Innovative Neutron Activation Approach for Analysis of Liquid Samples Based on Short-Lived Radionuclides

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Flowing sample neutron activation analysis (FSNAA) is a subclass of NAA, which has been developed for analysis of liquid samples [1]. It involves continuous pumping of a large volume of the sample, in a tube, between the irradiation site and the γ-ray detector [1]. Analysis of large volume of a sample improves the detection limits, while continues pumping allows better measurement of short-lived radionuclides. The set-up was previously tested with ^{252}Cf as a neutron source [1, 2]. The purpose of the present work is to install FSNAA at a research reactor to take the benefit of its high flux. Irradiation durability test was performing to select a suitable tubing material. Samples of different types were irradiated for different periods and then a simple bending test was performed [3]. The FSNAA set-up was constructed using the selected tube. The general procedures including: placing the sample in a sample tank, pumping it to the irradiation site, and then record a γ-ray spectrum with HPGe. A run with de-ionized water was carried out for leakage test and to check the performance of the set-up components as well as for background measurements. FSNAA was tested for analysis of tap and river waters samples. The analyzed sample volume was ~1l and the flow-rate was 30 ml/min. However, irradiation durability test showed that all tested tubes have acceptable radiation resistance; TYGON was used for constructing the system due to its excellent radiation durability. Nine elements were detected and quantified (Al, Mn, Mg, V, Na, K, Cu and Ca), while Cl, Br, I, and ^{18}O were detected but not quantified due to the lack of reference standard. The detection limits obtained from this preliminary study are satisfied in comparison to conventional NAA and other techniques. Levels of the quantified elements in the tap water are below the WHO guidelines [4].Under the current experimental conditions, the decay time (the travelling time between the irradiation site and HPGe) was ~ 3.5 min. This relatively long decay time hinders the analysis of several elements (those with shorter half-lives isotopes ex: ^{20}F, ^{46m}Sc, ^{77m}Se, ^{107m}Pb,…). Also, it adversely affects the detection limits of ^{28}Al, ^{52}V, and ^{66}Cu due to the decay of major fraction of their radioactivities before reaching the HPGe. As a future plan, use of powerful pump will be considered to reduce the decay times; and hence it is expected to increase the number of measured elements and improves the detection limits for some elements like Al, V, and Cu. The capability of FSNAA to measuring ^{18}O reveals its potential for determining past climate temperatures using, for example, water samples collected from ice cores.

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