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Distribution of chemical and isotopic components in the stream water of Otsuchi town, northeastern Japan

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Otsuchi town in Iwate prefecture, northeastern Japan, was totally devastated by giant tsunami on March 11, 2011. This town is mainly composed of watersheds with three rivers (Otsuchi, Kozuchi, and Unosumai rivers) flowing into the Otsuchi Bay. The coastal plain area is small, but it is rich in groundwater of good quality and has been used for daily lives and industries such as Japanese sake, Tofu, and salmon hatchery. The wise use of this groundwater is expected to play an important role toward the rehabilitation of this town. In order to get basic information regarding the recharge area and flow system of the groundwater, we collected river water samples at about 200 sites in the tributaries and main streams of the three rivers and determined their chemical compositions and isotopic ratios. The distribution of water quality component was analyzed using ARC-GIS software.

The δD and δ^{18}O values of tributaries tend to decrease, whereas the excess-deuterium (d) value tends to increase, with the distance from the coast and/or elevation. The value of δD is expressed as $7\delta^{18}$O+5, showing the small evaporation of atmospheric precipitation. Accordingly, the high d-value in inland, mountainous area seems to suggest the high input of winter snow or re-precipitation of water vapor evaporated from the watershed area. The concentration of Cl, Na, Mg, and B tends to decrease along with the hydrogen and oxygen isotope ratios, indicating the decrease of sea-salt particles toward the inland atmosphere.

The watershed geology is composed of granite of Cretaceous age and sedimentary rocks of sandstone and shale in the Paleozoic to Mesozoic age. Sedimentary rocks contain chert blocks in the vicinity of the coastal area and basaltic rocks in the inland area. The strontium isotope ratio (^{87}Sr/^{86}Sr) of tributary water is correspondent to the distribution of watershed rocks; it is low in granite area (0.705-0.706) and is high in chert-dominant downstream areas (0.709-0.712). The Sr/Ca ratio is also high in the granite area but is low in other areas. This correspondence of water quality and watershed geology demonstrates the major source of Sr and Ca in the water is derived from rocks through chemical weathering. However, the distribution of the concentration of Sr and other elements in the water is not correspondent to the watershed geology, indicating other processes play a role in the chemical composition of water.

Heavy metals such as lead and cadmium in the water are low, indicating a negligible role by human impacts. However, some waters contain arsenic (As) whose concentration is above 2 mgL-1. As there are many abandoned gold deposits in the area, which accompanies As-bearing sulfides, it is likely some As in the water is ascribed to sediments derived from Au deposits.

The chemical and isotopic compositions of main stream are different from those of tributaries due to the mixing of waters. This difference becomes large in the main stream at downstream sites, indicating that the water quality map is based on the river with the same watershed area. Groundwater in the coastal area can be divided into three recharging areas, which are downstream waters of Otsuchi and Kozuchi rivers and small dale waters from Mt. Shiroyama in the west. The quality of the three recharging waters is consistent with the present river water data. In particular, strontium isotope ratios can separate three types' groundwater, demonstrating the usefulness of ^{87}Sr/^{86}Sr as an index of recharging water.

Keywords: Otsuchi town, groundwater, chemical compositions, stable isotopic ratios, Sr isotope