Provenance Study of Archaeological Clay Artifacts by a Standard-less Method using Large Sample Neutron Activation Analysis

K.B. Dasari[1,2], R. Acharya[3]

[1]GITAM Institute of Science, GITAM University, Visakhapatnam, India
[2]Neutron Utilization Research Division, Korea Atomic Energy Research Institute, Daejeon, S. Korea (Present)
[3]Radiochemsitry Division, Bhabha Atomic Energy Research Center, Trombay, Mumbai -400085, India
E-mail: dasari@kaeri.re.kr / racharaya@barc.gov.in

Keywords: Archeological Clay Artifacts, Large Size Samples, Internal Monostandard NAA, *In situ* detection efficiency, Elemental Concentration Ratio, Provenance Study

Routine analysis, in most of analytical techniques, requires small sample mass (about 50-500 mg) to get the mass fraction of elements and to get representative results replicate samples (n ≥3) are analyzed. For samples that are available in large size, difficult to break/destroy or not homogeneous in microscopic scale, it is advisable to analyze a large size sample (g to kg scale) to get the better representative analytical results. In this respect, Instrumental Neutron Activation Analysis (NAA) is a suitable technique for large sample analysis as it can easily give bulk analysis results due to high penetration powers of neutrons and gamma-rays [1,2]. The major issues in large sample analysis are neutron self-shielding and gamma- ray attention, which are negligible in small sample analysis. In the present study, we present a summary of application of k_0-based internal mono-standard INAA (IM-NAA) method using in situ relative detection efficiency for analysis of large and non-standard geometry of archaeological clay pottery and brick samples (0.5 -53 g) for provenance study. Samples were irradiated in highly thermalized (>99.9 % thermal neutron flux) neutron flux (about 10^{7-8} $cm^{-2}s^{-1}$) irradiation position available at research reactor of BARC, Mumbai. Samples were assayed for gamma activity using HPGe detector coupled to MCA. The IM-NAA gives relative elements mass fractions with respect to the internal monostandard like Na or Sc. In IM-NAA, internal mono-standard will take care of neutron absorption in the sample and *in-situ* relative detection efficiency takes care of γ-ray self-attenuation and geometrical effects making the method geometry independent. In-situ relative detection efficiency calibration was carried out using γ-rays of four activation products in the real sample namely ^{152m}Eu, ^{140}La, ^{56}Mn, ^{24}Na and covered energy range is 122–2754 keV (Fig.1). Statistical cluster analysis in conjunction concentration ratios of key elements such as Cr, Fe, Co, Zn, Cs, La, Ce, Eu, Yb, Lu and Hf were used for grouping / provenance of the said artifacts. We have demonstrated that elemental concentration ratios can be used for grouping /provenance study instead of absolute concentrations, which is a standard-less approach as it does not need any external standard.

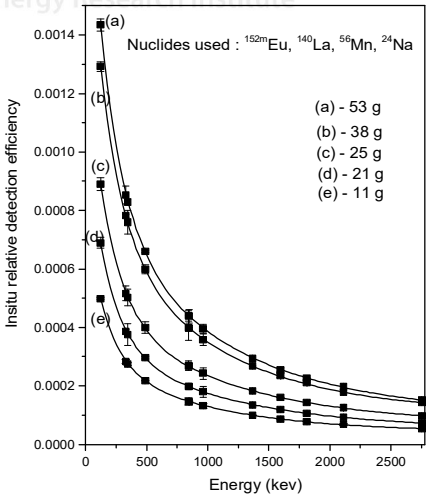

Fig.1: Relative detection efficiency of five irregular clay samples

References

1. IAEA TECDOC-1838 "Advances in neutron activation analysis of large objects with emphasis on archaeological examples" International Atomic Energy Agency Vienna, 2018.
2. K.B. Dasari, et al., J. Radioanal. Nucl. Chem. 286 (2010) 525-531.