

OPINION

Distinguishing autotrophic and heterotrophic respiration based on diel oxygen change curves: revisiting Dr. Faustus

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SUMMARY

1. In his paper 'Climate change, nutrient pollution and the bargain of Dr. Faustus', Moss (*Freshwater Biology*, 55, 2010, 175) described the interacting and mutually reinforcing effects of climate change and nutrient pollution on aquatic ecosystems.

2. Among other things, Moss (*Freshwater Biology*, 55, 2010, 175) proposed a simple method for determining autotrophic and heterotrophic respiration rates (R_a and R_h) based on the diel oxygen change technique. Here, we show that one of the assumptions on which the method is based is flawed and that R_a and R_h cannot be derived mathematically from diel oxygen change curves.

Keywords: autotrophs, ecosystem respiration, heterotrophs, methods, primary production

Introduction

Climate change and eutrophication are two stressors that individually compromise water quality and affect aquatic ecosystems deleteriously. Additionally, the two stressors interact and often work synergistically, although the exact effect on aquatic systems is uncertain (Moss, 2010). One uncertainty concerns the effect on the greenhouse gas balance of aquatic systems. Moss (2010) and others (e.g. Gudas *et al.*, 2010; Kosten *et al.*, 2010; Yvon-Durocher *et al.*, 2010a,b; Demars *et al.*, 2011) suggest that aquatic systems will emit more greenhouse gases when they warm due to climate change. The combined effect of eutrophication and warming is not straightforward (Moss, 2010), however, because primary production and respiration increase simultaneously (Moss *et al.*, 2011). One of the challenges in predicting the combined effect of both stressors on the balance in emissions of greenhouse gases from aquatic systems is to assess their effects on autotrophic and heterotrophic respiration.

The problem

Disentangling autotrophic and heterotrophic respiration has been a long-standing challenge in both terrestrial (Bond-Lamberty & Thomson, 2010) and aquatic ecology (Robinson & Williams, 2005). In aquatic ecology alone, a range of methods has been used, all with their merits and shortcomings (Robinson & Williams, 2005), but with the common feature that they are often time-consuming and come with large uncertainties. In his paper 'Climate change, nutrient pollution and the bargain of Dr. Faustus', Moss (2010) proposed a simple method for determining autotrophic and heterotrophic respiration rates (R_a and R_h) based on the diel oxygen change technique.

Moss (2010) based his method on the postulate that the area ABCDEGF (Fig. 1) is the sum of gross primary production [$PP_{\text{gross}}(24 \text{ h})$] and $R_h(\text{light})$. Although this postulate seems convincing at first, the area ABCDEGF has no readily definable meaning. Based on the classical

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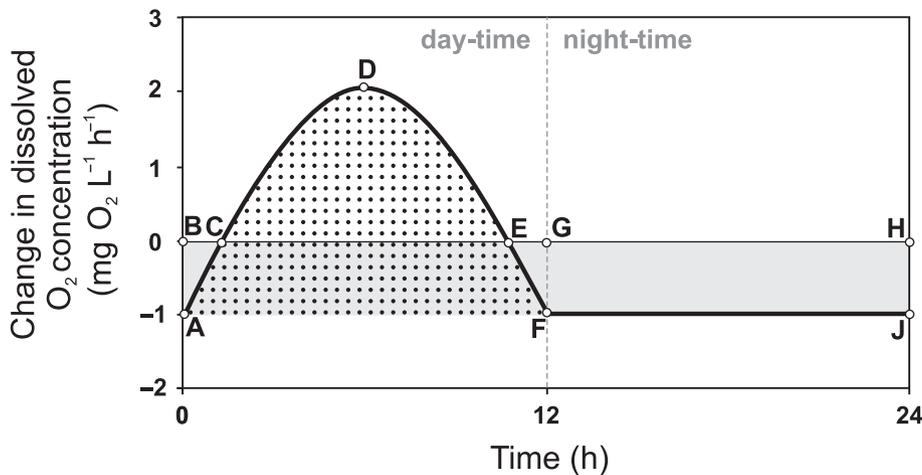


Fig. 1 Idealised diel oxygen change curve for a standing water system.

analysis of the diel oxygen change technique by Odum & Hoskin (1958) and Seeley (1969), who identified the dotted area in Fig. 1 (ACDEF) as an estimate of the gross primary production of the system (PP_{gross}) and the grey area (ABHJ) as the community respiration (R_c), we can derive that $PP_{\text{gross}}(24 \text{ h}) + R_c = \text{ACDEF} + \text{ABHJ}$. If we assume that autotrophic respiration does not exceed PP_{gross} (reasonable since autotrophs cannot consistently respire more than they produce), then the area representing autotrophic respiration is confinable within ACDEF (Fig. 1). However, it is still not possible to distinguish respiration by autotrophs and heterotrophs. What is clear is that ABGF represents the diurnal respiration, but which portion of the area can be contributed to R_a and R_h cannot be assessed solely by the diel oxygen curve.

Implicitly, however, the diel oxygen change curves method does convey approximate information about the relative importance of autotrophic and heterotrophic respiration. The assumption that a fixed proportion of PP_{gross} is respired by autotrophs (e.g. 10% Cole, Caraco & Peierls, 1991; or 35% Duarte & Cebrian, 1996) enables a rough estimate of R_a and (because $R_c - R_a = R_h$) therefore also of R_h . However, this approach is hard to justify when studying the effects of warming and eutrophication on R_a and R_h , because both temperature and nutrient status are likely to influence the percentage of PP_{gross} that is respired by autotrophs. Although other techniques exist to disentangle autotrophic and heterotrophic respiration, for instance the use of biomass-respiration algorithms or respiration measurements in filtrates with different particle sizes (assuming the smallest fraction to be bacteria), they all come with considerable uncertainties (see Robinson & Williams, 2005 for an overview). Recently, the determination of autotrophic respiration as the difference between PP_{gross} and

^{14}C -derived PP_{net} (Marra & Barber, 2004; Marra, 2009) has received more support (e.g. Nicholson *et al.*, 2012). The question remains, however, under which conditions the assumption that the ^{14}C method provides PP_{net} is valid. With growing interest in the global carbon cycle, the partitioning of community respiration will certainly receive more attention in future work. Fine-tuning existing methods and development of new ones are needed to advance in this respect.

Acknowledgments

SK thanks the NIOO-KNAW literature discussion group, specifically Susanne Wilken and Jan Kuiper, for help in clarifying ideas on this subject. Thanks to Raquel Mendonça for the figure preparation and to Prof. Alan Hildrew and three anonymous reviewers for suggestions to improve the manuscript. SK was supported by NWO-VENI grant 86312012.

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(Manuscript accepted 12 November 2013)