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Water storages and fluxes within the small watershed in continuous permafrost zone

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It is widely accepted that the main source of river runoff in continuous permafrost zone is surface flow and the flow in the seasonally thawing layer. Although the existence of taliks (a layer of year-round unfrozen ground that can be found in permafrost areas) is acknowledged they are usually not considered in the analysis of streamwater sources and in hydrological modelling approaches. The study aims at assessing the possible river sources in small permafrost basin and their contribution to streamflow with special attention to hydrological role of taliks. The study is based on field surveys in 2015 and 2016, the analysis for stable isotopes (δD and δ18O) and the application of a simple mixing model.

The Shestakovka River (basin area 170 km2) is a left tributary of the Lena River in the vicinity of Yakutsk city, Eastern Siberia. The climate is dry and continental. Mean air temperature is -9.5°C, precipitation is 240 mm/year, annual runoff depth – 24 mm. Dominant landscapes are pine forest (47% of the watershed area), larch-birch forest (38%) and bogs (14%). Suprapermafrost talik with an area of 58 000 m2 was found on the slope covered by the pine forest in 1980s. Field studies showed that the summer flow depth in talik is 60 mm.

In 2015 and 2016 264 water samples from river streams, lakes, snow, rain, suprapermafrost groundwater and ground ice were taken in the Shestakovka River watershed and analyzed for stable isotopes composition. Snow has the lightest isotopic composition that varies between -230 and -275‰ in δD and between -30 and - 37‰ in δ18O. Rain water is on average most enriched in δD (-70…-150‰ and in δ18O (-6…-19‰. River water and surface flow in bogs are depleted during snowmelt (April – May) and enriched at the end of the summer. δ18O and δD concentrations in lake water vary from -20‰ and -185‰ in snowmelt period to -10‰ and -110‰ in July and August respectively. Suprapermafrost groundwater in two taliks has δ18O values between -19‰ and -24‰ δD values between -150‰ and -175‰İsotopic concentrations of groundwater are stable through the year.

Field surveys and the analysis of isotopic concentrations showed that some surface flow occurs only in bogs. Subsurface flow forms in larch forests in seasonally thawing layer in July and August. Dry sandy deposits at some slopes in pine forests do not produce surface or shallow subsurface flow but could contain deeper groundwater in taliks.

The results of simple two-component mixing model application has shown that in 2015 snowmelt water contributed only 54-70% of streamflow while 30-46% of freshet was supplied by pre-event water. In our opinion suprapermafrost talik water is the most feasible source of the pre-event water. The presence of groundwater in streamflow is indirectly confirmed by the fact that the correlation of total river runoff with last-year precipitation is stronger than with this-year precipitation. It suggests that large and slow water storages in the basins are important chain of hydrological cycle. Taliks could potentially be a significant source for the small rivers in permafrost environments that is not reflected in current process understanding and modelling approaches.

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