Carbon, oxygen and hydrogen isotopes in pine and oak tree rings from Poland as climatic indicators

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Carbon, oxygen and hydrogen isotope ratios in the α-cellulose of pine wholewood (*Pinus sylvestris* L.) and oak latewood (*Quercus robur* L.) were measured. Investigated trees came from two different ecologically and climatic sites in Poland: ecologically clean site in North-East Poland (influence of continental climate) and site in close neighborhood of industry centre in Southern Poland (influence of oceanic climate). Presented isotope records cover the periods of last hundred years for hydrogen and last four hundred years for carbon and oxygen isotopes.

For those periods, comparison of obtained values of $\delta^{13}C$, $\delta^{18}O$ and $\delta^{2}H$ between sites as well as between trees was done. High correlation coefficients was always observed between $\delta^{13}C$ and $\delta^{18}O$ from the same site and between $\delta^{18}O$ between sites. Significant correlation values were also observed between $\delta^{18}O$ and $\delta^{2}H$ values between sites. Obtained values of $\delta^{13}C$, $\delta^{18}O$ and $\delta^{2}H$ were also compared with available meteorological data which was temperature, precipitation and sunshine. Calculated correlation coefficients shows strong, negative relationship between oxygen isotope composition and annual precipitation. Negative relationship can also be observed for precipitation and $\delta^{13}C$ values. High, positive correlation coefficients between oxygen and summer sunshine in both pine and oak prove, that oxygen isotope is the best indicator of summer sunshine. Similarly, positive correlation coefficient values are observed for carbon isotope composition and summer sunshine. Our investigation show, that hydrogen can be very good indicator of summer temperature. On the basis of our investigations pine seems to be more sensitive indicator of environmental changes than oak.

Human impact on environment is also visible in annual records of pine from Southern Poland site, where rapid decrease of $\delta^{13}C$ values in 1966 from level -22.46‰ to -24.64‰ is observed. Very low values of $\delta^{13}C$ are observed till 90s' which can be related with activity of steel works in the site's neighborhood.

Based on the correlation between meteorological, dendrochronological and obtained data of isotopic composition of carbon and oxygen in tree rings, climate changes over last 400 years were deduced. Moreover relationship coefficients between $\delta^{13}C$ values from pine from both sites and meteorological data (temperature and precipitation) were calculated with use of multiple regression models. On the basis of this calculations, climate reconstruction for the last 400 years was made. Comparison of reconstructed values of temperature and precipitation with available meteorological data show, that reconstruction was more accurate for the ecologically cleaner site form Northern Poland. Climate reconstruction was also made with use of neural networks. First, single parameter reconstructions are very promising and calculated correlation coefficients between reconstructed parameters and known meteorological data are high and significant. Multi parameter neural networks were also build and used for reconstruction.