2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 30 to October 5, 2007
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: 978-85-99141-02-1

STUDY OF NOMINAL DAILY OUTPUT OF URINE FROM WORKERS

Marina F. Lima, Janete C. G. Gaburo Carneiro, Alberto S. Todo

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
mflima@ipen.br

ABSTRACT

A retrospective study of the 24-hour urine volumes from workers selected for the internal individual monitoring compares the average volume collected by sample and the average volume per individual with the nominal daily output of urine from "Reference Man". This work considers 134 registers of urine samples from 18 male workers, with semester routine sampling, between the years of 2000 and 2005. For this group, the average volume per collection was (971±371)mL and (962±376)mL per individual. In a cohort group of 9 male workers, which supplied at least 10 samples in this period, it was observed that the average volume per collection decreased to (955±308)mL and the average volume per individual increased to (1027±400)mL. For the female group, composed by 11 individuals, the 29 urine samples supplied between 1999 and 2005 were considered. The average volume per sampling and for worker was, respectively, (1122±337)mL and (1105±337)mL. Another cohort group of only 4 female workers with at least one annual collection during five years, of the seven years considered, the values decreased to (1112±336)mL per collection and the average volume per individual was maintained. The major variability of the volume among all the individuals was 927%, and for the same individual was 562%. This difference can be indicative of the individual differences of retention and excretion, alimentary diet interferences and for lack of awareness by the individual to collect urine during a period of 24-hour. The radionuclides clearance does not occur in constant rates and for the purpose of assessing intakes, in our routine analysis, the total volume of urine from worker is corrected for 1,4L. Based in the results obtained over the years, and to minimize the errors of the nominal daily excretion rate in urine, actions about the aware of the individual in carrying out an accurately sampling and/or the implementation of the measurements of creatinine levels in urine are suggested.

1. INTRODUCTION

The most widely used bioassay method for assessing intakes of radionuclides is urine analysis. The samples are readily collected, and there is usually little doubt that the radioactivity is being excreted from extra cellular body fluids [1]. The urinary excretion rate for different radionuclides is usually related to the body content by one or more exponential terms, ICRP Publication 78 [2] describes the relationships between intake and urinary excretion rate for the commonly encountered radionuclides and this document should be referred to for further information.

In principle, urine analysis can be applied to all radionuclides. In practice, however, the relationship is a tenuous one, because it may be based in limited experimental data, or the chemical compound involved may be site-specific; hence, the biokinetics of the radionuclides will not be certain. The interpretation of urine analysis data should thus be considered carefully and dose estimates revised in the light of local knowledge.

The collection of urine samples involves thee considerations. Firstly, care must be taken to avoid contamination of the sample. Secondly, it is usually necessary to assess the total activity excreted in urine per unit time from the sample provided. For most routine analyses, a 24-h collection is preferred but, if this is not feasible, it must be recognized that smaller samples may not be representative. Thirdly, the volume required for analysis depends upon the sensitivity of the analytical technique. For some radionuclides, adequate sensitivity can be achieved only analyzing excreta from several days [2].

An indirect monitoring program to assess workers of IPEN has been carried out at the Centro de Metrologia das Radiações (CMR) by the Laboratório de Radiotoxicologia (LRT).

Currently, for estimation of intake by workers the total volume has been corrected according to the ideal value of 1.4L, which is the volume of urine excreted daily by a standard man, adopted by ICRP 23 [3].

The main objective of this study is to assess urinary records data from workers for both genders, during 6 years, between 2000 and 2005 to the male group and in 6 years, between 1999 and 2005 (except 2004) to the female group. In addition, the average excretion volume per worker will be compared with 1.4L reference value. Based on the results obtained some considerations about the volume variability of urine samples collected and the use of a urinary excretion rate index is also discussed.

2. METHODOLOGY

2.1. Group selection studies

The individual monitoring for the estimation of intakes of thorium workers, by urine samples, was used in this study. The main concern was to choose a representative group composed by male and female with a series of measurements within a routine program.

The thorium workers are 39 individuals and were classified into two groups according to gender. The male group is composed by18 workers and the female group consisted of 11 workers. In spite of the monitoring program to establish the frequency of measurements twice a year, only 10 of the 18 workers of male group collected more than 10 samples between the years of 2000 and 2005. In the female group, the collection of urine sample was less frequent, with only 4 of the 11 workers collecting at least 4 samples between 1999 and 2005. No samples were collected by the female group in 2004.

2.2. Collection urine sample and records

Two clean plastic containers are used for each worker to collect all the urine excreted during a 24-h period according to LRT procedures. The urine samples are received by LRT and a check list is used to confirm the sample identification and purposes of analysis. After this, the data of interest such as radionuclide, worker name, workplace, total urine volume and date are registered at log book.

2.3 Data analyze

The collection period (years) of 24-h urine samples (mL) data from male and female groups of workers are presented in Table 1 and 2, respectively.

The procedures to analyze the 263 values urine sample by gender are simple and geometric averages and standard deviation.

The data of 134 urine samples from the male group of workers are shown in the Table 1. The data takes into account all the 134 samples and all the individuals from the male group considering average volume/sample and average volume/sample/worker; sample per all individual from the male group; cohort male group of 9 from 18 workers: average volume/sample and average volume/ sample/worker.

Table 2 shows the data of 29 urine samples from the female group of workers. The data takes into account all 29 samples and all the individuals from the female group: average volume/sample and average volume/sample/worker; sample per all individual from the female group; cohort female group of 4 from 11 workers: average volume/sample and average volume/ sample/worker. Each one worker was also separately considered in the fluctuation of the samples volume by the years.

Table 1. The collection period (years) of 24-h urine samples (mL) from male group.

Worker	Collection Period (years) and Total Urine Volume/Collection (mL)						Average Volume (mL)
	2000	2001	2002	2003	2004	2005	
1	1000/280	480	420/250	590/260	600/300	920/200	482±273
2					1140/860	1030/1490	1130±266
3	1070/1450/1410	2000	2040	1820/1900	1900/1800	2000/1470	1715±315
4			1220/250	280/250	640/340	310/830	515±354
5	590/420	1000	1080/1030	1000/1110	1600/1000	970/940	976±297
6	1150/610	1000	840/540	640/610	660/760	850/510	743±297
7	460/1300/620	1010	1000/790	660/800	1160/580	840/430	804±200
8	950	760	1020/570	830/220	840/860	710/810	757±225
9	820/650/420	900	1660/610	1840/1760	1080/2000	1700/1800	1270±575
10	650		1100	780	540/860	1010/1320	894±270
11	1800/1690	1700/960	1600	1410/1810	1600/1360	320/860	1374±472
12					1420	1740	1580±226
13				750	1280	1380	1136±339
14	510/210	680	360	490	620		478±172
15	1020/350		640	1050			765±334
16	1210/865	840	1020	990	900		971±137
17			520	1010			765±347
18	1440	760	1540	2000			1435±512

Note: The urine data from workers that has collected more than one sample for year is separated by the mark (/) .
The empty rows refer to no collected samples in the considered period.
Cohort workers group #: 1; 3; 4; 5; 6; 7; 8; 9 and 11.

Table 2. The collection period (years) of 24-h urine samples (mL) from female group.

Worker	Collection Period (years) and Total Urine Volume/Collection (mL)						Average Volume (mL)
	1999	2000	2001	2002	2003	2005	
1	800	510		1116			854±264
2	990						990
4	700						700
5	1450	990		1080	1520	1308	1242±235
6	1600	1300		1520			1410±155
7	1600	1400		1560	2050	1300	1577±288
8	850	520/450	1000/670	1000			748±156
9						1540	1540
10						1560	1560
11				1320	1600	2000	1640±342

Note: The urine data from workers that has collected more than one sample to year is separated by the mark (/).
The empty rows refer to no collected samples in the considered period.
Cohort workers group #: 1; 5; 7 and 8.

The comparison between the average urine sample for individual from the male workers group and the value for the Reference Man (ICRP23) is shown in the Fig. 1.

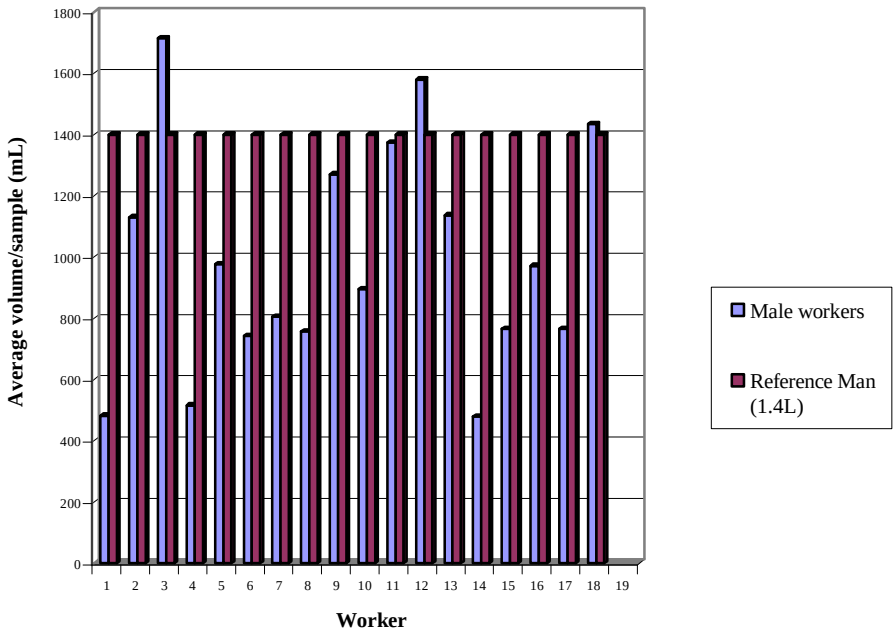

Figure 1. Male workers group: comparison between the average volume urine sample for individual and the value for the Reference Man (ICRP23).

The comparison between the average urine sample by individual from the female workers group and the value for the Reference Man (ICRP23) is shown in the Fig. 2.

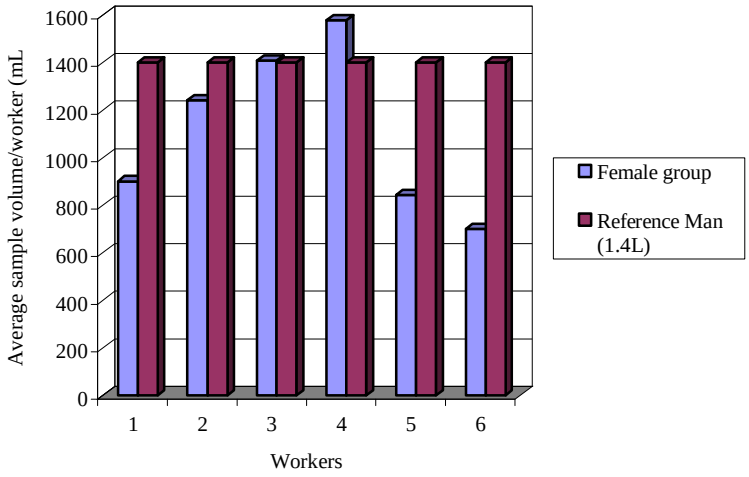

Figure 2. Female workers group: comparison between the average volume urine sample for individual and the value for the Reference Man (ICRP23).

3. RESULTS AND DISCUSSION

3.1 Workers average urine 24-h volume

The volumes data collected by the male group of workers show variability from 220mL to 2040mL indicate that 927% in the group and between 36% and 562 % to each individual. The average of volume/sample and volume/sample/worker are quite similar (971±371)mL and (962±376)mL and indicate that 69% of the Reference Man value. In the cohort male group the averages volume/sample and volume decreases to (955±308)mL, while the average volume/sample/worker increased to(1027±400)mL. These values represent 68% and 73% of the Reference Man value.

The data volumes collected by the female group of workers show variability from 450mL to 2000mL that indicate that 444% in the group and between 23% and 122% to each individual. The average of volume/sample and volume/sample/worker are quite similar (1122±337)mL and (1105±332)mL and represent 80% and 79% of the Reference Man value.

In the cohort female group the averages volume/sample and volume decreases to (1112±33)mL, while the average volume/sample/worker is maintained and represent 79% of the Reference Man value.

The predicted monitoring frequency of twice per year for thorium workers group to estimation of intake by urine sample, are in the middle of spring and autumn, when the climatic conditions are very kind. Under these conditions, the daily diet and metabolism are

quite similar. In consequence, the daily urine excretion for the same individual would not present wild variations.

Currently, all the concentration of uranium, thorium and actinides measured in the urine samples are normalized to the volume of 1.4L. Such practice could carry an intake sub estimation to 3 workers of the male group (35%) and to 5 workers of the female group (45%).

Some occupational programs have adopted the normalization to creatinine to express results of toxic metals concentration in the urine [4, 5]. This practice, recommended by the IEA – Safety Guide (No-RS-G-1.2)[6] substitutes the kind of expression of results from concentration/urine volume to concentration/creatinine mass in the urine.

The creatinine level must be measured in a 24-h urine sample or estimated on the basis of the height and the weight of the individual worker. This simple procedure brings up best accuracy in the results and minimizes the lack of voiding collection.

3. CONCLUSIONS

The present study leads to the following conclusions:
-The average volume of daily excretion among the male and female genders workers of IPEN is around 30% smaller than the ideal value adopted by ICRP23 [3].
-The female group presents average urine volumes bigger than the male group.
-The variability by the years in the samples volume from the same individual worker suggests that some voiding is lost during the 24-hs collecting period that characterize a nominal 24-h sample.
To achieve better accuracy in the results, the LRT will improve a new explanation practices among the workers besides of the introduction of the normalization to creatinine method.
The real impact upon the calculated doses by the procedure currently adopted by LRT would be really evaluated only after the implementation of the measurement of the creatinine in urine as an index of urinary excretion rate.

REFERENCES

1. M. H. Bhattacharyya, B. D. Breitenstein, H. Métivier, B. A. Muggenburg, G. N. Stradling, V. Volf. “Guidebook for the treatment of accidental internal radionuclide contamination of workers”. *Radiation Protection Dosimetry,* **Vol 41**, No 1, pp.21 (1992).
2. *International Commission on Radiological Protection*.”Individual monitoring for internal exposure of workers” (ICRP-78), Pergamon, Oxford (1998).
3. *International Commission on Radiological*. “Report of the task group on reference man”(ICRP-23), Pergamon, Oxford (1974).
4. S. Jacson, “Creatinine in urine as an index of urinary excrtion rate”, *Health Phys*.**12**: 843-850 (1966).
5. Z. Karpas, A. Lober E. Elish, P. Marcus, Y. Roiz, R. Marko, R. Kol, D. Brinker and L. Halicz, “Uranium in urine- normalization to creatinine”, *Health Phys*.**74**(1): 86-90 (1998).
6. *IAEA Safety Standards Series*. “Assessment of Occupational Exposure due to Intakes of Radionuclides”. Safety Guide No.RS-G-1.2 (1999).