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**Verification of EPA's "Preliminary Remediation Goals for Radionuclides" (PRG) electronic Calculator**

## Introduction

The U.S. Environmental Protection Agency (EPA) requested an external, independent verification study of their updated "Preliminary Remediation Goals for Radionuclides" (PRG) electronic calculator. The calculator provides PRGs for radionuclides that are used as a screening tool at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) sites. These risk-based PRGs establish concentration limits under specific exposure scenarios. The purpose of this verification study is to determine that the calculator has no inherit numerical problems with obtaining solutions as well as to ensure that the equations are programmed correctly. There are 167 equations used in the calculator. To verify the calculator, all equations for each of seven receptor types (resident, construction worker, outdoor and indoor worker, recreator, farmer, and composite worker) were hand calculated using the default parameters. The same four radionuclides (Am-241, Co-60, H-3, and Pu-238) were used for each calculation for consistency throughout.

## Results

1) The only problem found in the equations was in the Farmer direct consumption of agricultural products back calculated to soil and water – combined calculation. There is a decay factor that is included in each of the intercept equations (Equation 1); however, it is not included in the results calculated by the PRG calculator. The results from calculations performed by hand were approximately 110% different from the PRG results when the decay factor was included (Table 1). Since the slope results were almost exact to the PRG results; this left only the PRG factor and decay

factor as the possible problems. These were the only factors that were not included in the slope calculations as well as not being specific value parameters. After checking the PRG factor, these values were correct as shown by the results from the Farmer direct consumption of agricultural products (Table 2). Therefore, the factor that was causing the problem in the calculation was the decay factor. When the decay factor was removed from the hand calculations, the recalculated results showed a difference of ≤ 1% when compared to the current PRG results (Table 3).

2) For the air pathway, the hierarchal default slope factor for H-3 is the particle form with an "S" absorption type. It is cumbersome to change this to the much more common vapor form (tritum oxide). To make the PRG Calculator more user friendly, it is suggested that the isotope list include the more common forms of radionuclides instead of defaulting to highest slope factor form.

## Conclusions

After performing all the calculations for Am-241, Co-60, H-3, and Pu-238, EPA's PRG electronic calculator appears to be mathematically correct in all scenarios and pathways, except for the Farmer direct consumption – combined calculation.

Equation 1: The intercept equation for consumption of fruits and vegetables with a decay factor included.

$$\text{INTERCEPT}=\frac{PRG_{\text{f-prod-rad-ing}}\ (pCi/g)}{(R_{upv}+R_{es})}\ x\ \left(\frac{t_f\ (yr)\ x\ \lambda\ \left(\frac{1}{yr}\right)}{(1-e^{-\lambda t_f})}\right)$$

Table 1: The results from hand calculations using Co-60 compared to the PRG results when the decay factor was included in the hand calculations.

| **Co-60** | | | | |
|---|---|---|---|---|
| | | Calculated | PRG | % Differ. |
| F&V | Slope | -2.33E+01 | -2.32E+01 | 0.4% |
| | Intercept | 1.50E-01 | 4.35E-02 | 110.1% |
| Fish | Slope | -4.80E-01 | -4.80E-01 | 0.0% |
| | Intercept | 5.01E-01 | 1.46E-01 | 109.7% |
| Beef | Slope | -1.54E+01 | -1.54E+01 | 0.0% |
| | Intercept | 4.67E+01 | 1.37E+01 | 109.3% |
| Milk | Slope | -1.93E+01 | -1.93E+01 | 0.0% |
| | Intercept | 4.97E+01 | 1.45E+01 | 109.7% |
| Swine | Slope | -7.19E+00 | -7.19E+00 | 0.0% |
| | Intercept | 4.02E+01 | 1.18E+01 | 109.2% |
| Poultry | Slope | -5.43E+00 | -5.43E+00 | 0.0% |
| | Intercept | 1.63E+00 | 4.76E-01 | 109.6% |
| Egg | Slope | -5.43E+00 | -5.43E+00 | 0.0% |
| | Intercept | 9.58E+01 | 2.80E+01 | 109.5% |

Table 2: The results from the hand calculations using Co-60 compared to the PRG results from the Farmer direct consumption calculations.

| Co-60 | | | |
|---|---|---|---|
| | Calculated | PRG | % Differ. |
| F & V | 1.18E-02 | 1.16E-02 | 1.7% |
| Poultry | 3.41E-02 | 3.40E-02 | 0.3% |
| Eggs | 6.82E-02 | 6.82E-02 | 0.0% |
| Beef | 2.02E-02 | 2.02E-02 | 0.0% |
| Milk | 7.43E-03 | 7.42E-03 | 0.1% |
| Swine | 3.73E-02 | 3.73E-02 | 0.0% |
| Fish | 2.32E-02 | 2.32E-02 | 0.0% |

Table 3: The results from hand calculations using Co-60 compared to the PRG results when the decay factor was not included in the hand calculations.

| Co-60 | | | | |
|---|---|---|---|---|
| | | Calculated | PRG | % Differ. |
| F&V | Slope | -2.33E+01 | -2.32E+01 | 0.4% |
| | Intercept | 4.40E-02 | 4.35E-02 | 1.1% |
| Fish | Slope | -4.80E-01 | -4.80E-01 | 0.0% |
| | Intercept | 1.47E-01 | 1.46E-01 | 0.7% |
| Beef | Slope | -1.54E+01 | -1.54E+01 | 0.0% |
| | Intercept | 1.37E+01 | 1.37E+01 | 0.0% |
| Milk | Slope | -1.93E+01 | -1.93E+01 | 0.0% |
| | Intercept | 1.46E+01 | 1.45E+01 | 0.7% |
| Swine | Slope | -7.19E+00 | -7.19E+00 | 0.0% |
| | Intercept | 1.18E+01 | 1.18E+01 | 0.0% |
| Poultry | Slope | -5.43E+00 | -5.43E+00 | 0.0% |
| | Intercept | 4.76E-01 | 4.76E-01 | 0.0% |
| Egg | Slope | -5.43E+00 | -5.43E+00 | 0.0% |
| | Intercept | 2.81E+01 | 2.80E+01 | 0.4% |