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Photosynthetically Active Radiation Dynamics in Wetland Ecosystem: A Decadal Study in the Biebrza National Park, Poland

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Photosynthetically active radiation (PAR) is one of the most important ecosystem steering factors. This study presents the results of 10-year (2013-2022) continuous measurements of incoming (PAR_d) and reflected (PAR_u) photosynthetically active radiation made at the Kopytkowo site (53°35'30.8'' N, 22°53'32.4'' E, 109 m ASL) within the Biebrza National Park in northeastern Poland. The site represents a unique wetland ecosystem on a European scale. The assessment employed a PQS1 Quantum Sensor positioned at a height of 2.7 m AGL, capturing PAR with a time step of ten seconds. Subsequently, the data underwent averaging to establish a 5-minute time step used in the study. The results were expressed in photosynthetically active photon flux density (PPFD in $\mu mol \cdot m^{-2} \cdot s^{-1}$).

Two distinct seasons corresponded to different PAR_d regimes in the Biebrza Basin. On average the first season (the warm part of the year) commences in the latter half of March and lasts until early October. Throughout this period, the development of convective cloudiness impacts daily photosynthetically active radiation values. The winter season, which lasts for the remainder of the year, is characterised by a higher proportion of cloudy days, influencing the reduced values of surveyed radiation. In general, the annual and daily PAR_d course reflects the incoming radiation on the top of the atmosphere and its attenuation in the atmosphere. On the contrary, the highest values of PAR_u manifest during the winter months, resulting from reduced vegetation development and snow cover present at the measurement site. Around mid-April values of PAR_u begin to drop due to vegetation growth and the assimilation of light.

Simultaneous measurement of PAR_d and PAR_u allowed the calculation of albedo in terms of photosynthetically active radiation, which was then used to trace changes in the growing season of plants and their growth dynamics in the study area. Research shows an average of about 210 days of increased absorption of photosynthetically active radiation per year, which falls during the vegetation development period (April to November). The first stage (rapid development) starts at the beginning of April and lasts until the middle of the month. It is characterized by a sharp decline in the proportion of PAR. This is followed by a period of stable expansion, which lasts until the end of May, after which the PAR_u/PAR_d ratio remains at a similar low level until mid-November. The highest values occur in January and February, due to the presence of snow cover, which increases the reflection of radiation, and due to reduced plant activity.

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