# Decades of personnel and environmental safety in the management of radioactive waste facility in Ghana for a sustainable socio-economic development #8

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## 1. Background and Goal of the present work

The radioactive wastes produced in Ghana typically as disused sealed radioactive sources (DSRS) are received and stored at the Centralized Radioactive Waste Management Facility (CRWMF) for pre-disposal and disposal management. The occupationally exposed persons (OEP) at the CRWMF comprising of technologists, radiation safety officers, and scientists undertake all the cradle-to-grave management of the waste. The CRWMF currently contains circa five hundred DSRS in either conditioned or unconditioned form with total activity of around 55 TBq.The prudent management practices employed by the personnel are aimed at ensuring that both present and future generations are protected from the harmful effect of ionizing radiation associated with the waste. The safety of the OEP is however, fundamental to the attainment of the fundamental principle of radioactive waste management. In this context, personnel, workplace and environmental monitoring for radiation exposure and doses are very important to the sustainable management of radioactive waste.

This paper gives an overview of individual annual dose records of OEP at the CRWMF in relation to the radiation levels interior and exterior of the Facility from 2011 to 2022 in order to ascertain the efficacy of current radiation protection measures.

The applicability of principal component analysis (PCA) multivariate statistical technique in evaluating the radiological data is highlighted.

## 2. General Materials and methods

### *2.1. Radiation dose rate measurement interior and exterior of the Facility*

The ambient dose equivalent rate at different sections of the CRWMF as shown in Fig. 1 was monitored monthly using a calibrated Radiagem™ 2000 personal portable dose rate and survey.

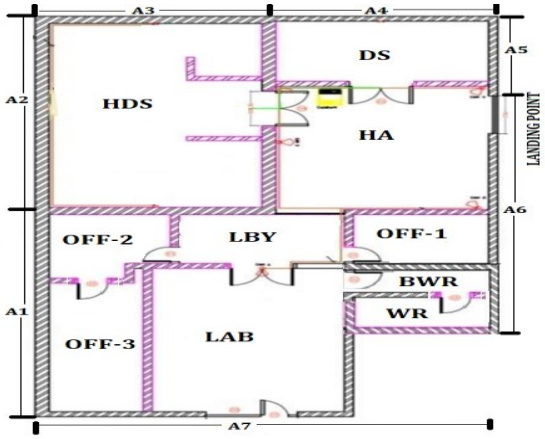


Fig. 1: Floor plan of the Centralized Radioactive Waste Management Facility (CRWMF)

### *2.2. Measurement of occupational radiation dose*

Two personal dose equivalent values, Hp(0.07) and Hp(10) were quantified and recorded for each personnel. The Hp(0.07) depicts the dose to the extremities of the body at a 0.07mm depth from the skin surface. It represents the dose received by the skin of an OEP. Hp(10) denotes the dose received by tissue (effective dose) at a 10 mm depth within the skin. It is estimated as the dose to the whole body (that is the total effective dose) since the internal radiation exposure through the intake of radionuclides at the CRWMF is presumed to be insignificant. Therefore, Hp(10) is the recommended international operational dose measurement for individual radiation protection monitoring. The external radiation exposure of each OEP is regularly monitored using thermoluminescent dosimeter (TLD) badges which are used to estimate the Hp(0.07) and Hp(10). The TLDs are read on quarterly durations at the Personal Dosimetry Laboratory (PDL) of the Radiation Protection Institute (RPI). The PDL utilizes LiF-100 TL with the state-of-the-art Harshaw 6600 Plus Automated TLD Reader dosimetry system for the measurement.

### *2.3.* Data Analysis

*The radiological data from the CRWMF and OEP for the twelve (12) years monitoring duration was subjected to both univariate and* principal component analysis (PCA) *multivariate statistical analysis.*

## 3. Results and discussion

### *3.1. Univariate analysis of* radiological data

The mean annual average radiological data for the CRWMF ranged from 0.07 – 1.06 µSv/h which is less than 0.46 – 0.57 µSv/h that was recorded for a similar radioactive waste storage facility in Brazil by **Pereira et al. (2017).** The decay store (DS see Fig. 1) of the Facility where scrap metals from dismantled DSRS, and low-level wastes from Ghana's Research Reactor are kept demonstrated the highest mean annual average dose rate of 1.06 ± 0.92 µSv/h. The range of the mean annual average personnel dose equivalent is 0.41 – 2.07 mSv (see Fig. 2) is below the ICRP limit of 20 mSv for OEP in a year.

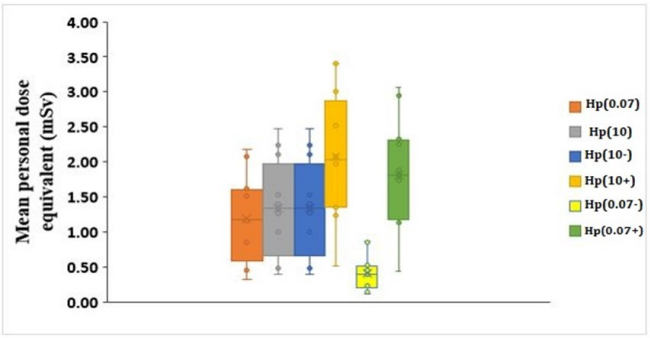


Fig. 2: Variations in the mean annual average personal dose equivalent

### *3.2. PCA multivariate analysis of* radiological data

A 12 objects x 30 variables radiological data matrix was subjected to principal component analysis. The data was initially normalized due to the differences in units and variance of the variables. The result of the analysis indicates that four (4) principal components (PC) were found to be significant based on Eigenvalues > 1. PC1 and PC1 contributed 82.8 % of the variance in the data, thus, only the biplot between PC1 and PC2 (see Fig. 3) was considered.

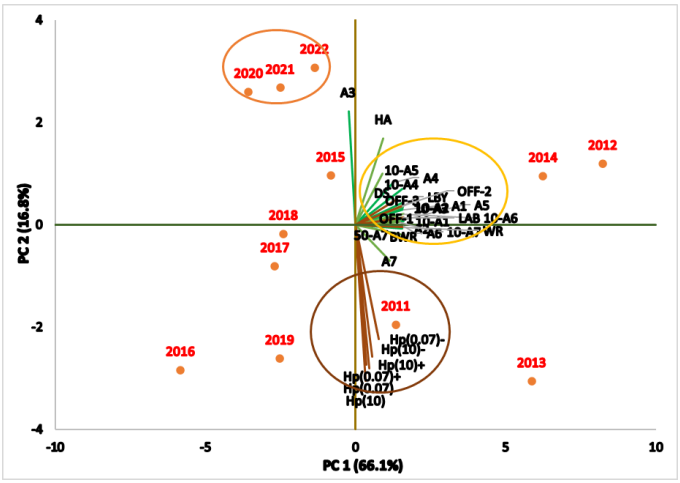


Fig. 3: PC2 vs. PC1 Biplot

The Biplot indicates that the dose equivalent of the OEP is influenced primarily by the radiation from the outer wall surface, A7 which is made up of OFF-3, LAB and washroom, WR (see Fig. 1) where no DSRS are stored. This observation implies that the dose equivalents are not essentially due to the radiation exposures of personnel during their regular operations at the CRWMF where DSRS are stored. Therefore, it can be inferred that the existing ALARA principle based radiation protection measures deployed at the Facility during operations are effective at ensuring that personnel are not unnecessarily exposed to ionizing radiation.

## 4. Conclusions and Acknowledgements

- This paper evaluated the individual annual dose records of OEP at the CRWMF in relation to the radiation levels interior and exterior of the Facility from 2011 to 2022 in order to ascertain the efficacy of current radiation protection measures. The range of the mean annual average personnel dose equivalent is 0.41 – 2.07 mSv is below the ICRP limit of 20 mSv for OEP in a year. Principal component analysis shows that the OEP dose equivalent is influenced by radiation from areas where no sources are stored.
- The support from the management of the Radiation Protection Institute and Ghana Atomic Energy Commission towards this study is highly appreciated.