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DECONTAMINATION OF RADIOACTIVE CESIUM FROM OCEAN SLUDGE BY MICRO-BUBBLE AND MICROORGANISMS

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ABSTRACT: The Fukushima nuclear accident of March 11, 2011, soil and water had been contaminated by radioactive cesium. Moreover, radioactive cesium was found in the ocean sludge in Tokyo Bay by flowing from rivers. Here, it cannot be easily removed the cesium which is adsorbed to the sludge. On the other hand, one of the authors had developed the decomposition system for ocean sludge with circulation type by micro-bubbles, which decompose and purification sludge by activating the aerobic bacteria, after creating an aerobic state by micro-bubbles. Here, based on the hypothesis that radioactive cesium is adsorbed on the surface of the sludge deposition. It is considered that radioactive cesium can be eluted, after decomposing the deposited sludge by using the decomposition system for ocean sludge with circulation type. If the cesium will be eluted in the water, we can fix the cesium to existing technology such as “Zeolite”. In this study, our objects is to consider the performance of removal of radioactive cesium after the decomposition of the deposited sludge, by using the decomposition system for ocean sludge with circulation type by micro-bubbles and activating microorganisms.

Keywords: Decontamination, Radioactive Cesium, Ocean Sludge, Micro-bubble, Microorganisms

1. INTRODUCTION

The Fukushima nuclear accident on March 11, 2011, soil and water had been contaminated by radioactive cesium. Moreover, radioactive cesium was found in the ocean sludge in Tokyo Bay by flowing from rivers. A report says it becomes 13 times of the cesium for 7 months from August, 2011 in [1]. Here, it cannot be easy to remove the cesium which is adsorbed to the sludge.

On the other hand, one of the authors had developed the decomposition system for ocean sludge with circulation type by micro-bubbles, which decompose and purification sludge by activating the aerobic bacteria, after creating an aerobic state by micro-bubbles.

Here, based on the hypothesis that radioactive cesium is adsorbed on the surface of the sludge deposition in [2], it is considered that radioactive cesium can be eluted, after decomposing the deposited sludge by using the decomposition system for ocean sludge with circulation type.

If the cesium will be eluted in the water, we can fix the cesium by the existing technology such as “Zeolite”.

In this study, our objects is to consider the performance of removal of radioactive cesium after the decomposition of the deposited sludge, and also show the mechanism of adsorption, elution and fix of cesium as our hypothesis, by using the decomposition system for ocean sludge with circulation type by micro-bubbles and activating microorganisms.

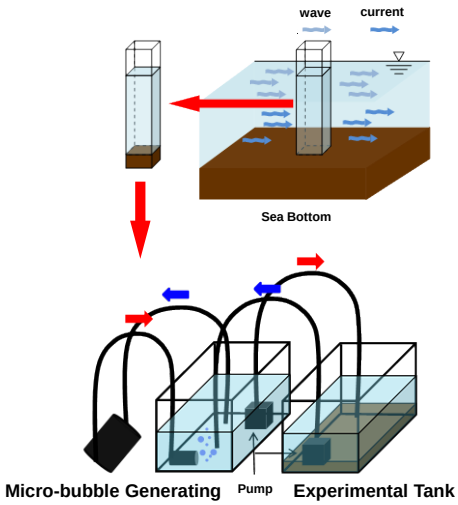

Fig. 1 Purification System of Circulation Type.

2. DECOMPOSITION SYSTEM WITH CIRCULATION TYPE

It is very important to reduce sedimentary sludge in the ocean. Plans to reduce the sludge are usually dreading or sand covering. Dredging is a simple way and aims to cut off the sludge. But after cutting off, treating the dredged sludge takes much more time and, of course, cost. Sand covering, in

general, gives a big load to living organisms and the ecological system.

So that, a more efficient way is needed to reduce the sludge while not imparting environmental load in the local sea area. Here, attention was paid to micro-bubble technology for application to the purification of the sludge. The important point in this technique is to activate the bacteria existing in the area by micro-bubbles. Micro-bubbles (that is MB) can change conditions into an aerobic state. If the bubbling stops, the situation changes into anaerobic state, according to recent research. So, we selected a method for decomposing the sludge by microorganisms.

One of the authors had developed the decomposition system for ocean sludge with circulation type by micro-bubbles, shown in Fig.1, which decompose and purification sludge by activating the aerobic bacteria, after creating an aerobic state by micro-bubbles.

3. MECHANISM ON FIXING OF CESIUM FROM ELUTION

In general, ocean sludge has a negative charge. When cesium with a positive charge flows from river, sludge was adsorbed cesium, shown in Fig 2. So that, sludge adsorbed cesium cannot eliminate by usual way.

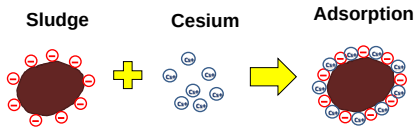

Fig.2 Mechanism on Adsorption of Cesium.

Here, we have a way by using of the decomposition system for ocean sludge with circulation type. After decomposition of the sludge adsorbed cesium by our system, cesium is eluted into water, shown in Fig 3. That is our hypothesis.

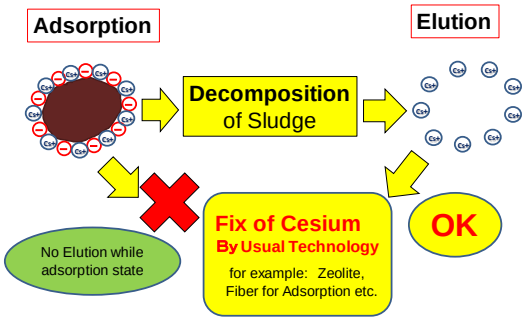

Fig.3 Mechanism on Fixing of Cesium from Elution.

4. ELUTION EXPERIMENTS FOR CESIUM

4.1 Procedure of Elution Experiment

The experimental devices consist of two parts, shown in Fig. 1. The water circulates through two tanks. In one tank (Width40xLength28x Hight28cm), micro-bubbles are generated. The micro-bubbles have micro-size diameter and high solubility. This means the water with high concentration of dissolved oxygen circulates through these tanks. The other part is the experimental tank (W60xL29xH35cm). We used sea-water 30(litter) and sludge 1(kg). Here, a micro-bubble generator is based on [3], [4] and the flow rate is 900 (litter/hour). The flow rate of water pumps connected each tanks are 300 (litter/hour).

We had caught the sludge and the sea water at Funabashi Port in Chiba Prefecture in JAPAN, as shown in Fig.4 and 5. Here, we had removed under 10cm of the sludge from seabed before sampling as experimental procedure, because we have to remove the initial value of cesium in the sludge, as shown in Fig. 6.

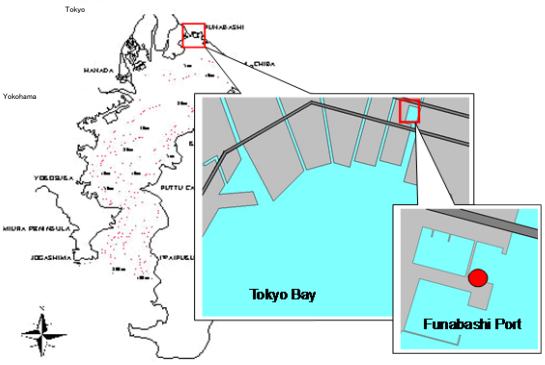

Fig.4 Catching Point of Sludge and Sea Water at Funabashi Port in Tokyo Bay.

Fig.5 Scene of Catching Sludge.

We used the cesium chloride before 24 hours of starting time and the concentration of cesium ion is 100 (ppm). An air conditioner for water tank was set at the tank for generating microbubbles, for the purpose of setting water temperature 30 degree

centigrade.

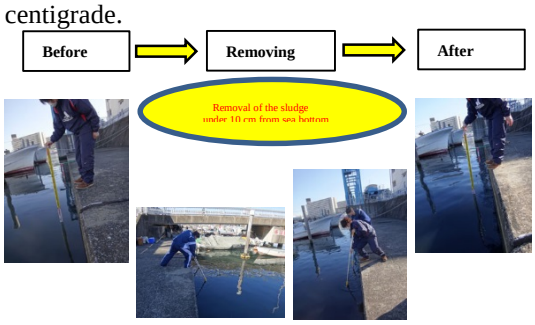

Fig.6 Removal of the Sludge under 10 cm from Sea Bottom Surface before Catching Sludge.

After setting the decomposition system for ocean sludge with circulation type by micro-bubbles, experiment starts at the same time of generating micro-bubble device.

After 6 hour, the microorganism activator was put in the experimental tank. Main staff of the activator is Kelp and including nutrients and some enzyme. Our used activator is reported to show effective results in purification for grease trap.

Dissolved oxygen (DO), water temperature and pH are measured by using of multi-parameter water quality meter. Ammonium nitrogen (NH4-N), total nitrogen (T-N) are measured by using of digital-water-analyzer by digital "Packtest", by water filtered after sampling in experimental tank.

4.2 Experimental Conditions

As experimental conditions, Case 1 is a case of using the decomposition system for ocean sludge with circulation type by micro-bubbles, shown in Fig.7. Case 2 is no micro-babbles and no circulation but is used the microorganism activator, shown in Fig.8.

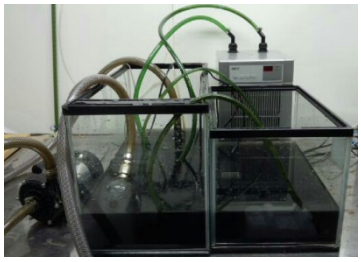

Fig.7 Case 1 of Experiment for Elution of Cesium.

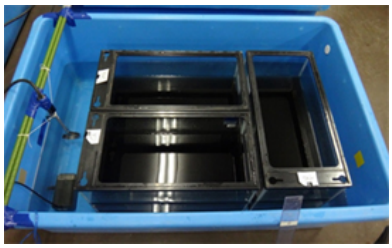

Fig.8 Case 2 of Experiment for Elution of Cesium.

5. EXPERIMENTAL RESULTS

5.1 Water temperature, pH and DO as environmental conditions

Fig.9-11 show the water temperature, pH and DO (Dissolved Oxygen) as the results of environmental condition of this experiment.

Water temperature is almost constant about 30 degree centigrade after 6 hours. pH is also constant about 7.2 to 7.8. DO in Case 1 is saturation state but DO in Case 2 rise because of mixing at putting microorganism activator after 6 hours, and then became constant. After 24 hours, DO value rise slowly, it seemed that water is mix by the work of sampling for measurement.

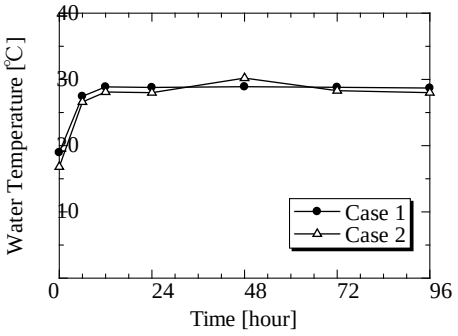

Fig.9 Changes in Water Temperature as environmental conditions.

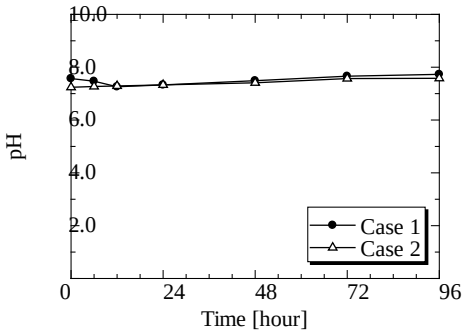

Fig.10 Changes in pH as environmental conditions.

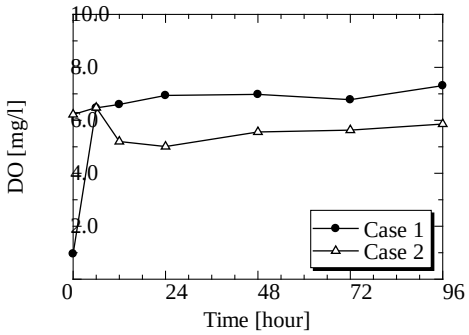

Fig.11 Changes in DO as environmental conditions

5.2 Results of H_2S, NH_4-N and T-N

Fig.12-14 are shown in results of H_2S (Hydrogen sulfide), NH_4-N and T-N.

H_2S (Hydrogen sulfide) in Case 1 decrease rapidly, it seemed by the supply of Oxygen. Case 2 showed always lower limit of measurement, the reason is no H_2S in sampling water by separation of water and sludge because of no movement of water.

NH_4-N in Case 1 has tendency of decrease but Case 2 has no decrease. T-N in Case of 1 also has tendency of decrease over 50% but Case 2 has no decrease.

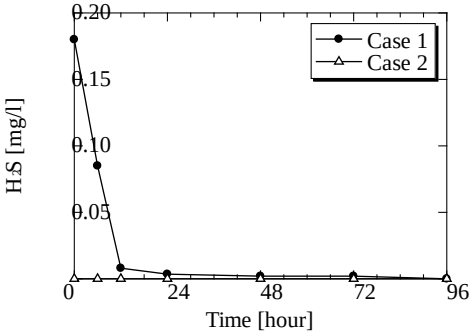

Fig.12 Changes in H_2S.

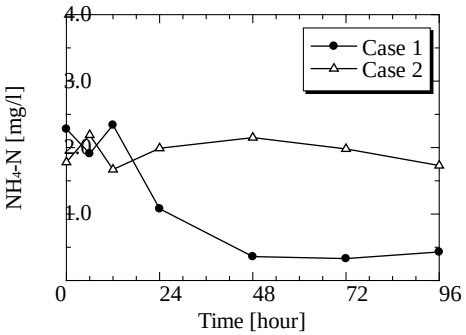

Fig.13 Changes in NH_4-N.

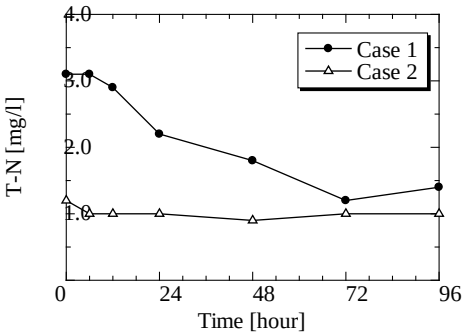

Fig.14 Changes in T-N.

5.3 Results of Cesium (in liquid)

The results cesium were obtained by the iron chromatography shown in Fig 15. The result of Case 1 is considered about 30.9% elution. Results of Case 2 is not bigger than initial value, this means no elution.

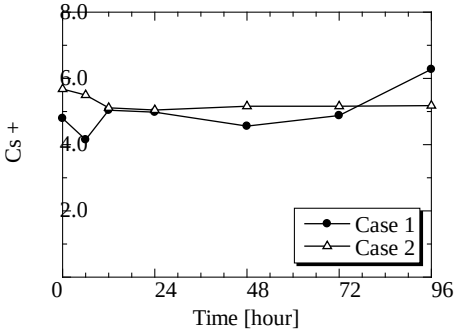

Fig.15 Changes in Cesium.

5.4 Results of Cesium (in solid)

We paid attention to cesium and silica (Si), as there are many chemical element in sludge. We used the energy dispersion type X-ray analysis device, because we can measure by the solid state. Weight ratio of cesium and silica (CS/Si) in solid of dry sludge are shown in Fig.16.

Ratio of Case 2 increase 50% after 72 hours but final result is same of initial one. It seemed cesium in solid is no change of initial value.

Ratio of case 1 decrease at first after 24 hours, it increase at 48 and 72 hours and it decrease at 96 hours. This is considered that Cs elutes in water by decomposition of sludge at 24 hours and then cesium adhere again to unwrapped silica. It is considered “Re-adsorption” occurs.

Mechanism of Re-adsorption is shown in Fig.17, as our hypothesis.

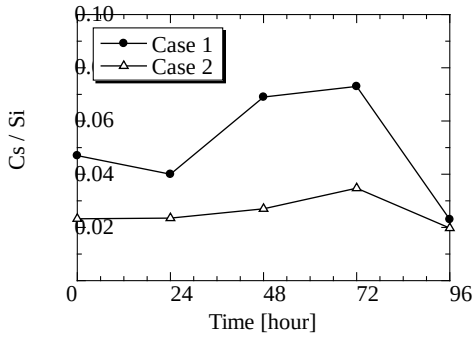

Fig.16 Changes in (Cesium)/(Silica).

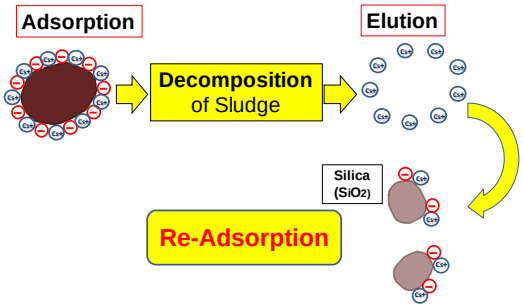

Fig.17 Mechanism on Re-Adsorption after Elution.

6. CONCLUSION

We had carried out the elution experiments for cesium after decomposing the deposited sludge by using the decomposition system for ocean sludge with circulation type by micro-bubble and microorganisms.

From the results by iron chromatography,

(1) The elution of cesium is maximum 30.9% in sea water. It seemed it is very useful system.

From the results of the energy dispersion type X-ray analysis device, the weight ratio of cesium and silica (CS/Si) in solid of dry sludge denote,

(2)This is considered that Cs elutes in water by decomposition of sludge at 24 hours and then cesium adhere again to unwrapped silica. It is considered “re-adsorption” occurs.

(3) We showed the mechanism as our hypothesis, of adsorption to sludge of cesium, elution of cesium after decomposition of sludge, and “re-adsorption”.

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