

# Impact of Strontium Substitution on Electron Transport in Photosystem II of *Limnospira maxima*

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The role of calcium in the water-oxidizing complex (WOC) of Photosystem II (PSII) is established as facilitating the structure and function of the manganese oxidation cycle, with strontium ( $\text{Sr}^{2+}$ ) being the only known functional substitute. *Limnospira maxima* was chosen as the model organism for this study due to its robust PSII activity, making it ideal for determining the physiological impacts of metal substitution *in vivo*. Biosynthetic substitution of  $\text{Ca}^{2+}$  with  $\text{Sr}^{2+}$  was investigated in *L. maxima* to determine its effects on photosynthetic electron transport. 77K fluorescence spectroscopy revealed that  $\text{Sr}^{2+}$  substitution alters the stoichiometry of the photosystems, resulting in fewer overall photosystems but with a higher proportion of healthy PSII and stronger antenna association compared to the control. Despite this, fewer excitons reached the PSII reaction center, suggesting impaired energy transfer. Fast repetition rate fluorometry demonstrated reduced oscillation quality and increased accumulation of the  $\text{S}_2$  state, suggesting  $\text{Sr}^{2+}$  rate-limits the opening and closing of the WOC.  $\text{Q}_\text{A}^-$  reoxidation kinetics demonstrated that  $\text{Sr}^{2+}$  does not limit the acceptor side of PSII in *L. maxima*, possibly due to bicarbonate mitigation, contrasting prior findings in *Thermosynechococcus elongatus*. Cytochrome  $\text{b}_\text{f}$  redox kinetics revealed greater oxidation and faster electron resupply under  $\text{Sr}^{2+}$ , while plastocyanin was less oxidized by PSI. P700 kinetics demonstrated that PSI draws electrons more rapidly than PSII can supply under  $\text{Sr}^{2+}$  substitution. These findings indicate that  $\text{Sr}^{2+}$  substitution shifts the balance of PSII and PSI electron dynamics by altering redox potentials, altering WOC efficiency, and potentially promoting reactive oxygen species production.