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CHARACTERISTICS OF THE SLUDGE PARTICLES IN REMOVAL PROCESS OF RADIOACTIVE CESIUM FROM OCEAN SLUDGE BY DECOMPOSITION SYSTEM WITH CIRCULATION TYPE USING MICRO BUBBLES AND ACTIVATING 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 flowing from rivers. Cesium which is adsorbed to the sludge cannot be easily removed. One of the authors developed decomposition and purification system, a circulation-type system by micro bubbles, that is, by creating aerobic state, aerobic bacteria are activated resulting to decomposition and purification of ocean sludge. Based on the hypothesis that radioactive cesium is adsorbed on the surface of the sludge deposition. It is considered cesium can be eluted after decomposing the deposited sludge. Once the cesium is eluted in the water, it can fix to a mineral such as zeolite. Now we need the properties of sludge in removal process by decomposition system with circulation type. In this study, our objects is to check the characteristics of the sludge particle in removal process of radioactive cesium from ocean sludge by decomposition system with circulation type using micro bubbles and activating microorganisms. As the results of this experiments, we had very good purification ratio on total nitrogen and had made 40 times of smaller size on diameter of the particle of sludge.

Keywords: Decontamination, Radioactive Cesium, Ocean Sludge, Micro-bubble, Microorganism, Zeolite

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 flowing from rivers. A report says radioactive cesium is still existing in seashore in Tokyo Bay, 2015 in [1]. Cesium which is adsorbed to the sludge cannot be easily removed.

One of the authors developed decomposition and purification system, a circulation-type system by micro bubbles, that is, by creating aerobic state, aerobic bacteria are activated resulting to decomposition and purification of ocean sludge. Based on the hypothesis that radioactive cesium is adsorbed on the surface of the sludge deposition. It is considered cesium can be eluted after decomposing the deposited sludge.

Once the cesium is eluted in the water, it can fix to a mineral such as zeolite. Now we need the properties of sludge in removal process by decomposition system with circulation type.

In this study, our object is to check the characteristics of the sludge particle in removal process of radioactive cesium from ocean sludge by decomposition system with circulation type using micro bubbles and activating microorganisms.

1. 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.

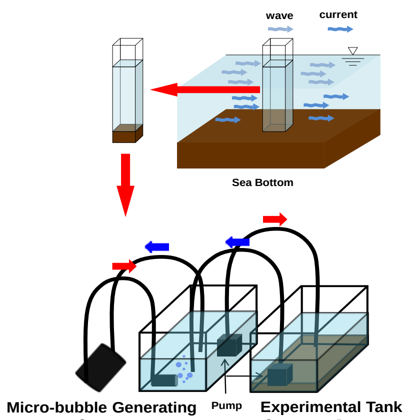

Fig. 1 Purification System of Circulation Type

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.

1. 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.

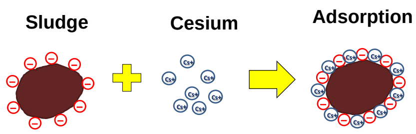

Fig.2 Mechanism on Adsorption of Cesium

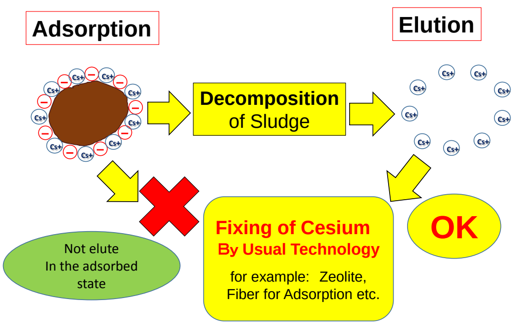

Fig.3 Mechanism on Fixing of Cesium from Elution

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.

2. ELUTION EXPERIMENTS FOR CESIUM

4.1 Procedure of Experiments

The experimental devices consist of two parts, shown in Fig. 4. The water circulates through two tanks. In a 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 [4], [5] and the flow rate is 900 (litter/hour). The flow rate of water pumps connected each tanks are 300 (litter/hour).

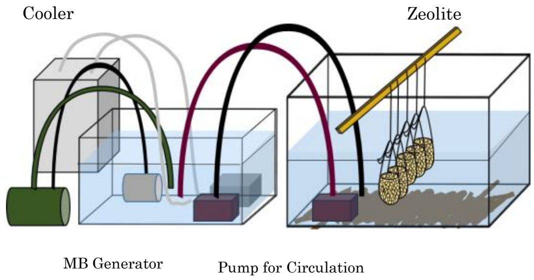

Fig.4 Experimental System for Elution of Cesium.

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, from [3].

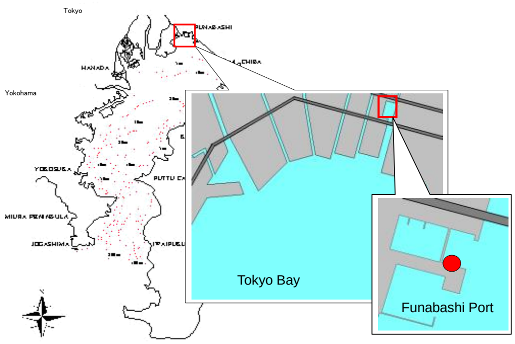

Fig.5 Catching Point of Sludge and Sea Water at Funabashi Port in Tokyo Bay.

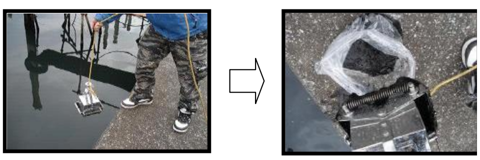

Fig.6 Scene of Catching Sludge.

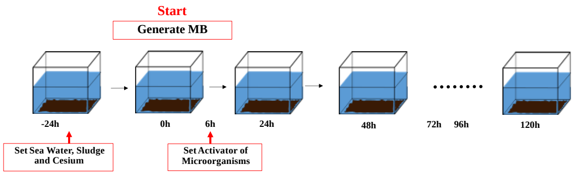

Fig.7 Procedure for Liquid Measurements.

4.2 Measurement Procedure for Liquid Phase

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

After setting the decomposition system with circulation type by micro-bubbles, experiment starts at the same time of generating micro-bubble device and also the zeolites were set in the tank.

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.

Measurements for liquid phase did each 6 hours until 12 hours, and then every 12 hours to120 hours, shown in Fig.7.

Dissolved oxygen (DO), water temperature and pH are measured by using of multi-parameter water quality meter. Ammonium nitrogen (NH_4-N), total nitrogen (T-N) and total phosphorus (T-P) are measured by using of digital-water-analyzer by digital "Packtest", by water filtered after sampling in experimental tank.

4.3 Experimental Condition

Case 1 is to use our purification system with circulation type and Case 2 is not use the system which means do not use the micro bubble and activator of microorganisms.

Case 3 is to do current velocity control in purification system for reducing hydrogen sulfide. As procedure of experiment in case of current velocity control by our purification system with circulation type, setting the water pomp (2400L/h) in a tank is worked from starting time to 24 hours later.

3. RESULTS AND CONSIDERATION

5.1 Results and Consideration for Liquid Phase

5.1.1 Results of water temperature, pH and DO as environmental condition

Fig.7-9 show the water temperature, pH and DO (Dissolved Oxygen) as the results of environmental condition of this experiment.

Water temperature was almost constant about 30 degree centigrade after 6 hours, by setting the cooler for water tank in the experimental system. pH was also constant about 8.0 to 9.0. DO in Case 1 and 3 were 7.0 to 8.0 and also saturation state after 24 hours, but DO in Case 2 was about 4.0 and lower oxygen state.

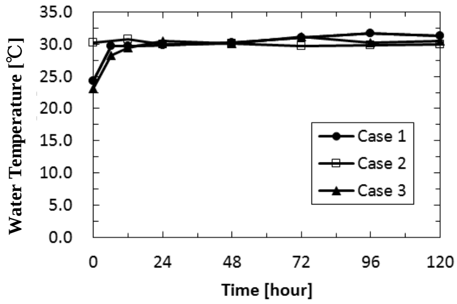

Fig.7 Changes in Water Temperature as Environmental Conditions.

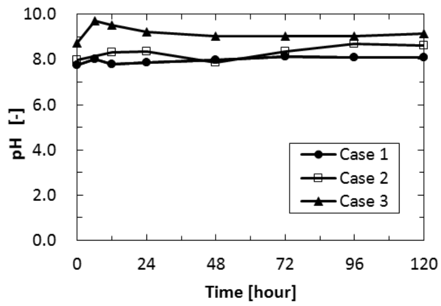

Fig.8 Changes in pH as Environmental Conditions.

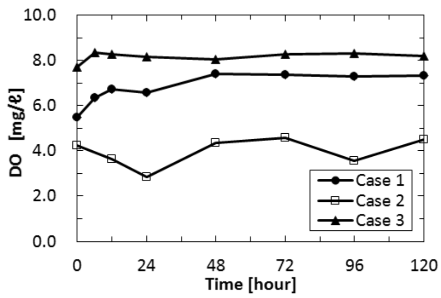

Fig.9 Changes in DO as Environmental Conditions.

5.1.2 Results of H_2S, DIN and T-N

Fig.12-14 are shown in results of H_2S

(Hydrogen sulfide), DIN (Total Inorganic Nitrogen) and T-N (Total Nitrogen).

H_2S (Hydrogen sulfide) in Case 1 and 3 decrease rapidly, it seemed by the supply of Oxygen. It decreased more rapidly in Case 3 by flow control and then became N.D. value. Case 2 showed not big change and relatively constant values, because of no supplying oxygen.

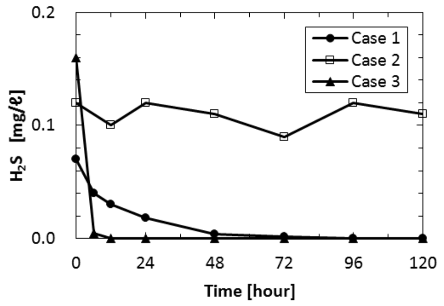

Fig.10 Changes in H_2S.

DIN (Total Inorganic Nitrogen = NH_4-N+NO_2-N+NO_3-N), shown in Fig. 11. DIN of Case 1, 3 reduced 100% at 120 hours, it seemed it happen to denitrification by microorganism from [7].

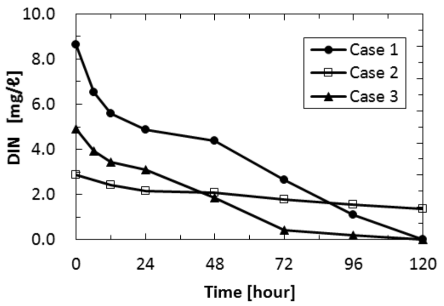

Fig.11 Changes in DIN.

T-N (Total Nitrogen) is expressed in normalization; initial values in Case 1, 2 and 3 were
4.0, 1.5, 4.3, respectively. T-N in Case 1 and 3 reduced 80 and 85 %, respectively. It seems these are activated by microorganisms. A little high values in Case 3 caused rapidly decreasing of H_2S by flow control, so that it seems purification efficiency is very good.

5.2 Results and Consideration for Solid Phase

5.2.1 Measurement Procedure for Solid Phase

Measurements for solid phase did every 24 hours to120 hours, shown in Fig.13. There are 6 patterns; 0, 24, 48, 72, 96, 120 hour. When it comes each closing time, the experimental tanks are prepared for measurement of solid phase. The sediment in the tanks are carried out filtration and dry. After filtration and dry, cesium in solid was analyzed by the energy dispersion type X-ray analysis device (EDX).

The characteristics of the sludge particle in removal process are also measured by Scanning Electron Microscope (SEM).

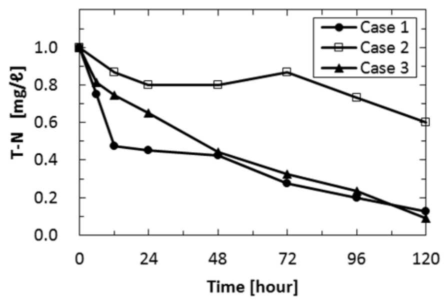

Fig.12 Changes in T-N.

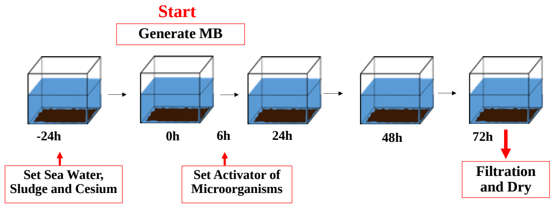

Fig.13 Measurement Procedure for Solid Phase.

5.2.2 Results of Cesium (solid)

We paid attention to cesium and silica (Si), as there are many chemical elements in sludge. We used the energy dispersion type X-ray analysis device (EDX), 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.15.

Results of cesium in solid phase by EDX in Case 1 reduced 47.1% but in Case of 2 did not reduce. It seems cesium adsorbed on sludge was decomposed and eluted to water by decomposition and purification system of **c**irculation **t**ype.

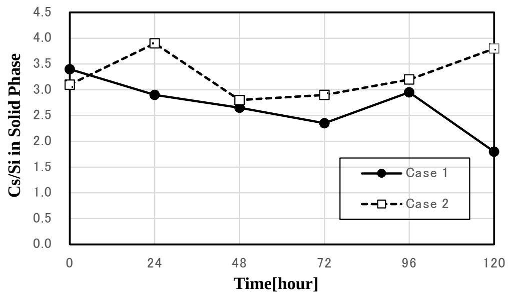

Fig.15 Changes in (Cesium)/(Silica) in Solid Phase.

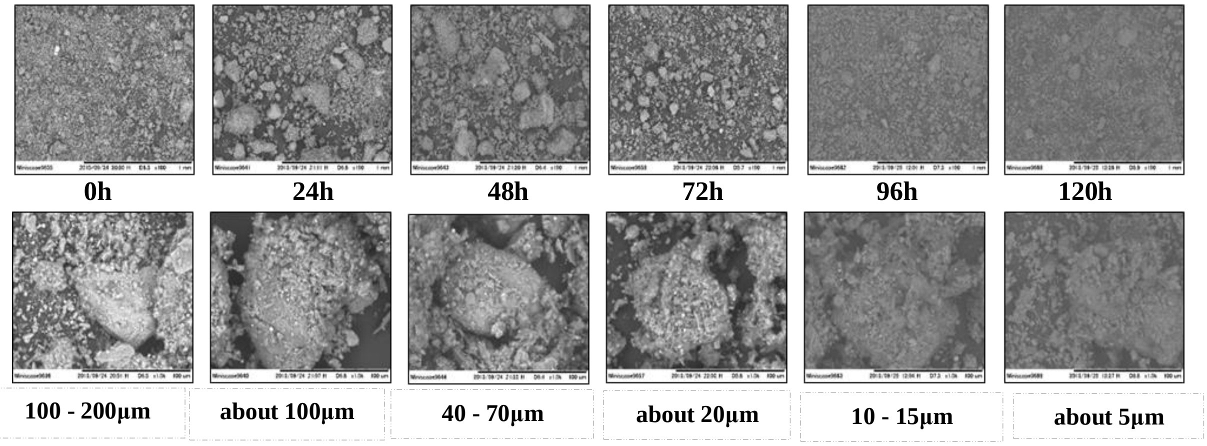

Fig. 16 Photo by SEM (Scanning Electron Microscope) of Case 1 (Upper=100 times / Lower=1000 times)

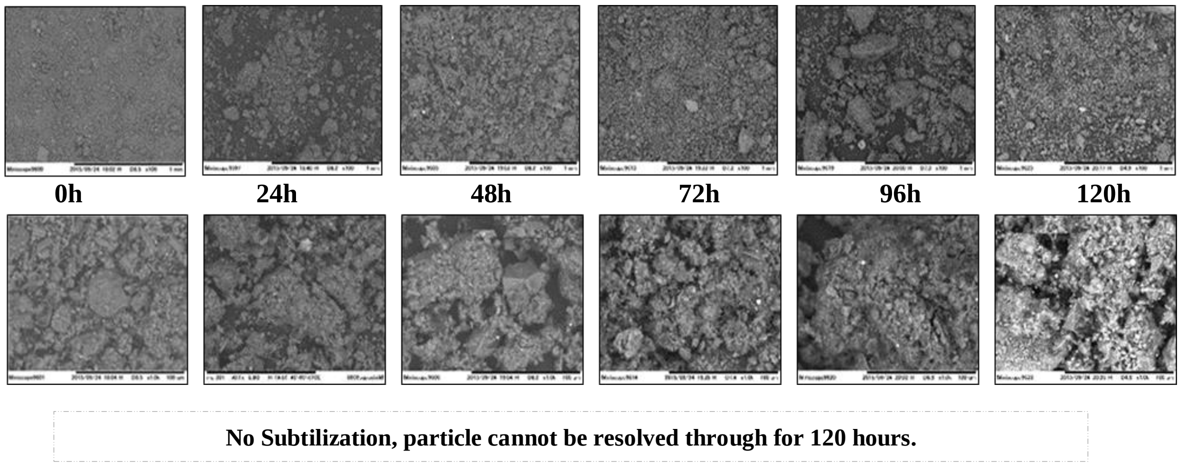

Fig. 17 Photo by SEM (Scanning Electron Microscope) of Case 2 (Upper=100 times / Lower=1000 times)

5.2.3 Characteristics of Sediment by SEM

Results of SEM (Scanning Electron Microscope) are expressed for each 24 hours from 0 to 120 hours, shown in Fig.16 and 17.
Diameter of sludge particle in Case 1 is 100 to 200 (micro meter) when experiment starts, and then it becomes 5 (micro meter) at 120 hours later, so that the size became about 40 times small. That in Case 2 denoted no change. It seems the diameter of sludge particle is decomposed and becomes very small according to the working time of decomposition and purification system of circulation type.

4. CONCLUSION

We had carried out the elution and fixing cesium by setting zeolite, after decomposing the by using the decomposition system with circulation type, by not using it and by using it adding flow control.

From the results for water qualification,

(1) for T-N, it decreased 80% in case of use the decomposition system and decreased 85% in adding flow control.

From the results for cesium in solid phase,

(2) the eluted performance of absorbed cesium on the sludge is indicated 47.1% by using the decomposition system, compared with no use of microbubble and activator of microorganisms.
(3) Diameter of sludge particle in removal process by using the decomposition system became about 40 times small.

5. ACKNOWLEDGEMENTS

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