CHARACTERIZATION OF IRON ELUTION IN THE METHOD OF RESTORATION OF SEAWEED BEDS WITH STEELMAKING SLAG AND HUMUS MATERIALS

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Abstract

Barren grounds in coastal area are serious problems in Japan and other parts of the world. It has been developed a method that the mixture of steelmaking slag and humus materials, such as composts, were supplied in seawater for restoring seaweed beds. A concentration of dissolved iron can be increased in the method, since complexes, iron-humates, are produced from iron in steelmaking slag and humic substances in compost. The effect of this method was already confirmed in the field test. In this study, we evaluated the effect of the mixing humus materials with steelmaking slag in this method for increasing dissolved iron concentration. Iron elution tests in actual seawaters were attempted by using three kinds of samples for iron elution, only steelmaking slag, only compost, and a mixture of steelmaking slag and compost. We found that the mixture of steelmaking slag and compost was more effective for extending the lifetime of iron elution besides increasing iron concentration in seawater.

Keywords: *humus materials, compost, steelmaking slag, iron elution, seaweed bed restoration*

1. Introduction

Seaweed depletion in barren grounds is a serious problem along the coast of Japan and other parts of the world. Although several factors, such as elevated seawater temperature and grazing by herbivorous animals, have been proposed to account for barren ground, we have especially focused on the lack of dissolved iron (Fe) in seawater for restoring seaweed beds. It has been developed a method that a mixture of steelmaking slag (slag) and humus materials, such as composts, were supplied to coastal areas of barren grounds [1, 2]. This method contributes not only to the restoration of seaweed populations, but also to the effective use of industrial by-products and unutilized biomass.

The mixture of slag and compost was applied to a coastal area in Mashike (Hokkaido, Japan) in 2004 for confirming the actual availability of this method. Three plots on barren ground were considered in the field test. The first was treated with slag, the second was treated with a mixture of slag and compost, and the third plot was left untreated (control plot). The types of seaweed and their fresh weights were recorded in the three subsequent years. Restoration of a seaweed bed was especially confirmed at the location, treated with the mixture of slag and compost. The amount of restored seaweed and the restored area at the site with the slag-compost mixture were significantly larger than other sites. The Fe concentrations at the site with slag-compost mixture were also greater than those with the other sites. It was found that applying a mixture of slag and humus materials was an effective technique for restoring seaweed in a coastal area.

Although field tests with this method have been carried out in other coastal areas in Japan, further fundamental studies are required for understanding the mechanism of Fe supply to a coastal area and translating this method into practical applications. Especially, the understanding of characterization of Fe elution from the mixture of slag and compost (Fe supply unit) is one of the most important issues for practical use. Although we already evaluated the effect of humic substances on Fe elusion in this method [3], additional evaluations are needed for understanding the characterization of Fe elution and improving the method.

In this study, we made an attempt at further laboratorial Fe elution tests by using actual and artificial seawaters. The characteristic of Fe elution from Fe supply unit was evaluated. Meanwhile, the effect of the kinds of composts also has been investigated. We introduce one of the main results of Fe elution tests in this abstract.

2. Materials and Methods

The following three samples were used in the experiment.

(1) Only slag
(2) Only compost
(3) Slag : compost = 1 : 1 (in volume)

The amount of each sample is the same based on volume. The volume of 40g slag (sample (1), V_0) is the standard of this experiment. The volumes of samples (2) and (3) are the same as V_0, respectively. The kind of slag is the same as that used in the field test in Mashike, Hokkaido [1, 2]. The morph of calcium on the surface of slag is changed from $Ca(OH)_2$ to $CaCO_3$ in order to

decreasing the alkalis component. The compost in this experiment was produced from wood waste (bark) with a composting accelerator (Tateyama Engineering Co. Ltd.) obtained by fermenting sewage sludge containing microorganisms capable of growth in an anaerobic environment [4].

Each sample was installed in a small tank filled with 11L actual seawater, respectively. The seawater was collected in Omura bay, Nagasaki prefecture. As seawater had not been changed during the experiment, aeration system was used in each tank in order not to putrefy seawater. Fe concentrations in seawaters were analyzed with spectrophotometric method [3] every per 7 days.

3. Results and Discussion

Fig.1 shows the time dependence of dissolved Fe concentration of three samples. Initial Fe concentration was extremely small (1.2μg/L). However, Fe concentrations of three samples increased after one week. Especially, Fe concentrations of sample (1) and sample (2) were increased drastically. Meanwhile, Fe concentration of sample (2) was larger than that of sample (3). This implies that Fe elution rate from compost is larger than that from slag. As the amount of compost in sample (3) was half as small as that in sample (2), Fe concentration of sample (2) in seawater was larger than that of sample (3).

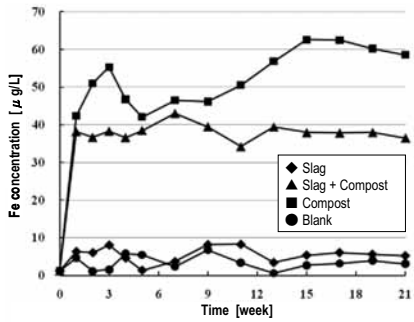

Fig.1 The time dependence of dissolved Fe concentration

Table 1 shows the amount of Fe elution and the Fe elution rate from three samples until 21 weeks. The amount of Fe elution from sample (2) was the largest and Fe elution rate of sample (2) was also largest. However, total amount of Fe elution of sample (1) and sample (2) are smaller than double amount of Fe elution of sample (3). This implies that the mixing of slag and compost accelerate the Fe elution from both slag and compost. Meanwhile, compost is the most effective in respect of the amount of Fe elution and Fe elution rate, if we install the same volume of the sample. However, the content of total Fe in compost is only 2.55wt%, although that in slag is 22.2wt% [3]. In respect of lifetime of Fe elution, compost is disadvantage. It was confirmed in this study that the mixture of slag and compost was more effective for extending the lifetime of Fe elution, in addition to the increase of iron concentration in seawater.

Table 1 The amount of and rate of Fe elution from sample

	slag	compost	slag + compost
The amount of Fe elution [μg]	20	610	360
Fe elution rate [μg/day]	0.162	4.12	2.48

Fe elution rates in Table 1 are expected to be smaller than the true value of Fe elution rate, because both oxidation and sedimentation of Fe was expected in seawater under this experimental condition. Fig.2 shows the time dependence of dissolved Fe concentration in the condition of removing slag-compost sample (no sample) after 13 weeks compared to that in the condition of not removing the sample. We found that dissolved Fe concentration was decreased after removing the sample. This indicates that true Fe elution rate is larger than those in Table 1. We should take account of this result in the case of estimating the lifetime of Fe supply unit.

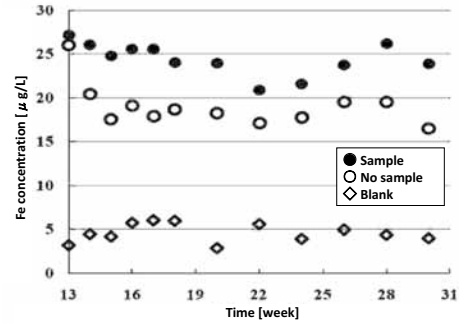

Fig.2 The time dependence of dissolved Fe concentration after 13 weeks

4. Conclusions

Characteristic of Fe elution from the mixture of slag and compost in the method of restoration of seaweed beds was evaluated in this study. It was found that the mixture (Fe supply unit) was more effective not only for increasing iron concentration in seawater but for extending the lifetime of Fe elution.

References

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