A composite adsorbent of lanthanum and zeolite for water remediation

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Abstract
We recently developed a composite adsorbent of lanthanum and zeolite for water remediation, specifically, controlling a lake eutrophication. Since phosphate is a well known nutrient responsible for algae bloom, internal phosphate control in both water and sediment columns was proposed in water remediation. The hypothesis of this study was made that the fabricated adsorbent binds phosphate to settle, and prevent the resuspension of phosphate from sediment. Substantially, phosphate efflux into the water column is reduced. For this purpose, the composite adsorbent was composed of lanthanum as substituted ion and zeolite as embodiment material. In this study, a column test was performed to further evaluate the composite adsorbent by mimicking a lake system including water and sediment column. The developed adsorbent proved to have the effectiveness of algae control by a means of phosphorus control in both water and sediment.

1. Introduction
Eutrophication of surface water is caused by excessive inputs of nutrients, especially phosphorus and nitrogen, which stimulate nuisance growth of algae [1]. Particularly, phosphorus is a limiting nutrient for the algae growth. Internal phosphorus control has been generally studied in many years to prevent the massive growth of algae. Hence we recently developed the remedial material as internal phosphorus control method in the water environment [2]. The remedial material was known to enable the continuous control of phosphate in water to be practical [3]. In this study, the developed remedial material was further evaluated using the column test, which mimicked a lake system including both water and sediment.

2. Theoretic concept of remedial material
The remedial material is a modified substrate with a body material negatively charged and a substituted ion. The body material has high ion-exchange capacity, and the substituted ion will react with specific nutrient. We hypothesize that the remedial material binds nutrient in the water
column to settle and substantially reduces nutrient efflux from the sediments; this material also
has the physical coagulation or aggregation with algae, of which products settle together with a
nutrient binding materials [2]. Zeolite, naturally occurring ion-exchange materials, can be used as
the body material because it has high capacity to exchange ions. The selected ion embodied in
zeolite is lanthanum ion. Lanthanum is easily reacted with phosphorus to produce a precipitate
with a low solubility (La$^{3+}$ + PO$_4^{3-}$ → LaPO$_4$; Ksp = $10^{-24.5}$ ~ $10^{-28.08}$ at pH 4 to 11).

3. Methods and Materials

3.1. Fabrication of a remedial material

Full details can be found in elsewhere [2].

3.2. Column test

Three identical reactors were prepared to mimic a lake system with about 1.8L of water and
about 0.2L of sediment (58% of moisture content) as shown in Fig. 1. Each was designated as the
test with the fabricated adsorbent (1mg of supplied dose), the control with the alum (20mg of
supplied dose), and the blank control without any addition, respectively. Each of the supplied doses
was calculated based on the theoretical demand for removing the whole phosphate in the water of the
column. Initial concentrations were 0.039±0.005, 2.33±0.6, and 0.27±0.01 for PO$_4^{3-}$-P, NH$_4^+$-N, and
chlorophyll-a, respectively.

Since the nutrients efflux from the sediment

Fig. 1 Schematic diagram of lad-scale column test

4. Results and Discussion

Fig. 2 summarizes the observed results in all column tests during the experimental period.
Phosphate concentration gradually decreased, but for the blank control test, slightly increased
during the latter period of the experiment. Phosphate can be potentially released from the
sediment while organic matters decomposed if no action was applied. For this reason, the
fabricated adsorbent was consistently effective in controlling phosphate in both water and
sediment, and it also decreased the ammonia-nitrogen concentration in water. The observation
might be due to the secondary effect of zeolite as the body material of the composite. These analyses of the data reveal that the fabricated composite can have a big role in adsorbing both ortho-phosphate and ammonia-nitrogen. Hence a decrease in chlorophyll-a was definite in the composite test, while the massive growth of algae was observed only in other two controls. Further evaluation should be followed to elucidate the chemical and physical functions of the composite toward the removal of algae and nutrient in the practical application.

![Graph showing Ortho-Phosphate and Ammonia-nitrogen concentrations over time](image)

**Fig. 2 Observed behaviors by sequential time**

### 5. Conclusions

The composite adsorbent of lanthanum and zeolite proved the effectiveness in removing ortho-phosphate and ammonia-nitrogen without any dismantlement of the composite, subsequently indicating long-term efficiency of the algal control in a lake system.

### References

