Summary on Hydrological Processes Revealed by Multi-tracer Approach in *RAISE* Project

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1. Isotopic variation of precipitation

For understanding mechanisms of precipitation variability causing severe droughts/floods, it worth quantifying contribution ratio of local and non-local water vapors to precipitation. We investigated characteristics of monthly/daily precipitation-isotopes over eastern Mongolia as a basic knowledge to assess the above. Temporal variation of precipitation isotopes, which has a dominant periodicity of 1-year, was considerably homogeneous in and around the Kherlen River basin. Local characteristics were not significant. Precipitation appears to be in isotopically equilibrium with water vapor within the atmospheric boundary layer (ABL). Considering a water-vapor-isotope result which suggests that contribution of locally evapotranspiring water vapor to that within the ABL is not dominant, great portion of precipitation (e.g., more than 80%) should be outside of the Kherlen River basin in origin.

2. Spatial and temporal variation of stable isotopes in atmospheric water vapor and subsurface water at grassland and forest sites

The source of atmospheric water vapor on the ground surface was investigated using stable isotopes of water in Kherlen River basin, eastern Mongolia. We observed stable isotopic compositions of atmospheric water vapor at the heights of 0.5 to 1000 m above the ground surface by aircraft and ground observations from June to October 2003. Also, soil water at the depths of 0.1 to 1.5 m, groundwater, stream water and plant water were also sampled and analyzed for stable isotopes. Seasonal variation trend of stable isotope in water vapor agreed well with that of precipitation at the grassland and forest sites. The ratio of transpiration rate to the evapotranspiration rate was estimated to be 60 to 73 % at the forest site, whereas that was estimated to be 49 to 58 % at the grassland site.

3. Groundwater flow system

We investigated recharge and flow system of groundwater in the semi-arid region of the Kherlen River Basin, using ^{2}H, ^{18}O, ^{3}H and solute concentrations in groundwater, river, spring water and precipitation. The relationship between altitude and ä^{18}O of river and precipitation suggests that the recharge altitude of Kherlen River would be from 1750 m to 2500 m which is corresponds to the headwater of the basin. Considering the ^{3}H concentration in river and groundwater, the residence time of river water should be much shorter than that of groundwater. Based on the stable isotope and Cl^{-} data on the groundwater, the precipitation with high amount and low isotopic ratio might preferentially recharge the groundwater, whereas small rainfall might be evaporated after the infiltration and not cause the groundwater recharge. It is probable that the groundwater would not have a contribution by a regional groundwater flow system. It is possible that the groundwater in the flat plain consisted mainly of a local groundwater flow system caused by topographical small relief.

We focus on the interaction between the groundwater and Kherlen River (catchment area: 40,095 km^2) water considering the stream runoff and stable isotope data. The stream base flow discharge was measured in main stream and tributaries flowing into the main stream during a dry period in June 2004. The main stream runoff rate increased from 10.8 m^3/s to 12.6 m^3/s during a flow of 300 km. A simple mass balance model including runoff rate and stable isotope ratio in the stream was used to estimate the inflow rate of the groundwater into the main stream. The inflow rate was estimated to be 1.0 m^3/s/58km in the upper stream, whereas that of lower stream was estimated to be 2.6 m^3/s/247km. Thus, approximately 10 % of the stream runoff was recharged by groundwater in the upper stream in the Kherlen River.

4. Overland flow generation and surface erosion

The purpose of our research is to study and assess the state and the causes of soil erosion through the monitoring of overland flow and soil erosion. The study site locate 60-100 km east of Ulanbaatar. One site is Kherlen Bayaan Ulaan (KBU), and the other site is Baganuur (BGN). The drainage area of the watershed is 7.1 ha and 8.0 ha, and relative height is 105 m and 160 m, respectively. Parshall flumes and sediment traps were installed at the outlet of the catchments. Also we established 2 hillslope plots (50 m x 50 m) in each area in which one is surrounded by fens Discharge flow plots were monitored by Parshall flumes, and tensiomters, raindrop impact sensors wind velocities were also recorded. About 50 Soil cores were sampled in each catchments and Cs-137 analysis were conducted. The runoff peak in 2003 in KBU is greater than BGN. Through the Cs-137 analysis, long term soil erosion is very significant throughout the catchment is KBU, but deposition area were detected downslope of the catchment and lower overall erosion rate in BG. These data suggest the overlandflow erosion is significant in the study area, but importance of surface erosion varied between place to place.

5. Difference in runoff process between steppe and forest-steppe sites

We compared the runoff process of steppe drainage basins with those of forest-steppe ones. The study sites (Gr and Sa) of forest-steppe areas locate about 30km east and north of Ulaanbaatar. The drainage area of drainage basin of Gr and Sa is 1.7 km^2 and 2.7 km^2 and relative height is 450 m and 500 m, respectively. Both sites are covered with coniferous forest and grassland. The steppe sites (KBU and BGN) locate 60-100 km east of Ulaanbaatar. The drainage area of the watershed is 7.1 ha and 8.0 ha, and relative height is 105 m and 160 m, respectively. The vegetation of steppe sites occurs more sparsely than that of forest-steppe sites. Parshall flumes were installed at the outlet of the drainage basins. Not only quick discharge with very steep rising limbs and recession curves, but also continuous runoff occurred in forest sites, whereas only quick discharge occurred in steppe sites associating with heavy rainfall. These facts imply that regolith layer acting as a flow path in forest-steppe sites generates continuous discharge, but only overland flow occurs in steppe sites.