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Water quality map in the southern part of Mt. Fuji for establishment of groundwater governance

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The local ecosystems in the area of Mt. Fuji have been supported and characterized by the large amount of groundwater. Human being has also received much benefit from the groundwater and spring not just for domestic and industrial use but for local traditional culture concerning water. The stable use of groundwater is important for the sustainable development of this area, and it is necessary for developing strategy for groundwater conservation and use to elucidate the mechanism of groundwater flow in the basin.

We summarized the quality of spring waters in the southern part of Mt. Fuji in map for the purpose of estimating the origin and recharge area of these springs. Study area is the foot of Mt. Fuji in Shizuoka Prefecture, including surrounding mountains (e.g. Mt. Ashitaka, Mt. Hakone, Tenshu Mountains). We collected 133 spring water samples from the study site in early winter (November to December 2009). We are also monitoring the quality of 35 spring water and 17 precipitating water samples. Samples were analyzed for major ions, trace elements and hydrogen, oxygen, and strontium isotopes. Geographic Information System was used to make the water quality map, which also contains information of e.g. geology, vegetation, land use and social conditions, in the study area.

The concentrations of Cl and Na of the monthly precipitation were higher during winter, whereas lower during summer and autumn. The isotopic composition of oxygen ($d^{18}O$) and hydrogen (dD) of the monthly precipitation did not vary seasonally, but $d^{18}O$ and dD values became lower at high altitude. The deuterium-excess values (d-values) of precipitation were higher at winter period and lower at summer period. In Mt. Fuji area, the snowfall in winter as well as the rainfall in summer is supposed to be formed by water vapor from the Pacific Ocean, so the seasonal fluctuation pattern of $d^{18}O$ and dD values would result from the seasonal difference in forming process of water vapor at the Pacific.

Relatively low $d^{18}O$ values were observed in the foot of Mt. Fuji except for spring waters in the southwestern foot. Low $d^{18}O$ values indicate that the groundwater was recharged at high altitude, which is estimated between 1,000 and 1,800 meters above sea level. The d-values tended to increase (>14) at the springs which showed low $d^{18}O$ values, probably because the winter precipitation amount including snow is large in the recharge area.

The concentrations of oxyanion-forming elements (e.g. V, P, As) are negatively correlated with $d^{18}O$ values. The high concentrations are interpreted as resulting from the elution of the elements by long-term interaction between rock and groundwater recharged at high altitude of Mt. Fuji. Conversely, high concentrations of NO_3 were observed at the springs in the southern foot of Mt. Ashitaka and the southwestern foot of Mt. Fuji, where high $d^{18}O$ values were observed. We consider the high concentrations of NO_3 to be of agricultural origin, because tea plantation predominates in the area. The spring waters in the basaltic rock area (Mt. Fuji, Mt Ashitaka and Mt. Hakone) display low $^{87}Sr/^{86}Sr$ values under 0.7040. In contrast, the $^{87}Sr/^{86}Sr$ values of spring waters in sedimentary rock area (Tenshu Mountains) are much higher (over 0.7055). In the monitoring data of spring water in the south foot of Mt. Fuji, high concentration of major ions and high $^{87}Sr/^{86}Sr$ values were observed between October and December, while low concentration of V and large quantity of spring water were observed in the same term, probably because of the difference in layers of original groundwater.

As described above, we can clarify the regional characteristics of spring water through the analysis of stable isotopes and dissolved elements. Mapping the information of water quality with GIS made it possible to analyze factors which contribute to the regional variations and, in addition, to form a basis for building a groundwater governance in the study area.

Keywords: Mt. Fuji, spring, water quality, GIS, groundwater recharge, groundwater governance