Effects of artificial light at night (ALAN) on alpine stream periphyton: a flume simulation

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Artificial light at night (ALAN) is one of the most widespread human-induced alterations of the landscape, it is increasingly recognized as a contributor to environmental change and a threat to biodiversity at the global scale. Increasing research efforts have demonstrated numerous adverse effects on aquatic and terrestrial animals, microorganisms and plants. Aquatic primary producers, however, have rarely been studied, and our understanding of ecological effects on benthic autotrophs remains limited. Benthic autotrophs, such as diatoms, green algae and cyanobacteria, grow attached to underwater surfaces within complex periphyton communities and form the basis of the food web in many streams and clear, shallow waters. They use light both as a source of energy as well as a source of information for the regulation of physiological processes according to light/dark cycles. The main autotroph groups differ in their preferences for light conditions, therefore the alteration of light regimes may cause changes in periphyton growth and community composition. We conducted experiments in an outdoor flume system mimicking a sub-alpine stream (Trentino, NE Italy). We simulated the night-time light conditions of a waterbody in a light-polluted area (approx. 20 lux), and compared the biomass and community composition of benthic autotrophs in periphyton grown under ALAN with those grown under natural nights. The experiments were performed in two seasons in order to account for seasonal differences in community composition. The LED-based nighttime illumination resulted in a decrease of autotroph biomass and an increase in the proportion of diatoms. The effects depended on the season and the growth stage of the periphyton, indicating higher sensitivity to ALAN exposure in early growth stages (one to three weeks) compared to the later ones (four to seven weeks). Our results show that artificial light can have profound effects on the primary producers of aquatic ecosystems. By negatively affecting the biomass and altering community composition, artificial light at night may hinder primary production, which is a vital ecosystem function. Streams with frequent flooding events, droughts, sediment transport or physical perturbations that all reset the development of periphyton are expected to be more affected by ALAN than those with stable conditions. ALAN may therefore negatively impact the resilience of aquatic ecosystems.