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Interactive comment on "Vertical transport of sediment-associated metals and cyanobacteria by ebullition in a stratified lake" *by* Kyle Delwiche et al.

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Transfer of substances across interfaces assumes significance to understanding material balances, drivers and functioning of ecosystems. In aquatic systems transport of materials from sediments to overlying water column is known to occur through diffusive fluxes and episodically under sediment disturbed conditions. The role of bubbles is well recognized as transporters of materials from water column to surface layers but the current manuscript adds a new dimension by demonstrating export of sediment particles to surface and quantifying associated substances including biota transfer to upper layers by this mechanism. The results are significant with particular reference to

shallow aquatic ecosystems and also highlight the role of bubbles in material exports in other in systems of relevance. In general the manuscript is presented well but requires some minor revisions as per the following observations:

Abstract

Line 9: 'Bubbles adsorb and transport particulate matter both in industrial and marine systems' – include lakes systems here.

Line 9-12: 'methane-containing bubbles emitted from anoxic sediments are found extensively in aquatic ecosystems' – the word "extensively" is inappropriate for marine systems since methane- containing bubbles can only be found in a few select coastal ecosystems. However, this issue assumes greater and global significance in vertical transportation of dissolved and particulate materials scavenged across a few meters below to sea surface by the rising wind-induced bubbles, particularly in shallow marginal systems.

Introduction

Lines 34-35: 'Metals can be mobilized from sediments via solubilization by oxidation-reduction reactions, and by sediment resuspension or bioturbation' – mobilization can also occur through acidification of lakes.

Line 35-36: 'transport to surface waters of contaminants mobilized from the sediment is affected by lake hydrodynamic conditions, notably stratification' – an interesting question to the current investigation be how does stratification influence methane bubble rising to surface during minimal wind induced turbulent conditions? A strongly stratified upper water column will inhibit (slow down speed of rising) or even prevent particularly small sized but proportionately with large surface areas from rising across the strong pycnocline. This is possible if vertical profiling is done with close intervals of sampling to find density gradients across the pycnocline and assessing the bubble rise rates in hypo- and epilimnion layers.

Lines 40-41: 'Verspagen et. al. (2005) showed that recruitment from sediments of the potentially toxic cyanobacterium Microcystis was a major driver of the summer bloom (Verspagen et al., 2005)' – referenced twice in the same sentence!

Lines 66-67: 'the full extent of bubble particle flotation in aquatic systems remains unknown.' – even the present manuscript cannot make it 'full', which requires many attempts by many investigators!

Line 70: Fig. S1 should show pictures before and after the bubble event to highlighting the emergence of particles following the bubbling.

Lines 78-80: 'Given the expected importance of both bubble size and total bubble volume, we used a bubble size sensor (Delwiche et al., 2015; Delwiche and Hemond, 2017) to measure bubble diameter distributions both in the lake and in the laboratory.' – adsorption or scavenging of particles by bubbles is expected to be proportional to the surface area of the bubble (similar to metal adsorption on to a particle) and therefore representing bubble characteristic in terms of 'surface area' than its 'size' or 'volume' would be preferable.

Methods

Lines 101 and 250: 'another lake' – please name the lakes.

Lines 111-112: 'All bubbles rising through the bubble size sensor or collection funnel entered the flexible tubing and rose into the sample cup.' – as the particles and the associated substances are adsorptive in nature it is likely that some of the rising bubble attached particles are adsorbed in the flexible tubing etc. before they reached sample cup. Authors may include a statement on this possible loss of particles during sample processing.

Line 117: Word 'approx.' may not be necessary as the coordinates are specified to third decimal.

Lines 119-120: 'preventing mixing from of the sediment to the surface.' – requires

rephrasing.

Lines 121-124: Good strategy.

Line 250: Please correct the flux units 'cells m-2' to cells m-2 d-1.

Results and Discussion

Lines 262-263: 'demonstrate that bubbles transport particles from depths of at least 15 m to the lake surface.' – It may be revised as "demonstrate that bubbles transport particles from depths to the lake surface" since bubbles if formed even in deeper waters can transport materials to surface.

Line 307: Lines 134-135 mention 'On 26 June 2018 we sampled for cyanobacteria bubble transport using similar procedures, except we used a simple inverted funnel instead of a custom bubble size sensor to intercept rising bubbles' whereas Fig. S7 caption shows "Frequency distribution numbers are approximate because the bubble size sensor is unable to measure fast bubble flux or very small bubbles" – It is important to check the compatibility between these statements, particularly for data of 26 June 2018 if used.

Line 317: replace ug with μg.

Lines 342-343: Besides 'a significant fraction of the arsenic input to epilimnetic waters can be attributed to inflow from the Aberjona River (Hemond, 1995)' aerial transport of dust associated arsenic/metals should be invoked here to be among the unknown inputs.

Lines 361-362: 'Bubble-transported particulate matter contained cells at a rate of approximately 30 cells mL-1 gas, indicating that bubbles are capable of transporting cyanobacteria through' – May be revised as "Bubble-transported particulate matter contained cells at approximately 30 cells mL-1 gas, indicating that bubbles are capable of transporting cyanobacteria through". A 'rate' is expected to be material transferred during a specific duration (time). ***

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