Field Observation of Cesium Radionuclides in Ohori River and Lake Teganuma Sediments, Chiba prefecture, Japan

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1. Introduction

The Fukushima Nuclear Power Plant (FNPP) accident on March 2011 had led to the continuous discharge of radionuclide into the atmosphere and the oceans, in the form of radioactive gases or very fine radioactive particles (aerosols) scattered into the air (ISRN, 2012). These aerosols were mostly produced by the nuclear fission of Uranium-235 (^{235}U) and were released directly into the atmosphere. The radioactive nuclides, particularly the radioactive Cesium-134 (^{134}Cs) and Cesium-137 (^{137}Cs) were of health concern because they adversely affects human health through contamination of air, water, soil and food (Morino et al., 2011). The transfer and deposition of radiocesium is an important mechanism to determine the future effects on human health, ecosystem and natural environment and thereby the food chain (Domis, 1997).

The radiocesium nuclides are generally attached to small dust particles (aerosols) in the atmosphere and enter the terrestrial ecosystem through rainfall and are deposited on the soil surface. Over longer time periods, after being deposited by precipitation in the form of rain, radiocesium nuclides held in the soil catchment are slowly transferred to river water by erosion of soil particles and (in dissolved phase) by desorption from soil.

Therefore, this study aims to estimate the total amount and total mass of sediment that are contaminated radiocesium as well as the depth of the contaminated sediment in Ohori River and Lake Teganuma.

1.1 Background and purpose of the study

Ohori River and Lake Teganuma in Chiba Prefecture were selected as study sites of this research. After the accident at the FDNPP on 11 March 2011, the contamination of ^{134}Cs and ^{137}Cs around Kashiwa city, which is 195 km away from the FDNPP, was found on the terrestrial areas increased to around $6x10^4$ $Bq.m^{-2}$ (MEXT ,2012). Thus, in this study, the ^{134}Cs and ^{137}Cs contamination in the sediment as well as the total amount of radiocesium were studied.

Core sediment samples from both the river and the lake and surface sediment samples from the land near to the river and the lake were collected starting in from July 2012 to May 2013. The radionuclide content and the particles size of the soil in the sediment bed layer were then measured. The main objectives of this study are: 1) To measure the distribution of radiocesium in the core samples, 2) To measure and compare the radiocesium concentration from different particle sizes (45µm, 75µm, 106µm & 250µm) from the land surface soil profiles and sediment cores from Ohori River and Lake Teganuma, 3) To estimate the total mass of sediment contaminated with radiocesium in the Ohori River and Lake Teganuma and 4) To estimate the of total amount of radiocesium concentration in the Ohori River and Lake Teganuma.

2. Materials and Methods

2.1 Study site

The estuarine area of the Ohori River flowing to to the Teganuma Lake was selected as the measurement sampling site. The Ohori River starts at Aota-shinden, Kashiwa-city, Chiba prefecture, and passes through Nagareyama City and Kashiwa City, then drains into the Teganuma Lake. The catchment area is around 31 km^2 and the spanning 12.9 km. 11 stations along the Ohori River were chosen for this study. These stations found in the upper, middle, and lower parts of river.

Lake Teganuma is a landmark found within both Kashiwa City and Abiko City in the northern part of Chiba prefecture. It is a long lake with a length of about 7 km, and a shoreline of 17 km. Seven sampling points from the lake's upstream to downstream gradient were selected. (Figure.1)

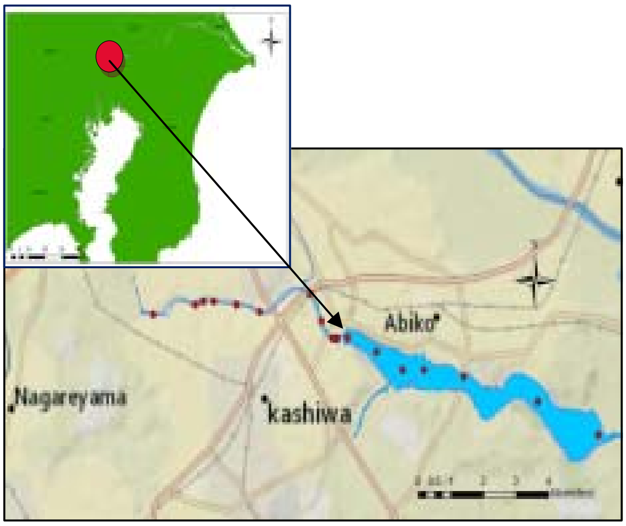

Fig 1. Study sites and sampling points in Ohori River and Lake Teganuma.

2.2 Field observation

Sediment core samples (Internal diameter of 5.4 cm) were collected from July 2012 from the middle part of Ohori River (Station 2 to Station 6). In August and September 2012, core samples were collected from the upper part of river (Station 1) in addition to Station 2 to 6. In October, surface sediments (3 cm of surface sediment) were collected in all 6 stations (Station 1 to 6) and core samples were collected in 2 stations (Station 5 and Station 6). In addition, sediment core sample were also collected from seven stations located along Lake Teganuma (Core sampler internal diameter of 4 cm) in 17 October 2012. Samples in the lower part of the river were only collected in November and December from Station 7 to Station 11. In February, March and May 2013 surface sediment and core samples in Ohori river and Lake Teganuma were collected again. Care were taken during the transport of the core sediments to prevent the sediments in the core from mixing.

2.3 Laboratory analysis

Sediment core samples were divided into layers of 2-cm heights and then dried in an oven at a temperature of 105°C within 12 or 24 hour. ^{134}Cs and ^{137}Cs were measured using γ-rays-detecting device (ORTAC,USA (GMX29 HP-Ge) equipped with a spectrum navigator (Seiko EG and G Co.).

Laser diffraction particle size analyzer (Shimadzu Co., SALD-3000S) were used to measure the particles size, the equipment used to measure median diameter. The sediments were also sieved and separated into diameters of 45µm, 75µm, 106µm & 250µm.

3. Results and Discussions

3.1 Radionuclide analysis of ^{134}Cesium and ^{137}Cesium in Ohori River

The depth of radiocesium concentration in the sediment layers of each station is considered as the parameter to calculate the total volume and mass of sediment accumulated in the bottom of river.

In the middle part of river (Station 4 & 5), it was found that the depth at which ^{134}Cs and ^{137}Cs were accumulated ranged from 14cm - 16cm. At Station 5, two radiocesium peaks were detected at the depth of 4cm and 12cm on July to October 2012, respectively. Generally, at the middle section of the Ohori River, the depth of sediment with highest radiocesium concentration was 16 cm.

At the lower part of the river in December, radiocesium were highest around the depth of 12cm -14cm with value 1.16×10^4 Bq.kg^{-1} in station 9 and 14cm - 16cm with value 1.80×10^4 Bq.kg^{-1} in station 11. Most of the radionuclide were concentrated at the lower part of Ohori River (river mouth adjacent to the lake).

Based on the results, a few questions were found to be of key importance: (1) Why was the radionuclide concentration at Station 4, 5 and 6 were to be concentrated at sediment depth ranging from 14 cm to 16 cm? One of the reasons that should be taken into consideration is the water velocity at this section of the River, (2) Radionuclide peaks were found at the lower sediment layer at Station 9 and Station 11 which could indicate downward advection or mixing of radiocesium in the core sample. In order to find out the input event that are causing the peaks in radionuclide concentrations along the river, it is suggested that the sediment dating should be carried out to find what kind of natural or artificial input events (e.g. atmospheric, erosion or manmade) that can be linked to it.

3.2 Radionuclide analysis ^{134}Cesium and ^{137}Cesium in Teganuma Lake.

Samples from Lake Teganuma were collected on three occasions in October 2012, March 2013 and May 2013. ^{134}Cs and ^{137}Cs concentrations were found to be highest at the depth of 15 – 18 cm in Station 1, which is located closest to the Ohori river mouth during the October 2012 sampling. Radionuclides released after the FDNPP disaster on March 2011 could have been concentrated at this part this lake via direct inflow from the Ohori River and erosion. Compared to the data from October 2012 sampling, the depth of which the radiocesium concentrations peaked has reduced during the March 2013 sampling. At Station 1, the depth in which the radiocesium can be found has reduced from 18cm to 6cm. There were a few factors which could contribute to the decreased radiocesium concentrations along the river during the 6 month's period between the October 2012 and March 2013 samplings. Firstly, rainfall events were recorded during this 6 month's period, Secondly, the water depth especially in Station 1 is quite shallow and this could promote mixing and flow of radionuclides downstream. Lastly, the radionuclide flux from the source has reduced.

3.3 Estimation of total mass of sediment and total amount of radiocesium in Ohori River and Lake Teganuma

Comparison of total mass of sediment contaminated with radiocesium in Ohori River and lake Teganuma based on the measurement results between October 2012 and March 2013, clearly shown that the total mass of sediment increased in 2013 as value 3.34×10^4 Ton to 3.52×10^4 Ton in Ohori river but decreased in lake Teganuma as value from 4.44×10^5 to 3.52×10^5 Ton, respectively. However, the total amount of radiocesium (Bq) decreased gradually in both river and lake as value 2.19×10^{11} Bq to 1.83×10^{11} Bq in Ohori river and lake Teganuma with value 7.41×10^{11} Bq to 6.13×10^{11} Bq, respectively. Since half-life of ^{134}Cs is approximately 2 years. The largest flux of radiocesium is found in 2012 as value 3.80×10^9 $Bq.year^{-1}$ and decreased in March 2013 to approximately 6.65×10^6 $Bq.year^{-1}$. In addition, the total amount of radiocesium within 6 months (October 2012 to March 2013) Ohori River and Lake Teganuma had decreased by 16% and 17%, respectively. However, the results of total amount of radiocesium still quite high when compared to the radiocesium flux.

4. Conclusion

The results of experiment, the total amount of radiocesium and total mass of sediment accumulated cesium was calculated. depth of sediment contaminated radiocesium was used as parameter. However, the result of total amount of radiocesium in Ohori river quite high if compare to radiocesium flux and lake Teganuma, time of sampling and measurement should keep moving on for next study. Moreover, the quantitative information of this results can be able to input in numerical modeling to estimate radiocesium transport and can be used as the tracer to find out bed load transport in future.

5. References

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