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Disposal date calculator for radioactive material

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ABSTRACT

A computer program in PHP programming language was developed to become easier the disposal calculus for radioactive material of low and medium radiation levels according to CNEN NN 8.01 (Low and medium radiation level waste management). The user selects some inputs as: the radionuclide name, its physical state, activity and obtains among others outputs: the number of days for disposal and disposal date. There is an option for calculation without considering the radionuclide where the parameters are only the half-life, initial and disposal activity. It can be accessed by the Internet or downloaded from a repository to be installed on the user's computer or server. The programming language can be chosen between Portuguese and English.

Keywords: **radioactive waste, radioactive disposal, disposal calculus, PHP.**

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1. INTRODUCTION

Radioactive material utilized in research, medical and other applications has to be disposed of according to regulations issued by each country through their nuclear regulatory authority. In Brazil it is made by the CNEN – National Nuclear Energy Commission (*Comissão Nacional de Energia Nuclear*), whose publication about this subject is the CNEN NN 8.01 (Low and medium radiation level waste management) [1].

Basically, the material has to reach a radioactivity level to be discharged, this level will depend on the radionuclide and its state: liquid, gaseous or solid. It will depend too if the material is a mixture of radionuclides, but it will not be addressed. The CNEN NN 8.01 indexes about seven hundred radionuclides and their disposal levels in Bq/m^3 for liquids and gaseous or in kBq/kg for solids.

To know how many days a radioactive material can be disposed of, the formula utilized [2] is derived from the nuclear decay leaving it in the function of time in days (t):

$$t = \frac{-th}{\ln(2)}.\ln\left(\frac{A}{Ao}\right) \tag{1}$$

Where:
t = time in days
th = Half-life time in days
A = Final activity in Bq/m^3 or kBq/kg
Ao = Initial activity in Bq/m^3 or kBq/kg

The number of days determination for disposal is made manually or by spreadsheet programs and many times the date determination is made counting the days on a calendar. It is a hard work mainly when the laboratory handles several types of radionuclides. It is desired to automatize this process, where the user only inputs the radionuclide name, its state, initial activity and current date to obtain the number of days for disposal and its date.

Some companies or institutions around the world, for example in USA [3-5], United Kingdom [6], France [7] and Cuba [8] developed software products for this purpose, among other functions, according to each national regulation. To supply this necessity in Brazil a computer program was developed.

2. MATERIALS AND METHODS

2.1. Materials

- Laptop i3 processor with windows 7 or higher
- XAMPP package (Apache web server, MySQL database, PHP 7.3)
- Integrated development environment: Visual Studio Code to write the code
- Web host: 000webhost

2.2. Methods

The computer program development was made according to the requirements below:

- The menu language could be chosen between English or Portuguese.
- The radionuclide physical state could be chosen among liquid, gaseous, solid or calculus without a radionuclide specific state.
- The input data: radionuclide name from a list, physical state, activity, activity unit and measurement date.

Observation: When the radionuclide name and its physical state are chosen, automatically its half-life and disposal activity should be selected from the data bank.

- The outputs data: radionuclide name, physical state, measured activity, measurement date, disposal activity, half-life utilized, number of days for disposal and disposal date.
- The input data without a specific radionuclide and its state: activity, disposal activity, half-life and measurement date.
- The output data without a specific radionuclide and its state: measured activity, measurement date, disposal activity, half-life, number of days for disposal and disposal date.

The half-lives utilized were obtained from Live Chart of Nuclides [9]. The block diagram in Figures 1 to 3 show the computer program logic. The physical states liquid and gaseous are together and separated from solid because they are in this way in tables from CNEN NN 8.01. The option without radionuclide or ‘parameters of your choice’ is for cases of radionuclides that are not in CNEN NN 8.01 or disposal limit is different from Brazilian legislation.

Figure 1: *The program starts with the language option (English or Portuguese), after there is the options to set the language again go to liquid/gaseous, solid disposal or to set Parameters of your choice.*

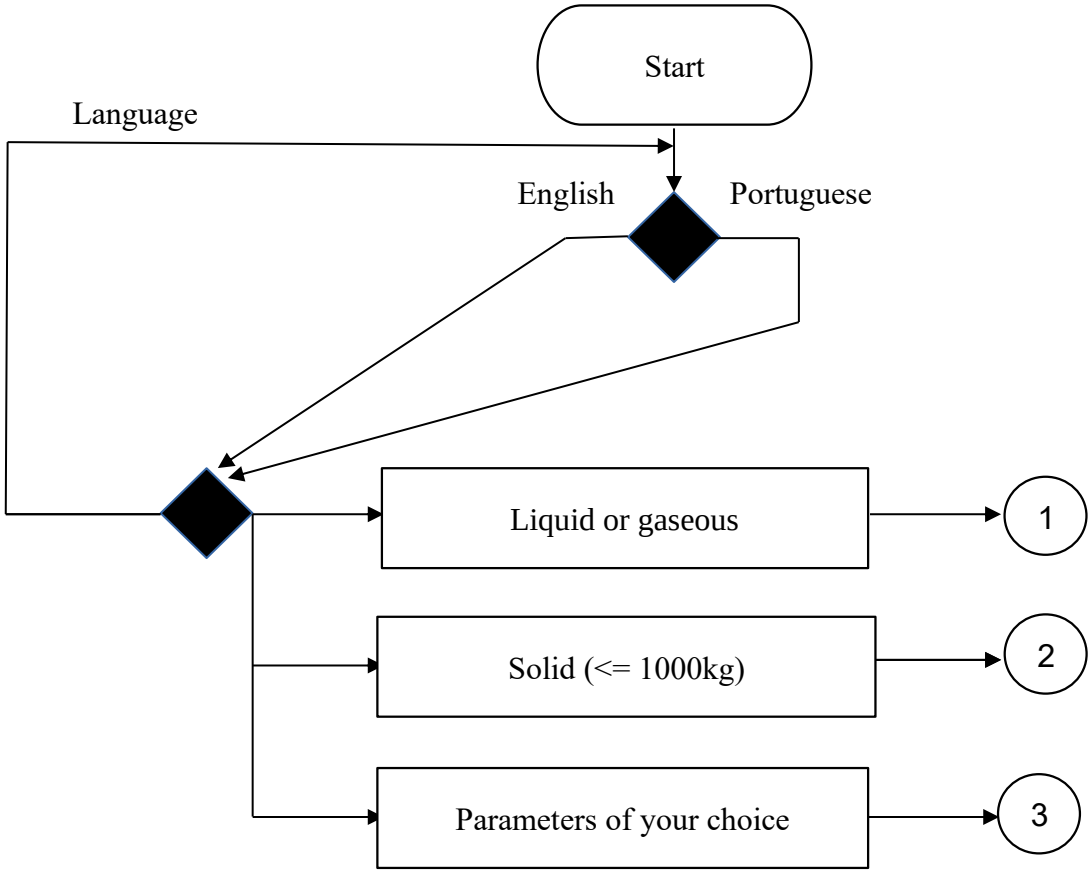


Figure 2: *Diagram for liquid/gaseous and solid disposal calculus showing the inputs and outputs. The physical states liquid and gaseous are together but separated from solid because they are in this way in tables from CNEN NN 8.01*

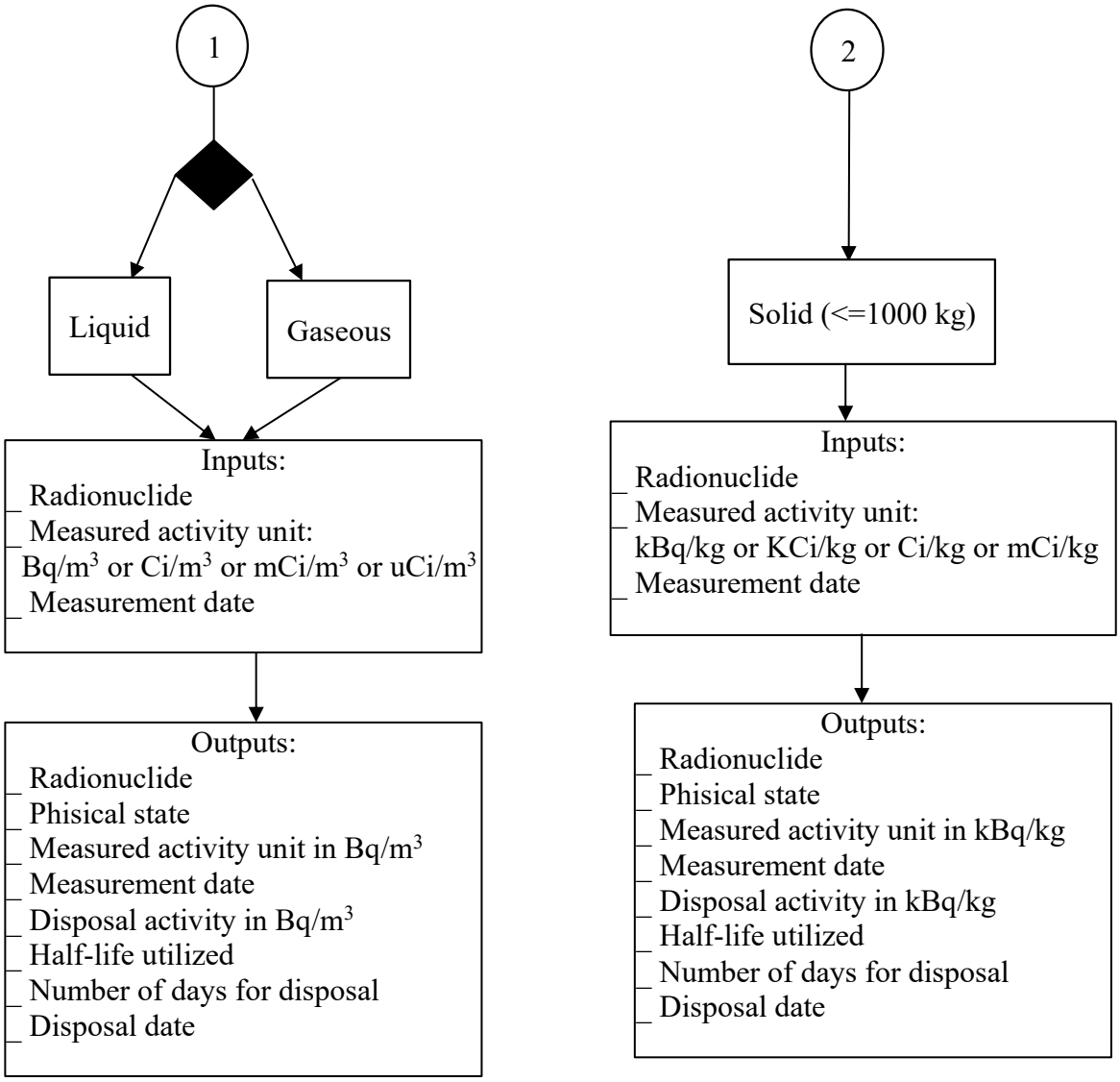
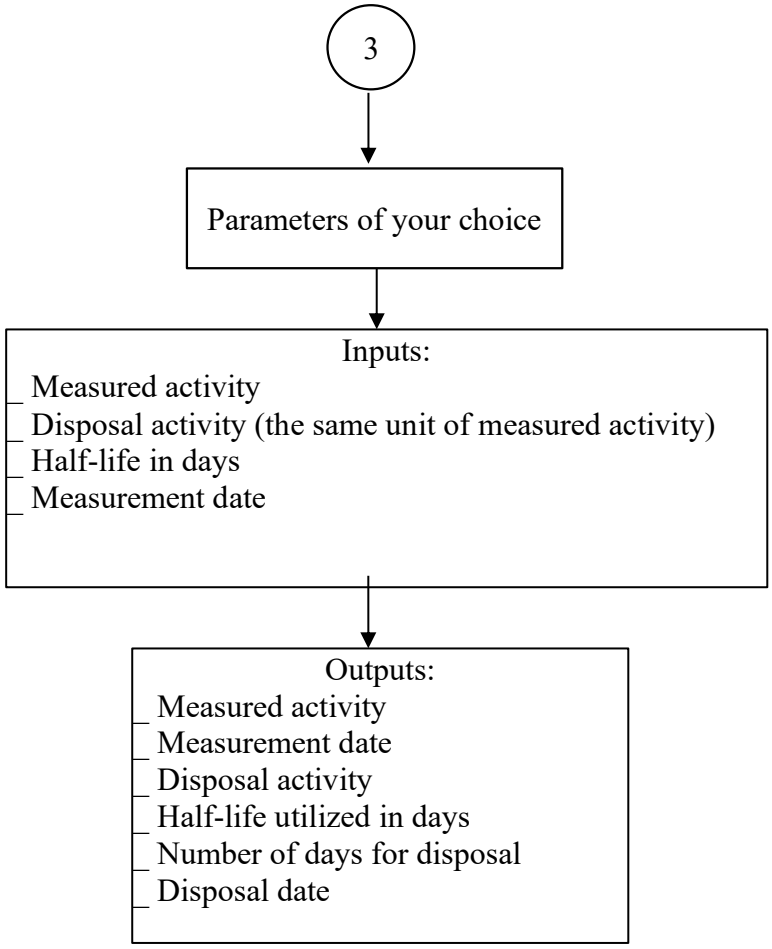


Figure 3: *Diagram for choosing the "Parameters of your choice" option, for cases of radionuclides which are not in CNEN NN 8.01 or disposal limits are different from Brazilian legislation.*



The program was uploaded to a free web hosting service and tested for some contributors from CENA (Center for Nuclear Energy in Agriculture) and CDTN (Nuclear Technology Development Center) in Brazil, who issued several criticisms and suggestions, which improved the project

3. RESULTS AND DISCUSSION

Nowadays the final version is hosted in https://calcradio.000webhostapp.com, it is better visualized utilizing the Google Chrome navigator. The complete program and its database are available to free download at Github author page: https://github.com/aryarj/tcc2_ooingl. The final front-end program version could be seen in Figures 4 to 8.

Figure 4: *Initial program page showing the language option: Portuguese or English and the hyperlink for CNEN-8,01 publication.*

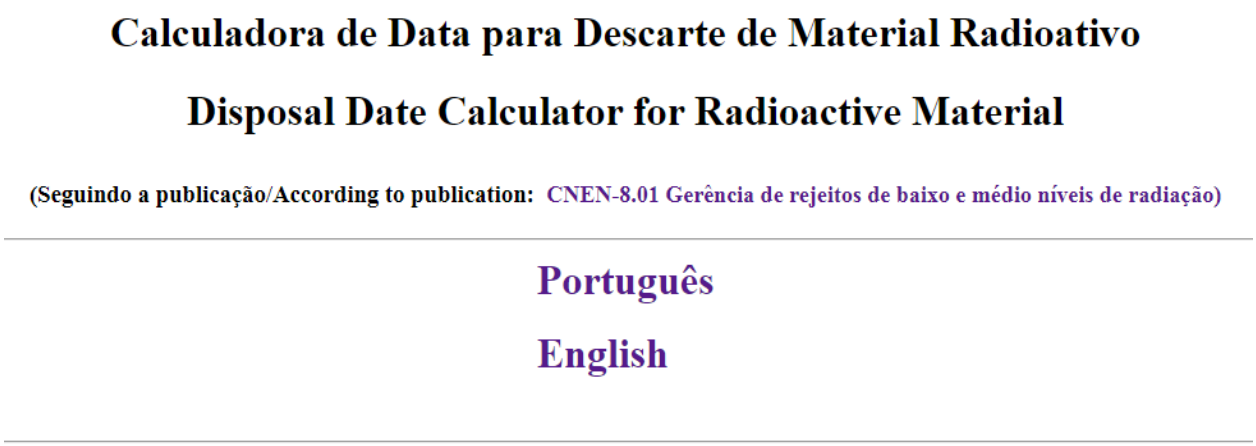


Figure 5: *Program options page:*

- *To set the language again.*
- *Liquid or gaseous state.*
- *Solid state.*
- *To choose the parameters*.

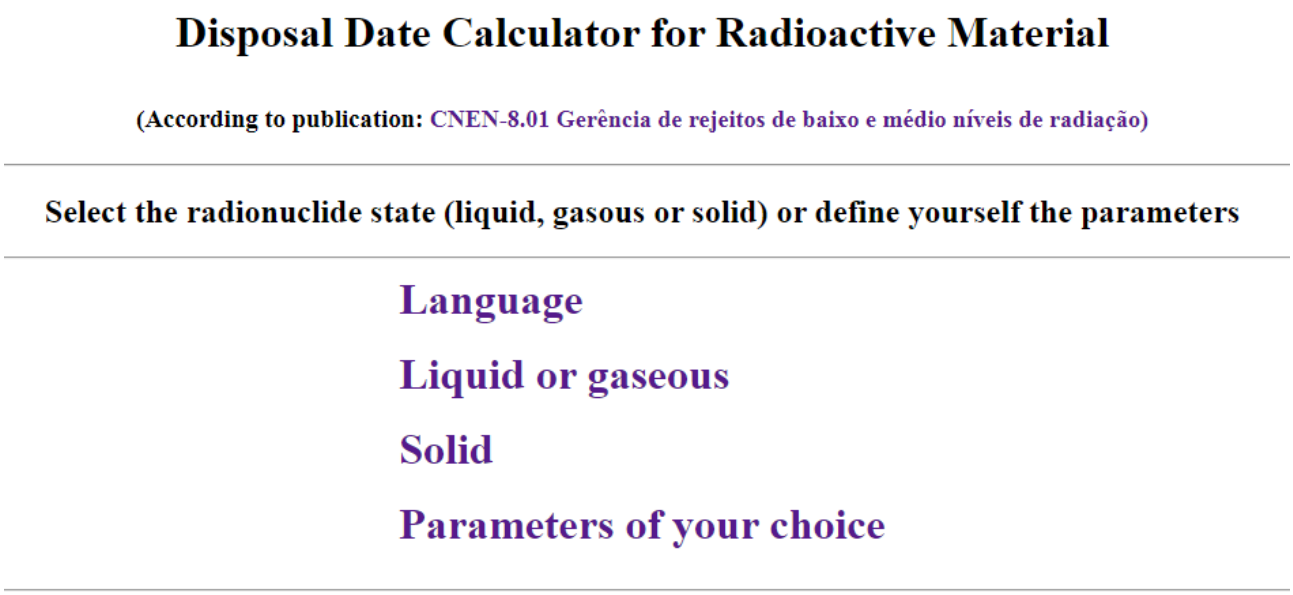


Figure 6: *Program page for liquid or gaseous disposal date calculus with an output example and hyperlinks for CNEN NN 8.01 and IAEA Live Chart of Nuclides.*

Disposal Date Calculator for Radioactive Material

Language Go to solid waste Go to Parameters of your choice Back

(According to publication: CNEN-8.01 Gerência de rejeitos de baixo e médio níveis de radiação)

Radionuclide: Select

State: Liquid Gaseous

Activity: Ex: 1234 ; 1.234e3

Activity unit: Bq/m^3 Ci/m^3 mCi/m^3 uCi/m^3

Measurement date: dd/mm/aaaa Calculate

Radionuclide	State	Measured activity (Bq/m^3)	Measurement date	Disposal activity (Bq/m^3)	Half-life utilized* (days)	Numbers of days for disposal	Disposal date
Actinium-225	Liquid	37000000	01/01/2000	13000	9.9203	114	24/04/2000

* The half-lifes were obtained from IAEA (International Atomic Energy Agency):https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html/

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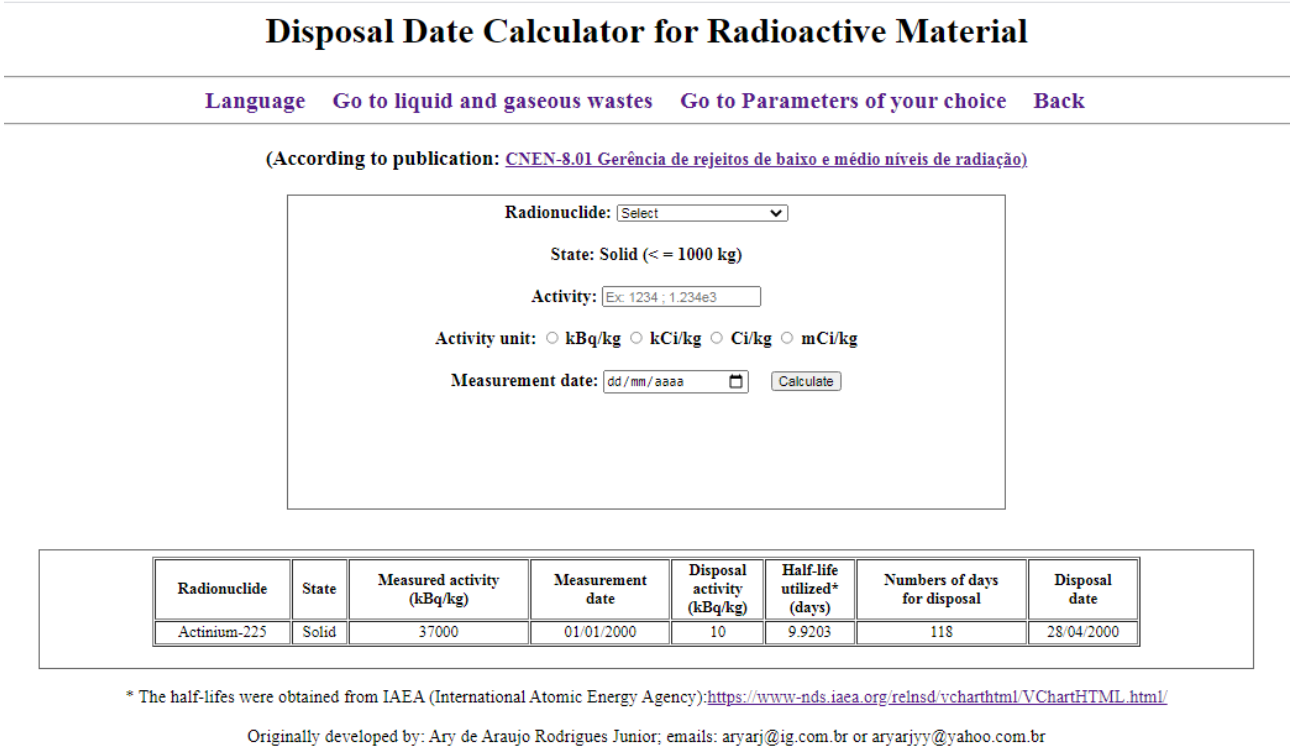
Figure 7: *Program page for solid disposal date calculus with an output example and hyperlinks for CNEN NN 8.01 and IAEA Live Chart of Nuclides.*



Disposal Date Calculator for Radioactive Material

Language Go to liquid and gaseous wastes Go to Parameters of your choice Back

(According to publication: CNEN-8.01 Gerência de rejeitos de baixo e médio níveis de radiação)

Radionuclide: Select

State: Solid (< = 1000 kg)

Activity: Ex: 1234 ; 1.234e3

Activity unit: ○ **kBq/kg** ○ **kCi/kg** ○ **Ci/kg** ○ **mCi/kg**

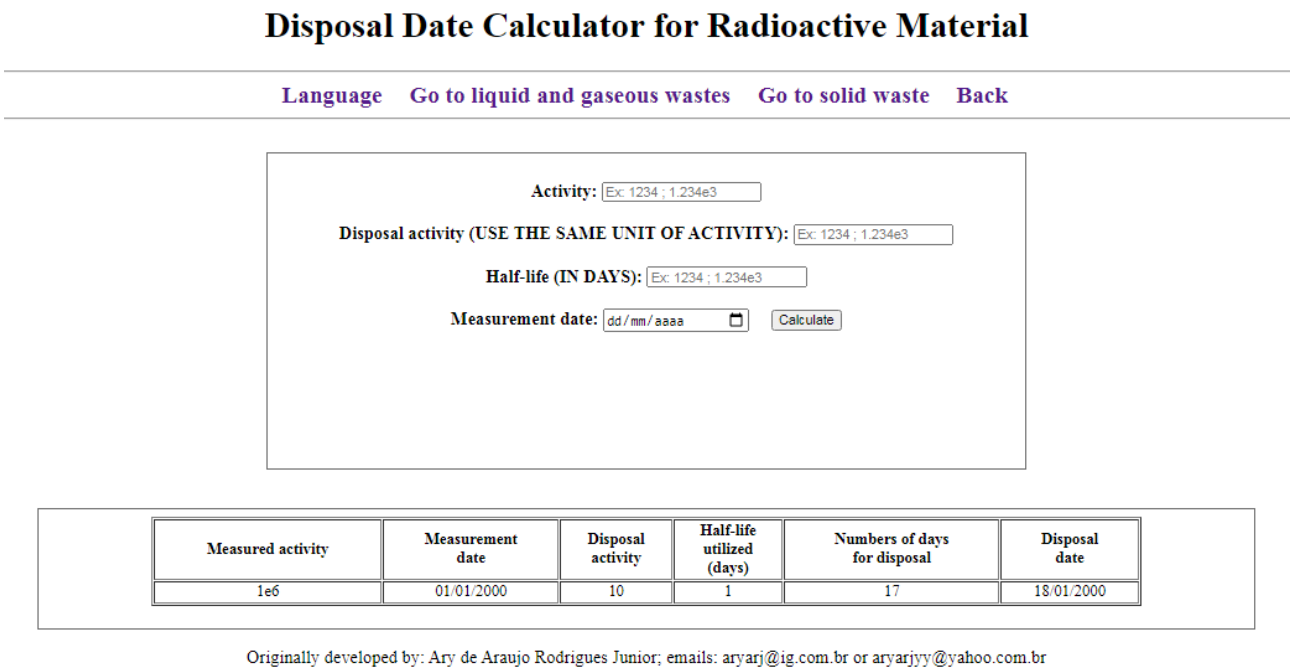
Measurement date: dd/mm/aaaa Calculate

Radionuclide	State	Measured activity (kBq/kg)	Measurement date	Disposal activity (kBq/kg)	Half-life utilized* (days)	Numbers of days for disposal	Disposal date
Actinium-225	Solid	37000	01/01/2000	10	9.9203	118	28/04/2000

* The half-lifes were obtained from IAEA (International Atomic Energy Agency):https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html/

Originally developed by: Ary de Araujo Rodrigues Junior; emails: aryarj@ig.com.br or aryarjyy@yahoo.com.br

Figure 8: *Program page for setting parameters and disposal date calculus with an output example.*



4. CONCLUSION

The tests carried on by contributors in CENA and CDTN showed that the program works properly and becomes the calculus for radioactive disposal date easier.

Nowadays the program is in a free web hosting service (https://calcradio.000webhostapp.com) and it is better visualized utilizing the Google Chrome navigator. There is the highly recommended option of downloading it for your computer or server from Github author page (https://github.com/aryarj/tcc2_ooingl), because this kind of hosting is not much stable.

This program could be extended to include the output registers, due to the concern about keeping the data safe against criminals it was not implemented.

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Gilberto Ribeiro Furlan (CENA)
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