

Adsorption of Acetate to Coastal Sediment Particles ^{*1}

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A seashore sediment column, 3.6 cm in diameter and 15 cm in length, was infiltrated with artificial seawater containing acetate at the concentration of 100 $\mu\text{g}/\text{ml}$. The acetate concentrations in the effluent reached the level of the influent after a quick and the following gradual increase, and then quickly decreased to zero when the influent was switched from the acetate-seawater to pure seawater. The total amount of acetate removed from the acetate-seawater during the filtration was calculated to be 7.66 mg, by integrating the difference in the concentration between the effluent and the influent. Acetate in the pore water of the sediment was quickly washed out by filtration of the pure seawater, whereas acetate adsorbed on the sediment particles was not.

1 Introduction

Seashore sediment has been interested as a possible scavenger of dissolved organic compounds in seawater ^{1,2)}. Dissolved organic and inorganic compounds are supplied to the sediment when seawater was pumped up due to wave actions and infiltrated through the sediment ³⁾. In previous paper ⁴⁾, we performed a filtration experiment in order to examine the role of down-ward movement of water for the purification of seawater; acetate was utilized as one of the possible dissolved organic compounds contained in the seawater. Data in the experiment clearly indicated that acetate was removed from the seawater during the infiltration through the sandy shore sediment. A non-biological process caused the removal, and the effect of the microbial activity was negligible in this scavenging, since heat sterilization did not affect the seawater purification activity. However, role of sorption onto the surface of the sediment particles or trapping in the pores was not determined in the experiment.

To clarify the role of the sorption or the trapping, how long do dissolved organic compounds remain on the surfaces or in pores is a crucial problem to be answered. In this experiment, we determined the amount of acetate adsorbed on the sediment particles and retained in the pores, after filtration with pure seawater. The results indicated that the acetate in the pores was quickly washed out, whereas acetate adsorbed on the sediment particles was not.

2 Materials and Methods

2.1 Preparation of sediment column

Sandy shore sediment was scooped with a shovel and collected in a glass beaker at Yoshimi Bay, where fine sands are major particles ⁴⁾. After gently mixed in the beaker, the sand was mounted up to 15cm in an acrylic pipe, 3.6cm in diameter.

2.2 Infiltration of seawater through the sediment column

An artificial seawater ⁵⁾ containing acetate at the

水産大学校研究業績 第1644号, 2000年11月10日受付.

Contribution from National Fisheries University, No.1644. Received Nov. 10, 2000.

^{*1} 沿岸整備事業推進会議 (平成12年3月7日, 於 水産工学研究所) で発表

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Table 1. Amount of acetate extracted from the sediment with different solvents

Solvent for Extraction	Extracted Acetate (mg /150 ml of sediment column) *
Ethyl alcohol	7.54
0.1N HCl	4.12
0.1N NaOH	2.40
Distilled Water	0.00
Distilled water, boiled	0.00
Artificial seawater	0.00
Artificial seawater, boiled	0.00

* calculated as Na-acetate

concentration of 100 $\mu\text{g} / \text{ml}$ was autoclaved, cooled at room temperature, and infiltrated through the sediment column. The filtration speed was controlled at 1 ml / min with a peristaltic pump. The pH of the artificial seawater remained at 7.8 without adjusting. When the concentration in the effluent reached the level of the influent, the acetate-seawater was switched with pure seawater.

2.3 Extraction of pore water

Sediment was extruded from the acrylic pipe with a gentle gravity, and sliced into 1-cm sections. Pore water was extracted and fractionated by a centrifuge-filtration method^{6,7)}. Pore water collected with the centrifugation at 500 rpm was designated as large pore water in this paper, while that at 3,000 rpm was small pore water. Diameter of the large pore was calculated to be larger than 48 μm from acceleration due to the centrifugation, based on the equation of Khonke^{6,8)}. Diameter of small pore was in the range from 1.4 to 48 μm .

2.4 Extraction of acetate from the sediment particles

After extruded from the acrylic pipe and collected in glass beaker, the sediment sample was mixed uniformly with glass rod. About five g of the sediment sample was collected, weighed and used for determination of acetate. Acetate adsorbed on the sediment particles was extracted with three serial extractions. At each extraction, 10 ml of solvent listed in Table 1 was added to the sediment sample.

2.5 Determination of acetate

Acetate concentration was determined by a high performance liquid chromatography (HPLC) using a KC811 column (Shodex, Osaka, Japan)⁹⁾. Phosphoric acid solution (0.4 % vol. / vol.) was introduced at a flow rate of 1 ml / min at 60 °C. A chromatogram of acetate was monitored at 210 nm.

3 Results and Discussions

Fig. 1 indicates the result of filtration experiment, with a sediment column prepared with the sand of Yoshimi bay. As in the figure, the concentration in the effluent was around zero in the initial phase of filtration, and began to quickly increase at the elution volume of 63 ml, and then reached the concentration of 78 $\mu\text{g} / \text{ml}$. After reaching the level of 78 $\mu\text{g} / \text{ml}$, the concentration gradually increased and finally reached the level of the influent, 100 $\mu\text{g} / \text{ml}$. The acetate concentration in the effluent began to quickly decrease when the influent was switched from the acetate-seawater to pure seawater. Total amount of acetate filtrated through the column was 70 mg (: 700 ml times 100 $\mu\text{g} / \text{ml}$). Total amount of acetate removed from the acetate-seawater during the filtration was calculated to be 7.66 mg, by integrating the difference in the concentration between the effluent and the influent.

To clarify whether the acetate removed from the seawater was trapped in pore or adsorbed on sediment

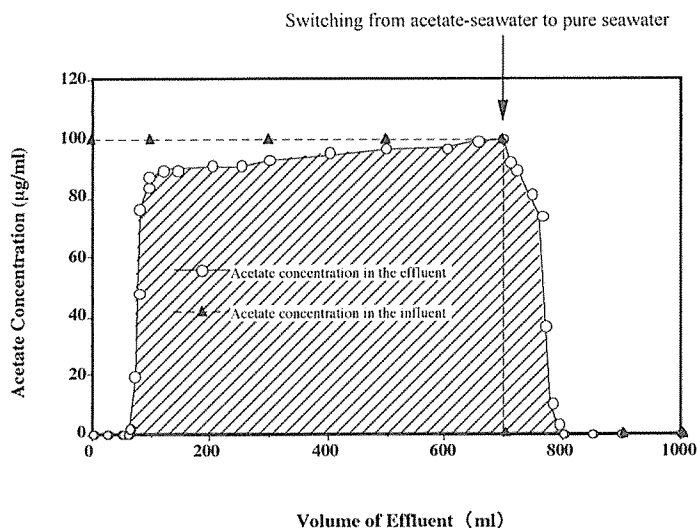


Fig. 1. Change of acetate concentration in the seawater effluent from sediment column. Open circles, the concentration in effluent ; closed triangles, influent. Shadow area indicates the amount of acetate eluted from the column (: 62.44 mg). We could switch the influent just after the concentration in the effluent reached the level of the influent, as shown in the figure, by deciding the switching time after several similar experiments.

particles, acetate was extracted from the sediment particles extruded from the column. As summarized in Table 1, the highest value was found in the extraction with ethyl alcohol among the seven different extraction solvents. The amount of acetate extracted with ethyl alcohol was 7.54 mg, and comparable to the amount removed from acetate-seawater. Neither of seawater nor distilled water extracted acetate, in spite that the solutions were heated. Acetate trapped in pore water was determined on different sediment samples collected in different series of filtration experiments. After switching from acetate-seawater to pure seawater, the filtration was stopped at appropriate time and the sediment was extruded from the column. Acetate was determined on the pore water extracted by the centrifugation method.

As shown in Fig. 2 and 3, the concentration of acetate in pore water decreased very quickly after the outset of the filtration with pure seawater. The decreasing curve in Fig. 3 did not fit any exponential curve, indicating that the decrease in the pore waters was not caused only by the dilution with the pure seawater.

Although the acetate level in the large pore water quickly decreased to zero, a very low level of acetate (ca. $2 \mu\text{g/ml}$) was still detected in the small pore water even after the filtration of 1,800 ml of pure seawater. Since the total volume of the small pore water was only 4.5 ml (3 % of the sediment column), the total amount of acetate retained in the small pore water was calculated to be 0.009mg. The amount is very small, in compare to the amount adsorbed on sediment particles.

Hence, from the data in this experiment, it could be concluded that pore in sandy shore sediment is not so important in directly removing dissolved organic compounds from seawater being pumped up to the sediment by wave action. Pore would be important as a transporter of dissolved organic and inorganic compounds. Only the dissolved organic compounds adsorbed on sediment particles could be utilized and/or digested by the living things indigenous to the sediment where efficient filtration occurs.

Acknowledgement

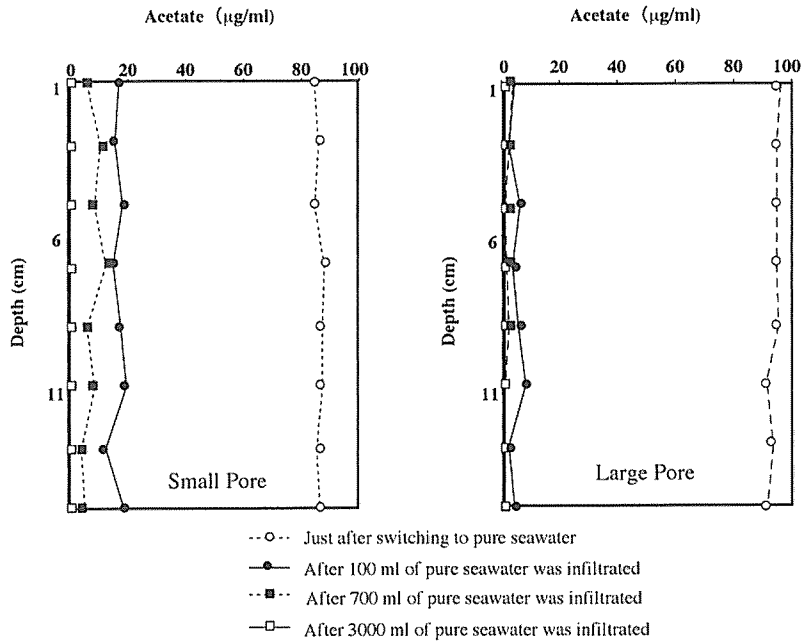


Fig. 2. Acetate concentration in pore water after different volume of pure seawater was infiltrated through sediment column.

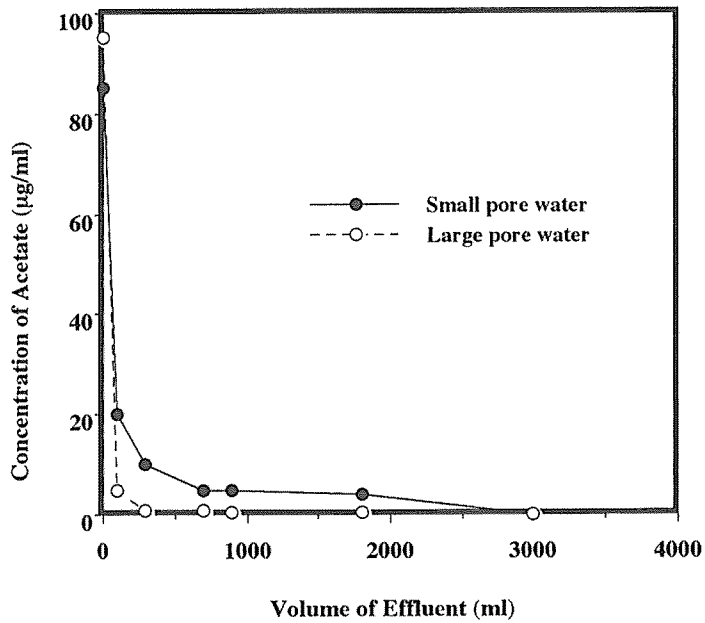


Fig. 3. Change of acetate concentration in pore water after the influent was switched from acetate-seawater to pure seawater. Each spot represents the average of 8 different depth samples.

The work was supported by the grant-in-aid from the Agricultural, Forestry and Fishery Ministry of Japan.

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海岸砂による海水中の酢酸の吸着

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長さ15cm, 直径3.6cmの海岸砂カラムを用いて, 海岸砂による海水の浄化過程を調べた。実験では, 100 $\mu\text{g}/\text{ml}$ の酢酸ナトリウム/人工海水を用いて実験を行ったところ, 150mlの海岸砂カラムの酢酸浄化能は7.66mgであった。このうち, 7.54mgが砂粒子に吸着されていた。海岸砂の間隙にも酢酸は貯留されたが, これらは純粋の人工海水で急激に押し流されたことから, たとえ有機物が間隙に貯留されたとしても, それは一過性であり, 海岸砂に吸着されない限り, これらが海岸砂の細菌群によって分解無機化される可能性は小さいと考えられた。