

The BiDAS-2007 : Bioassay Data Analysis Software for Evaluating a Radionuclide Intake and Dose

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1. Introduction

The BiDAS (Bioassay Data Analysis Software) computer code Ver. 1.0 [1] was developed in 2003 by KAERI (Korea Atomic Energy Research Institute) for the purpose of estimating the radionuclide intakes and doses of a radiation worker. The BiDAS computer code Ver. 1.0 enables the user to estimate the intakes of radionuclides at an internal exposure condition, for example intake type (acute, chronic), intake pathway (inhalation, ingestion), absorption type (Type F, M, S), and particle size (AMAD, activity median aerodynamic diameter) [2], from bioassay measurements. However if the internal exposure condition for a worker is changed, a continual estimating for their intake is impossible in the BiDAS Ver. 1.0 computer code.

Intakes of radionuclides are estimated in most cases from bioassay measurements based on an in-vivo or an in-vitro method [2]. However the intakes estimated by one method are often considerably different from those by another for the same person. For a better estimation of such intakes, a simultaneous or combined analysis by utilizing two types of bioassay has been attempted [3,4]. But the BiDAS Ver. 1.0 computer code does not have the function of a simultaneous analysis by using two or more types of bioassay.

To solve these problems of the BiDAS Ver. 1.0 code, the BiDAS-2007 computer code has been developed in this study. This paper describes the new functions and the results of a validation of the BiDAS-2007 computer code.

2. Methods and Results

2.1 Features of the BiDAS-2007 computer code

The calculations of the predicted bioassay quantities following an acute intake either by an inhalation or ingestion pathway are based on the parameter values and dose coefficients used in the human respiratory tract, GI-tract and various biokinetic models [2] for the Reference Man, currently recommended by the International Commission on Radiological Protection (ICRP) as in the BiDAS Ver. 1.0 code.

The BiDAS-2007 computer code enables the user to not only do a simultaneous analysis by using two or more types of bioassay but also do a continual evaluation from a change of an internal exposure condition. Moreover this code enables the user to estimate the intakes for the various conditions of an

internal exposure at the same time, and it has been improved for some of the errors in the BiDAS Ver. 1.0 software program.

2.2 Simultaneous Analysis of Different Bioassay Types

In the case of a single acute intake, intakes of a radionuclide at the supposed intake time can be estimated by equation (1) based on a weighted least-square fit. If the time of an intake is unknown, the best-fit time of an intake can be determined by minimizing the mean relative deviation D^r in equation (2).

$$I_n = \frac{\sum_{l=1}^s \left\{ C^{b_l} \sum_{k=j_1^{b_l}}^{j_2^{b_l}} \left(W_k^{b_l} R^{b_l}(t_k - \tau_n) \left[M^{b_l}(t_k) - \sum_{i=1}^{n-1} I_i R^{b_l}(t_k - \tau_i) \right] \right) \right\}}{\sum_{l=1}^s \left\{ C^{b_l} \sum_{k=j_1^{b_l}}^{j_2^{b_l}} W_k^{b_l} \left[R^{b_l}(t_k - \tau_n) \right]^2 \right\}} \quad (1)$$

$$D^r = \frac{1}{\sum_{l=1}^s (j_2^{b_l} - j_1^{b_l})} \sqrt{\sum_{l=1}^s \left\{ (C^{b_l})^2 \sum_{k=j_1^{b_l}}^{j_2^{b_l}} \left(W_k^{b_l} \left[M^{b_l}(t_k) - \sum_{i=1}^n I_i R^{b_l}(t_k - \tau_i) \right]^2 \right) \right\}} \quad (2)$$

where I_i is the i^{th} acute intake, k is the index of the measurements, $M(t_k)$ is the measured data at time t_k , i is the index of the time interval, n is the current step number in the iterative analysis process, τ_i is the time of the i^{th} acute intake, $R(t_k - \tau_i)$ is the body retention fraction or daily excretion rate of the radionuclide at t_k after an acute intake at τ_i , j_1 and j_2 are the index of the extreme left and right points of the data series $M(t_k)$ included in the current interval of an approximation n , $(j_2 - j_1)$ is a count of the points in the data series $M(t_k)$, W_k [5] is the weighting factor for the measurement k , C is the weight assigned to a bioassay measurement set b_l by the assessor, and l is the index of the type of bioassay. Equations (1) and (2) are presumed to be the same as the equations used for a simultaneous analysis of different bioassay data in the IMIE (Individual Monitoring of an Internal Exposure) computer code [4].

2.3 Validation of the BiDAS-2007

The BiDAS-2007 has been tested to validate the accuracy of its results regarding a simultaneous analysis by using two types of bioassay and a continual evaluation in accordance with a change of an internal exposure condition. The aim of this test is not to gain an accurate solution but to validate the calculated results.

The urine and faeces bioassay data [3] of ^{239}Pu in the intake scenario case No. 6 provided by the 3rd European

Intercomparison Exercise on Internal Dose Assessment were used for this test. The internal exposure conditions given in a simultaneous analysis test are a single acute inhalation, 5 μm AMAD, Type S and the date of an intake(24th May). The measurement error was regarded as a uniform absolute form. Table 1 shows the estimated intakes and the committed effective doses calculated for the described intake scenario case by using the BiDAS-2007 and the IMIE-2004 computer code. Figure 1 shows the result calculated by the BiDAS-2007 code.

Table 1. Results by using simultaneous bioassay analysis for the described intake scenario of ^{239}Pu .

Code Content	BiDAS-2007	IMIE-2004
Intake (Bq)	31.4	31.4
CED ^a (mSv)	260	260

^a Committed effective dose.

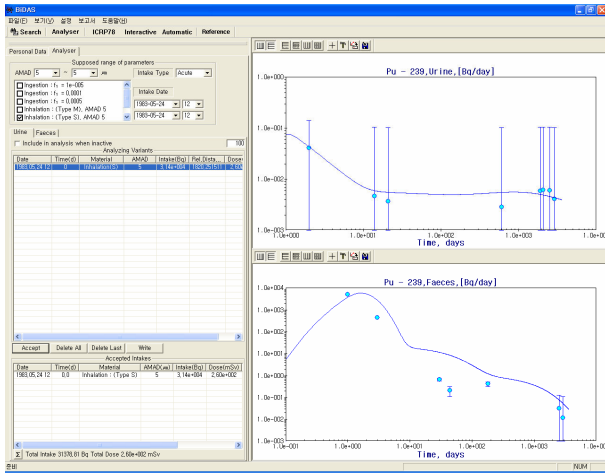


Figure 1. Displayed results of the simultaneous bioassay analysis by the BiDAS-2007 code in Table 1.

For testing for a continual evaluation in accordance with a change of an internal exposure condition, the arbitrary internal exposure conditions were assumed as in Table 2. Table 3 shows the results calculated at each continual evaluation step, Figure 2 shows the result calculated by the BiDAS-2007 code.

As a result, it is found that the values calculated by the BiDAS-2007 code are consistent and in good agreement with those values by the IMIE-2004 code.

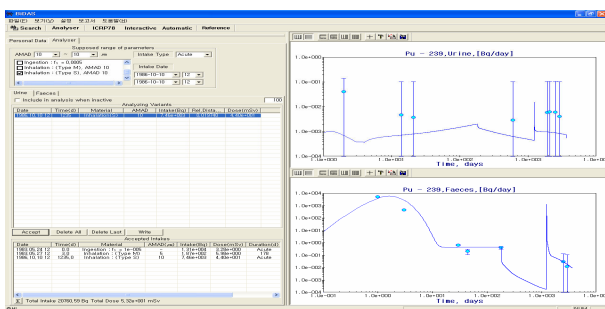


Figure 2. Displayed results of the continual evaluation by the BiDAS-2007 code in Table 3.

Table 2. The arbitrary different conditions of internal exposure in each continual evaluation step.

Step	Intake Type and path	f_1 or Absorption type, AMAD	Using data	
			Urine	Faeces
1	Acute, Ingestion	$f_1=10^{-3}$	1 st	1 st ~ 2 nd
2	Chronic, Inhalation	Type M, 5 μm	2 nd ~ 4 th	3 rd ~ 5 th
3	Acute, Inhalation	Type S, 10 μm	5 th ~ 8 th	6 th ~ 7 th

Table 3. Results of continual evaluation based on the internal exposure conditions of Table 2 in each evaluation step.

Step	Intake time	by the BiDAS-2007		by the IMIE-2004	
		Intake ^a	CED ^b	Intake ^a	CED ^b
1	'83.5.24	1.31×10^4	3.28	1.31×10^4	3.26
2	'83.5.27 ~ '83.11.21	1.87×10^2	5.98	1.87×10^2	6.03
3	'88.10.10	7.46×10^3	44.0	7.44×10^3	43.8

^a Intake (Bq).

^b Committed effective dose (mSv).

3. Conclusion

In this study the BiDAS-2007 computer code has been developed and upgraded from the BiDAS computer code Ver. 1.0 which was developed in 2003 by KAERI for the purpose of estimating the radionuclide intakes and doses of a radiation worker.

The new functions of the BiDAS-2007 computer code are to do a simultaneous analysis by using two or more types of bioassay, a continual evaluation from a change of an internal exposure condition, and to estimate the intakes for various conditions of an internal exposure at the same time. The values calculated by the BiDAS-2007 code are consistent and in good agreement with those values by the IMIE-2004 code. It is expected that the BiDAS-2007 computer code is more useful and user-friendly to estimate the radionuclide intakes and doses of a radiation worker than the BiDAS Ver. 1.0.

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