Atomic Energy Board of Namibia

Peaceful Atomic Energy

ATOMIC ENERGY BOARD OF NAMIBIA

ANNUAL REVIEW

2017 - 2018

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MINISTRY OF HEALTH AND SOCIAL SERVICES
Directorate of Atomic Energy and Radiation Protection Authority
Private Bag 13186 Windhoek

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TABLE OF
CONTENT'S

FOREWORD

Dr Nortin Titus
CHAIRPERSON (INTERIM): ATOMIC ENERGY BOARD

The Atomic Energy Board of Namibia in 2018 had to say Good-Bye to its inaugural Chairperson, Dr. Wotan Swiegers, who passed away in May 2018. Dr. Swiegers served the interests of the Board and the people of Namibia with total commitment and dedication and his vision for the Board and its future still holds high value. He will be sorely missed and remembered fondly.

Ten years ago, the Atomic Energy Board (AEB) started operations together with the National Radiation Protection Authority (NRPA) and set about in a systematic manner on implementing the Atomic Energy and Radiation Protection Act. The basic provisions and institutions of a strong regulatory regime focusing on radiation protection of people and the environment have been laid and needs to be strengthened and expanded.

Two years prior to 2009, uranium prices went through the roof, countries were ordering nuclear power plants and Namibia faced an influx of uranium explorers. During this period, Namibia started developing its Nuclear Fuel Cycle Policy with the foresight of participating actively in the nuclear power sector, come 2018. Then came March 11 in 2011 and overnight it seemed that the whole nuclear power industry is dead and buried following the Magnitude 9.0 Tohoku earthquake. Nuclear power plant orders were put on hold, Governments planning future nuclear power production ceased overnight and the uranium prices started falling sharply and has not recovered since.

The Tohoku earthquake was impressive: 600km of the underlying Pacific plate moved 24 meters westward, Japan's Honshu island was displaced eastward by two (2) metres and about 400km of Japan's northern coastline dropped by half a metre. Built during the 1960/70s, the General electric designed Fukushima Diiachi Generation II boiling-water nuclear reactors and buildings survived the violent quake, however, lost back-up power connection. The tsunami that followed the earthquake caused the Diiachi plant to lose its on-site diesel backup generators to cool the reactors sufficiently. Insufficient cooling lead to the partial melting of the reactor cores followed by the production and build-up of hydrogen in the containment building, and, finally three explosions resulting in the release of radioactivity into the environment. Many studies have so far pointed out what could and should have been done, but critical to this disaster was the role the Regulator played prior to the accident in ensuring safe operations of the nuclear power plant.

The Nuclear Regulator plays a central role in the nuclear industry to ensure safe conduct of all nuclear related activities and it is within this context and of great concern to the Board that the NRPA continues to face insufficient funding and staff shortages in carrying out their mandated activities. The Board has consistently and repeatedly recommended a review of the organisational arrangements and this position of the Board has not changed. Furthermore, the Board is still firm on its view that promotion and regulation of nuclear science and technology remain clearly separate. It is therefore of utmost importance to strengthen and capacitate the regulatory body and ensure its independence.

The AEB will continue to promote the peaceful use of nuclear energy and therefore will continue to proactively engage with Government and industry to advance and promote the beneficial uses of nuclear energy, the active participation in the nuclear fuel cycle- and non-nuclear fuel cycle activities and promote the support and funding for nuclear science and technology. It has become evident that the position and mandate of the AEB needs to be reviewed and that the Atomic Energy and Radiation Protection Act be amended to include the regulation of nuclear installations.

It is important to take note that more nuclear power stations were connected to the grid in the last 8 years than 10 years before the Fukushima accident. Systematically, nuclear nations such as Russia and China are proactively seeking new buyers for their nuclear fuel cycle products and services. Furthermore, small modular reactors (SMRs) and Generation IV designs have over the past 15 years received substantial funding in the United States to return the United States to the top nuclear fuel cycle product and services supplier. Nations that have seemingly put off their nuclear power plans have shaken off the shocks of the Fukushima disaster and have either completed their builds or put the nuclear option back on the table.

Facing the future, Namibia, will continue to supply the world with nuclear source material and will therefore remain a participant in the front-end of the nuclear fuel cycle, however, to participate in nuclear fuel cycle activities much work lies ahead and we must continue along the correct path. It is clear that the AEB together with the NRPA take a leading role in driving the national agenda on the promotion of the peaceful uses of nuclear energy and nuclear science and technology coordinating sectorial activities to achieve the desired outcomes.

Dr Nortin Titus
Chairperson (Interim)

PREFACE

Axel Tibinyane
SECRETARY : ATOMIC ENERGY BOARD

The Directorate Atomic Energy and Radiation Protection Authority is mainly tasked with the administration of the Atomic Energy & Radiation Protection Act, Act No 5 of 2005. As per requirement of the Act, an annual report must be made describing the activities of the Atomic Energy Board, as advisory body on nuclear and radiation matters, and activities of the National Radiation Protection Authority as technical arm responsible for the administration of the Act.

This report is prepared in fulfilment of this requirements and is organized to inform the audience about the progress on matters relating to nuclear and radiation, especially regulatory issues. It provides progress and challenges that relate to the policy, legislatives and institutional framework for the regulation and control of radiation sources, radioactive and nuclear material. Technical details are provide with regard to regulatory activities; occupational radiation protection; public exposure control; medical radiation exposures; radioactive waste management; and nuclear security.

It further provides information of various activities to enhance the promotion and contribution of nuclear technology to developmental priorities in Namibia as it relates to cooperation with the Internal Atomic Energy Agency. The appropriateness of the legislative infrastructure and institutional capacity, more specifically the effective and independence of the National Radiation Protection Authority and its staffing, continues to be highlighted in this and previous reports as foundational issues that are necessary to make regulatory activities robust.

I would like to take this opportunity to commend the staff for the high level of performance despite the understaffing. The scope and depth of themes covered and reported herein is quite substantial and it is only through the commitment from staff and hard work that progress is reported

Axel Tibinyane
Secretary : Atomic Energy Board

1. INTRODUCTION

This report is prepared pursuant to Section 15 of the Atomic Energy and Radiation Protection Act, Act No 5 of 2005, which obligates the National Radiation Protection Authority to prepare a report on the activities of the Atomic Energy Board and the Authority. The report considers the overall appropriateness of the legislative and organisational arrangements and provisions in place to ensure robust regulation of radiation sources, radioactive and nuclear material. It further elaborates on the specific aspects undertaken since the current Board took office, including matters relating to regulatory activities, radiation safety, nuclear security, nuclear safeguards. compliance with international, institutional capacity, and stakeholder engagements.

The report is intended to inform the Board, the line Minister, Cabinet and Parliament and all stakeholders about the progress in the implementation of the Atomic Energy and Radiation Protection Act, Act No 5 of 2005.

2. ATOMIC ENERGY & RADIATION PROTECTION ACT

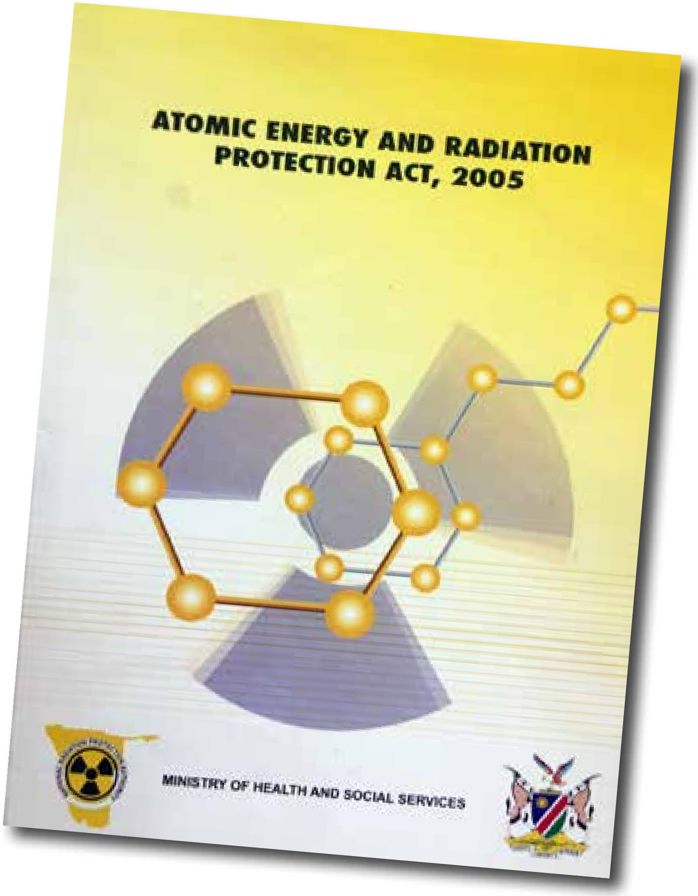
The Atomic Energy & Radiation Protection Act was enacted in 2005 to provide for:

(i) The regulation of all activities (possession, use, transport, import, export, disposals) that involved radiation sources, radioactive and nuclear material.

(ii) To provide for the legislative and institutional framework through which exposure to radiation, both ionizing and non-ionising, can be optimised (i.e. to ensure minimal hazardous exposure to radiation while fully exploiting the benefits derived from it)

(iii) The establishment of the legal and institutional framework through which Namibia can facilitate accession to and compliance with international legal instrument in the areas of nuclear energy, radiation safety, nuclear security and nuclear weapons non-proliferation.

(iv) Establishment, functions and operations of the Atomic Energy Board and the National Radiation Protection Authority.



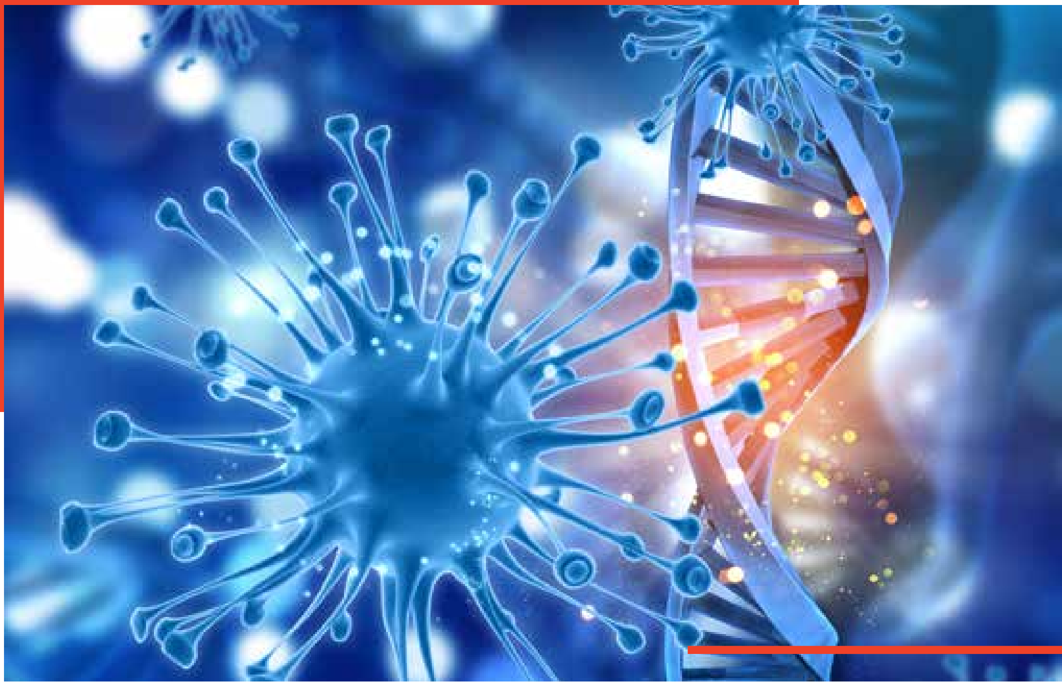
3. ATOMIC ENERGY BOARD

The Atomic Energy Board was established in 2009 to serve as an advisory board to all organs of Government on matters relating to nuclear energy and radiation sources. The Board has no executive powers, but merely serves as a body of experts and representative of key O/M/As to advise on nuclear energy and radiation matters. The Board is constituted of representatives from the Office of the President; Ministries of Heath & Social Services, Mines & Energy; Environment & Tourism; International Relations & Cooperation; Industrial Relations & Employment Creation. The current AEB is the third since the establishment of the AEB and its three- year term of office is from 2016 – 2019.

The Atomic Energy Board was inaugurated by the Honourable Minister of Health And Social Services, Dr Bernard Haufiku in 2016.

The Director of the National Radiation Protection Authority serves as the Secretary to the Atomic Energy Board, while the work of the Board is administered by the Division: Nuclear Applications in the Directorate Atomic Energy & Radiation Protection, Ministry of Health & Social Services.

Figure 1: Standing from left: Mr C. Namalambo, Ms M. Hitenanye, Mr F. Sikabongo, Mr S. Kapeng, Mr A. Tibinyane (Secretariat), Dr. W. Swiegers (Chairperson). Seated from left: Ms H, Itamba (replaced by Dr N. Titus), Dr Bernard Haufiku (Minister of MHSS), Dr P.Emvula (replaced by Dr Nakangombe)



4. NATIONAL RADIATION PROTECTION AUTHORITY

The NRPA is established as an independent regulatory body, but must act independently in the exercise of the functions under the Act and considers only the relevant provision of the Act and such scientific and technical matters as may be relevant to the issues concerned. The NRPA is not a juristic person and therefore does not have the administrative autonomy as is the case with other state enterprises.

The organisational requirements for the NRPA and that of the staff performing the work of the AEB are contained in the Directorate Atomic Energy & Radiation Protection Authority, an administrative entity in the Ministry of Health and Social Services.

Therefore, the NRPA functions independently in as far as it concerns technical and scientific matters within the scope of the Act, but administratively functions as a Directorate in the Ministry of Health and Social Services

The National Radiation Protection Authority (NRPA) serves as the administrator of the Atomic Energy & Radiation Protection Act.

The main duties of the NRPA is to

(i) Maintain an inventory of and record of activities (production, processing, handling, transport, use, storage, disposal) involving radiation sources, radioactive and nuclear material in Namibia

(ii) Regulate all activities (production, processing, handling, transport, use, storage, disposal) involving radiation sources, radioactive and nuclear material in Namibia

(iii) Inform the Atomic Energy Board about the extent of radiation exposure in Namibia

(iv) And generally enforce all provisions of the Act

5. APPROPRIATENESS OF THE LEGISLATIVE FRAMEWORK & INSTITUTIONAL ARRANGEMENTS

One of the key matters that continue to dominate the deliberations of the Board is the appropriateness of the Atomic Energy & Radiation Protection Act and the institutional framework that governs the administration of the Act. The Board and its Secretariat continued to be ceased with ways and means how Namibia could improve its governance framework for nuclear science and technology matters. To this end the Board has considered the gaps and made recommendations based on the following fundamental principle:

the regulatory body must be effectively independent, in protection and safety related decisions, of persons and organizations using or otherwise promoting the use of radiation and radioactive material, so that it is free from any undue pressure from interested parties and any conflict of interest

Considering the above principle, the Board has adopted the following recommendations for consideration by Government Authorities

- Ensure the governance structure and provisions for regulation and promotionof nuclear science and technology are clearly separated.
- Strengthening the legislative, regulatory and institutional infrastructure for the regulation of Namibia's nuclear and radiation-based technologies;

The following have been observed

- Current institutional arrangements are neither compliant with international recommendations nor does it have the appropriate stature as a regulatory body for nuclear and radiation matters.
- International practices and trends, including in the SADC region, establish autonomous regulatory infrastructure with the responsive capacity and capability to deal with the appropriate scope of applications in the country.
- Current institutional infrastructure is also not responsive in terms of technical and human resource capacity to be able to appropriately adjust to the developing and expanding scope of the nuclear applications in the country.

In view of the above it is recommended to

- Designate a single and appropriate O/M/A to steward regulation of nuclear safety, security and safeguards
- Amend current Act to expand scope to include nuclear installations
- Create an institutional arrangement for the effective and independent regulation of nuclear safety, security and safeguards

As part of this undertaking to improve the legislative provisions, the Atomic Energy & Radiation Protection Act is under review with the assistance of the International Atomic Energy Agency to ensure that it meets the current expectations and needs in terms of scope, depth and governance framework

6. REGULATORY BODY STAFFING AND TRAINING

The appropriate number of staff and the competency of staff is essential for any regulatory body to discharge its functions effectively and efficiently. Any regulatory body such as the NRPA must be resilient in terms of its staff establishment so that it is responsive to the scale and depth of its regulatory responsibilities. This has however not been the case and the current staff component of 13 technical staff is far below the scope of regulatory responsibilities.

In terms of its technical capabilities the NRPA has a reasonable depth of skills, but limitations due to number staff and the spread of functions result in loss of focus and optimal utilisation of the available skills.

Training opportunities are widely available through the IAEA and other partners, but utilisation of the opportunities is constrained by number of staff available. Training during the reporting period, has been facilitated in the following areas to sharpen technical skills:

- QA/QC in nuclear medicine
- transport of radioactive material
- safety case and assessment of radiation waste
- operation and preventive maintenance of the TLD Reader system.
- basics of operation of the gamma spectroscopy system
- quality management in dosimetry services
- radioactive waste management
- radiological emergencies and response
- nuclear security inspections and authorisation in uranium mining

Capacitating operators at the operational level will go a long way to create a radiation safety and nuclear security culture and thereby enhance regulatory compliance. Hence modular training programmes for radiation safety officers have been developed in the following areas:

- Radiation Protection in Diagnostic and Intervention Radiobiology;
- Radiation Protection in Nuclear Medicine;
- Radiation Protection in Radiotherapy;
- Radiation Protection in Mining;
- Radiation Protection in Industrial Radiography.

It is anticipated that the short courses will be rolled out in 2018/19 in collaboration with the Namibia University of Science and Technology (NUST).

7. REGISTER OF RADIATION SOURCE, RADIOACTIVE AND NUCLEAR MATERIAL

One of the obligations of the NRPA is to establish and maintain a register of radiation sources, radioactive and nuclear materials in Namibia and corresponding activities including imports, exports, products and premises licensed to install, store and use radiation sources or dispose of radioactive waste.

An inventory of the radiation sources, radioactive and nuclear materials in Namibia is kept in the Regulatory Authority Information System, which provides details of the name of the owner of the materials; particulars of the premises; details of the material concerned and the regulatory status.

There is a total of 263 practices or facilities and 607 radiation sources recorded in the Regulatory Information Management System. Figure 2 below shows that the inventory of radiation sources is predominantly from the medical sector. It should however be noted that while this is the case the lowest radiological risk occurs in theses sector while the greatest risk occurs in the nuclear medicine, radiotherapy, uranium mining and other mining activities, especially in the Erongo region. Hence regulatory activities are aligned to the risk and those areas where there is highest risk is prioritized.

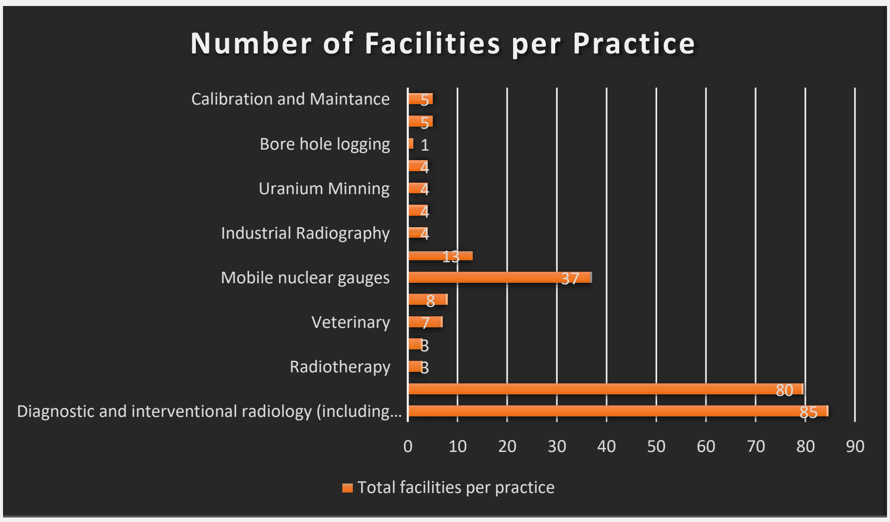


Figure 2: Facilities Per Practices

8. REGULATORY ACTIVITIES

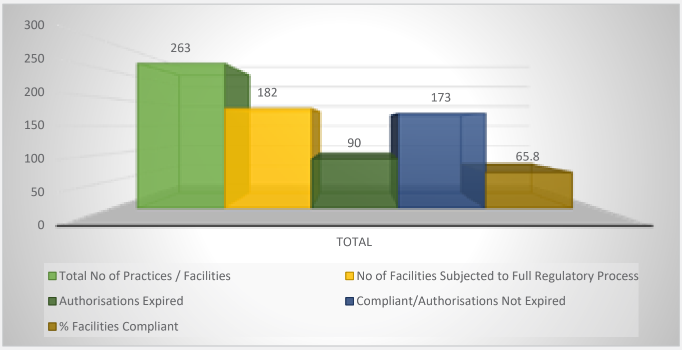
The NRPA's duties are to inspect at such intervals as may be necessary any radiation source or nuclear material to assess radiation safety conditions and other requirements imposed by or under the Act and to take such action as is necessary to enforce any provision of the Act. A regulatory regime has been adopted in line with the provisions of the Act, which includes a framework for notification, authorisation, registration, licensing, inspection and enforcement.

The regulatory regime is aimed at ensuring that : (i) every practice has in place a organisational arrangement to assure and guarantee radiation safety and security conditions; (ii) employees are adequately protected again any potential exposure from the radiation under eth control of the facility; (iii) the public is protected against any potential release or exposure from the radiation sources; (iv) the radiation sources in question is kept secure to prevent unauthorised action or malicious acts; (v) the facility is prepare and ready to respond to any potential emergency involving the radiation sources; (v) in case of transportation, export or import of the radiation source or material appropriate controls are in place, and (vi) radiation sources or radioactive material are appropriately disposed off.

Out of the 263 practices or facilities, 182 or 69% have been subjected to the full regulatory process. This implies that each of these facilities have made a notification; prepared a radiation management plan; have been inspected and the Authority has formed an opinion about the practice ability to assure radiation safety and security conditions satisfy legislative and regulatory requirements. 90 or 34 % authorisations or license have expired and these have not been renewed, while 173 or 66% are found to be compliant during the reporting period.

It is observed that most of those that are found to be non-compliant are predominantly from the public health sector, which further point to the need to enforce regulation.

There are still 81 or 31% of the facilities that have not yet been fully subjected to the regulatory processes. In addition, there are 34% facilities whose authorisation



have expired. Furthermore, many facilities that are high risk should be inspected more frequently than the low risk facilities. Many of these aforesaid depend on the institutional capacity of the NRPA and due to the acute shortage of staff and in some cases skills it is not possible to attend to all these activities.

At this point it is critical to improve the staff component of the NRPA to (i) cover all the practices and facilities earmarked for regulation and (ii) to provide regulatory oversight with the required frequency and intensity for high risk practices and facilities such as mining, radiotherapy, nuclear medicine and industrial radiography.

Despite the challenges in terms of staffing, the NRPA continued to improve its regulatory system and operations by conducting inspections, reviews, enforcement and develop a workflow system to improve efficiency in the regulatory business processes, and developing standard operation procedure manual for inspections. Standard Operating Procedures (SOP) for Notification, Review and Assessment, Authorization, Inspection and Enforcement have been completed and approved for inclusion in the Quality Management System of the NRPA.

9. PROTECTING WORKERS AGAINST THE HARMFUL LEVELS OF RADIATION EXPOSURE

Employees who are in sectors where radiation sources are used or where radioactive material is processed are at potential risk of receiving harmful levels of radiation exposure. A radiation worker is any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection. Hence controls must be in place to ensure that these workers are not subjected to the allowable annual dose of 20 mSv and even in cases where the dose is below this level, measures must be put in place to ensure the dose is low as reasonably achievable by applying as a minimum the regulatory requirements for occupational exposure.

Monitoring exposure to individuals in the workplace is the first line of defence to identify possible over exposure and irregularities in the operations of a facility or practices. Hence the exposure of radiation workers is monitored and recorded monthly to assess radiation safety conditions and protection of individuals.

Table 1 shows that there are currently 3555 radiation workers under surveillance for exposure to radiation in the work place.

The highest risk of exposure occurs in the uranium mining sector, where a maximum dose of 7.2 mSv/a has been recorded. The annual exposure is a sum of the different types of radiation that an individual is exposed to. For the uranium mining sector, the exposure recorded is predominantly from gamma

Practice	Dosimetry Service Provider	No of Workers Monitored	% of Practice Coverage	Average Dose (mSv/a)	Maximum Effective Dose Recorded (mSv)
Uranium Mining and Processing	Algade (France) & NCRS (New Zealand)	3324	100	1.44	7.2
Interventional Diagnostic Radiology	NRPA	146	100	0.55	1.66
Nuclear Medicine	NRPA	18	100	1.1	2.72
Radiotherapy	NRPA	30	100	0.841	1.57
Fixed Nuclear Gauges	NRPA	10	10	1.18	2.14
Veterinary Diagnostics	NRPA	11	29	1.11	1.5
Cath Labs	NRPA	11	100	0.49	0.56
Dental Radiography	NRPA	5	4	1.19	1.52
Total		3555	68	0.99	

exposure (52%), followed by radon / radon progeny (28%); and inhalation of radioactive dust (20%).

The progamme for radiation surveillance has been capacitated with the addition of 800 dosimeters (dose detection instruments) that will allow expansion of the services. As a quality assurance measure the NRPA regularly participates in the IAEA organised dose measurement programme which conducts intercomparison evaluation of the performance of the dosimetry system. The performance characteristics of the system were tested using International Radiological Protection (ICRP) performance Criteria: Linearity, angular response, energy dependence and blind tests. The result showed all tested parameters were within the ICRP trumpet curve, satisfying the ICRP recommendation and the NRPA laboratory passed the exercise.

Capacitating the staff is critical to maintain the service and two dosimetry staff attended training in Germany on the operation and preventive maintenance of the radiation measuring instruments (TLD Reader system). Improving the staff component is of utmost importance to ensure timely, efficient and effective management of the service as well as security of funding to support uninterrupted provisions of services.

CONTRIBUTION OF OVERALL EXPOSURE

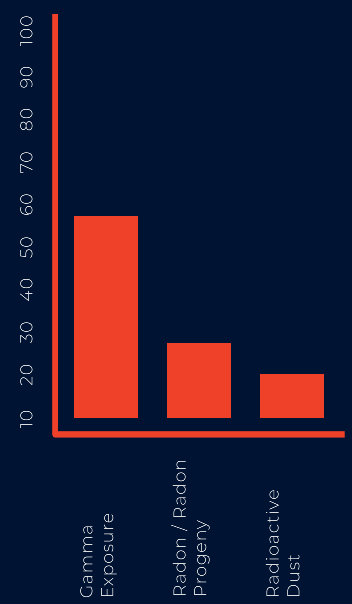


Figure 3: Contribution of respective exposure pathways to the effective dose (uranium mining and processing only).

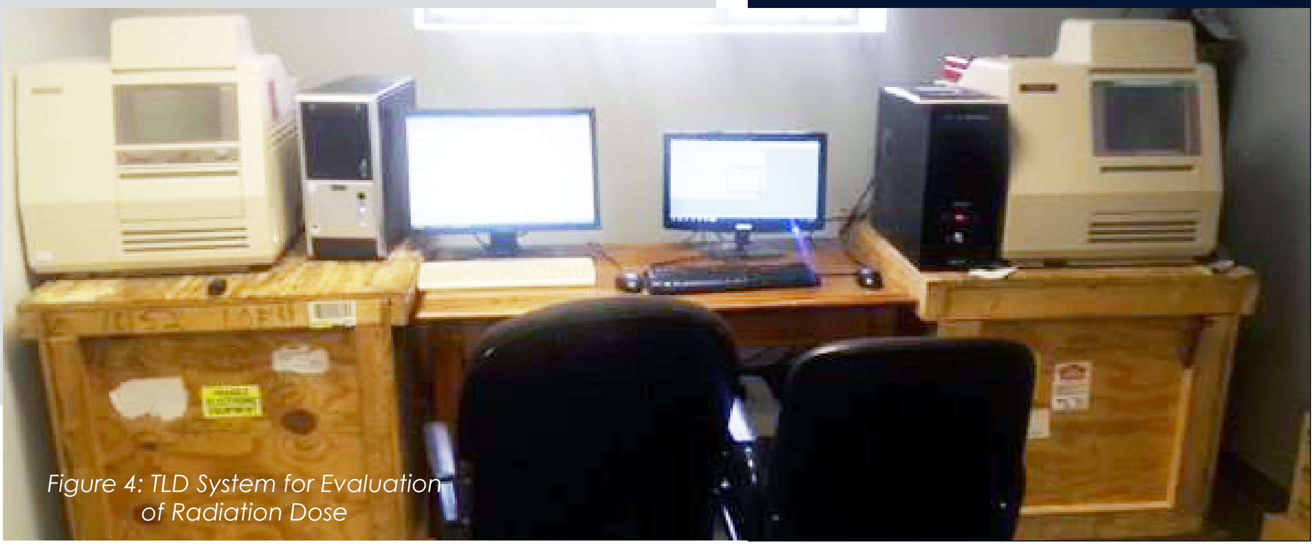


Figure 4: TLD System for Evaluation of Radiation Dose

10. PROTECTING THE PUBLIC AGAINST HARMFUL LEVELS OF RADIATION EXPOSURE

Indoor Assessment of Radon

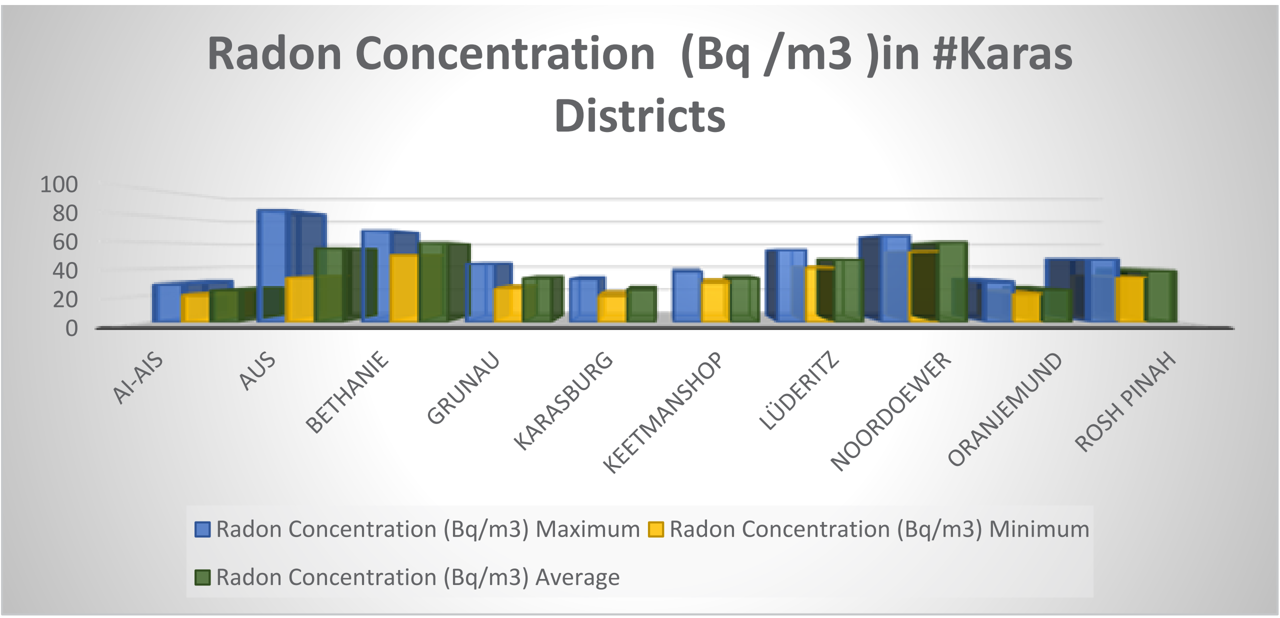
Radon is a naturally occurring radioactive gas which is released from rocks and is found in indoor environments such as homes, schools, and workplaces. If found to exceed concentration above action levels it can pose harmful radiation exposure to individuals. The recommended action level for radon concentration in inhabited enclosures is 100 Bq/cm3 The NRPA initiated a nationwide study in 2011 to investigate the level of exposure to radon gas in dwellings to determine if there is any occurrence of high concentration of radon and if intervention is required to protect members of the public who could potentially be exposed. The study was completed in Khomas, Erongo, Otjozondjupa, Omaheke and Hardap regions and further expanded to // Karas region and Kunene Region from 2015 to 2017.

The survey of radon gas in dwelling in //Karas region was done in the following towns, Ai-Ais, Aus, Bethanie, Grunau, Karasburg, Keetmanshoop, Lüderitz, Noordower, Oranjemund and Rosh Pinah.

The assessment was done in schools and public offices for a period of one year (on a 3 months' rotational basis) from June 2015 to August 2016.

An average annual radon concentration of 100 Bq /m3 in a dwelling assuming 80 occupancy factor translates to an annual dose of 1.8 mSv/year. For dwellings with radon concentrations above these levels remedial actions may be recommended.

A total number of 560 radon monitors were deployed in the selected dwellings in the afore-mentioned towns. 542 radon monitors were recovered successfully from their respective deployment points whereas 18 monitors could not be accounted for. The mean annual indoor radon concentration was determined as shown in the graph below for each town. The highest annual mean was recorded in Noordoewer (60.00 Bq/m3) and the lowest annual mean was recorded at Ai-Ais (23.73 Bq/m3. The results show that the mean indoor radon levels in //Karas region towns are found not to exceed the Reference Level, 100 Bq/m3 for a member of the public.



11. EXPOSURE TO SOURCES OF NON-IONISING RADIATION

There is rising concern about the health effects resulting from exposure to sources of non-ionizing radiation, especially radiation from electromagnetic fields (EMF) generated from mobile phones, cordless phones, local wireless networks and broadcasting transmission antennas.

Guidelines have been developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for limiting EMF exposure that will provide protection against known adverse health effects[1]. As provided for in the Atomic Energy & Radiation Protection Act, efforts are in progress to develop national regulations taking into account the ICNIRP Guidelines by incorporating them into regulations by reference. The guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF. In the case of potential long-term effects of exposure, such as an increased risk of cancer, ICNIRP concluded that available data are insufficient to provide a basis for setting exposure restrictions

Restrictions on the effects of exposure are based on established health effects and are termed basic restrictions. Different scientific bases were used in the development of basic exposure restrictions for various frequency ranges:

- Between 1 Hz and 10 MHz, basic restrictions are to prevent effects on nervous system functions;
- Between 100 kHz and 10 GHz, basic restrictions are provided to prevent whole- body heat stress and excessive localized tissue heating;
- Between 10 and 300 GHz, basic restrictions are provided to prevent excessive heating in tissue at or near the body surface.

Reference levels of exposure are provided for comparison with measured values of physical quantities. The reference levels are derived from basic restriction and compliance with all reference levels given in the guidelines will ensure compliance with basic restrictions.

The NRPA regularly conducts surveys to assess the exposure from Base Transmitter Stations (BTS) against ICNIRP reference levels.

During the period under review 15 BTS sites were assessed, in //Karas, Oshikoto, Oshana, Otjozondjupa Regions, Results are as indicated in the tables 1 & 2 below:

Table 1: Measurement results for //Karas Region

Base Station Name	Location	Max Measured Value (v/m)	Frequency [MHz]	ICNIRP limit (v/m)	Assessmen t (Times below limit)
Telecom BTS1 _Orajemund	28°32'52.8'' S 16°25'18.3'' E	1.29	951.00	42.40	32.95
Rosh Pinah	27°57'45.1'' S 16°45'43.7'' E	0.76	940.00	42.16	55.51
Westerkim BST_Karasburg	28°0'38.0'' S 18°44'20.9'' E	1.30	1817.00	58.61	45.24
Karasburg Telecom BST	28°1'24.0'' S 18°45'06.6'' E	0.68	951.50	42.41	62.16
Donkerhoek Sportfield_Keetmanshop	26°35'28.6'' S 18°9'04.4'' E	1.67	1817.50	58.62	35.16
Lüderitz	26°38'49.8'' S 15°9'34.4'' E	5.89	90.50	13.08	2.22
Agate_ Lüderitz	26°38'08.0'' S 15°9'45.3'' E	2.43	2122.50	61.00	25.11
Ausenkehr	28°21'41.1'' S 17°25'26.2'' E	1.09	1813.50	58.55	53.96
Telecom_Granuw	27°44'07.5'' S 18°22'32.9'' E	1.09	894.00	41.11	37.89

The electromagnetic radiation levels were measured at the point of highest emissions at different locations along selected base station which were determined near the site, to assess compliance with the ICNIRP Limits for public exposure to non-ionising radiation. Once the point of maximum NIR was determined, broadband and frequency selective measurements were conducted at that location.

The levels for each emission measured were compared to the relevant ICNIRP public guideline limit which applies at the frequency of the emission. It should be noted that the ICNIRP guideline limits vary according to frequency. At each site the highest emission were recorded as show in table above and compared to the limits for the different frequencies. At all sites surveyed, the maximum level of electromagnetic radiation emissions measured were found to fall below the limits for public exposure.

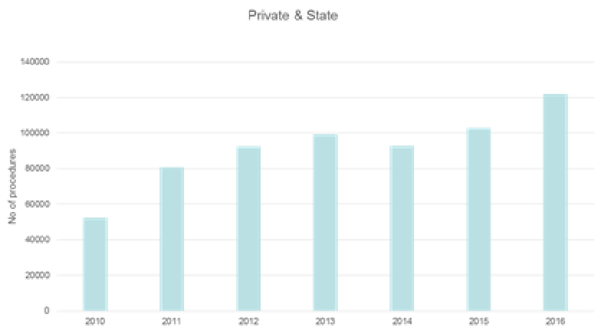
Table 2: Measurement results for tsome Districts in the Northern Regions.

Base Station Name	Location	Max Measured Value (v/m)	Frequency [MHz]	ICNIRP limit (v/m)	Assessmen t (Times below limit)
Eenhana	17°29'40.5'' S 16°19'54.7'' E	0.73	952.81	42.44	58.52
BST2_Tsumeb	19°15'03.7'' S 17°42'08.9'' E	1.60	2112.50	61.00	38.22
Tsumeb_BST1	19°14'51.4'' S 17°42'54.3'' E	1.06	2118.50	61.00	57.65
Otjiwarongo_ BST2	20°28'07.1'' S 16°38'46.6'' E	0.70	943.00	42.22	60.26
Otjiwarongo_ BST1	20°28'01.4'' S 16°39'45.1'' E	1.66	940.00	42.16	25.34
Telecom_NAMPOST_ Otavi	19°38'26.7'' S 17°20'41.6'' E	2.96	1718.00	56.99	19.27
Oshikango	17°24'02.3'' S 15°53'31.6'' E	1.47	2122.50	61.00	41.43
Oshakati_BTS1	17°46'20.0'' S 15°41'26.4'' E	0.91	951.50	42.41	46.77
Oshakati_BTS2	17°47'34.5'' S 15°43'02.7'' E	0.98	1812.00	58.53	59.82
Telecom building _Ondangwa	17°54'24.6'' S 15°58'13.6'' E	0.44	2115.00	61.00	139.26
School Site_ Ondangwa	17°55'30.7'' S 16°0'13.9'' E	0.77	943.00	42.22	54.90
Omuthiya	18°21'30.1'' S 16°35'06.4'' E	1.87	1820.00	58.66	31.32
Valombola_Ongwendiva	17°45'58.7'' S 15°45'53.4'' E	3.86	895.00	41.14	10.66
BST2_Ongwendiva	17°46'31.0'' S 15°45'27.7'' E	0.56	937.00	42.09	75.02
Puatuavanga_Opuwo	18°3'04.6'' S	1.98	1816.00	58.60	29.54

12. OPTIMIZING RADIATION DOSE IN MEDICAL EXPOSURE OF PATIENTS

Radiation exposure in the medical sector is among the most routine and frequent forms of delivering exposure and these can present additional health risk if the exposure is not optimized. Statistics indicate that medical radiation exposure is on the rise as shown in figure below.

Fig 5: Medical radiation exposure



Optimization implies that the least radiation dose is applied to the correct target or region of interest without compromising quality in either imaging or treatment. Therefore, optimization of radiation exposure in medical exposure depends largely on the following parameters:

- Competent professionals in imaging and treatment delivery with appropriate skills to correctly deliver radiation exposure
- Optimal performance of equipment
- Correct application of protocols and guidance levels

In order to ensure optimization of delivery of radiation exposure in diagnostic radiology, professionals are required to have the necessary basic academic qualifications and the competency in radiation protection. There are 85 diagnostic facilities in Namibia and all have the minimum technical expertise. However an accredited certifications schemes is yet to be roll-out for training as radiation safety officers in diagnostic radiology. None of the facilities have access to medical physics support to advice on optimization of radiation exposure and especially on the quality control of the equipment.

In terms of equipment performance there are 114 x-ray units in the country and out of these 18 were inspected during the reporting of which 77% performance are within the accepted levels of performance parameters standards.

To build the necessary capacity, a Code of Practices (COP) was launched on Diagnostic x-ray imaging system Quality. The COP stipulates the minimum quality control tests to be performed on imaging equipment during commissioning and periodically thereof. This was followed by training of 30 Radiation Safety Officer on regulatory requirements and radiation safety in diagnostic radiology.

In the area of nuclear medicine, there are currently three facilities under regulatory control. These facilities have have radiation management plans in place to facilitate compliance with regulatory requirements. These facilities have access to medical physics support and have radiation management plans in place to facilitate compliance with regulatory requirements. Only 2 facilities have medical physicists.

There are two radiation therapy facilities, both with medical physics support and demonstrated compliance with regulatory requirements.

13. NATIONAL NUCLEAR AND RADIOLOGICAL EMERGENCY RESPONSE PLAN

The use of radiation sources in different fields of practice is steadily growing. Despite safety precautions in design and operations, accidents involving radiation sources do occur. Often accidents with radiation sources occur due to the lack of regulatory control, or lack of adequate infrastructure for regulatory control or both. Experience has shown that advance emergency response preparedness is essential in order to mitigate the consequences of an accident. Lessons learned underscore the need to have in place emergency response plans and adequate response resources and capabilities at facility, on-site and offsite. Only in this way the country can cope with nuclear and radiological emergencies that have or could have significant consequences for public life, health, safety property and the environment.

At the facility level, every licensed facility is under obligation to develop its own Radiological Emergency Response Plan and have it approved by the NRPA.

At the national level the National Nuclear and Radiological Emergency Response Plan is currently at an advanced stage of drafting and is expected to be finalized during 2018. It is also anticipated to invite Emergency Preparedness Review (EPREV) Service from the IAEA which will

- Provide an assessment of the national capability to respond to nuclear and radiological incidents and emergencies, including those involving malicious or other unauthorized acts
- Assist in the development of interim arrangements to promptly respond to anuclear or radiological emergency

Participants during first workshop to draft the EPRP

- Assist in providing a basis upon which the State can develop a longer-term programme to enhance their ability to respond

In terms of compliance with the Global Regime for Emergeny Response, progress is under way to ratify the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. The Convention on Early Notification of a Nuclear Accident establishes a notification system for nuclear accidents that have the potential for international transboundary release that could be of radiological safety significance for another State.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency sets out an international framework for co-operation among States Parties and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies.

14. INTERNATIONAL LEGAL INSTRUMENTS

The use of nuclear energy has not only a national but also an international dimension, hence international legal instruments adopted under the auspices of the International Atomic Energy Agency (IAEA) establish internationally-recognized principles and requirements to adequately regulate nuclear activities. They seek to ensure the safe, secure and peaceful uses of nuclear energy and ionising radiation. While responsibility for nuclear policy rests entirely with each State, participation in, and implementation of, the relevant international instruments help enhancing global cooperation. Universal adherence to the relevant instruments makes a major contribution to nuclear safety and security worldwide.

Namibia has been a member of the International Atomic Energy Agency since 17 February 1983. Since then Namibia has ratified the following agreements which are in force:

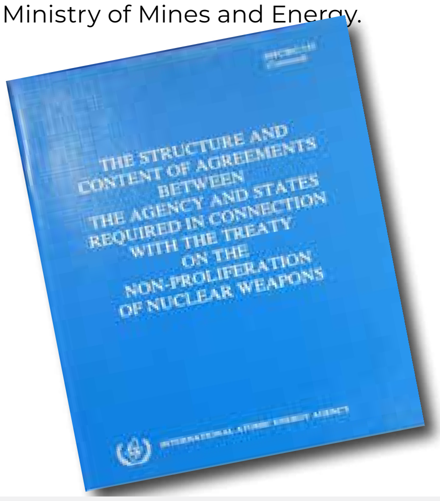
1. Agreement between the Republic of Namibia and the IAEA for the application of safeguards in connection with the NPT
2. Protocol additional to the agreement between the Republic of Namibia and the IAEA for the application of safeguards in connection with the Treaty on the Non-Proliferation of nuclear weapons
3. Convention on the physical protection of nuclear material
4. African Nuclear Weapon-Free-Zone Treaty (Pelindaba Treaty)
5. Amendment to the Convention on the physical protection of nuclear material
6. Revised supplementary agreement concerning the provision of technical assistance by the IAEA (RSA)
7. African regional co-operative agreement for research, development and training related to nuclear science and technology

Namibia is already engaged in the process of considering adherence to, or intends to do so soon, in relation to the following legal instruments:

1. Agreement on the privileges and immunities of the IAEA
2. Vienna Convention on civil liability for nuclear damage
3. Convention on early notification of a nuclear accident
4. Convention on assistance in the case of a nuclear accident or radiological emergency
5. Joint protocol relating to the application of the Vienna Convention and the Paris Convention
6. Convention on nuclear safety
7. Joint convention on the safety of spent fuel management and on the safety of radioactive waste management
8. Protocol to amend the Vienna Convention on civil liability for nuclear damage
9. Convention on supplementary compensation for nuclear damage

The IAEA provided a legislative assistance mission in 2016 to support Namibia in gaining an understanding of the obligations arising from the relevant international legal instruments adopted under IAEA auspices and in revising its national legislation to bring it in line with the instruments to which Namibia is a party or to which it intends to become a party. The review process of the current Atomic Energy & Radiation Protection Act No. 5 of 2005 has commenced and will be guided by international nuclear law.

Seven legal advisors attended the workshop and the ensuing consultations with other officials from the following institutions: National Radiation Protection Authority, Atomic Energy Board, Ministry of Health (1 legal advisor), Ministry of International Relations and Cooperation, Ministry of Defence (1 legal advisor), Ministry of Justice (2), Attorney General's Office (3), Financial Intelligence Centre, National Forensics Institute, Ministry of Mines and Energy.



15. NUCLEAR SECURITY

The Integrated Nuclear Security Support Plan (INSSP) has been agreed with the International Atomic Energy Agency (IAEA), which is a three-year strategic document on how the IAEA can support Namibia's nuclear security regime from 2016 to 2018. The development of the INSSP was done with the involvement of all key stakeholder, including IAEA staff, Ministry of defense, Ministry of Safety and Security, Ministry of Finance; Ministry of Mines & Energy; Ministry of Health & Social Services and National Forensics Institute.

The INSSP identifies and consolidate the nuclear security needs of Namibia in an integrated manner that includes the necessary nuclear security improvements, based on the IAEA's Nuclear Security Series documents and to provide a customized framework for coordinating and implementing nuclear security activities conducted by different stakeholders, the IAEA and potential partners.

Creating awareness and building capacity among law enforcement agencies and key stakeholders is a central part of the INSSP. As of the implementation of the INSSP, several capacity building workshops and training events were held, focusing on the following topics:

1. National Meeting for Development of Integrated Nuclear Security Support Plan (INSSP)
2. International Legal Instruments adopted under IAEA auspices
3. Review of the Atomic Energy and Radiation Protection Act
4. Risk Informed Approach for Nuclear Security Measures for Nuclear and Other Radioactive Material out of Regulatory Control
5. National Response Plans for Nuclear Security Events — Methodology and Capability
6. Physical Protection and Security Management
7. Regional Coordination of INSSP for Southern African Development Community (SADC) States
8. Nuclear Law for African Member States

In looking ahead the following will be priorities for the implementation of the INSSP:

- The Nuclear Security Committee, constituted from all law enforcement agencies and key stakeholders, will be re-activated to provide a guidance and support in the implementation of the nuclear security programme.
- There is willingness by partners to provide technical assistance for the development of a temporary safe storage of sources kept for criminal procedures (Namibian Police Force) outside of the responsibility of NRPA and temporary storage facility for the NRPA. However, availability of land is stumbling block and stakeholder will be engaged for acquisition of land.
- Border control measures are of a concern due to infiltration of unauthorized radioactive sources, thus efforts must be strengthened to bring about improvement.
- Stakeholders in nuclear security who are directly involved in detection be encouraged to invest in detection equipment and training.

16. RADIOACTIVE WASTE MANAGEMENT

Radioactive sources are being used in roads construction, mining activities, brewery and beverages bottling companies, medical industries, scientific establishments, etc. for a wide range of applications. When radioactive sources are no longer used for the intended purpose or have outlived useful life, they are treated as radioactive waste and needs to be managed in a safe and secure manner to avoid unplanned exposure to members of the public and workers.

Currently there are 68 registered facilities with a combined total 292 radioactive sealed sources in Namibia, of which 44 of the 292 are stored in interim storages at the licensed facilities and managed as radioactive waste. The regulatory requirement obliges licensees to enter into contractual agreement with suppliers / manufacturers on returning the radioactive sources at the end of its useful life. There are cases where the suppliers could not be located and therefore these sources can not be returned to the suppliers and would remain in Namibia.

Therefore, a long terms strategy is needed on how Namibia will manage its radioactive waste now and in future. Hence a policy and strategy on radioactive waste has been developed with the support of the IAEA Experts. The strategy is now in final stage of drafting and awaits approval from authorities before finalization.

17. INTERNATIONAL COOPERATION IN THE AREAS OF NUCLEAR SCIENCE AND TECHNOLOGY

The International Atomic Energy Agency is the specialist UN Agency that support its members states to acquire nuclear technology for developmental purpose. This is pursued through its Technical Cooperation Programme, which promotes tangible socio-economic impact in areas where the peaceful application of nuclear technology holds a comparative advantage.

The Technical Cooperation Programme is tailored to meet the specific needs of Member States and responds to the evolving needs and priorities of Member States through capacity building, transfer of nuclear technology, and the sharing of knowledge among Member States. Some examples of the past and current projects that have contributed in the context of Namibia's development priorities are cited below.

12.1 Establishing Teaching, Research and Technical Capacity in Nuclear

The project has assisted in the development of a Postgraduate Diploma in Applied Radiation Science and Technology which commenced in 2016 with at the Namibia University of Science & Technology (NUST), with a total of 20 students registered for the programme

An MSc programme in Nuclear Science and Technology was also developed under the project and is currently offered at the University of Namibia since 2015.

12.2 Developing National Capacity for Research and Development in Nuclear Science and Technology

The project has assisted through various stakeholder engagements, scientific visits, expert mission to develop a business model for the establishment of a National Centre for Nuclear Science and Technology.

In addition, the project has and will continue to support candidates for PhD postgraduate studies in various specialities of nuclear science and technology. These candidates are expected to support the Nuclear Science & Technology Centre and educational institutions in terms of research and skills production.

12.3 Building National Capacity for Cancer Diagnostics and Treatment

The IAEA has been instrumental in the establishment of cancer diagnostic and treatment capabilities, including the setting of the current Radiotherapy facility in Windhoek, strengthening the nuclear medicine facility in Windhoek central hospital and establishment of a nuclear medicine facility in Oshakati.

Cooperation is now in progress to support planning for the expansion of the radiotherapy facility at the Windhoek Central Hospital to accommodate a linear accelerator and capacity building to operate the expanded services. It will further assist the Government with the planning of a new radiotherapy facility in the north of the country (Oshakati).

12.4 Enhancing Food Security Through Crop Mutation Using Nuclear Techniques

The project is aligned with the "Green Scheme" project and research programme to increase food production as well as biodiversity management. The objective of the project is to apply plant mutation breeding and soil management techniques to develop new mutant lines/varieties with high yield potential and enhanced tolerance to drought conditions and environments.

Advanced mutant lines have been developed in cowpea, sorghum and pearl millet with better yield (10-20% higher than local varieties), better seed shape, large and different coloured seed, early maturity and drought tolerance. To date seven (7) cowpeas are ready for release and sixteen (16) to be listed as national variety; four (4) sorghum to be released and twelve (12) to be listed as national variety; fourteen (14) pearl millet will be listed as national variety

12.5 Nuclear Techniques to Promote Food Safety

Food safety and food security are priority areas for the Government and particularly the capability to provide assurance that food consumed locally or exported is of acceptable quality and fit for consumption.

A project will commence in 2018 to strengthen laboratory capacity at the NSI and AMTA to ensure domestic market food safety, in particularly marine products and agro-derived products of plant origin, while strengthening the country's export capabilities.

12.6 Capability to for Assessment of Nutritional Status Using Nuclear Techniques

The University of Namibia has been assisted by the IAEA to develop capacity in using the deuterium dilution technique (stable isotope) as an objective means of assessing nutritional status in Namibia. Under this project several Namibians have been trained in both field work and laboratory analysis. A fully functional laboratory for analysing samples using the stable isotope deuterium oxide technique has been established at the University of Namibia.

12.7 Building Capacity for the Regulatory Body to Conduct Radiological Assessment

The project has assisted the NRPA in various form, including training if its staff and provision of accessories and equipment to conduct sampling and sampling analysis for determination of radioactivity and radioactivity concentration.

12.8 Study Of Marine Radioactivity Baseline And Selected Contaminants In The Northern Benguela Upwelling System Off Namibia

IN 2014 the Ministry of Fisheries and Marine Resources requested the International Atomic Energy Agency's Environment Laboratories in Monaco (IAEA NAEL) to participate in a scientific sampling expedition during a regular monthly oceanography monitoring (MOM) survey along the Namibian coast. One of the aims of the collaboration was to establish a baseline of marine natural and anthropogenic radioactivity levels in the northern Benguela upwelling system (nBUS) and to provide assistance to Namibia to set up a future marine radioactivity monitoring programme.

The report has been released in 2017, pointing to a very low level of radioactivity in the marine environment and this augurs well for the fishing industry as a significant contributor to the national economy. The report is an excellent basis that informs the current status and at the same time provides the basis for future radioactivity monitoring activities in the marine environment.

12.9 Future Outlook for Nuclear Science and Technology

Technical Cooperation between Namibia and the International Atomic Energy Agency (IAEA) dates to 1990 soon after independence. The total assistance provided in monetary terms since then is 5,912,250 (EUR) or 82,771,500 N$. This includes amongst others 106 long terms fellowships; 28 scientific visits; over 700 training at workshops/meetings, 241 expert missions, and equipment.

One of the cornerstones of the IAEA TC programme is to promote sustainability and self-reliance in nuclear science and technology. Despite the long-standing technical cooperation with the IAEA sustainability and self-reliance continues to be the major stumbling block to enhanced contribution of nuclear science and technology in Namibia.

Some of the challenges facing nuclear science and technology in Namibia the retention of skilled staff, lack of national infrastructure, absence of a national institution to sustain and maintain technology utilization, and low investment in nuclear science and technology.

Hence the current initiatives to establish a Nuclear Science and Technology Centre or Institute that will support research, development and innovation in nuclear science and technology and through which nuclear technology can be deployed sustainably.

CONCLUSION

The basic components of the regulatory infrastructure has been established and Namibia has made good progress in this areas. It is pertinent to build on this foundation and strengthen the infrastructure, both in terms of legislative and regulatory provisions; human resources development and continuous performance assessment and improvement.

It is time that Namibia moves a step up and create the institutional framework through which nuclear applications can make a larger contribution to national development. Hence a nuclear science and technology institute to conduct research and development is a must for value addition in many priority areas of development.

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