Background Reduction around Prompt Gamma-ray Peaks from Korean White Ginseng

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1. Introduction

Prompt gamma-ray activation analysis (PGAA) is recognized as a very powerful and unique nuclear method in terms of its non-destruction, high precision, and no time-consuming advantages [1]. This method is used for the analysis of trace elements in various types of sample matrix such as metallurgical, environmental, biological samples, etc. When a spectrum is evaluated, background continuum is a major disturbing factor for a precise and accurate analysis. Furthermore, a prompt gamma spectrum is complicate with a wide range as shown in Figure 1. To make the condition free from this limitation, a reduction of the background is important for the PGAA analysis. The background-reducing methods are divided into using the electronic equipment like a suppression mode and principal component analysis (PCA) based on a multivariate statistical method [2, 3]. In PGAA analysis, Lee *et al.* [4] compared the background reduction methods like PCA and wavelet transform for the prompt gamma-ray spectra. Lim *et al.* [5] have applied the multivariate statistical method to the identification of the peaks with low-statistics from the explosives. In this paper, effective reduction of background in the prompt gamma spectra using the PCA is applied to the prompt gamma-ray peaks from Korean Baeksam (Korean white ginseng).

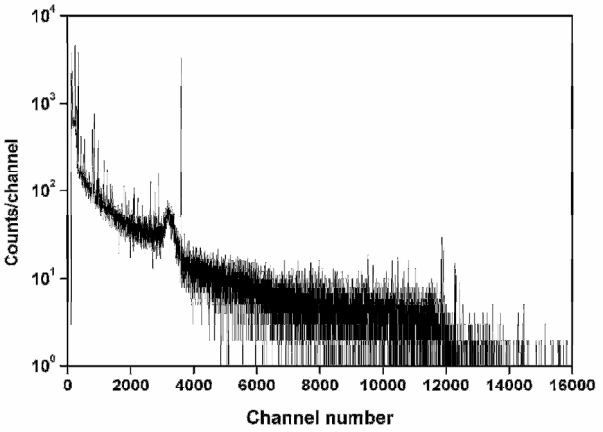


Figure 1. Prompt gamma-ray spectrum from a Korean white ginseng sample. Live time = 600 sec.

2. Theory

The PCA is one of the multivariate statistical methods developed to examine an underlying structure that exists in large data set. The PCA simplifies a complex variables structure in multivariate data set into only a few principal components by a grouping method. Principal components (PC1, PC2,…, PCp) are ordered with the explanation amount. Thus the first principal component (PC1) shows the greatest amount of the variation. This means that the first principal component (PC1) should have abundant information of the raw data as possible. Computational principal components signify acquired eigenvectors and eigenvalues of covariance matrix of the data. If some eigenvalues of the principal components were below threshold value, these eigenvalues and the corresponding eigenvectors were discarded. The PCA simulation for our purpose was conducted with following 5 steps as shown Figure 2; 1) PGAA experiments, 2) Normalization of the data set, 3) spectral composition of the covariance matrix, 4) SVD calculation, and 5) plotting the background reduction.

For the process of the PCA, because the principal components are calculated from the covariance matrix, the PCA and SVD (Singular Value Decomposition) matrix have a direct relation. The SVD is used to establish the eigenvalue and eigenvector. Finally, this result leads to a background reduction in the prompt gamma spectra.

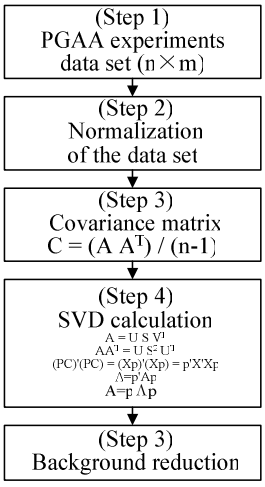


Figure 2. Flow chart of PCA Simulation for Background Reduction of the Spectrum.

3. Experiments and Results

For this study, the various ginseng samples such as Korean Baeksam, Japanese Jukjeolsam, Chinese Jeonchilsam, and Canadian Hwagisam were analyzed in a SNU-KAERI PGAA facility [6, 7] at the HANARO research reactor. Freeze-dry ginsengs were pulverized by a muller and then transferred into a teflon vial and

irradiated for several hours in the PGAA facility. Irradiation time was optimized by pre-adjustments. The spectrum file from Korean Baeksam measured during 600 seconds was used as a target file and those from other ginsengs during long period of about 10,000 seconds were used as history files to reduce the background of that from Korean Baeksam. The PCA code was properly modified to calculate the SVD and produce the background-reduced spectrum. Figure 3 shows a SCREE plot for the partial spectrum around 770.3 keV peak of potassium (K), which shows that PC number 1 explains 99.1% of the variance and those up to 4 explain 99.9 % of the variance. Figure 4 shows the raw data and the background-reduced lines. Figure 4(a) show the background-reduced lines for K 770.3 keV peak according to the number of the PCs applied to the projection of the raw data. Figure 4(b) and 4(c) shows those for Al 7724 keV line and for Fe 362.2 keV line, respectively. Table 1 shows a background reduction factor defined as a ratio of standard deviation of the raw data to that of the background reduced line.

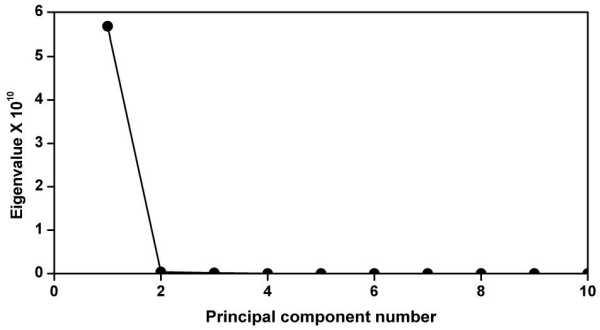
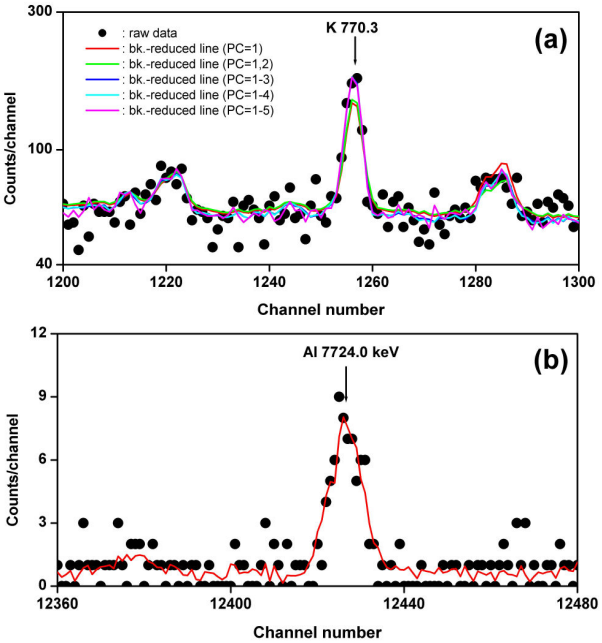


Figure 3. SCREE plot for the partial spectrum around a K770.3 keV peak.



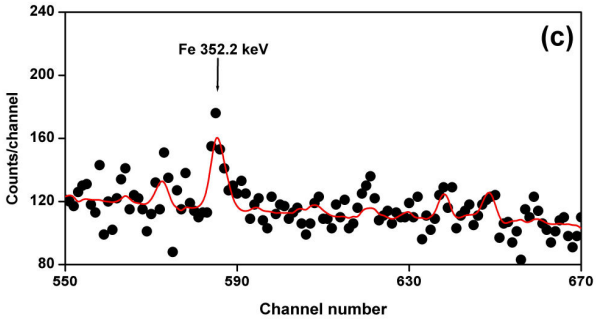


Figure 4. Background reduction by the PCA: ● is raw data and lines represent the reduced data, Respectively. (a) for K 770.3 keV line, (b) for Al 7724.0 keV and (c) for Fe 352.2 keV line.

Table 1. Background reduction factor.

	Background reduction factor
K 770.3 keV	1.10
Al 7724 keV	1.04
Fe 352.3 keV	1.18

4. Conclusion

In this study, the background reduction procedure using the PCA was investigated for the prompt gamma-ray spectrum from Korean Baeksam sample. The backgrounds around a peak of interest like K 770.3 keV, Al 7724.0 keV and Fe 352.2 keV lines were clearly reduced by projecting the raw data onto the dominant eigenvalues typically up to 3-4. This procedure will be applied to the peak search and identification in the complex prompt gamma-ray spectrum.

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