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Daily Changes of Elemental Concentration in a Human Body Over 218 Days Obtained by Quantitative Analyses of Beard Samples

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Abstract. Beard samples were taken from a person in the morning and at night over successive 218 days, and 543 samples were analyzed in total by means of a standard-free method developed by us. Concentration changes with passage of time in a day were also studied. As a result, both short-term and long-term changes have been observed reflecting the changes of elemental concentration in a human body, and their correlation with the food intakes is investigated. It is found that concentrations of sodium, potassium and chlorine show the same trend both in short- and long-term changes, which indicates that they mostly exist in the chemical forms of NaCl and KCl in a human body. Difference of elemental concentration between the beard samples collected in the morning and at night is also discussed. It is found that the standard-free method for beard samples is quite useful for investigating daily changes of elemental concentration in a body and it is expected to give us information about the pathways of human exposure to toxic elements.

Keywords: PIXE, Beard, Daily changes, Elemental concentration, Toxic elements

INTRODUCTION

It has become quite important to analyze biological samples taken from a human body in order to investigate exposure to certain toxic elements, such as arsenic and mercury, and various studies on the problems of human exposure in South-east Asia have been pursued in our laboratory [1-3]. On the basis of a standard-free method [4], we have established and reported the methods of quantitative analysis for untreated-blood [5], hair [6], nail [7], urine [8] and beard [9]. These methods have some analytical attributes in comparison with a traditional internal-standard method combined with a chemical-ashing method. They are: 1) the procedure for target preparation becomes fairly simple and a large number of samples can be treated in a short time, 2) it is perfectly free from any ambiguity otherwise induced by complicated sample treatments such as volatilization of certain elements from the sample and contamination of samples during ashing, and 3) it allows us to quantitatively analyze samples of extremely small quantity of less than 1 mg.

In order to study human exposure to some toxic elements, daily changes of elemental concentration in the body give us valuable information, since they are mainly influenced by ingestion of foods and water, as well as inhalation of the surrounding air. Therefore, daily changes of elemental concentration are expected to give us information for specifying the causes and routes of the exposure. From this viewpoint, beard (including mustache and whiskers) analysis is the most effective method, since the sample is easy to get as many men shave every day with a shaver in the same manner, at almost the same time in the morning. Moreover, the collected samples exactly correspond to the total beard, growing in one day. As our standard-free method allows us to quantitatively analyze powdered beard samples of extremely small quantities (<0.1 mg), it is also possible to investigate elemental changes with passage of time in a day. Some problems such as how to wash and to prepare powdered beard samples have been mostly solved in our previous studies [9]

In the present work, changes of elemental concentration in beard have been studied using the samples collected from the same person over successive 218 days, and both the short- and long-term changes are investigated. Correlation of the daily concentration changes among elements is studied in detail. The relationship between the rise and fall of concentration of certain toxic elements and special food intakes is also discussed. Further, elemental changes with passage of time in a day are also studied by analyzing beard samples of small quantities.

EXPERIMENTAL

Target Preparation of Beard Samples

Experimental procedure is almost the same as is described in our previous paper [9]. Beard samples were taken from a man (54 years old, 65 kg) with electric shaver in the morning and at night every day over 218 days (2006 1/27-8/31). On 2-3 July, samples were collected in every 2 hours from 8:15 (7/2) to 0:15 (7/3) in order to investigate changes of elemental concentration with passage of time. In total, 543 samples were taken and analyzed. Quantities of the collected sample are mostly less than a few mg.

Beards are washed in acetone according to the manner described in reference [9]. Sample of nearly 0.3 mg was dropped onto a 4 μm-thick polypropylene backing, and was fixed with 1 μL collodion solution diluted with ethyl alcohol to the concentration of 1%.

Measurements and Analysis

A small size cyclotron at NMCC (Nishina Memorial Cyclotron Center) provides a 2.9 MeV-proton beam on a target after passing through a beam collimator, which defines spot size of the beam (in this work it is 6 mm in diameter). A 300 μm-thick Mylar film was used as an X-ray absorber for the Si(Li) detector No.1, while detector No.2 was used simultaneously without absorber for light elements detection. A more detailed description of the beam arrangement and the measuring system are described in reference [10].

Figures 1-a, b show the typical X-ray spectra obtained with the detector No.1(a) and No.2(b), respectively, where a large peak of nickel is attributed to the outer blade of the shaver made of pure nickel. In this study, the results of nickel were excluded in the discussion. It has been confirmed that the effect of contaminations coming from the shaver on the other elements is negligible [9]. The spectra were analyzed by means of the standard-free method for powdered beard samples [9]. More than 25 elements were detected for most of the beard samples.

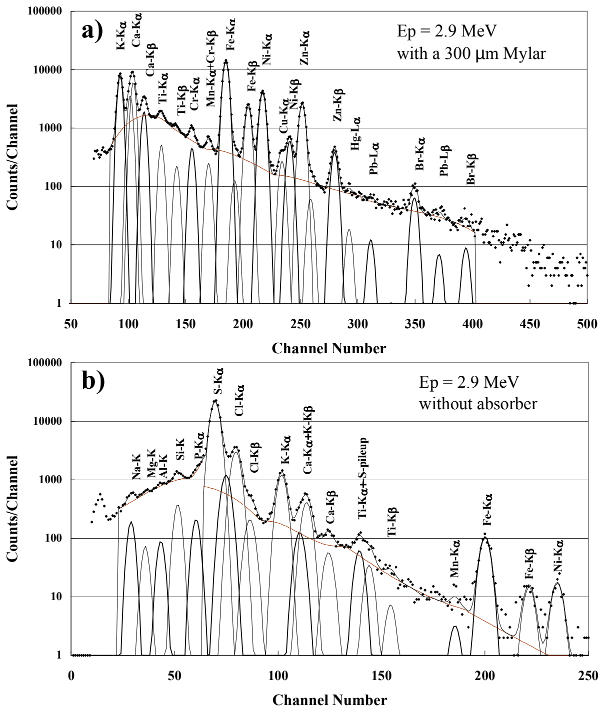

FIGURE 1. Typical X-ray spectra obtained with the detector No.1(a) and No.2(b), respectively.

RESULTS AND DISCUSSION

We compared average elemental concentrations in beard samples taken at night with those in the beard samples taken in the morning for 218 days (436 samples). Although a few elements show higher values for the samples taken in the morning, there are no clear differences considering their standard deviations. Therefore, the average values in a day are taken in the following discussions.

Figure 2 shows comparisons of daily changes of elemental concentration over 218 days for principal elements. It is clear that S concentration keeps almost constant for this period, while that of Zn shows slight changes in a few weeks. It is found that K, Cl and Na show quite similar trend with both short- and long-term variations indicating that these elements mostly exist in the chemical forms of KCl and NaCl in a human body. Mg, Si and Ca show certain long-term variations in the period of a few months, while Br shows some seasonal elevation. Cu also shows sudden rise, where the concentration becomes more than three times higher from the end of March to April.

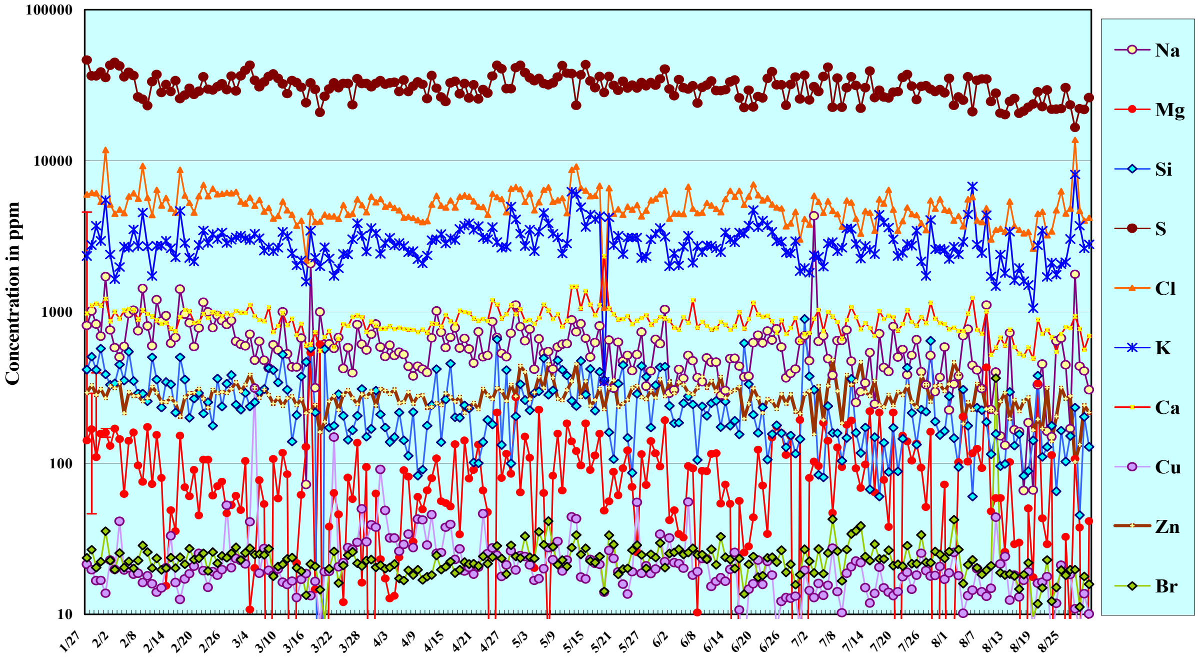

FIGURE 2. Daily changes of elemental concentration of principal 10 elements in beard samples taken successive 218 days.

Figure 3 displays the daily changes for six trace elements, including toxic ones. Al concentration shows sudden rise in the middle of March and slowly decreases toward August. Ti concentration shows long-term elevation in May and keeps high values for nearly one month. In our previous study, no certain trend for Hg was recognized since the study was done over only 33 days [11]. In the present work, certain long-term changes of Hg concentration are observed reflecting its long biological half life; it shows low values for the first three months and rises in May, and keeps the high value to July. On the other hand, As shows no long-term trends but rapid variations in the period of a few days. Pb and Ti show both short- and long-term variations, while Cr shows no clear trend.

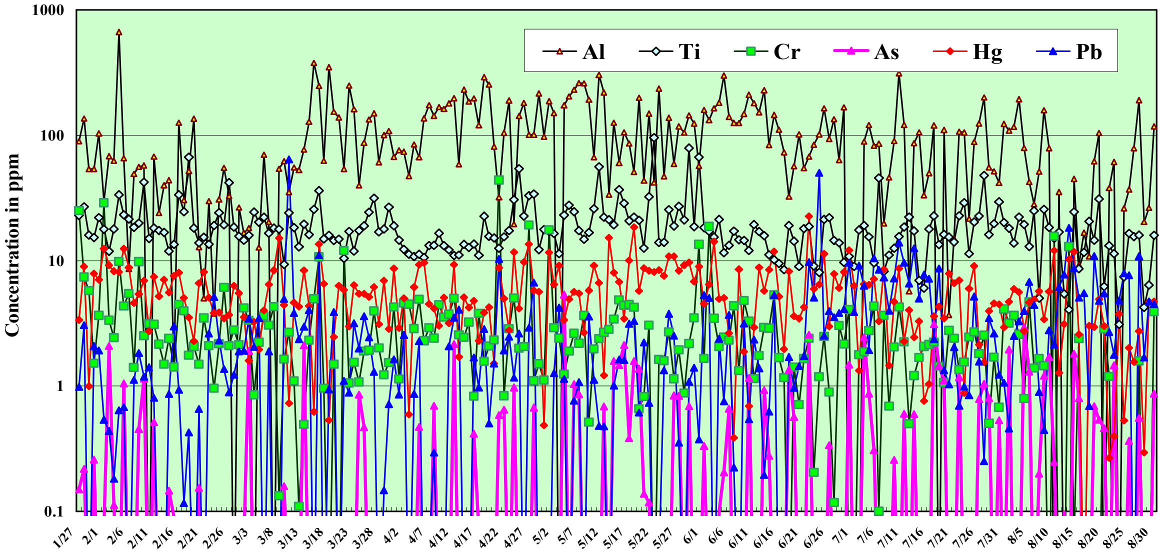

FIGURE 3. Same as Fig. 2 but for six trace elements including toxic ones.

In order to estimate the effect of metabolism in the body, changes of elemental concentration with passage of time were also investigated. Figure 4 shows variations with passage of time for principal elements (a) and trace elements (b), where beard samples were taken every two hours on 2 July. Si and Na show large time dependence. Cl and K show the similar trend each other as in the same manner as shown in Fig. 2. Many elements except S and Zn show the highest values at evening. In respect to trace elements, Ti shows sudden elevation in the evening and a few elements such as Pb, Hg and Mn show certain trend. Some trace elements such as As and Al show large scattering due to their poor statistics and they are omitted from the figure.

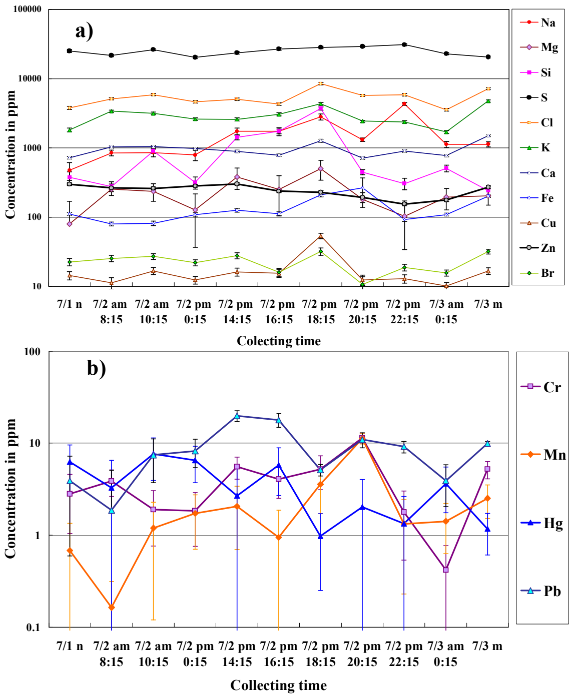

FIGURE 4. Changes with passage of time for principal (a) and trace (b) elements.

Figure 5 shows short-term daily changes in elemental concentration in May. This person ate a large amount of sea products including laver and scallop, which is known to be quite arsenic-rich, as hand-rapping sushi on 5/13 and 5/17. It seems that intakes of As give effect on its concentration in beard with 1-2 days delay. In this figure, certain correlation is observed between As and Pb concentration, while no clear correlation was observed in the other periods. Other elements show no clear trend considering their uncertainties shown in the figures.

In conclusion, it has been confirmed that the beard analyses give us valuable information about daily changes of elemental concentration in a human body, both in respect to short-term and long-term variations. It is expected to give us a clue to the elucidation of the pathways of exposure to toxic elements.

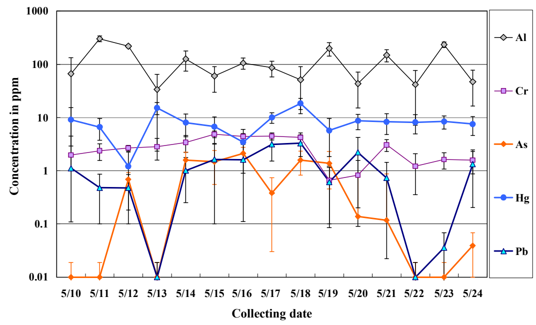

FIGURE 5. Short-term changes of elemental concentration for trace elements from 10 to 24 May.

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