Environmental Radiation Protection

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Introduction

Many organizations today use ionizing radiation. The demand for using radiation is inevitable and thriving more and more over the years. The industries extensively use unsealed and sealed radioactive sources to evaluate the safety and the integrity of equipment and structures. However, these processes are potentially hazardous to the health of the staff if the radioactive materials are not handled correctly (Sklet, 2006). Additionally, such industry workers may be exposed to high doses of radiation when using the radioactive materials (IAEA, 2010). Acute exposure has destructive effects on the environment and may cause the main threat that leads to sickness or death depending on the amount of exposure. The majority of industries demand the use radiation and need safety management of the radiation sources (Johnston et al., 2011). Therefore, with these potential hazards, a need arises to better comprehend the standards of controlling ionizing radiation and enforcing suitable protection measures to minimize and regulate the occupational exposure of workers.

A proper understanding of the hazards arising from radiation as well as the protection principles within the industrial fields would result in increasingly safer and efficient operations (Davies et al., 2005). Essentially forming a basis under which the study will focus on protection from environmental radiation in the industrial fields and comprehension of the major concepts of radiation protection. In addition to the role of radiation safety officers, and the procedure that will lead to the minimization of adverse effects ensuring trusted work conditions and good health for workers. The field of ionizing radiation is one that is plagued with myths and misconceptions involving application in industries. Most of these claims have to do with how harmful the ionizing radiation rays are. Some people believe that radiation rays are harmful to human lives at any level of exposure. Others even believe that the use of radiation on food products is harmful and that

using radiation on such makes them radioactive. Therefore, it is a field filled with suspicion, and their correction or stamp heading is essential to make people more welcoming and willing to embrace this technology. Moreover, knowing the truth about radiation creates awareness on the need for people to use this technology safely, to maximize its use while still protecting human beings and the environment upon exposure.

Research Questions

- What are the principles and concepts of radiation protection in the industrial environment?
- What are the basic duties and responsibilities of the radiation safety officer (RSO)?
- Why do organizations have to use and follow radiation protection standards?
- Which are the worst consequences or risks of unintended radiation exposure and health hazards to the staff and work environment?

Hypotheses

H1: Compliance with the radiation protection principles and standards can reduce consequences and risks of radiation exposure and health hazards to workplace environment and staff.

H2: Competent safety officer in the field ensures compliance with the radiation protection measures that reduce or avoid exposure to workers.

Research Problem

The research on the environmental radiation protection aims at investigating the main principles and concepts of radiation protection in the industrial field. It also examines the importance of using and following radiation protection standards, and the worst consequences workers can experience if the principles are not supported. The study will review the related literature on radiation protection as well as the health effects and barriers associated with exposure

to radioactive materials. Moreover, the purpose of the research is environmental protection against radiation exposure to workers in the industrial field.

The relevance of Research Study

The study aims at examining the way radiation exposure can be reduced among workers in the industrial field. Therefore, its findings can be relevant to many companies that use radioactive sources in their operation to minimize adverse health effects. The study will help in improving industries ability and adhere to the radiation safety and protection protocols during their practices (Marshall & Keene, 2007). The research will also add and update knowledge about adequate environmental radiation protection to radiographers.

Problem Statement

Use of ionizing radiation is applicable in a variety of fields, and its benefits are phenomenal especially in the inspections sector in various fields. It is a resource that most firms have been quick to adopt upon understanding its benefits. However, there are some hazards that come with the use of radiation protection despite the benefits and therefore, there is need to understand these hazards as they relate to radiographers in the industrial fields. Henceforth, it is essential to identify ways of handling the hazards by putting some principles in place. It is also necessary to evaluate the role of the necessary personnel in the prevention efforts to minimize the risk and the effects of the radiation.

Aim and Objectives

The purpose of this project is to clarify key issues that have to do with the hazards involved in the utilization of ionizing radiation for various purposes. Safety management is the focus of the study and understanding it allows the protection of the workers from harm while handling radiation. The specific aims of the project are as follows:

- Identify the standards that protect workers from harmful exposure to ionizing radiations as they go about their work
- Evaluate the roles and responsibilities of the radiation safety officer (RSO) within an organization towards the prevention of radiation exposure
- To investigate the harmful health implications that ensue because of lack of awareness pertaining the accidental exposures to ionizing radiation.
- To redefine the methods of dealing with excess radioactive materials by avoiding unnecessary exposure to radiation to prevent the exposure instead of dealing with consequences that follow.
- To explore the educational needs of people that use radiation in their work and identify training opportunities to impart safety training skills and rapid emergency response.

Data Extraction

Data Extraction Protocol	Comments
Title of the paper	Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
Year of publication	2011
The Author	Yukiya Amano
Methods	Review of publications and government provisions concerning protection from harmful radiations.
Participants	NP

Results	There are procedures towards protection of people from harmful radiation.
Conclusions	The governments and various publications and commissions feature protection procedures against radiation.
Data Extraction Protocol	**Comments**
Title of the paper	Is Ionizing Radiation Harmful at any Exposure? An Echo that Continues to Vibrate
Year of publication	2016
The Author	Edouard I Azzam, Nicholas Colangelo, Jason D. Domogauer, Neha Sharma, and Sonia M. de Toledo
Methods	Literature Review
Participants	NP
Results	Although there exist great reservations pertaining a causal relationship between low dose contact and detrimental health outcomes, it is all the same clear that there is a slight direct proof of risk to the human population at low doses to ionizing radiations.

Conclusions	A selection of redundant and inter-related mechanisms exist in mammalian cells to repair the reparation when it ensures and to provide optimum protection not only for the irradiated cell but to the entire system.
Data Extraction Protocol	**Comments**
Title of the paper	Survey on the impact of regulations on radiation safety and development of radiation safety culture in 25 countries.
Year of publication	2017
The Author	Berris, T., Žontar, D., & Rehani, M.
Methods	Primary research using Questionnaires
Participants	Radiologic professionals working in healthcare facilities
Results	Radiologic professionals believe that regulation enhances radiation safety and the development of safety culture.
Conclusions	Safety levels were perceived to be satisfactory, and future needs point toward strengthening of regulations regarding patient dose control, patient dose consideration, and patient exposure tracking.
Data Extraction Protocol	**Comments**
Title of the paper	Radiation safety for radiologic technologists.

Year of publication	2018
The Author	Bradley, L.
Methods	Mixed research
Participants	NP
Results	Occupational dose limits, devices used to quantify exposure, and safety practices enable technologists to maintain radiation exposure "as low as reasonably achievable" the workers and patients too.
Conclusions	The appropriate use of mobile equipment, personal protective gear, and safety considerations on imaging gear minimizes preventable radiation exposure.
Data Extraction Protocol	**Comments**
Title of the paper	Radiological protection in North American is naturally occurring radioactive material industries.
Year of publication	2015
The Author	Chambers, D.
Methods	Literature review
Participants	NP

Results	Apprehensions over radioactivity amongst non-governmental Organizations and the public have led to the termination of NORM mining, and the inhibition of the safe utilization of by-product materials in available NORM industries.
Conclusions	It is important to follow the work of ICRP and provide comments to ICRP on proposed new guidance as it is developed.
Data Extraction Protocol	**Comments**
Title of the paper	Ionizing Radiation Injuries and Illnesses. Emergency Medicine Clinics Of North America,
Year of publication	2014
The Author	Christensen, D., Iddins, C., & Sugarman, S.
Methods	Primary research in North American Clinics
Participants	Hospital staffs
Results	Many people exposed to harmful radiation suffer great health losses that can be avoided
Conclusions	Radiations can be harmful to the health of those exposed and should be avoided.
Data Extraction Protocol	**Comments**

Title of the paper	Radiation protection principles.
Year of publication	2012
The Author	Cooper, J.
Methods	Review of the ICRP guidelines
Participants	NP
Results	A key assumption for protection at low doses is that there is a simple proportional relationship between the increase in dose and subsequent increments in risk.
Conclusions	Following the stipulated protection principles is the basis of the protection of workers against harmful exposure to ionizing radiation.
Data Extraction Protocol	**Comments**
Title of the paper	Inferences, Risk Modeling, and Prediction of Health Effects of Ionizing Radiation.
Year of publication	2016
The Author	Dainiak, N.
Methods	Literature review
Participants	NP

Results	Compliance with medical practices with radiation guidelines proves to be an arduous task. This drives regulators to be well-versed in the potential consequences of their actions and exercise restraint.
Conclusions	At the moment patients have been enabled to achieve accurate predictive results through the combination of epidemiological and experimental lab techniques.
Data Extraction Protocol	**Comments**
Title of the paper	ALARA: What is Reasonably Achievable? Radioactivity In The Environment
Year of publication	2013
The Author	Hansson, S.
Methods	Literature Review
Participants	NP
Results	ALARA has been interpreted differently in different practical applications.

Conclusions	Interpretation should be universal since the limit each person should be exposed to in a year is the same.
Data Extraction Protocol	**Comments**
Title of the paper	Radiation Safety Compliance.
Year of publication	2016
The Author	Koth, J., & Smith, M.
Methods	Literature Review
Participants	NP
Results	Compliance with the standards minimizes risks associated with ionizing radiation
Conclusions	Firms should comply with the set standards to protect their workers.
Data Extraction Protocol	**Comments**
Title of the paper	Overview of ICRP Committee 5
Year of publication	2015
The Author	C-M. Larsson, K.A. Higley, A. and Real A.
Methods	Literature Review involving the ICRP Committee 5

Results	Human activities and natural occurrences may affect the environment, and there is need to protect the environment from harmful radiation effects.
Conclusions	ICRP system for environmental protection adds an element to the decision-making process allowing the decisions to be made by an all-inclusive understanding of consequences for health and the environment.
Data Extraction Protocol	**Comments**
Title of the paper	Application of the Commission's recommendations to naturally occurring radioactive material
Year of publication	2015
The Author	J-F. Lecomte
Methods	Review of the recommendations of the ICRP
Participants	NP
Results	Harmful effects of Norm occur mainly depending on the level of exposure
Conclusions	Regardless of the NORM exposure situation, management is mainly by the optimization process. The corresponding protection approach should be based on a determined, realistic, and classified approach.

Data Extraction Protocol	Comments
Title of the paper	What should a radiation regulator do about the naturally occurring radioactive material?
Year of publication	2015
The Author	J. Loy
Methods	Review of several standards that govern exposure to radiation.
Participants	NP
Results	NP
Conclusions	ICRP needs to advocate pragmatism and flexibility, supported by radiation protection principles when it comes to NORM.
Data Extraction Protocol	**Comments**
Title of the paper	Ionizing radiation in the workplace. *BMJ*
Year of publication	2015
The Author	Little, M.
Methods	Literature review
Participants	NP

Results	Identification of occupational radiation as the leading form of radiation exposure incidences.
Conclusions	Occupational radiation can be harmful, and the RSO should guide the firm to minimize radiation
Data Extraction Protocol	**Comments**
Title of the paper	Awareness and attitude of radiographers towards radiation protection.
Year of publication	2011
The Author	Mojiri, M
Methods	A cross-sectional survey using questionnaires
Participants	Radiographers who work in various hospitals in Hamadan city.
Results	51.2% of radiation employees have relative information about dose limit and the result of our study show higher amount of such index (58%).
Conclusions	Knowledge and education have strong direct effects on technical protection against health hazards associated with radiation exposures.
Data Extraction Protocol	**Comments**

Title of the paper	Radiobiological basis in the management of accidental radiation exposure.
Year of publication	2010
The Author	Pandey, B., Kumar, A., Tiwari, P., & Mishra, K
Methods	Literature review
Participants	NP
Results	The management of accidental radiation exposure is quite convoluted due to reservations in dose, duration, organs involved and radionuclides internalized, and, require multi-faceted approaches.
Conclusions	An in-depth understanding of the science behind radiation injury in the event of accidental radiation exposure that aids improvement of prevention and post-radiation management of affected individuals.
Data Extraction Protocol	**Comments**
Title of the paper	Radiation Safety of Sealed Radioactive
Year of publication	2015
The Author	Pryor, K.
Methods	Literature Review

Participants	NP
Results	Mishandling radioactive materials in storage increases the risk of exposure.
Conclusions	Radioactive isotopes should be sealed and handled with care

Literature Review

Larsson, Higley, and Real (2015) show the need and willingness of the ICRP to protect the environment from ionizing radiation exposure and harmful effects that result from unskilled workers who are not handled radioactive materials correctly. The application of radioactive materials is utilized for different purposes in medical, industrial, and academic research. To effectively control the application of radiation in various activities and avoid unintended consequences, there is a need to spread the culture of radiation protection awareness among the workers who are working directly and indirectly with these materials in the field where the radiation is. (Larsson, Higley, Real. 2015)

Radiation has a wide array of uses with both medical and industrial applications. Radiation is an effective method of treating certain forms of cancer with high doses of ionizing radiation administered to patients to halt the growth of cancer cells. Radiation also being used in various imaging tests to assist medical teams in creating accurate pictures of internal body structures. Industrially it is impossible to discuss all the varied uses and applications of radiation. However, generally, radiation is used in evaluating material density, sterilizing products, testing the quality of products, eliminating static and generation of electricity.

Such as radiology departments in hospitals, radiology labs in academic institutions and industries which have an insatiable demand for ionizing radiation for use in evaluating the safety and integrity of equipment and structures. Radiation that can only be obtained through non-destructive testing (NDT) and also in naturally occurring radioactive materials (NORM that can be found in oil and gas industries). All these facilities depend on using ionizing radiation in their daily processes. Thus, radiation safety management and radiation safety officers (RSO) require a set of clear strategies and procedures to protect the workers, the work environment and other potential victims of a breach in the protocol. (Larsson, Higley, Real. 2015)

International Organization Recommendation

International Basic Safety Standards assume that stochastic effects would be proportional to the quantity of radiation regardless of the threshold limit set. The requirements are determined by following practices in line with Fundamental Safety Principles. Principles that are an outcome of efforts and studies by international organizations on the impact of contact with radioactive materials on health and safety. As well as policies aimed at ensuring the safety and proper utilization of sources of radiation. This paper will discuss these principles and concepts espoused by international organizations such as the International Commission on Radiation Protection. (ICRP) It will show the issues related with improper handling and use of radioactive material. While addressing the lack of knowledge on radiation protection among radiographers and the adverse health effects arising from the same. The paper will ultimately show that these consequences can be prevented and a safe environment created for working with and storing radioactive materials through implementation of the radiation protection guidelines provided. (Amano, 2012).

Consequences of Long-Term Radiation Exposure

Internationally accepted levels have been set for limits of occupational radiation in a bid to attempt to protect the workers from long-term health consequences. Borrowing from OSHA that has set working minimums of 5 rem per year which translates to 2.5 mrem per hour for all work hours. The absorbed dose with regards to radiation is a measure of the energy deposited in a medium by ionizing radiation. Basing on this threshold there results a classification of effects into two separate categories: deterministic effects and stochastic effects. Deterministic effects are those that occur at a set threshold and may not occur when the threshold is not met. The severity of these effects rise as the dosage of radiation increases and include skin erythema, hair loss, sterility, cataracts, fetal abnormality and irreversible skin damage. (Christensen, Iddins, Sugarman. 2014)

On the other hand, stochastic effects occur by chance as contrasted with deterministic effects that will occur once exposure passes a certain threshold. This has led to application of the equivalent dose in an attempt to greater understand stochastic health effects. The equivalent dose is a dose quantity representing stochastic health effects of low levels of ionizing radiation on the human body. A major example of stochastic effects is induction of various forms of cancer as there is no specific level of radiation exposure linked to cancer cases. (Christensen, Iddins, Sugarman, 2014). Unskilled radiographers and lack of knowledge of standard safety procedures when handling radioactive elements could result in disastrous consequences involving acute exposure. Exposure resulting in the destruction of the environment, and causing sickness or death with intensity of the adverse effects varying with the quantity and period of exposure. In addition, the acute health effects of high ionizing radiation include nausea and vomiting, skin and deep tissue burns, the inability of the body to fight infections, and general malaise (Azzam, Colangelo, Domogauer, Sharma, & Toledo, 2016).

Chronic exposure from the name appears to be intermittent exposure to the radioactive material over extended periods of time. Often recording a substantial delay between the exposure and the resulting health effect. (Bradley.2018)Upon prolonged exposure, the radiation interferes with the functioning of internal organs, hence damaging immunity system, and affecting cell division (Dainiak, 2016). This exposure can also promote the growth of cancerous cells throughout the body. Since ionizing radiation in high doses interferes with cell division and growth, it may cause the growth of cells abnormally, leading to cancer (Christensen, Iddins, & Sugarman, 2014). The radiation can also affect the chromosomal properties of the cells, inducing mutations that cause cancer in subsequent generations. This exposure to radiation may also damage the eyes depending on the level and period of exposure (Christensen, Iddins, & Sugarman, 2014).

In facilities that use radioactive materials, storage should be limited to zero exposure to human beings and the environment surrounding the facilities. (Koth & Smith, 2016). The access and use of the radioactive materials should be by people dressed in the proper shielding to protect themselves from the radioactivity sources. Storage places should be periodically tested with a gamma survey meter for the making of bremsstrahlung radiation (Pryor, 2015). To reduce the ionizing radiation, as a result, to inspect the workplace any time to ensure that the radiation safety protocols are complying with regulations (Chambers, 2015). There should also be precaution signs to alert people of the presence of radioactivity sources in the storage areas (Berris, Žontar, & Rehani, 2017).

Principles and Concepts of Radiation Protection

The first principle pertaining to the use of radiation provides that the exposure to radiation should do more good than harm (Cooper, 2012). ALARA (as low as reasonably achievable) is the idea behind the second principle protecting workers from exposure. It provides that the contact to

radiation needs to be as low as possible (Hansson, 2013). The third provision is that the dose for planned exposure other than medical exposure should not exceed limitations provided by the ICRP. The exposure of radiation to workers is known as occupational exposure and is the responsibility of the safety management. The annual Shallow Dose Equivalent, Whole-body for adult workers, is 50 rem or 0.5 Sievert. For pregnant women, the limitation is ten percent of the annual dose (Amano, 2011).

This current system of radiation protection is hinged on three major principles. The principles of optimization, justification and dose limitation. Justification is the principle that requires decisions changing radiation exposure limits should achieve more positive than negative effects on the surrounding environment and on workers. It is important to note that the use of radioactive materials should ultimately result in greater benefit to all reaches of society enough to overturn the risk it brings along with it. More clearly, the positive impacts of radioactive materials should be maximized to bring the maximum good that is adequate to overrun the risk suffered by individuals, populations, and the environment at large. Optimization follows the idea that the occurrence of exposure to radioactive elements should be limited to as low as can be reasonably expected from the organizations. Dose limitation is a principle that avers planned exposure limits should adhere to quantity caps with appropriate commission guidelines. (Hanson. 2013).

Exposure to high radiation while working may have detrimental effects on the health and life of a worker. First of all, as mentioned above, pregnant women should avoid exposure to occupational exposure even more than other people. This is because the unborn child is extremely vulnerable to the effects of ionizing radiation as it would interrupt the growth and development of critical organs before birth. (Christensen, Iddins, & Sugarman, 2014). Owing to the detrimental effects of high and low exposure to ionizing radiation, there is need to control and minimize the

exposure to protect workers as they handle the radiation. The first way of reducing the exposure and hence the effects is using time. The time of exposure should be as low as possible. The radiation safety management should ensure there are enough workers and working shifts to minimize the exposure time. (Christensen, Iddins & Sugarman. 2014)

The machinery dealing with the ionizing radiation should also consist of notifications to alert the workers of impending exposure to the radiation. The radiation safety management should also provide personal protective equipment (PPE) to ensure the worker's body does not absorb as much radiation. The management also utilizes shielding to limit exposure to the lowest number of people possible. The safety management should also, as mention before, ensure proper storage and safe disposal of radioactive waste (Little, 2015). Storage facilities for radioactive materials should be lined with lead between the walls to prevent leakage of radiation and ensure decontamination of the environment. (Little, 2015)

To implement these precautionary measures and to ensure the facility follows the set principles and regulations of radiation protection, there has to be a platform to create awareness among staff within radiology departments that utilize ionizing radiation. A 2011 study by Mojiri and Moghimbeigi posits the existence of an apparent link between education levels, work experience and the competence of a radiographer in protecting others against harmful radiation. Therefore, while hiring, it's a requirement that the applicant must be having comprehensive knowledge about ionizing radiation.

Basic Duties and Responsibilities of the Radiation Safety Officer

A radiation safety officer is required to ensure that all employees are compliant with protection recommendations set by the ICRP such as wearing personal protective gear. Employees should also be knowledgeable in applying time, shielding, and distance during periods of contact

with radioactive material in line with ALARA He/she is responsible for managing people in a way that would ensure exposure is limited to the lowest levels of radiation as possible. He/she also identifies loopholes in the department that may lead to unnecessary exposure. As an RSO duty is to train people on how to avoid unnecessary exposure to radiation (Bradley, 2018). RSO also is to ensure the appropriate storage of the materials and ensure the suitable disposal of wastes (Loy, 2015).

The RSO is required to have in his/her possession appropriate gear that will enable monitoring and supervision of radiation safety guidelines are implemented. The officer should be adequately trained and possession of an identification kit showing their specialization is a requirement that cannot be taken lightly. Part of the equipment the officer should be trained in the administration of Geiger meters to assess radiation levels and emergency kits should there be an accident. Aside from being in charge of coming up with a contingency plan, the safety officer should be involved in environmental monitoring. It is also expected that the officer should carry out a routine inspection of machines emitting radiation and on storage sites of hazardous materials within facilities. (Koth, Smith. 2016)

To tackle issues pertaining to occupational radiation exposure a platform is needed that will enable management to effectively raise staff awareness. (Bradley, 2018). It is the work of the RSO to organize and ensure the workers get the message by ensuring periodic checks. Training the staff should include sensitization on the need to use the appropriate equipment protection, minimizing the effects of unnecessary exposure that is totally unavoidable, and interpreting the signs and alerts concerning radiation to avoid panicking (Loy, 2015). It should also include lessons or course on an emergency plan to avoid others the risk of radiation. This kind of training eases

the work for the RSO and ensures competency among workers and protection against ionizing radiation. (Koth, Smith, 2016).

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