On-site Experiments of Bioremediation on Crude Oil in Coastal Areas of Japan Conducted by the National Institute for Environmental Studies

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In recent years, bioremediation (a method of direct remediation of polluted sites using microorganisms), which had been used mostly as a partial method of cleaning up soil pollution, has been the focus of attention because of its usage also as a method for cleaning up coastal areas that have been polluted by drifting oil that originated mainly from oil tanker accidents. Bioremediation not only has the character of making use of organisms that exist in the natural field and decompose polluting substances, but also has only a slight influence on the ecological system. Moreover, bioremediation's further advantage of being low-cost also gives rise to high expectations, so that its application for cleaning up crude oil that has drifted to the coast can be considered for areas where methods of physical collection would be difficult, or for residual oil left behind in cases when complete removal was unable to be carried out.

In bioremediation for oil that has drifted to the shore, the kind of method that has so far been used overseas mostly involved promoting decomposition through biostimulation by adding from the outside nutritive salts such as nitrogen and phosphorous, which act as rate-determining factor in the decomposition of crude oil, for indigenous crude oil decomposing microbes. However, in reports of actual examples in the past, since all the conditions prevalent at the sites where such applications were made, such as geographic features, the marine environment, climate, and ecological systems, varied greatly, the crude oil decomposition promotion effect achieved through adding nutritive salts was by no means uniform, and there were cases where hardly any improvement at all could be seen. There were very few instances of implementation of bioremediation at polluted sites on the coasts of Japan, and we were in the state of having almost no knowledge that had been obtained either on a scientific basis or from neutral evaluation by a public organization.

In the light of these circumstances, our institute conducted developmental studies of

methods to evaluate the effects and safety of bioremediation of oil that has drifted to coastal areas, mainly through on-site experiments in coastal areas of Japan. Through the understanding and cooperation of various organizations located near the sites, we were able to carry out on-site experiments in areas facing the Japan Sea, the Pacific Ocean, and the Sea of Okhotsk. At this symposium, I will introduce the outlines and results of several of these experiments.

The experimental method involved aerating Arabian Light crude oil produced in the Middle East, and forcibly mixing it in advance with sea water, thus creating a mousse-like substance, which was mixed with pebbles of sand from the local area. This mixture was then combined with multi-purpose synthetic fertilizer granules with controlled release (a slow-acting effect) for agricultural use, for the purpose of supplying nutritive salts, and the resulting substance laid under the sea in a coastal area. At specified interval, samples were collected and the process of decomposition of the crude oil evaluated.

The following results were obtained:

For typical saturated or aromatic hydrocarbon compounds that are contained in crude oil, such as alkanes, naphthalene, and phenanthrene, a significant promotion effect in the microbial decomposition, through the addition of fertilizer, could be seen.

Also, regarding the total amount of crude oil removed from the matrix polluted by crude oil (that is, the pebbles of sand), including physical exfoliation, when compared with the areas where fertilizer had not been added, in the areas where fertilizer had been added, the amount removed had increased considerably.

When the figures related to the crude oil removal were calculated, it appeared that the substantial rate of contribution of decomposition through microorganisms was about 20% in areas where fertilizer had been added while, physical removal due to exfoliation was from about 40 to 60%.

When we compared the effects of adding fertilizer that featured different forms of nitrogen such as nitrate, ammonia and urea, organic nitrogen (urea, cross-linked urea) indicated greater crude oil decomposition and a greater physical exfoliation enhancing effect than inorganic nitrogen (nitrate, ammonia) did.

Compared to coastal areas by the Sea of Japan, where there is a small tidal difference, areas on the Pacific Ocean coast, where there is a large tidal range, showed a higher active decomposition of crude oil, and this difference was especially dramatic in relation to alkanes.

The activation of crude oil decomposition through the addition of fertilizer was accompanied by a reduction in the diversity of microorganism consociation (in other words, the growing dominance of specific bacteria). However, although during the fertilizer addition experiments, diversity decreased, it gradually recovered over a period of time. As a result, the respective compositions of the microorganism groups in the areas where the nutritive salts had been added and those where they hadn't came to resemble each other.

No negative effect from the addition of fertilizer on marine crustaceans (amphipods) or on diatoms was seen.

As shown above, even for the experiments we have so far carried out in two separate locations, the Japan Sea side and the Pacific Ocean side, quite different results were obtained, and it is felt that we need to accumulate deeper knowledge through on-site experiments in a wide variety of coastal areas.

In the future, in order to develop methodology to evaluate the degree of recovery of areas that are habitats of living beings that is brought about through bioremediation, and to evaluate the state of diffusion of nutritive salts into surrounding ocean areas, through conducting further large-scale on-site experiments in conditions that are close to actual ones, we believe that bioremediation of oil that has drifted to coastal areas in Japan can approach readiness for practical implementation.

We were able to carry out this research and development only through the understanding and cooperation of Hyogo Prefecture, Kasumicho, Kagoshima Prefecture, Nishinoomote City, and the Ministry of the Environment, as well as that of those associated with fishery cooperative associations in areas near the experimental sites. I would like to take this opportunity to sincerely thank them all.

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