safe waste management , in full compliance with all relevant regulation , is considered and planned for at the early stages of any projects involving radioactive materials . it is the responsibility of the licensee to provide safe management of the radioactive waste . it should be supervised by RPO and local rules should be available.

Contamination is associated with radioactive spills ,animal experiments, emergency surgery of therapy patient and autopsy of therapy patient . however, traces of the radionuclide's used in a nuclear facility can be found almost everywhere , especially 0n door handles , taps , some specific equipment and in the patients toilet. Some procedures , such as ventilation scans, might also cause contamination of both personnel and equipment. Whole body measurement of workers have revealed an equilibrium internal contamination of up to 10 Kbq of 99mTc , which will result in an effective dose of ~0.05 msv/a. although this is a small fraction of the external exposure , every precaution must be taken to avoid contamination of the facility.

2.1.2 Sources of Radioactive Waste :

Radioactive Waste is material contaminated with radioactive substances which arises from medical or research use of radionuclide's. It is produced , for example , during nuclear medicine, radio immunoassay and bacteriological procedures , and be in a solid liquid or gaseous from and be included in the body waste of patient under treatment . reference should be made to the Radiation Control Act 1990 and the Radiation Control Regulation 1993.

Radioactive waste, once lead shielded and allowed to decay to safe level as set by the Regulatory authority, is no longer deemed to be radioactive waste. Some radioactive wastes are classified as hazardous waste in the Waste Regulation.

2.1.3 Handling of Radioactive Waste:

Radioactive substances should be handled in a safe manner ensure that all personnel have minimal exposure to radiation . A radiation safety officer must be responsible for the safe handling , storage and transport of radioactive waste . There must be a specifically identified area for the storage of radioactive waste , which should be suitably packaged and labeled (IAEA 2000).

The handling , storage and disposal of radioactive materials must comply with requirement of the Radiation Control Act 1990 . Where such requirement do not exist, observe the principle in National Health and Medical Research council (NH and MRC) Code of Practice for the Disposal of Radioactive Wastes by the User (1985).

2.1.4 Type of Radioactive waste:

2.1.4.1 General:

The use of wide range of radionuclide's in medicine and medical research leads to the generation of waste, which requires a comprehensive management system. In many instances, the potential additional hazards, either from the chemical, biological or physical properties are greater than the radiological hazard due to the presence of radionuclide contamination (IAEA 2005).

2.1.4.2 Liquid waste:

Liquid radioactive waste includes contained water effluent, waste arising from chemical processing and decontamination solution , solvent , blood or body fluids, discarded liquid radiopharmaceuticals, wound or oils and scintillation fluids.

Waste that includes both radioactivity and a hazardous chemical component is usually referred to as a mixed waste (IAEA 2005).

2.1.4.3 Gaseous waste:

Xenon-133 and 81mKr are use in diagnostic imaging for assessment of regional lung ventilation. Since they are noble gases, they are difficult to treat and are often released to the atmosphere through an exhaust system .It is essential to ensure that there is no possibility of re-entry of the released gases back into the building through open windows or ventilation system.

2.1.4.4 Solid waste:

At health care, medical and research facilities , solid waste is generated in the form of paper and plastic , animal carcasses, contaminated materials, discarded radiopharmaceutical containers, bandages, contaminated equipment or organs and tissue . solid waste is typically classified as combustible /non-combustible waste. It generally contains a relatively low level of radioactivity when compared to liquid wastes.

Solid radioactive waste consists mainly of general biomedical waste, which includes:

Protective clothing ,plastic sheets and badges, gloves , masks, filters, overshoes, paper wipes, towels, metal and glass, hand tools and discarded equipment.

2.1.5 Assessment and optimization of Radioactive Waste:

radioactive waste from the medical sector does not present a significant long term waste management problem when compared to wastes generated from nuclear fuel cycle operations. The most important characteristic of

biomedical waste are its short half- life and low radiotoxicity. Biomedical waste typically contains low energy and emitters and is generally of low total and specific activity. Important considerations are the volumes of waste and other hazardous properties associated with the waste such as biological and chemical risks (IAEA 1982I).

An effective programmer for biomedical radioactive waste management is based on the principle of waste prevention and minimization, whilst providing for the protection of personnel and the environment , consistent with the requirements of the regulatory authority . Such management should integrate all associated hazards that are found in the waste .

The basic principle of radioactive waste management are described elsewhere and include providing for the protection of the general public and the environment .

A comprehensive waste management programmer requires a thorough prior assessment to ensure that the primary focus is waste prevention and minimization whilst providing for protection form all associated hazards of the waste . This assessment will include an analysis of the total radionuclide inventory and pattern of use, waste types and amounts generated and the potential routes for disposal.

This review will seek to harmonize the waste management activities of all areas within a facility (IAEA 1982).

Such an evaluation is best carried out at the planning stage of a facility allowing for the incorporation of specific features which will enhance waste management throughout the facility . In most circumstances, however, the evaluation will be carried out on an existing facility which may have individual laboratories with their own specific waste management practice and instructions. For such circumstances , harmonization of waste management activities becomes even more important. Only when all uses of radionuclide's have been evaluated can it be ascertained waste minimization practices need to be implemented and how waste management can best be organized.

The radioactive waste management programmer must be comprehensive and should consider all aspects, starting with radionuclide purchase though to the final clearance of waste packages from the facility to disposal or discharge. Clearance of radioactive waste from further regulatory control can only be achieved through a careful programmer of waste flow control and measurement of residual radioactivity . Biomedical waste is usually best managed on-site by decay storage, with minimal transport risks and ALARA exposure levels. Since quantitative estimation of isotope activity can be difficult where waste packages contain a mixed combination of emitters, segregation at the time and place of waste production is essential.

An important component of effective waste management is the preparation of universal documented procedures . such procedures will detail requirement for practice such as waste segregation at source and appropriate containers /receptacles for accumulation of waste.

All staff should be appropriately trained in the implementation of these procedures. Responsible personnel should be identified for each stage in the waste management process, with management committing total support to the implementation of the overall waste policy (IAEA 1982).

As part of the evaluation of waste management programmer, it is necessary to collect information specific to each facility. This data will provide the basis for determining potential opportunities for further waste management optimization.

The data should be recorded in a data management system allowing for follow-up of waste flows from source to final disposal, and should include:

- Data on all characteristics of the waste generated and radionuclide's used within the facility
- Organizational responsibility for the radioactive waste management programmer (collection , transport , storage , clearance).
- Reference to procedures that are currently in use for management of radioactive waste
- Specifications of how the radionuclide content and activity of individual waste packages is quantified and verified

- Types of packaging used for each type of medical radioactive waste
- Data on decay storage and pretreatments of medical radioactive waste
- Reference to quality control procedures, and if in place , audit as part of on overall quality assurance programmer
- Data to verify whether all regulatory requirements are being met
- Certification of measurements made.

The subject of the waste management programmer evaluation.

Collation of data obtained by utilization of these guidelines will give an overall picture of radionuclide usage and management requirements. The data will enable a full review of current practices to be undertaken with a view to implementing an overall strategy for purchasing control of radionuclide's and management of radioactive waste (IAEA 1992).

It is essential at an early stage to co-ordinate with the on-site radiation protection supervisor (s)/ advisor and seek support in taking the necessary steps .

These people will have > first hand = knowledge of the working environment and be able to provide specific advice on where information can be obtained relating to any non-radiological hazards which might necessitate the continuation of the current waste segregation and management procedures. By collaboration, the practical implementation of optimization of waste management can be taken forward, with additional training of staff as required (IAEA1992).

In some instances, modification to the radioactive storage room, or the organizational arrangements for its use, will be necessary before it would be appropriate to alter the period that waste is held on the premises to permit radioactive decay . Although these improvements may have cost implications, they can often be met by saving that will be made by decaying short half-life radionuclide such that they can be disposed of at clearance levels (IAEA 1992).

The overall development of a waste management strategy is not a static process. It should be subject to periodic review , at least annually, to

ensure optimization of waste management practices , e.g. by cost-benefit analysis and continued compliance with regulatory requirements. Usage of individual disposal routes , i.e. incineration, landfill, a repository for low level radioactive waste and sewers for discharge to drain , should be reviewed when disposal routes change their pricing structure to ensure cost-effective and environmentally sound use disposal routes , whilst maintaining full complications with regulations governing both the radiological and non-radiological hazards that may be associated with the wastes (IAEA1992).

Figure (2.2) Management of radioactive waste

2.1.6 Segregation and packaging of Radioactivewaste :

An essential component of an integrated radioactive waste management system is to ensure adequate control of the activity , activity concentration , and the volume of radioactive waste . The waste management plan should consider the waste produced both as a result of the original waste activity and the secondary waste generated by the subsequent treatment and conditioning of the original waste . In all instances , this will involve implementation of waste prevention and minimization practices. However, in some countries under certain well defined circumstances it is allowed to dilute the overall radionuclide content of the waste .

This is achieved by increasing the volume of very low level radioactive waste by addition of other non-radioactive wastes to comply with specific activity limits laid down by the regulatory authority (IAEA 1993).

2.1.7 Waste prevention and minimization :

Waste prevention is an essential precursor of any radioactive waste management strategy . When designing experiment or planning patient diagnosis, the need to use radionuclide's should always be justified and only the required quantities should be procured (IAEA 1993).

In the case of medical treatment , this done on the basis of individual benefit/risk evaluation, whereas in research, the existence of an alternative technology and the high costs of radioactive waste management are important considerations. furthermore , the public is becoming increasingly sensitive to disposal of radioactive materials environment . This is of concern to the waste producing establishment , both in terms of public perception of their corporate image, and in respect of contributing to sustainable environmental and global development. Some alternative for waste production include calorimetric or chemiluminescent assays as substitutes for radioimmunoassay, or substation of radionuclide's with shorter half-life, such that the shorter decay times will permit storage for decay and disposal at clearance level (IAEA 1993).

The objective of waste minimization is to reduce the activity and the volume of wastes for storage, treatment and disposal .consequently the environmental impact will also be reduced, as the costs associated with contaminated material management (IAEA 1996).

Waste minimization can be achieved by considering the following fundamental principle:

1/ Keeping the generation of radioactive waste to the minimum practicable , in terms of both its activity and volume, through appropriate design measures, facility operation and decommissioning practices practices specific for medical facilities . This includes the selection and control of material , and the implementation of appropriate procedures. Emphasis

should be placed on the segregation of different types of materials to reduce the volume of radioactive waste and to facilitate its management.

2/ Minimizing the spread of radioactive contamination, which leads to the production of radioactive waste .This should be achieved, as possible, by maximizing efforts of containment and minimizing the creation of secondary waste. It is desirable to use all means to prevent contamination , provided such measures are economically justified.

3/ As far as it is practicable, separating valuable materials from waste and to clear valuable materials for recycling and reuse. This principle is limited application in the case of biomedical waste, however it may be appropriate in some circumstance, for example during decommissioning of medical irradiation facilities.

4/ Minimizing the amount of radioactive waste once it has been created through optimizing the use of available treatment technology. The volume of radioactive waste from medical facilities may be reduced by increased use of processes such as compaction, incineration ,filtration and evaporation.

In particular, practical implementation of waste minimization can be achieved by minimizing:

-The activity of the waste by using short-lived radionuclide's whenever possible, which can be decayed prior to disposal.

-The volume of waste, in part by ensuring that non-essential non-radioactive materials are not taken into controlled area , hence reducing potential cross contamination and the need for decontamination or disposal.

Reduction at source is the most effective step in achieving waste minimization. Proper design may be minimize the generation of waste by several orders of magnitude.

2.1.8 Dilution of waste :

Dilution can be considered as the release of radionuclide's to the environment (gases or liquids) while maintaining proper clearance level or the addition of nonradioactive waste to decrease specific activity level.

In many countries, the practice of increasing the volume of radioactive waste prior in disposal to achieve compliance with a maximum specific activity limit per unit volume is ether not practiced or specifically prohibited. However, in some countries, the regulatory process authorizes practice for disposal of wastes to landfill or via municipal incinerator which exempt from further regulatory control. It is a common practice in some countries for non-biologically hazardous, every low level radioactive waste to be subject to addition of other non-radioactive waste to increase the volume to bring the overall consignment within a specific activity limit .

In India this waste is subject to a restriction of a maximum of 500KBq/0.1m3,with a single item limit of 50KBq whereas in the UK, the limits are 400 KBq/0.1m3, with a single item limit of 40 KBq. The above limits are increased by a factor of ten where the radionuclide is tritium . such practices can be carried out only when authorized by the regulatory authority, having due consideration for the environmental impact (IAEA 1996).

2.1.8.1 Principle for collection and segregation of waste:

To minimize waste a risings and optimize use of available radioactive waste disposal routes , waste should be accumulated and segregated with due regard to the future steps used in the waste management process. In contrast to other nuclear application , the use of radionuclide's in medicine nearly always involves only one radionuclide being used per procedure. This makes segregation of waste by individual radionuclide's possible and practicable to organize (IAEA 1994).

Collection should be made in containers suitable for the waste, having due regard to its physical, chemical, biological and radioactive properties . Due regard should also be taken of any specific approved packaging requirements of the final disposal route. Waste bags/containers should not be over-filled such that their integrity is compromised.

Segregation of waste at the point of generation is an essential component of the waste management process. Storage for decay is particularly important for medical radioactive wastes, since many of the radionuclide's used in

medicine are short lived and the activity of the radioactive waste produced is well defined. Practical experience shows that segregation can be used to deal with the large volumes of medical radioactive wastes that are produced, such that most of the wastes can subsequently be disposed of as inactive refuse . In most instances, it is convenient to segregate wastes according to their half-life, e.g.:

- Waste with a half-life of about 10 hours or less

- Waste with a half-life of less than 10 days

- Wastes with a half-life of less than 100 days

- Waste with a half-life of greater than 100 days

Further considerations for segregation should include such criteria as :

-Non –radioactive and radioactive materials

-Radionuclide and activity content

-physical and chemical form

-Spent sealed sources

-Non-radiological hazards (toxic, biological, carcinogenic, infectious, flammable, etc.)

Liquid biomedical wastes should be collected and segregated in accordance with the particular procedures accepted at the establishment , considering not only current requirement ,but likely developments in the future <liquid radioactive wastes that meets clearance levels (section8.1) can be discharged directly to an approved drainage\ sewage system such as municipal sewer. In some circumstances the biological hazard makes the radioactive waste unsuitable for immediate release, hence the necessity for deactivation prior to discharge. the liquid waste may also contain carcinogenic chemical products which may also contain ethidium bromide which may need disposal as chemical waste . if meeting all release criteria, namely radiological ,chemical and biological , can not be assured , biohazard

us radioactive waste must not be discharged directly into a drainage \ sewerage system.

Liquid waste should be collected , segregated and characterized , as far as possible radiological properties.

It necessary to segregate liquid wastes taking the following criteria into account :

-radionuclide content and activity

-Half life of radionuclide and suitability for decay storage

-Organic \ aqueous liquids

-Non-homogeneneity

-Infectious hazard

-Chemical hazard

-Flammability

Segregation is required in order to minimize waste hazards and to facilitate subsequent processing of waste. The segregation of waste at the point of origin is more efficient than performing segregation can be achieved by using simple laboratory equipment(e.g separating funnel).

2.1.8.2 Discharge of waste to environment below the clearance level to environment :

Sources and practices may be removed from the system of regulatory control provided the radiological impact of these practices/sources is sufficiently low as not to warrant any further control. Such removal of sources and practices from regulatory control is called “clearance” (IAEA 1998).

The basic criteria for determining whether sources and practices should no longer be subject to regulatory control are identical to the exemption criteria set out in the International Basic Safety Standards for protection against Ionizing Radiation and for the Safety of Radiation Sources They are follows:

(a)The radiation risks to individual caused by the particle or source should be sufficiently low as to be of no regulatory concern.

(b)The collective radiological impact of the practice or source be sufficiently low as not to warrant regulatory control under the prevailing circumstances.

(c)The practices and sources be inherently safe, with no appreciable likelihood of scenarios that could lead to a failure to meet the criteria in (a) and (b).

A practice or a source within a practice may be exempted from regulatory control (or cleared) without further consideration provided that the following criteria are met in all feasible situations:

(i)The effective dose expected to be incurred by any member of the public due to the practice or source is of the order of 10Sv or less in year

(ii)Either the collective effective dose committed by one year of the performance of the practice is no more than about 1Sv or an assessment for the optimization of protection shows that exemption is the optimum option.

2.1.8.3 Clearance level:

Setting clearance levels for the discharge of radionuclide's is difficult process. IAEATECDOC-1000 discusses the clearance of materials resulting from the use of radionuclide's in medicine, industry and research . This document is a considerable step forward after review period extending over the last 10 years . It presents both numerical values and a number of conditions to be considered when establishing particular clearance levels, such as :

- No appreciable likelihood of scenarios that could lead to a failure
- It is assumed that radionuclide's are more or less uniformly distributed throughout a moderate quantity of material.
- If more than one radioactive waste producing establishment is discharging into the same environment , the combination should be taken into account.
- If larger quantities of materials are involved , the clearance levels might no longer be appropriate .

When the predicated exposure from released material is not certain to be trivial, then disposal at a specialized repository must be considered.

Many countries have previously defined clearance levels for radionuclide's which are based on annual limits of intake (ALI) or fractions of ALI or refer to statistically significant differences from background activity . It is responsibility of the regulatory authority to define clearance levels and site specific discharge authorizations (IAEA 1998).

The recent European Commission approach to exemption of radiation sources from regulatory control extends the exemption concept to non-nuclear fuel cycle materials and introduces a new clearance approach . These regulations should be mandatory in all European Member States by May 2000.

In the revised Basic Safety Standards Directive , the European Commission sets minimum requirements for conditions where reporting, licensing, and prior authorization are not needed. The Annex to the Directive contains a list of nuclides with values of quantities (Bq) and concentration of activity per unit mass (KBq/Kg) that are not to be exceeded . More detailed information on existing practices on exemption in the European Community countries can be found in Reference .

Examples of generic clearance levels for selected radionuclide's are provided in Reference .

As a rule, local authorities in each country establish clearance levels depending on location and capacity of facilities . In Russia each facility has a temporary license for a few years with the indication of clearance levels for every radionuclide. In Belgium discharge of liquid releases to drain below 1/100 ALI public/L is allowed without dilution provided ALARA can be demonstrated .

For quality certification of waste to be released, it is necessary to have an appropriate .

System for measurement of very low activity in samples of waste. Some commercial measuring systems have recently been developed for measuring the radionuclide content in medical and biological waste. It has been demonstrated that even low energy such as I bremsstrahlung emitted from packages of radioactive waste containing emitters, or even low energy's such as 35S can be measured in plastic waste containers, Isotope characterization by spectrometry allows verification both qualitatively and quantitatively of the presence of particular radionuclide's in a waste container.

If a selective collection of isotopes has been made the amount can be measured far below clearance level in low density waste forms. It is however not possible to detect tritium in waste containers. Procedures and quality control should be sufficient to comply with the usually very high clearance levels for tritium.

The quantitative measurement of initial activity can also result in an optimized choice of the decay period. The decay priod of collected waste id generally defined by the rule (10half lives of the longest lived radionuclide present) .

Measurements can confirm that this is sufficient to comply with clearance levels.

The final clearance measurement should confirm that the residual activity doses not exceed release criteria.

Segregation of waste dependent of half-life of radioisotopes involved, combined with sensitive activity measurement , allows for waste management to be organized in such a way that clearance levels for waste as non-radioactive can be reached.

Risk assessment of potential maximum releases of radionuclide's should be prepared to convince the regulatory authority , as well as improve public confidence, that the discharges are environmentally sound (IAEA 2000).

2.2 Previous studies :

ArnalAarnal (2000) carried out Streams containing I125 coming from radio immune analysis (RIA) classified as low-medium activity radioactive waste are generated by different treatments applied in “in vitro” techniques. The consequence is an accumulation of solution containing I125 whose storage at sanitary centers poses an important problem. On the basis specific activity of the waste and the dumping authorization of the facility, there are three possible ways of handling:

Direct discharge, discharge after temporal storage during which the activity of the solution decays, and the management by the authorized company (ENRESA).

When the third way is applied, membrane treatment should be considered.

Using membranes, important reduction coefficients in volume, about 10:1 can be achieved. The aim of this work is the declassification of I125 solutions as a radioactive liquid waste using membrane techniques (J.M. Arnal , J.M. Campayo Esteban , J. Lora Garcia , M. Sancho Fernandez, I. IborraClar, I. Alcaina Miranda, 2000).

Aziz et al, 2002 was study the first use of ionizing radiation on Jordan wase in the medical application when the first Xray machine wase installed in a big governmental hospital more than fifty years old, and the solid sealed radiation source were used in medicine applications (brachytherapy) are the first radioactive wastes generated over the kingdom in the absence of any appropriate national legislation on radiation protection and waste safety. The nuclear energy and radiation protection law was adopted by the Jordanian Parliament in 1987 and authorized the Ministry of Energy and Mineral Resources (MEMR) as the national competent authority to implement the law in co-operation with other national institutions.

Details the draft of the regulations on management and safe disposal of radioactive wastes in Jordan which was formulated with the assistance of the IAEA experts and adopted by the national commission on radiation protection and these regulations are in the stage of approval by the council of ministries according to the law mentioned above (Aziz et al, 2002).

Banzil et al, 2006 was carried out the Radioactive waste, like many other hazardous wastes , is of great concern in Tanzania because of its undesirable health effects. The stochastic effects due to prolonged exposure to ionizing radiation produce cancer and hereditary effects. The deterministic effects due to higher doses cause vomiting. Skin reddening, leukemia, and death to exposed victims. The aim of this paper is to an overview of the status of radioactive wastes in Tanzania, how they are Qenerated and managed to protect humans and the environment. As Tanzania develops, it is bound to increase the use ionizing radiation in research and teaching, industry, health and agriculture. Already there are more than 42 centers which use one form of radioisotopes or another for these purposes:

Teletherapy (Co^{60}), Brach-therapy (Cs^{173} , Sr^{89}), Nuclear medicine ($P^{32}, Tc^{99m}, I^{131}$), Nuclear gauge ($Am^{241}, Cs^{173}. Sr^{901}, Kr^{85}$), Industrial radiography ($Am^{241}, Cs^{173}, Co^{60}$), Research and Teaching (, I^{125}, Cs^{173}, H^{3} etc). According toIAEAdefinition, these radioactive sources become radioactive waste if they meet the following criteria: if they have been displaced without authorization; and if they contaminate other substances. Besides of radioactive wastes, special emphasis will also be placed on the existing radiation regulations that guide disposal of radioactive waste, and the radioactive infrastructure Tanzania needs for ultimate radioactive waste management. Specific examples of incidences (theft, loss, abandonment and illegal possession) of radioactive waste that could have led to serious deterministic radiation effect to humans will also be presented (F.PBanzil ,F.M.Bundala I,P. M.Nvandal,2006).

Elamin et al, 2004 carried out The regulatory framework as established by the Sudan Atomic Energy Commission (SAEC) Act, promulgated in 1996, is described in the report . Three levels of responsibility in meeting radiation protection requirements are established: the Board, the Radiation protection Technical Committee as the competent authority in the fild of radiation protection, and the SAEC Department of Radiation protection and Environmental Monitoring as the implementing technical body . The report also refers to environmental activities , patient doses in diagnostic radiology,

the management of disused sources , emergency preparedness and orphan sources, and the national training activities in the radiation protection .(O.I.ELAMIN,E.A.HAJMUSA,LA.SHADDAD,2004).

Steve et al, 2008 was study These calculations were based on the whole-body dose. We also estimated the production of these radionuclide's from all naturally occurring elements with atomic numbers less than 84(po) in the first wall of a typical fusion reactor, and thereby derived concentration limits for these elements in first-wall materials, if the first wall is to be suitable for Class-C disposal. In part II we use the "effective dose equivalent" (EDE), which is a much better indication of the risk from radiation exposure than whole-body dose, to calculate specific activity limits for all long-lived radionuclide's up to Cm248. In addition, we have estimated the production of long-lived actinides and fission products from possible thorium and uranium impurities in first-wall structures. This completes our study of long-lived radionuclide's that are produced from all elements that occur in the earth's crust at average concentrations greater than one part per trillion. (Steve FETTER, E.T. CHENG and F.M.MANN, 2008).

Charles Streeper, 1999 was carried out A lower-activity analogue of the transnational problem of spent fuel management and disposal is the global problem of radioactive sealed source: The IAEA definition of a sealed source is "Radioactive material that is permanently sealed in a capsule or closely bonded and in a solid from "Taken from glossary of Nuclear Waste Data Management.

Disposal.Sourece are found in almost every country in the world because of their beneficial medical and commercial or industrial applications. Some of the isotopes used have short half- livesdiridium -192 (Ir^{192}),73.8 days while others have very long half-livesdmericium-241 (Am^{241}), 432 years or plutonium-239 (Pu^{239}), 24.130 years. It is critically important, particularly for longer-lived isotopes, to find final disposition pathway . Lack of a permanent disposition pathway such as recycling or irretrievable disposal creates numerous problems, including the potential loss of regulatory control, which increases the risk of inadvertent or deliberate misuse of the material.

The misuse of radioactive materials has the potential for substantial public health and economic damage. Disused sources also pose an inherent risk to the end-users from a liability, safety, and public health perspectives. This paper examines various disposition pathways employed by several key source manufacturing or possessing nation-states for discussed sources. Example of source disposition pathway includes long-term storage, deep geological disposal, borehole disposal and shallow land burial. The Off Site Source Recovery Project (OSRP), part of the office of Global Threat Reduction Initiative (GTRI), acts as an intermediary in the recovery and ultimate disposition of US origin sealed radiological materials.

Several concepts that could help mitigate the challenge of a lack of long-term disposition option for source are available, but these tools have not yet been applied by most nation-states. For example, regional consolidation and repatriation of sources to the country of manufacture would ease or eliminate the need for in situ disposal or storage in a number of developing nation-states (Charles Streepr, Julia Whithwortha,J.Andrew Tompkins,1999).

Shoukat Khan,2000 was study the most of the tertiary care hospitals use radioisotopes for diagnostic and therapeutic applications. Safe disposal of the radioactive waste is a vital component of the overall management of the hospital waste. An important objective in radioactive waste management is to ensure that the radiation exposure to an individual(Public, Radiation worker, Patient) and the environment does not exceed the prescribed safe limits. Disposal of Radioactive waste in public domain is undertaken in accordance with the Atomic Energy (Safe disposal of radioactive waste) rules of 1987 promulgated by the Indian Central Government Atomic Energy Act 1962. Any prospective plan of a hospital that intends using radioisotopes for diagnostic and therapeutic procedures needs to have sufficient infrastructural and manpower resources to keep its ambient radiation level within specified safe limits. Regular monitoring of hospital area and radiation workers is mandatory to assess quality of radiation safety. Records should be maintained to identify the quality and quantity of radioactive waste generated and the mode of its disposal. Radiation safety officer plays a key role in the waste operation (ShoukatKhan,AT Syed, Reyaz Ahmad, Tanveer A. Rather, MAjaz, and FA Jan, 2000).

Hasan et ,2014 was study The application of radioisotopes and radiation sources in medical diagnosis and therapy is an important issue. Physicians can use radioisotopes to diagnose and treat diseases. Method of treatment, conditioning and management of low level radioactive waste from the use of radiation sources and radioisotopes in hospitals and nuclear medicine application, are described.

Solid Radioactive waste with low-level activity after accumulation, minimization, segregation and measurement, are burned or compressed in a compactor according to the international standers. Conditioned drums are transported to the interim storage site at the Egyptian Atomic Energy Authority (EAEA) represented in Hot Labs and Waste Management Center (HLWMC) for storage and monitoring (M.A.Hasan, Y.T.Selim and Y.F.Lasheen 2014).

Gabriel Borowski, 2013 The paper presents a survey of radioactive waste disposal technologies used worldwide in terms of their influence upon natural environment. Typical sources of radioactive waste from medicine and industry were presented. In addition, various types of radioactive waste, both liquid and solid, were described. Requirements and conditions of the wastes storagewere characterized. Selected liquid and solid waste processing technologies were shown. It was stipulated that contemporary methods of radioactive waste utilization enable their successful neutralization. The implementation of these methods ought to be mandated by ecological factors first and only then economical ones (Gabriel Borowski, Michal Wosko, 2013).

Chapter Three

Materials and Methods

3.1 Materials:

3.1.1 Monitor 4:

Monitor 4 and 4EC/Analog Radiation detector – a α Y X Detector Halogen-quenched uncompensated tube with thin mica window 1.5-2.0 mg/cm^2 thick . effective diameter of window is 9.1 mm.

Figure (3.1): Monitor4 at nuclear medicine department

3.1.2 Storage containers:

Waste containers provide protective barrier against physical and chemical stresses during transportation , interim storage , and disposal .

Containers are classified into different subcategories (depending upon the activity contents and half –life of the nuclides in the waste) . containers made from plastic and lead .

Figure (3.2): Storagecontainers

3.1.3 FHT 111 CONTAMAT

Full specifications:

Description FHT111 CONTAMT Contamination Monitor Height (Metric) 111mm .

Depth 8.5 in Depth (Metric)216 mm

Weigh 2.1Ib weight (Metric) 950g

Width 5.4 in width (Metric) 138mm

Air pressure 700 to 1060 hpa

Battery life 150 hours of continuous operation with natural background battery type 5AA cells or 5 Nicd rechargeable cells detectors butane flow type counter tubes with refillable gas reservoir .

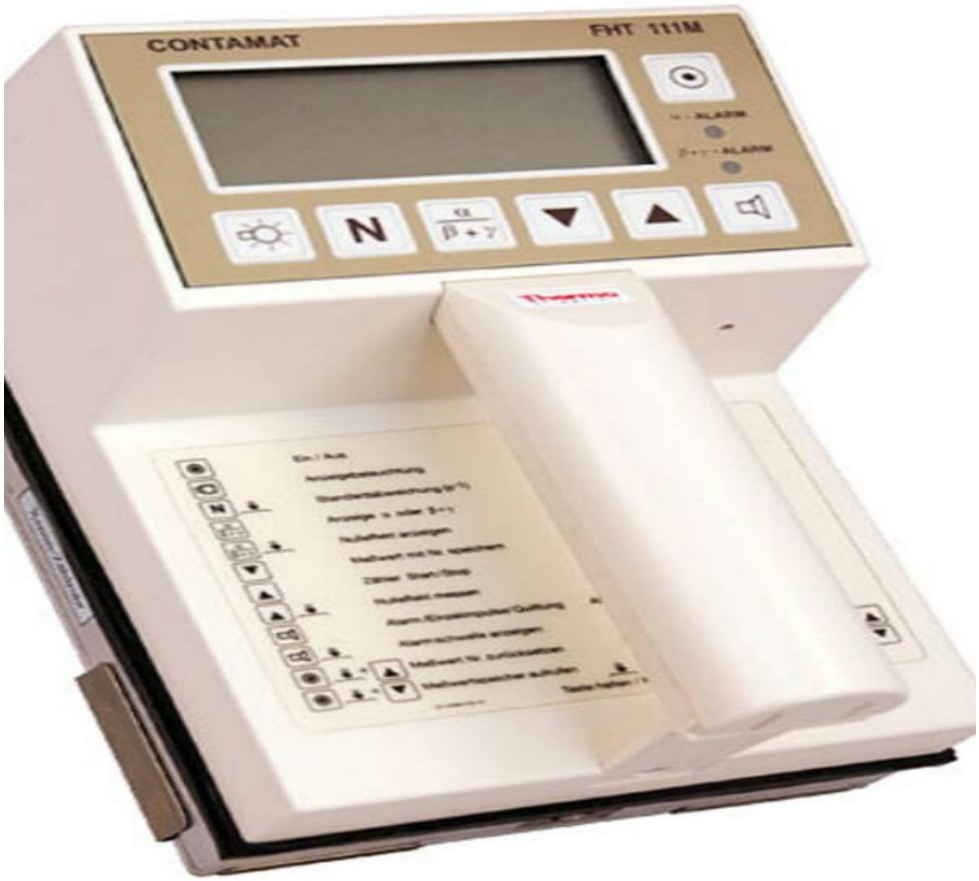

Figure (3.3): FHT 111 CONTAMAT MONITER

3.2Methods:

Data had been collected from records in Royal Care hospital.

Measurement were taken by Analog Radiation detector.

Methods of data collection include the following :

Visiting a nuclear medicine department.

Visual inspection ofequipment , facilities and records .

Close observation of the waste disposal procedures

Interview of the RPO at the Nuclear Medicine department .

Chapter Four

Result and Discussion

4.1 Results:

Table 4.1 shows storage and activity of Tc^{99m} radioactive waste at Royal Care Hospital – Nuclear Medicine Department

No	Radionuclide	storage date	Activity before storage	Disposal date	Activity before disposal
1	Tc^{99m}	11/3/2018	234 KBq/cm^2	16/3/2018	0.1 KBq/cm^2
2	Tc^{99m}	23/3/2018	113 KBq/cm^2	29/3/2018	0.1 KBq/cm^2
3	Tc^{99m}	2/5/2018	518 KBq/cm^2	15/5/2018	0.12 KBq/cm^2
4	Tc^{99m}	19/5/2018	22.6 KBq/cm^2	25/5/2018	0.083 KBq/cm^2
5	Tc^{99m}	22/6/2018	23.3 KBq/cm^2	28/6/2018	0.083 KBq/cm^2
6	Tc^{99m}	20/7/2018	770 KBq/cm^2	29/7/2018	0.133 KBq/cm^2
7	Tc^{99m}	2/8/2018	7.93 KBq/cm^2	10/8/2018	0.05 KBq/cm^2
8	Tc^{99m}	18/8/2018	6.73 KBq/cm^2	4/9/2018	0.03 KBq/cm^2

Table shows storage and activity of I^{131}radioactive waste at Royal Care Hospital – Nuclear medicine department

No	Radionuclide	Date of Storage	Activity before storage	Disposal date	Activity before disposal
1	I^{131}	5/3/2018	773 KBq/cm^2	26/6/2018	1.66 KBq/cm^2
2	I^{131}	25/11/2018	244 KBq/cm^2	30/7/2018	0.133 KBq/cm^2
3	I^{131}	3/5/2018	519 KBq/cm^2	3/8/2018	1.33 KBq/cm^2
4	I^{131}	7/6/2018	122 KBq/cm^2	2/9/2018	0.006 KBq/cm^2

4.2 Dissections:

The main objective of radioactive waste management is to protect human and the environment.

Discharge to the environment or whether it is to be disposed of in a landfill or a specially built facility , more complicated classification by activity level and half-life , discharged of the Radioactive Waste in Royal Care Hospital by storing in hospital , Interval of storing depend on the half life of the Radionuclide, and storing in Royal Care Hospital by separate Radioactive waste regardless of type of Radioactive waste .

Solid radioactive waste separate into two type , type one involved absorbing paper , gloves, cotton swabs and mask are collected in one bag , type two involved syringe, needles and any sharp tool collected in shielded container , after terminating duration can be discharge with ordinary waste .

Liquid radioactive waste storage in shielded container , after terminating duration can be discharged in sewerage of hospital .

Gas radioactive waste discharge by fume hood.

The collection , storage and discharge of waste in Royal Car Hospital follows the international Recommendation in processing of radioactive waste.

Table 4.1 shows Tc^{99m} Radionuclide's , Date of storage , measurement before storage , measurement before disposal in Royal Care Hospital .

Table 4.2 show I^{131} Radionuclide's , Date of storage , measurement before storage , measurement before disposal in Royal Care Hospital .

Chapter Five

Conclusion and Recommendations

5.1 Conclusion:

The main objective of this study was to evaluate of the radioactive waste management and this study was done in Royal Care Hospital using two types of radionuclide's Tc^{99m} andI^{131} .

Discharge of the radioactive waste to environment done after 10^{th} half life, and the result showed that it was done in Royal Care hospital.

Discharge to the environment or whether it is to be disposed of in a landfill or a specially built facility , more complicated classification by activity level and half-life , discharged of the Radioactive Waste in Royal Care Hospital by storing in hospital , Interval of storing depend on the half life of the Radionuclide, and storing in Royal Care Hospital by separate Radioactive waste regardless of type of Radioactive waste

The radioactive waste is be collected in one bag regardless of type of radioactive waste (gloves, syringe, vials..etc) without segregation of each type in a bag, that was done in Royal Care Hospital .

The Tc^{99m} discharge for the environment after at least four days and I^{131} after Three month in Royal care Hospital.

5.2Recommendations:

The storage space for radioactive waste must be located far from normal working areas, and must provide security and labeling for the wastes.

Differentiation should be made between Active and non-Active discharge waste.

Separate between type of waste regardless of radiation and energy of Radioactive waste.

The floor and walls of the storage room must be coated with easily de contaminated surfaces.

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