THE BIDAS-2007: BIOASSAY DATA ANALYSIS SOFTWARE FOR EVALUATING A RADIONUCLIDE INTAKE AND DOSE

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Bioassay data analysis software (BiDAS-2007) has been developed by KAERI, which adds several new functions to its previous version. New functions of the BiDAS-2007 computer code enable the user not only to do a simultaneous analysis by using two or more types of bioassay for the best internal dose evaluation, but also to do a continual internal dose evaluation from a change of the internal exposure conditions such as an intake type (acute, chronic), an intake pathway (inhalation, ingestion), an absorption type (Type F, M, S), and a particle size (AMAD, activity median aerodynamic diameter), and also to estimate the intakes in various conditions of an internal exposure at a time. The values calculated by the BiDAS-2007 code are consistent and in good agreement with those values by IMIE-2004 code by Berkovski and IMBA code by Birchall. The BiDAS-2007 computer code is very useful and user-friendly to estimate the radionuclide intakes and committed effective doses of a radiation worker.

KEYWORDS : BiDAS-2007 Computer Code, Internal Exposure, Simultaneous Analysis, Continual Intake Evaluation

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 not only to do a simultaneous analysis by using two or more types of bioassay for the best internal dose evaluation but also to do a continual internal dose evaluation from a change of an internal exposure condition. Moreover, this
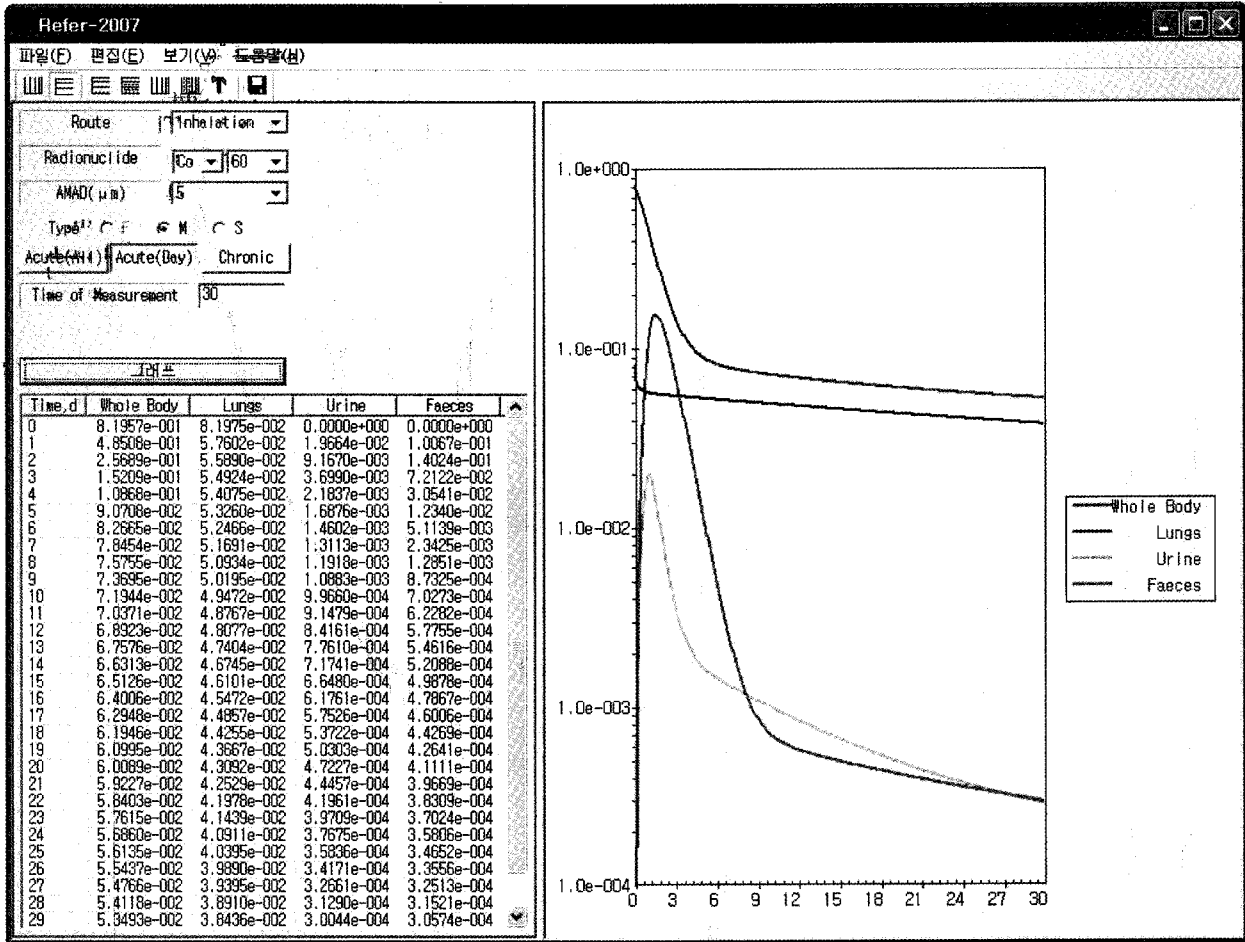
Fig. 1. Displayed Intake Retention Fraction and Daily Excretion Rate of ^{60}Co(Type M, 5μm AMAD) by Refer-2007 Function

	A	B	C	D	E	F	G	H	I	J	K
1	Company	KAERI							Evaluation period	1983-05-24	
2	Department	Health Physics Team								1985-03-04	
3	Name	Jong Il LEE									
4	ID	600101 - 1008888									
5	Nuclide	Intake time	Duration	Pathway	Intake type	f₁	Type	AMAD (μm)	Intake (Bq)	CED (mSv)	Measurements
6	Co-60	1985-01-01 12:00	1985-01-11 12:00	Inhalation	Chronic	–	M	5	1.31E+05	9.30E-01	Whole Body
7	Co-60	1985-01-13 12:00		Ingestion	Acute	0.1	–	–	5.55E+04	1.89E-01	Whole Body
8	Co-60	1985-01-17		Inhalation	Acute	–	S	1	2.89E+04	8.38E-01	Whole Body
9	Co-60	1985-01-18 12:00	1985-03-02 12:00	Ingestion	Chronic	0.05	–	–	1.92E+05	4.80E-01	Whole Body
10	Co-60	1985-03-04 12:00		Inhalation	Acute	–	S	10	2.80E+05	2.77E+00	Whole Body
11											

Fig. 2. Displayed Annual Dose Report for a Radiation worker by Annual Dose Report Function of BiDAS-2007

code enables the user to estimate the intakes for the various conditions of an internal exposure at a time.

Even though the BiDAS-2007 computer code has been developed by benchmarking the IMIE (Individual Monitoring of an Internal Exposure) computer code [5], the BiDAS computer code has new convenient functions, different from the IMIE code, such as not only the Refer-2007 function (Figure 1), which shows the intake retention fraction and the daily excretion rate of radionuclides as to the intake pathway, absorption type, AMAD, intake type (acute, chronic), and elapsed times after an intake but also the annual report function (Figure 2), which shows

all bioassay measurement data and dose evaluation results for each worker.

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).

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

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

where I_i is the ith 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 ith acute intake, $R(t_k-\tau_i)$ is the body retention fraction or daily excretion rate of the radionuclide at tk 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 [6] is the weighting factor for the measurement k, C is the weight assigned to a bioassay measurement set b_i 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 computer code [5].

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 feces 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 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 3 shows the result of simultaneous analysis by using the urine and feces bioassay data of ^{239}Pu by the BiDAS-2007 code.

To test the continual evaluation function 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 4 shows the result calculated by the BiDAS-2007 code by using the continual evaluation condition of Table 2.

Table 1. Results by Using Simultaneous Bioassay Analysis for the Described Intake Scenario of ^{239}Pu

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

^{a} Committed Effective Dose.

Table 2. The Arbitrary Different Conditions of Internal Exposure in Each Continual Evaluation Step

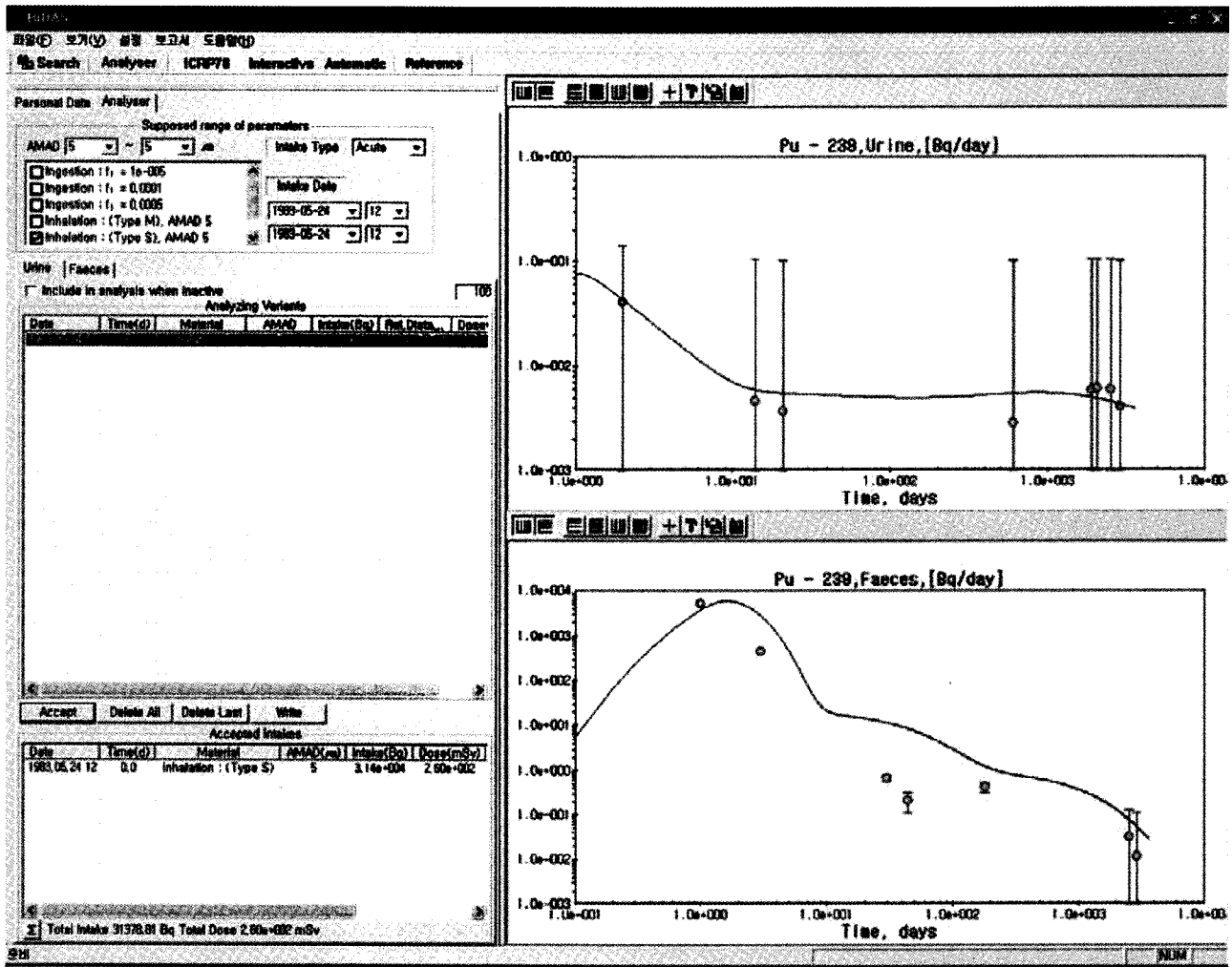| Step	Intake Type and Path	f$_1$ or Absorption type, AMAD	Using Data	
			Urine	Feces
1	Acute, Ingestion	f$_1$=10^{-5}	1st	1st ~ 2nd
2	Chronic, Inhalation	Type M, 5 μm	2nd ~ 4th	3rd ~ 5th
3	Acute, Inhalation	Type S, 10 μm	5th ~ 8th	6th ~ 7th

Fig. 3. Displayed Results of the Simultaneous Bioassay Analysis by the BiDAS-2007 Code in Table 1

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).

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

3. CONCLUSION
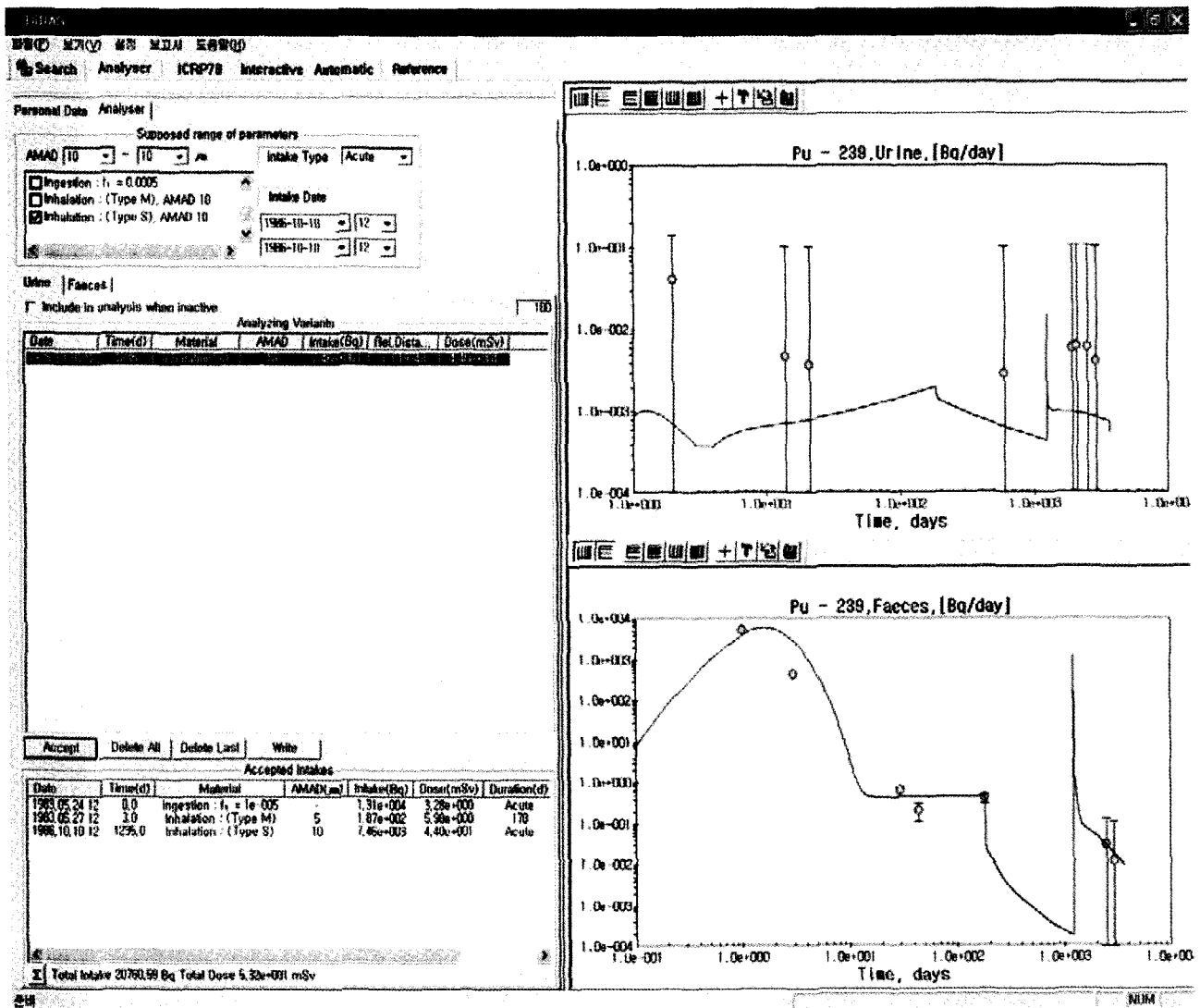
In this study the BiDAS-2007 computer code has been

Fig. 4. Displayed Results of the Continual Evaluation by the BiDAS-2007 Code in Table 3

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, to do a continual evaluation from a change of an internal exposure condition, and to estimate the intakes for various conditions of an internal exposure at a 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 IMIE computer code, as well as the BIDAS Ver. 1.0.

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