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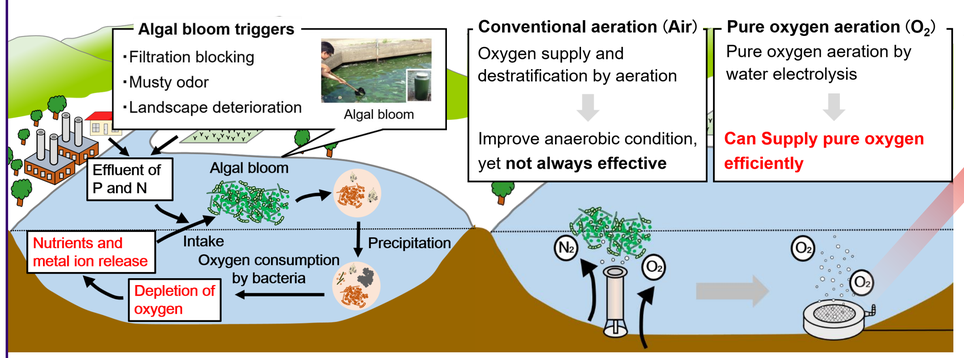
Study on availability of oxygen productive electrode (OPE) for improvement of anaerobic condition in lake

Shunichi Ohyama[1], Kazuya Shimizu[2], Motoo Utsumi[3]*

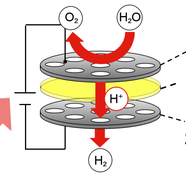
1: Graduate school of Life and Environmental Sciences, Univeisity of Tsukuba
2: Faculty of Life Sciences, Toyo University
3: Faculty of Life and Environmental Sciences, University of Tsukuba
* Correspondence to utsumi.motoo.ge@u.tsukuba.ac.jp

University of Tsukuba s1521061@u.tsukuba.ac.jp

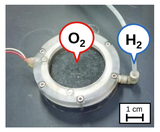
Introduction



OPE (Oxygen Productive Electrode)



- Keep high dissolved oxygen by producing microbubble
- Can collect hydrogen and utilize it as energy source

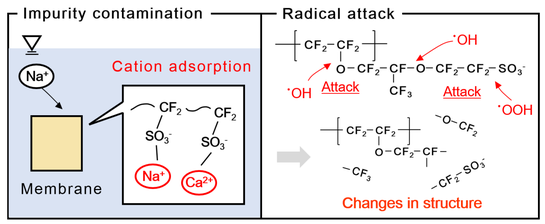


Picture of OPE

Objective 1

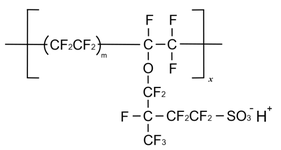
To elucidate whether OPE aeration can improve anaerobic condition and prevent nutrient release from sediment

Causes of membrane degradation



(Rogers *et al.*, 2012; Hongsirkarn *et al.*, 2010)

SPE membrane degradation on site



Structural formula of Nafion

Nafion 117 membrane degradation

Although Nafion is well-known for its chemical and mechanical stability, degradation occurred after mesocosm experiment

Objective 2

To elucidate the effect of cations in water on SPE membrane degradation

Materials and methods

Mesocosm experiment

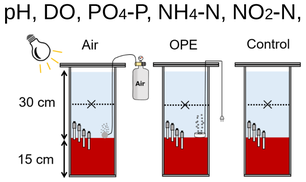
- Sampling point: Lake Kasumigaura
- Sampling date: 2014/12/22

Experimental condition

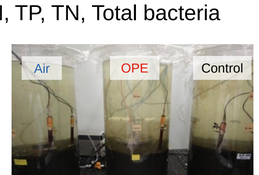
- Duration: 3 weeks
- 25℃, Light-dark cycle 12 h
- Aeration flow rate: 25 mL/min, Current density: 7.50 mA/cm^2

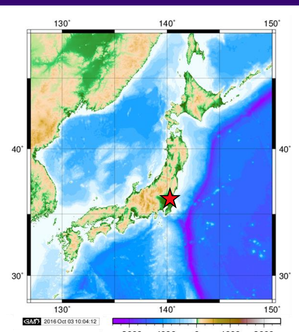
Measurement items

- pH, DO, PO_4-P, NH_4-N, NO_2-N, NO_3-N, TP, TN, Total bacteria

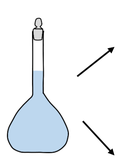


Sampling point(×)→15 cm above sediment

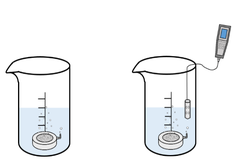




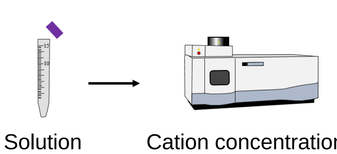
SPE membrane degradation experiment



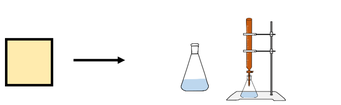
- Artificial lake water containing as the same amount of cations as Lake Kasumigaura (Used SO_4^{2-} or Cl^- salt)
  Concentration: Na^+: 25 mg/L, Ca^{2+}: 20 mg/L, Mg^{2+}: 7 mg/L, K^+: 6 mg/L, Al^{3+}: 0.1 mg/L
- Cation concentration: 20, 40 ppm (Used Cl^- salt)



Artificial water 20, 40 ppm



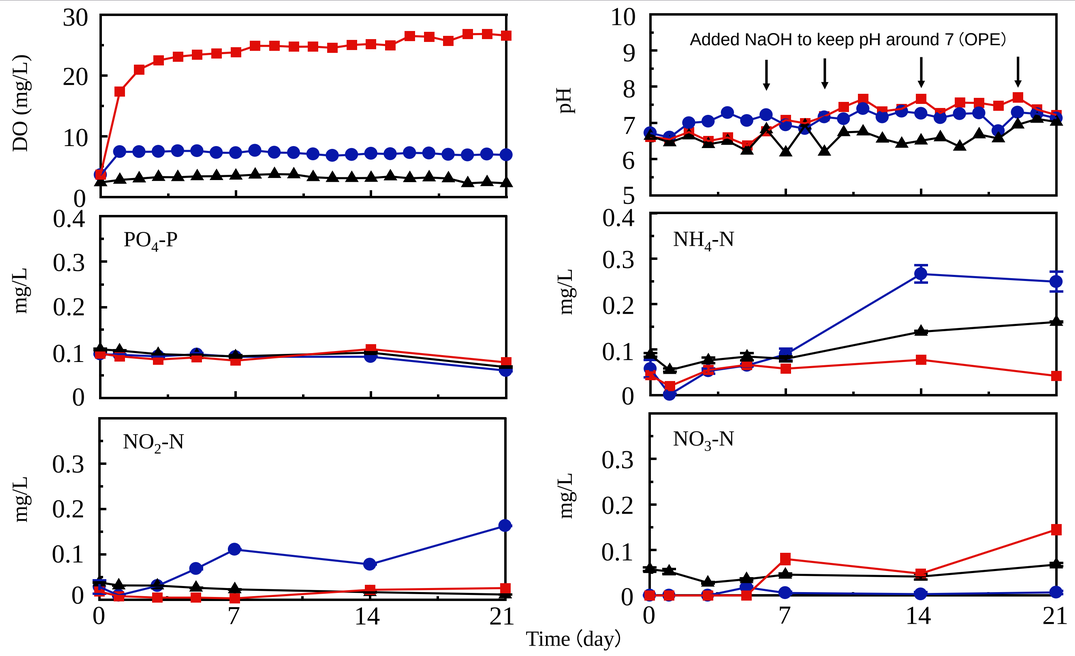
Solution Cation concentration



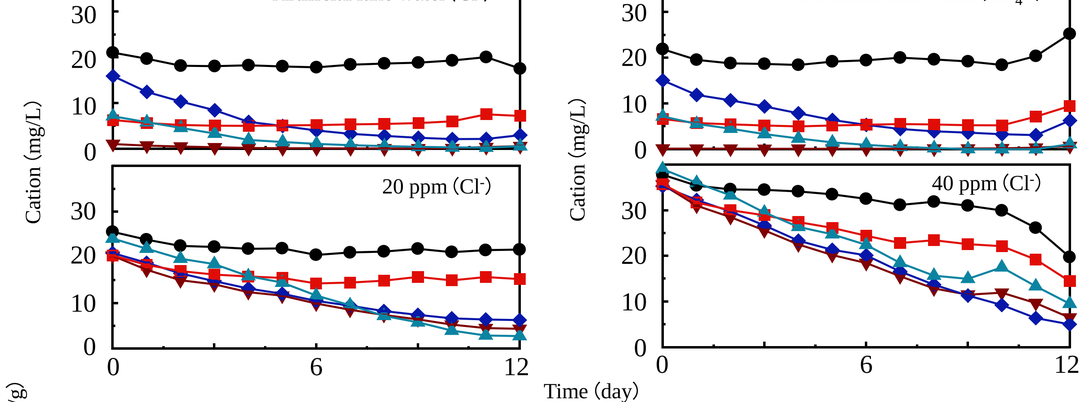
Membrane Ion exchange capacity

- Room temperature
- Duration: 12 days
- Current density: 3.0 mA/cm^2

Results and Discussion



- OPE aeration could keep high DO concentration during the experiment
- Ammonium release from sediment was suppressed by OPE aeration



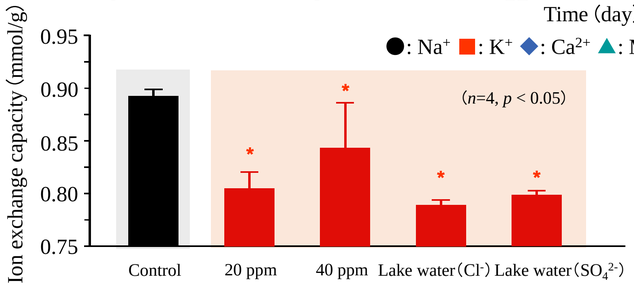


Table. Adsorption constant

Cation	k_{Cl^-} (d^{-1})	$k_{SO_4^{2-}}$ (d^{-1})	$k_{20\ ppm}$ (d^{-1})	$k_{40\ ppm}$ (d^{-1})
Na^+	3.10×10^{-3}	0	1.04×10^{-2}	3.58×10^{-2}
K^+	0	0	1.83×10^{-2}	5.69×10^{-2}
Ca^{2+}	1.69×10^{-1}	1.17×10^{-1}	1.08×10^{-1}	1.56×10^{-1}
Mg^{2+}	2.81×10^{-1}	5.43×10^{-1}	1.93×10^{-1}	1.02×10^{-1}
Al^{3+}	9.43×10^{-2}	0	1.32×10^{-1}	1.28×10^{-1}

- SPE membrane preferentially adsorped multivalent cations (Mg^{2+}, Ca^{2+}, Al^{3+})
- Ion exchange capacity significantly decreased compared with control

Conclusions

1. **OPE could keep high DO during the mesocosm experiment and prevent nutrient release from sediment**
2. **SPE membrane preferentially adsorped multivalent cations (Mg^{2+}, Ca^{2+}, Al^{3+}) compared with monovalent ones (Na^+, K^+), causing membrane degradation**