

## Computational Tool for Analysis of Dosimetric Quantities

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### ABSTRACT

Exposure of human to radiation is detrimental to health. It has been reported that when human body is wholly exposed to radiation, each organ of the body receives different amounts of radiation. The damage to each exposed organ depends on the amount of dose received, it is therefore necessary to analyze the amount of radiation dose that an organ of the body received when the whole body is exposed. A computational analysis tool was designed to facilitate the determination of the dosimetric quantities like equivalent and effective doses and provide an instant threat image analysis and hence provide a database where all the information inputted and generated are stored. The tool is able to determine the dose equivalent and effective dose to each organ when an amount of radioactive exposure value was input into the tool. The tool will assist the radiation safety officer in performing the task of radiation monitoring, quantification and thus assisting in protecting the workers in any organization where it is being used.

**Keywords:** Radiation Dose, Computational Tool, Radiation, radiation monitoring, human body

### 1. Introduction

The presence of radiation in our environment and the level at which humans are being exposed cannot be overemphasized. Nuclear and atomic particle are produced through artificial processes like radioactive waste from Nuclear power stations, emissions from medical X-ray. Millions of workers in medicine, construction, mining, shipping, agriculture and nuclear power station that are employed in such task as building, managing and the subsequent decommission of a power station, academic research, food processing, mineral deposit discovery, industrial imaging etc. are routinely exposed to ionizing radiation [1].

The human body is subjected to radiation dose from different sources all the time and there is the need to develop a tool that will assist in determining or calculating accurately all the dosimetric quantities as related to the organs and tissues and allow for future analysis based on information gathered from workers.

According to the [2], the exposure of the cells and tissue of the human body to ionizing radiation can result in both short term and long term health effect. It has been reported that different radiations have different effects on the organs of the body [3] and that the damage caused by radiation depends on the amount of dose received (absorbed dose in RAD or GRAY) and the potential damage is dependent on the type of radiation involved and the sensitivity of different tissues and organs.

In view of the damage that can be caused by particles that are radioactive in nature and the cost of treating cancer and other diseases that are caused by radiation overdose

through injection, inhalation, etc. to individuals, organizations and the government, it is therefore necessary to institute a policy framework using the principle of radiation protection in general and the policy of dose limitation in particular by monitoring the dose that are received by workers when they work in a controlled environment.

Therefore, there is the need to put in place a tool that will make use of the properties of the particles in the dosimetric calculations and subsequent analysis to assist the radiation safety officers (RSO) to monitor and ensure that the prescribed dose limit according to regulatory organizations is not exceeded so as not to affect the body of the workers and also to prescribe the best practices to be used by the workers' environment.

### 2. Methodology

The Computational analysis tool is based on a stand-alone and basically implemented on a single system but can be accessed in a networked environment. And it is expected that to construct a computational tool that will provide an easy to use capability, the following features namely Robustness, Processing performance, scalability, easy to use interface and portability are essential [4].

#### 2.1 Modules of Computational Analysis Tool

The functional modules of the Computational analysis tool for dose monitoring and measurement consist of an input interface that is used to input the values and derive information by the system, a bio data panel for new workers where the information about the worker is input for storage, the conversion module to convert the RAD to GRAY, the calculation module to calculate the different

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dosimetric values like equivalent and effective doses. The database which is one of the key components of the tool is used to store the workers data and the dose information that are recorded. The threat level of exposure is used to generate the level of threat that may result from the level of exposure.

2.2. Interface sub-tool for exchanging data

The interface sub-tool handles the data input for further processing by the calculation module. The sub-tool is designed using Visualbasic.net (VB.net) which is a software development tool to design an interactive interface where the working data are registered for the first time and where the subsequent processing of data are started.

2.3. The Calculation Module

This is the sub-tool where the values that have been input are processed and the module was implemented using VB.net (visual basic.net) to program and visual studio to compile it and calculate the radiation values that are picked to get the dosimetric quantities being calculated. The design of this module makes the task of calculating the dosimetric quantities like dose equivalent and effective dose from absorbed dose as shown in equations 1 and 2 easy because of the automatic conversion of the values even with particles like Alpha, Beta, Gamma and X-ray (Table 1) interacting with all different parts of the body as recognized by the International Commission on Radiological Protection (ICRP) (Table 2).

The Total equivalent dose and Total effective dose was calculated using the protocol established by the International Commission on Radiological Protection in 1977 and 1990, respectively [5].

$$H_T = \sum_R (D_{TR} \times W_R) \tag{1}$$

Where:

$H_T$  is the total equivalent dose to an organ or tissue T delivered by all radiation types

$\sum$  is summation over the entire radiation R

$D_{TR}$  is the absorbed dose to an organ or tissue T delivered by radiation type R

$W_R$  is the radiation weighting factor for radiation type R

$$E = \sum_T (H_T \times W_R) \tag{2}$$

Where

E is the total effective dose to all exposed organs and tissues.

$\sum$  is summation of each organ or tissue type T.

$H_T$  is the equivalent dose to an organ or tissue type T.

$W_T$  is the tissue weighting factor for an organ or tissue type T.

Table 1: Tissue Weighting Factors

Tissue	Tissue Weighting Factor ( $W_T$ )
Gonads	0.20
Bone marrow (red)	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Oesophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surface	0.01
Remainder of the body	0.05

Table 2: Radiation Weighting Factors

Type and Energy Range	Radiation Weighting Factor ( $w_R$ )
Alpha particle , all energies	20
Beta particle , all energies	1
Gamma , all energies	1
X-ray , all energies	1

2.4 Database Module

The database serves as a key component of the computational platform, has all social information that are related to the individual like name, date of birth, identification number, gender, home address, office address, controlled area visited, phone number, email, height, blood group, dose quantities information and picture are stored. The dose measurement information includes records of the absorbed dose, the effective dose and dose equivalent as shown Table 3. This was implemented using Microsoft Access developed by the Microsoft Corporation. After the development of the database, it was linked to the front end (User Interface) and calculation module. All information input is expected to be stored in the database.

Table 3: Data elements for database objects

Database objects	Data elements
Social information	name, date of birth, staff identification number, gender, home address, office address, email, height, blood group, picture of worker
Dose quantities	Absorbed dose, dose equivalent, effective dose, Radiation Weighting Factors, Tissue Weighting Factors
Dose information	Particle suspected, region in the body, controlled area visited
Threat level	Level of severity and image

2.5 Threat generator and visualization tool

This was developed to analyse the dose parameters and thus compare it with established level so as to know the level of danger and present it in a simple graphical output that will show the level of danger faced by the exposed body. It was implemented using VisualStudio.net.

The threat generator and visualization tool use the following criteria as illustrated in Fig. 1.

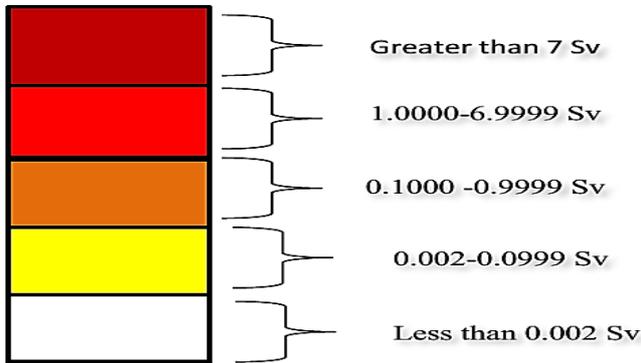


Fig. 1: The colour code for generating threat.

### 2.6. The Overall data flow

The Interface tool, calculation module, the threat level generator and visualization tool are all integrated together and subsequently integrated with the database as shown in Fig. 2 so that all information input and processed are stored. The process of analyzing the result involves quality assurance that the absorbed dose and particle suspected are correct and accurate.

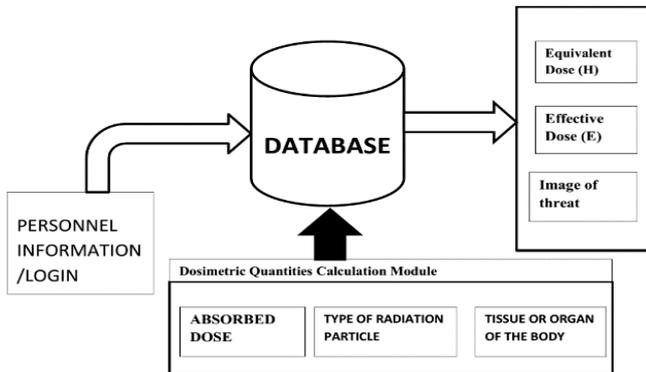


Fig. 2: Computational Analysis Tool for Dose Measurement and Conversion.

### 3. Result and Discussion

The operation of the tool is initiated by the Safety Officer by inputting his administrator (admin) code (Username: - ./user , Password. :- admin ) to the Admin page as shown in Fig. 3.

After the logging is successful as shown in Fig. 4. The home screen will be shown to the user. From the software home, the user will see three process buttons which includes the registration for new user, analyse records for exiting user in the system and check records for referencing and database purpose.

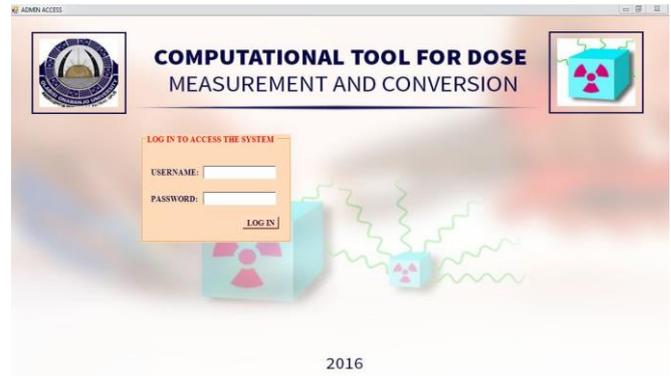


Fig. 3: Computational Tool Admin page.

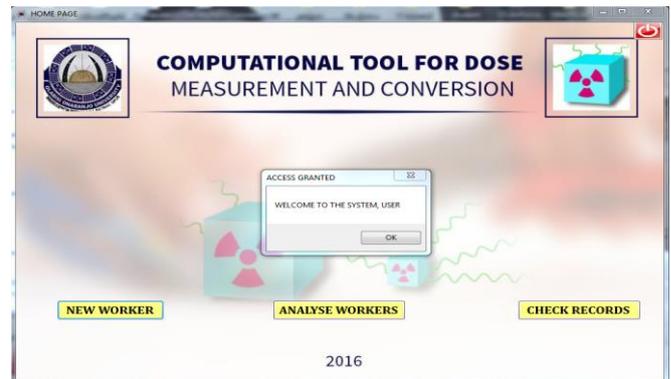


Fig. 4: Computational Tool Admin page successful



Fig. 5: Computational Tool Home Page

Any action from this buttons sends and pulls data from the database. The clicking of the button to analyze the worker will bring the user to the page that will ask if the record of the worker is existing or not. If it is a new record, the user is directed to the bio-data page Fig. 6 and after filling of the required space in the bio-data form Fig. (7-8), a profile is created in the database where subsequent information of the worker is inputted.

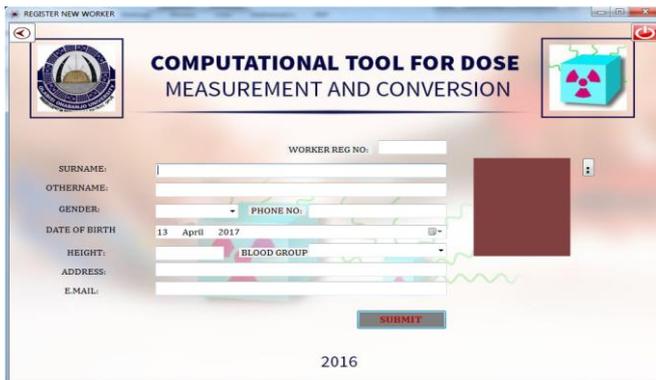


Fig. 6: Registration of New Worker

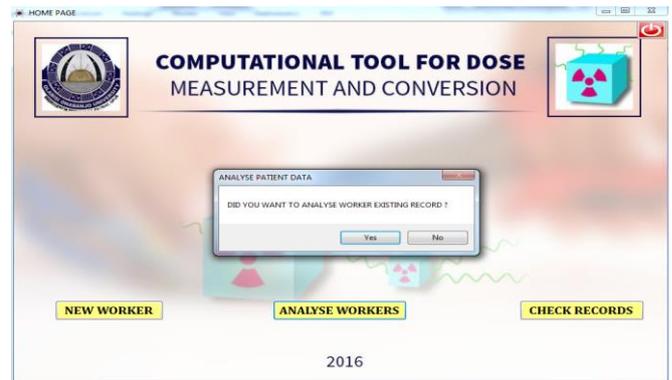


Fig. 9: Analyse of workers record continued

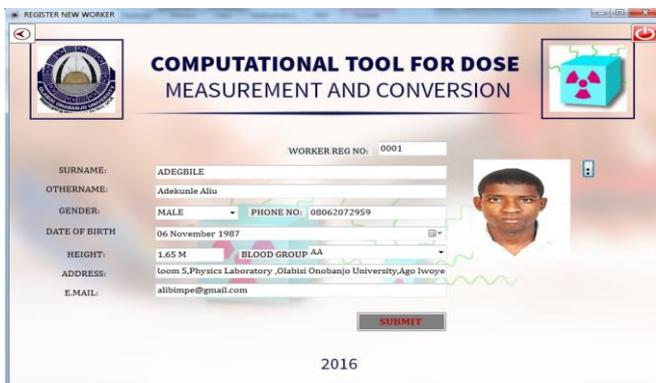


Fig. 7: Registration of New worker successful



Fig. 10: Calculation stage showing input of Absorbed Dose

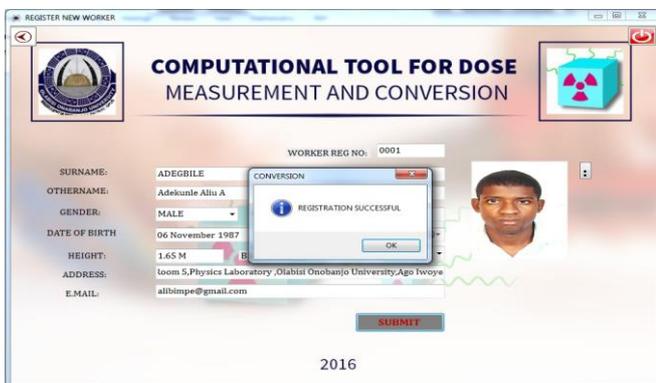


Fig. 8: Registration Successful



Fig.11a: Calculation stage showing conversion of Absorbed Dose.

If it is an existing record, Fig. 9 the search mode is used using the workers ID, Surname or sex, after the profile is retrieved, the pertinent questions like the amount of absorbed dose, type of particle and area of the body affected are asked and inputted as shown in Fig. 10.

The calculation stage is where the system performs the radiation calculations and generates the effective dose equivalent, dose equivalent, summation of dose equivalent and effective dose equivalent. A button labelled CALCULATE is clicked and a question is asked if the absorbed dose is in gray or rad and after the response is clicked as shown in Fig.(10, 11a, 11b & 12) the calculated quantities (effective and equivalent dose) is presented as shown in Fig. 13, as well as stored in the database.

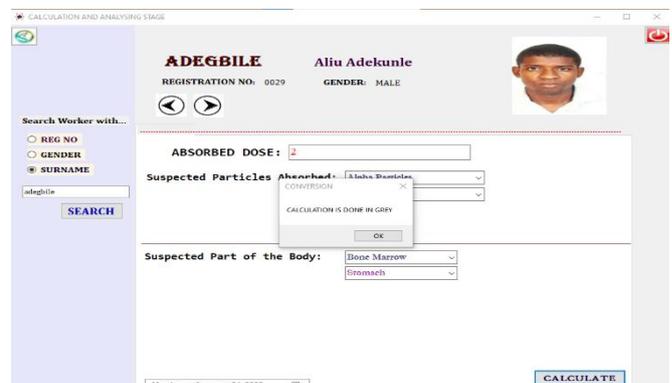


Fig.11b: Calculation stage showing conversion of Absorbed Dose in Grey.

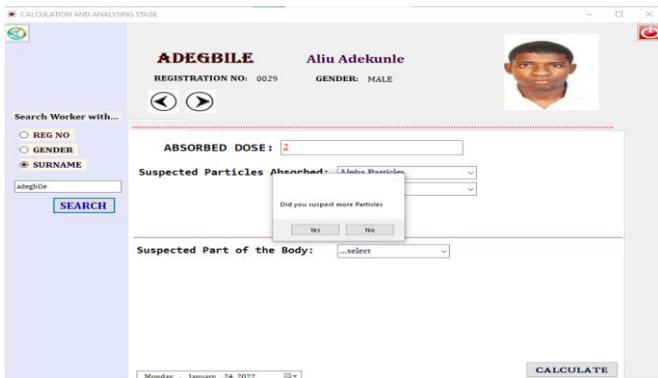


Fig.12: Calculation stage showing the selection of radiation particles and suspected part of the body irradiated.

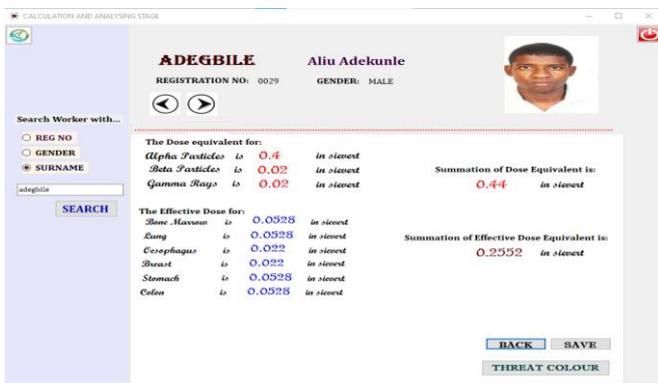


Fig.13: Result stage showing the Dose equivalent and effective Dose for the suspected parts of the body irradiated.

Then the user presses the next button to show the threat level. The threat level screen consists of human anatomy showing the part of the human body which the user suspected earlier as shown in Fig. 14.

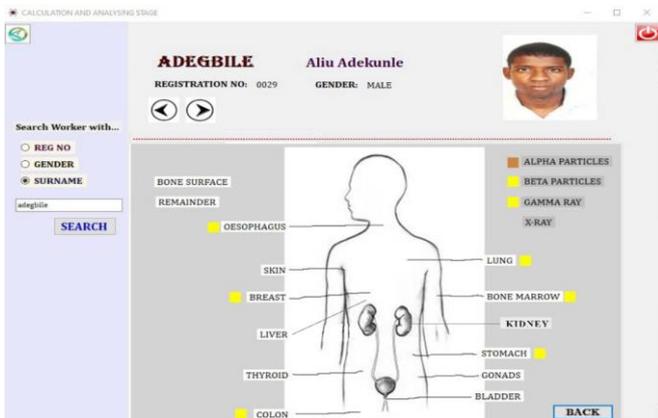


Fig. 14: Threat level visualization.

After the treat level is done, then the user selects the save button. All the radiation process and calculation performed earlier are saved for referencing purpose and records keeping when a message pop up showing “DATA SAVE”.

After the saving process, a message will pop up showing that “DID YOU WANT TO PERFORM ANOTHER OPERATION FOR ANOTHER USER” if yes then the same

step explained above right from the searching interface will be followed and if no, the system log the user out and return to the home screen.

The record stage Fig. 15 is where the system performs the process of checking the database for reference purpose, the page has two process button namely the USER REGISTRATION RECORDS and USER RADIATION RECORDS. The selection of the USER REGISTRATION RECORDS will bring about the checking of the worker profile once the search parameters are fulfilled as shown in Fig. 16.



Fig. 15: Record Checking.

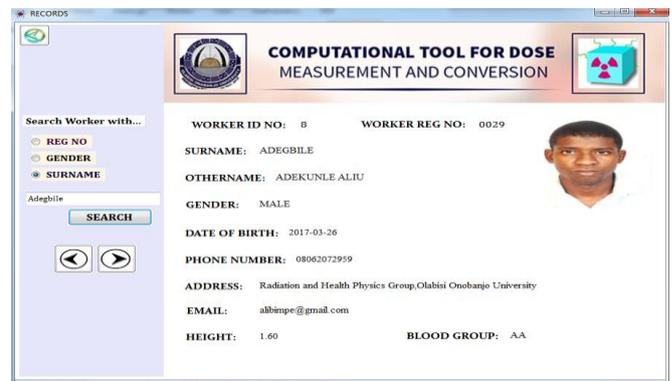


Fig. 16: Record Checking of workers profile.

The selection of the USER RADIATION RECORDS will lead to the checking of the radiation data of the workers and its threat level as shown in Fig. (17-18)

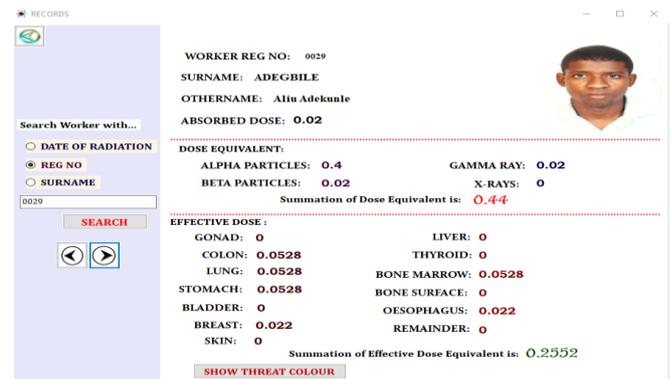


Fig. 17: Record Checking of calculation.

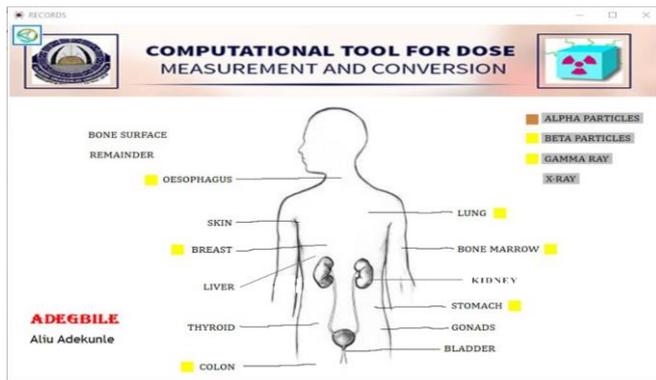


Fig. 18: Record Checking of Threat analysis visualization.

After the completion of the usage of the tool, the user logout of the tool as shown in Fig. 19.

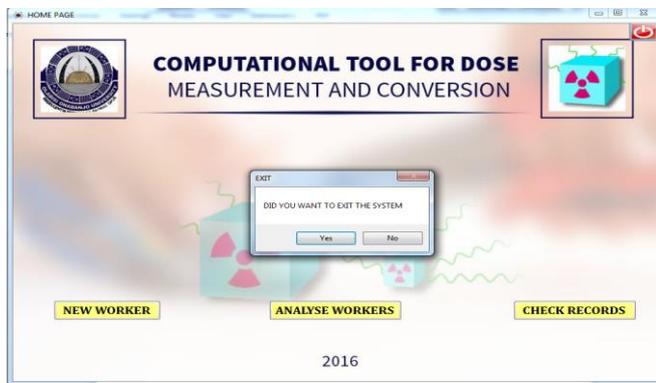


Fig. 19: Exiting the system.

#### 4. Conclusion

The overall aim of this study was to develop a flexible and yet easy to use computational analysis tool. The tool will assist the radiation safety officer in his day to day work by integrating different functionalities. The User interface was linked to the Calculation module and database from which the threat visualization generator derives the image information that it presents.

The effective and equivalent dose for each individual is calculated with the parameters already embedded in the

calculation module. The image visualization tool was introduced to compliment and provide the dose information that is received by the different part of the body.

The computational tool represents thousands of lines of computer code developed in the VB.NET language and complied with Visual Studio.

This tool is expected to impact positively on the management of radiation monitoring and protection in hospitals and other organization that uses radiation materials or where workers are exposed to radiation. The tool allows for the safety officers to make decisions on whether a person is exposed to radiation or not. Thus prescribe the next course of action based on the organization's policy to prevent or mitigate against problem associated with radiation exposure. It also helps the safety officers to keep records of past measurements and therefore provides up-to-date radiation protection programme.

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