Title : Occupational Radiation Protection in Mali - Case study of dose limit exceedings

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1. Background and Goal of the present work

This paper is a practice-based work. Its aim is to give an overview of some challenges faced by the personnel monitoring laboratory of the AMARAP especially regarding some high dose levels.

In Mali, Occupational Radiation Protection was relaunched in 2005 after many years of interruption.

Two TLD readers are being used (HARSHAW 4500 and HARSHAW 6600plus). About 650 radiation workers are monitored on a quarterly basis (montly for the radiotherapy department) for external exposure (Hp[10] and Hp[0,07]). There is neither extremity dosimetry nor internal dosimetry yet.

Since the 2nd International Conference on ORP, held in Vienna in December 2014, in our laboratory, we have developped internal procedures which include some dose reference levels such as: ***Recording Levels*** and ***Investigation Levels***.

According to our procedures:
- ***Recording Levels are:*** any dose obtained after subtraction of travel dose;
- **Investigation Levels** are as follows:
  - for Hp(10): 6 mSv quarterly and 2 mSv monthly;
  - for Hp(0,07): 25 mSv quarterly and monthly.

But ***dose limits*** not to be exceeded are given by regulations (Decree n°2014-0931/P-RM of 31st December 2014) which are compliant with GSR-Part3.

According to our regulations, for adult workers, dose limits are as follows:

- an average effective dose of 20 mSv per year over five consecutive years (100 mSv in five years) and a maximum of 50 mSv in a single year;
- an average equivalent dose to the eye lens of 20 mSv per year over five consecutive years and a maximum of 50 mSv in a single year;
- an equivalent dose of 500 mSv per year to the extremities or to the skin.

However, we noticed:
- one case of investigation levels being exceeded, and
- two cases of average annual dose limits being exceeded in facilities of different sectors (medical and non-medical).

The aim of this paper is:
- to share the levels of recorded doses,
- to share our experience of how we dealt with these situations: actions taken by the Regulatory Body (RB) and by the end-users,
- and to seek for advice on what could have been done to handle the issue a better way.

Method of dose evaluation: Direct readings from WinREMS Software with automatic subtraction of travel doses.

2. High dose Case Study:

2.1. Facility n°1 (medical facility)

This is a private medical clinic conducting x-ray procedures. Six (06) workers are monitored and for the 4th quarter of 2020 the dosimeter of one of them (Worker N°1) showed a deep dose twice higher than the investigation level.

Facility n°1: Summary of dose readings for Worker N°1

Monitoring Period	Dose readings: Deep dose (Hp(10)) (in µSv)	Dose readings: Skin dose (Hp(0,07)) (in µSv)	Observations
3rd Quarter of 2020	188,82	190,19	*Normal Doses*
4th Quarter of 2020	12 434	11 254	*Hp(10) higher than investigation level (6 mSv)*
1st Quarter of 2021	242,31	282,08	*Normal Doses*

The RB recommendation was: *to conduct investigations in order to avoid such dose levels in the future.*

The RB has not been informed about the results of their investigations but the situation came back to normal during the next quarter. So no more action was taken.

2.2. Facility n°2 (non-medical facility)

This is a service provider authorised by the Regulatory Authority for supply, installation and maintenance of X-ray equipments as well as their quality assurance. It has 4 monitored workers and for just the **2nd quarter of 2017 the dosimeters of two** of them (Workers n°2 and 3) showed high dose levels: up to 37 mSv for Hp(10) and 33 mSv for Hp(0,07).

Facility n°2: TLD Reading Results (Period: **2nd Quarter of 2017**)

N° of worker	N° of TLD card	Dose readings: Deep dose (Hp(10)) (in µSv)	Dose readings: Skin dose (Hp(0,07)) (in µSv)	Observations
01	a0000407t	40,34	119,89	*Normal Doses*
02	a0000458t	32 768,00	31 054,00	*Hp(10) higher than annual dose limit (20 mSv)*
03	a0000459t	37 801,00	33 360,00	
04	a0000495t	25,09	82,15	*Normal Doses*
BG Dosimeter	a0000499t	295,16	276,99	*Travel Dosimeter*

The *recommendations from the Regulatory Authority* (*on August 30th*) were:
- ✓ to immediatly change the workplaces of these 2 workers for the rest of the year (4 months), to avoid further exposure to radiations;
- ✓ to conduct medical checkups of the 2 workers;
- ✓ to conduct investigations in order to find out the reasons of such dose levels and to avoid their reoccurence.

The *company investigations* came to the conclusion that after a maintenance activity on an x-ray machine, the 2 workers forgot their dosimeters in the room while perfomance tests were being conducted.

The situation was normal for the next quarter and the workers were allowed to resume their work.

2.3. Facilty n°3 (non-medical facility)

This is a gold mine using nuclear gauges (Cesium-137 category 4 and 5 sources) for density measurements. It has about 40 workers monitored. Suddenly, from the 1st quarter of 2017 until the 3rd quarter 2018, the dosimeter of a 53-year old worker (N°8) started showing very high doses (up to 454 mSv (Hp(10)) and 448 mSv (Hp(0,07)) in 3 months).

Facility n°3: Summary of dose readings for Worker N°8

Monitoring Period	Dose readings: Deep dose (Hp(10)) (in µSv)	Dose readings: Skin dose (Hp(0,07)) (in µSv)	Observations
4th Quarter of 2016	9,21	10,71	*Normal situation*
1st Quarter of 2017	27 370,00	39 347,00	*High doses: Hp(10) up to more than 20 times the annual limit (20 mSv).*
2nd Quarter of 2017	1 020,33	578,52	
3rd Quarter of 2017	454 4600	447 900	
4th Quarter of 2017	453 300	90 050	
1st Quarter of 2018	89 650	114 00	
2nd Quarter of 2018	35 685	28 112	
3rd Quarter of 2018	-	-	*The whole batch of dosimeters was lost during transfer to the mining site.*
4th Quarter of 2018	0,00	0,00	*Normal situation*

Based on the results of the 1st Quarter of 2017, the *recommendations from the RB* (*on July 19th*) were:
- to immediatly change the workplace of worker n°8 for the rest of the year (5 months);
- to conduct medical checkup of this worker;
- to conduct investigations in order to find out the reasons of such dose levels and to avoid their reoccurence.

The company fully complied with recommendations:
- Medical checkup results were sent to the RB: no problem was found;
- Investigation report was transmitted to the RB: *the real causes were not found*;
- The proof of the tranfer of worker n°8 to another workplace was sent to the RB;

In addition, they requested an inspection from the RB which was conducted on 5th September 2017. This inspection revealed:
- ✓ The workplace was not close to the gauge: worker just could, from time to time, walk pass at about 2 meters from the gauge;
- ✓ From doserate measurements, it was impossible to reach such dose levels;
- ✓ The dosimeters of this worker were probably being exposed intentionally to direct radiation beam by someone.

Worker n°8 was no longer considered as a radiation worker but the *company insisted to continue sending his dosimeter for investigation purposes.*

For this *non-radiation worker*, the results for the 2nd Quarter of 2017 were almost normal *but for the 3rd Quarter*, they were much higher than the 1st Quarter. Then the RB made new recommendations (on *26th January 2018*) :
- worker n°8 is not allowed to work in a radiation environment for the next 25 years;
- his health conditions must be regularly monitored.

The dosimeters in the name of this worker started showing normal doses only from the 4th Quarter of 2018.

3. Conclusions:

To date, occupational radiation monitoring is done by the RB and Mali yet has to:
- monitor intakes of radionuclides (for Nuclear Medicine Department),
- start extremity dosimetry (for some research institutions and C-arm users), and
- make sure all radiation workers are monitored (currently, only a small proportion is covered).