Ecology of willow in the Arctic for reconstruction of Indigirka river condition and its tributaries

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Rapid and strong increases in temperature have been observed in Arctic region (Serreze and Barry, 2011) and further warming is expected to occur in next 50-100 years (ACIA, 2004; IPCC, 2013). It has been pointed out that boreal forest may expand northward (A J Hansen, et al, 2001). Taiga-tundra boundary ecosystem may potentially develop into either forest or tundra, and two ecosystems play important roles in cycling of materials and the global climate system. In Arctic region of northeastern Siberia, there is a large area of Yana-Indigirka-Kolyma lowland. River clearly links to reginal climate and shapes surrounding ecosystem through a change in river water level. And these changes definitely control plant community composition, carbon allocation, nutrient cycles and then material cycling.

From vegetation map around Indigirka river (Morozumi, 2015), one sixth of area covered by willow, and unlike larch trees, willow as a kind of shrub can stand disturbance and high soil moisture, therefore fields of willow cover large area along Indigirka mainstream and its tributaries. For this particular character, willow growing along the rivers can be good records of river condition.

Carbon and Nitrogen stable isotope ratios of plants are known as integrated indicators of environment: plant $\delta^{13}C$ is controlled by environmental factors like aridity and solar radiation, while $\delta^{15}N$ is depending on N sources. Plant $\delta^{18}O$ is expected to record source water isotope ratio. River water $\delta^{18}O$ values of Indigirka and its tributaries show seasonal variation, and usually mainstream had lower $\delta^{18}O$ than tributaries. However, in 2011, tributary river water had the same $\delta^{18}O$ value as mainstream (Takano, personal communication). This condition was caused by flowing of main stream water into the tributary because of a high water level of mainstream. Therefore, in this study, it is hypothesized that the difference in $\delta^{18}O$ of river water between mainstream and tributary indicates the relative water level between mainstream and tributaries. If the difference in $d^{18}O$ between mainstream and tributary can be estimated from that of willow tree ring, it can be used to know Indigirka river water level.

Therefore using stable isotope ratios of willow, reconstruction of river water level will be challenged. Investigation of river condition will be also conducted in this study. Better understanding of characteristics of willow contribute to know the lowland ecosystem in this region.

Purposes of this study is to know:

1) current environment of river for willow (controlling factor of willow distribution and production) using willow $\delta^{13}C$ and $\delta^{15}N$ and other parameters.

2) relationship between river water and willow $\delta^{18}O$, and confirm that it can be used to reconstruct water level differences between mainstream and tributaries.

3) water level reconstruction of the past by tree ring analysis.

The research site is near Chokurdakh (70.63°N, 147.91°E), Yakutia, Russian Federation, located in taiga-tundra ecosystem along Indigirka river. In this work, there are two steps. The first step is to use current year shoot to figure out the relationship between plant stable isotope and distance to river and to confirm spatial distribution. The second step is tree ring analysis. At the first step, three sites in total were set up, one of them is along Indigirka mainstream and two other sites are along tributary. At each site, three points along a transection from river to land. Samples were collected every 4 days totally 5 times from July 11th to August 1st, 2015. The samples including river water, soil water, willow stem, willow current year shoot. MAT253 was used for $\delta^{18}O$ analysis and Delta V was used for $\delta^{13}C$ and $\delta^{15}N$ analysis.

Observed willow foliar $\delta^{13}C$ and $\delta^{15}N$ apparently showed differences between water logging and no water logging points. This means these parameters may be useful to know the environment of growing sites of willow. From $\delta^{13}C$ and $\delta^{15}N$ of willows along the transection from river to land, sites of water logging range (water level) will be estimated. In summer of 2015, the $\delta^{18}O$ value of mainstream was also different from tributaries, which indicates the tributary had different water supplies from mainstream (mainstream water level lower than tributaries). In addition, soil water $\delta^{18}O$ at the nearest location of river was affected by river water. Stem water of willow was confirmed to reflect soil water $\delta^{18}O$.

The δ^{13}C and δ^{15}N of willow leaves at various site with different distance from the river will be analyzed to know the environment of each site. After deciding pretreatment method of samples and checking seasonal variability in growing season, δ^{18}O of willow will be analyzed to confirm that it reflects river water δ^{18}O. This research will turn to tree-ring studies to reconstruct water level and the water level differences between mainstream and its tributaries.

References

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