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Geochemical and isotopic map of stream water as a basis of environmental traceability an example of northeastern Japan

NAKANO, Takanori[1*] ; SHIN, Kichoel[1] ; TAYASU, Ichiro[1] ; YOSHIMIZU, Chikage[1] ; OKUDA, Noboru[1] ; KATO, Yoshikazu[2] ; KOHMATSU, Yukihiro[2] ; KURITA, Yutaka[3] ; AMANO, Yosuke[3] ; TOGASHI, Hiroyuki[3] ; ISHIYAMA, Daizo[4]

[1]Research Institute for Humanity and Nature, [2]Ecological Research Center, Kyoto University, [3]Tohoku National Fisheries Research Institute, [4]Faculty of International Resource Sciences, Akita University

Traceability, which can trace the route of a material from its utilization to production area, is a key concept based on the precautionary principle of global environmental issues. All materials in the earth is composed of 92 elements, most of which have stable isotopes (SI). The ratio of SI of an element can be utilized as a traceability index regarding the source and process of the element in the environment. In order to establish a traceability method in earth environment using multiple elements and SI, Research Institute for Humanity and Nature (RIHN) has been installed analytical instruments of elements and SI in the laboratory, and started a project of making water quality map, which aims to elucidate the spatial distribution of the concentration and SI ratios of elements in terrestrial water. This is because elements in organisms and agricultural-fishery products are derived ultimately from ambient water, and the concentrations and SI ratios of elements in the water vary geographically rather than seasonally. This geographical variation of terrestrial water is attributed to the amount and quality of atmospheric precipitation and the geology and human activities in the watershed. Accumulating the data of water quality map provides basic information on traceability studies including water-material circulation, biodiversity, and climate change as well as agricultural and fishery products and food.

In order to elucidate the impact of atmospheric precipitation and the role of chemical weathering and human activities on fresh water, we determined the concentrations of 6 major ions and 46 trace elements and the isotopic ratios of hydrogen, oxygen, and strontium for about 1000 stream waters in the Iwate, Miyagi, Akita, and Yamagata prefectures of northern Tohoku, and compared them with geomorphology, geology and the geochemical map of river sediments.

The δD and δ^{18}O values of stream water tend to decrease with latitude and elevation, but their relation is expressed as δD=6.6δ^{18}O. The slope value of 6.6 is lower than 8.0 in the precipitation and it becomes low in the water of high δD and δ^{18}O values, indicating that river water experienced with evapotranspiration, particularly in southern and coastal areas where both values are high.

The ^{87}Sr/^{86}Sr ratio of stream water in igneous rock watershed ranges from 0.704 to 0.706, which is slightly higher than that of water in the Green Tuff region (0.706-0.707). The ^{87}Sr/^{86}Sr ratios of sedimentary rocks in the north Kitakami region (0.7085-0.7124) are higher than those in the south Kitakami one. The distribution of Sr/Ca ratio of stream water in the igneous rock watershed also resembles to that of watershed rocks. This correspondence of the Sr isotopic ratio and the Sr/Ca ratio of stream water with those of watershed rock reflects the major source of Sr as well as Ca in the water is largely derived from rocks.

However, although the distribution patterns of alkali-earth elements (Sr and Ca) in the water is similar each other, it is different from those in the river sediment. The distribution pattern of other major and trace elements is also different between river water and river sediment. This inconsistent pattern of elements indicates the important role of element fractionation during the chemical weathering of rocks into water, such as the adsorption and desorption of elements on the sediment particles.

Rare-earth elements of river water in the Miyagi prefecture tends to be higher than those in the Iwate prefecture. As REE are present as colloidal form, this tendency suggests that rocks in the Green-tuff region supply colloidal particles than granite and sedimentary rock which widely distribute in Iwate prefecture. Adsorption-desorption reaction play an important role on the water quality of water.

Keywords: geochemical map, isotopic map, stream water, traceability, northeastern Japan