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Seasonal variation of contaminated geo-environmental condition of Yamaguchi bay tidal flat, Japan

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ABSTRACT

In this study, the seasonal variation of geo-environmental condition of Yamaguchi Bay tidal flat has been studied. Yamaguchi bay is located at the south part of Yamaguchi prefecture and was famous for its different kind of shells and other living creatures. However, a sharp declination of a catch of shells and crabs have been observed in recent years. Particularly, the living creatures related to the tidal flat mud have been suffered a damage. Recently, the horseshoe crabs which used to come onto shore to mate is declining in Yamaguchi bay which is not good for the marine ecosystem of this area. The mud samples were collected from the tidal flat area once in every month by using the tube sampler. Then the samples were cut into specified layer and measured the different geo-environmental parameters (acid volatile sulfide, pH, loss on ignition, COD, Electrical conductivity) at the laboratory in each layer. It was observed that the acid volatile sulfide (AVS) which is the most important parameter for the living condition of the living creatures is over the safe limit (0.2 mg/g-dry mud) during the summer. The other parameters such as pH, LOI, have also significant variation in different seasons but they were still within the safe limit. The COD value of the tidal mud also showed a significant variation during the summer and the winter. However, the higher AVS value was one of the reasons for the declination of horseshoe crabs and other living creature in the tidal flat of Yamaguchi bay, Japan.

1. Introduction

Yamaguchi bay which is located in the south part of Yamaguchi prefecture, Japan is very famous for the various kinds of living creatures. However, a sharp decrease of the catch of shells and other living creatures have been found in recent years. Especially, for the case of the horseshoe crab, it is declining and become almost nil in recent years. The reason of the declination of the catch of shells is not clear to the researcher. Horseshoe crab is a special type of creatures who usually live in the deep sea but come to the shore area for laying eggs in the tidal flat area. So the pollution of sediment could be one of the major causes of the declination of the catch of shells (Westrich and Berner, 1988; Yamanishi et al., 2002). The similar problem has been observed in the Ariake Sea, Japan in where the unfavorable geo-environmental condition was reliable for the declination of the catch of jackknife shell (Moqsud and Hayashi, 2016). Approximately 24% of the Japanese population resides in the proximity to the Seto Inland Sea—the largest enclosed sea in Japan; and Yamaguchi bay is one of the parts of it (Kameda and Fujiwara, 1995). These regions suffer from problems such as the mortality of fishes and macrobenthos. (The association for the environmental conservation of the seto inland sea, 2001.) An increasing trend of oxygen depletion in enclosed basins and estuaries is most probably related to human-induced eutrophication (Cooper and Brush, 1991; Bratton et al., 2003). However, no study has yet been carried out to assess the geo-environmental condition of Yamaguchi bay tidal flat area previously. Therefore, the objective of this study is to observe the seasonal variation of geo-environmental parameters (AVS, pH, LOI, COD etc.) of the Yamaguchi bay tidal flat (0–20 cm) and try to find a reason of the vanishing of living creatures in the Yamaguchi bay area.

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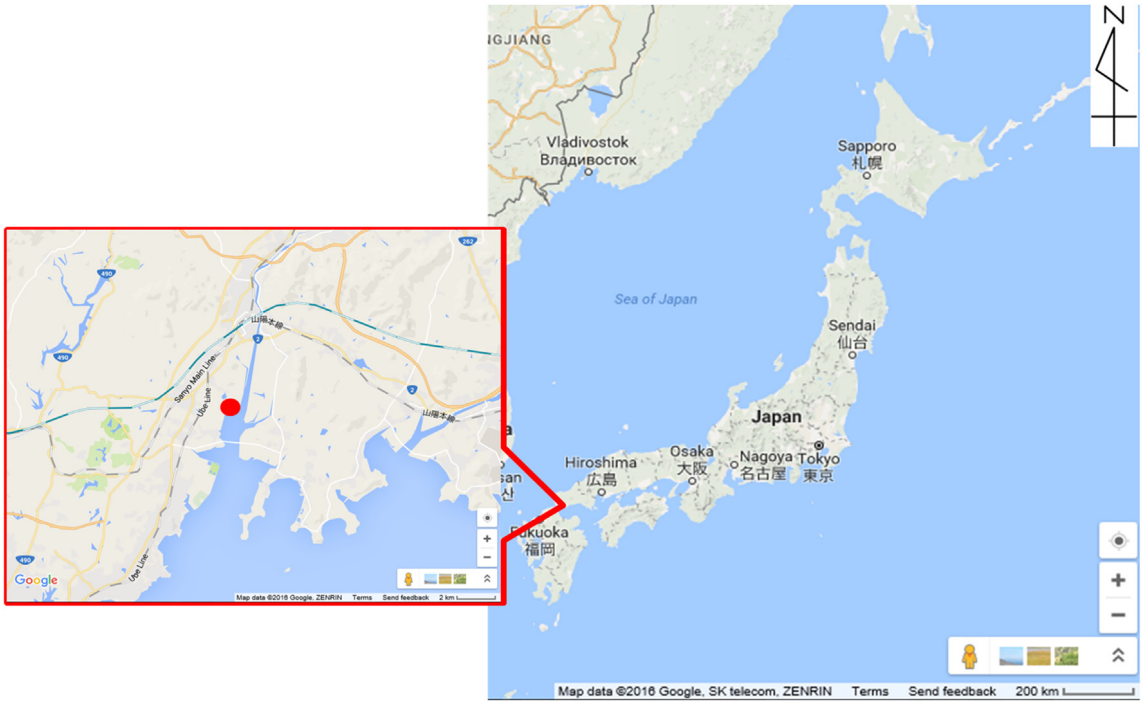

Fig. 1. Map of the study area indicating the sampling area at the Yamaguchi bay, Japan.

2. Study area

Yamaguchi bay is situated in the southern part of Yamaguchi and was famous for its different types of shells and living creatures and sea weed cultivation. The sample is collected from the Ajisu tidal flat area. Fig. 1 shows the map of the study area in Yamaguchi bay. The mean annual summer (July and August) and winter (January and February) air temperatures around the bay during the years 2015–2016 are approximately 25 and 6 °C, respectively (Yamaguchi Japan Meteorological agency). The annual precipitations are 1750 and 1200 mm, respectively. The sediment of the sampling sites is relatively sandy (60%) with a significant amount of clay particles (30%). The color of the sediment was dark and there was some unpleasant odor due to the gas-phased hydrogen sulfide during the sample collection. Very few sign of living creatures have been observed in the sediment during the sampling. Abe et al. (2017) showed that the substantial impact of large-scale disturbance such as earth quake and tsunami on an fisheries products in the sediment in Fukushima, Japan. However, in the Yamaguchi bay area there was not such type of natural disasters occurred in recent times.

3. Materials and methods

3.1. Test methods

In situ samples were collected by inserting the 0.2 m diameter PVC pipe down in the tidal flat mud at a depth of up to 0.5 m at the Yamaguchi bay area in every month to observe the seasonal variation of the geo-environmental condition. Due to the sandy nature of the sediment the tube sampler could not be inserted below the 20 cm depth. So the data presented in the studies are up to 20 cm depth. The sample was then sliced into several specified layers in the laboratory to measure the acid volatile sulfide, pH, loss on ignition, electrical conductivity etc. Acid volatile sulfide (AVS) is very important geochemical indices to identify the favorable inhibiting conditions of the benthos. The sulfide content was measured following the standard method prescribed by the Japan Fisheries Resource conservation association. The instrument which was used to measure the sulfide content was the Gastech 201L/H. Briefly, measuring sulfide content consisting of placing 0.2 g of mud at field moisture content on a fine porous disk placed in a 10×10^{-6} m^3 glass tube. Then 2 ml of diluted sulfuric acid was mixed with the mud sample and the generated hydrogen sulfide gas was collected. The weight of hydrogen sulfide gas was measured and expressed as mass of gas per unit mass of the mud (Ricard and Morse, 2005).

The value of pH, electrical conductivity, loss on ignition had been determined by following standard method introduced by Japanese geotechnical society (JGS) JGS 211, JGS 212, JGS 221, respectively.

4. Results and discussion

4.1. Variation of acid volatile sulfide with depth

Fig. 2 illustrates the variation of AVS with depth in different seasons. The maximum value of AVS is shown in August (during the summer). This is due to the fact that the summer temperature has influenced to increase the activity of sulfate reducing bacteria and consequently produced high amount of AVS. On the other hand, the AVS of December and January were the lowest. The lower temperature of winter has the effect to this value. The AVS value near the surface (0–5 cm) were always very low but it increased gradually with the deeper depth. As the sulfate reducing bacteria are anaerobic, they do not like the area where oxygen supply is more (Holmer and Storkholm, 2001). In the tidal area, when the tide comes it turbulates the sub-surface region and provides plenty of oxygen to the mud, the bacterial activities become slower and consequently produces small quantity of sulfide in the mud (Jorgensen, 1990). Moreover, the supplied oxygen makes the sulfate from the sulfide in the mud in that region (0–5 cm).