

Role of forest to the sea

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Iron is essential for photosynthetic and respiratory electron transport, and is directly involved in nitrate and nitrite reduction, nitrogen gas fixation, chlorophyll synthesis and number of other biosynthetic or degradation reactions [1]. The stable oxidation state of iron in oxic seawater is Fe (III), which has an extremely low solubility [2] and the dissolved inorganic species of Fe (III) in seawater is predominantly the hydrolysis product $\text{Fe}(\text{OH})^{2+}$, rather than $\text{Fe}(\text{OH})_3^0$ [3-4].

In contrast, the measured amounts of iron in river water are often orders of magnitude higher than the dissolved iron concentration in seawater since humic substances present in waters, which produce complexes with metals, control their solubilities [5-6], especially forest derived fulvic acid make a complex with iron [7-10] and copper [11-12] because humic substances have many groups such as carboxyl, carbonyl and amino groups.

Previous studies showed that a FA-Fe complex plays an important role for supporting phytoplankton growth in the bay [13] and for the growth rate of young sporophytes of *Laminaria religiosa*, the rate was about 3 times higher than that with amorphous iron [14]

As for the other role of humic substances derived from the forest, barren ground in the rocky shores is a world-wide phenomenon which can be seen in the north-eastern and western America, Canada, Norway and Japan, especially in the Japan Sea at Hokkaido Island [15]. This means that rocks and rock beds are covered with crustose coralline algae subsequent to the disappearance of kelp forest community. On the rocks or rock beds covered with coralline algae, seaweed (*L. religiosa* or *Undaria pinnatiida*) cannot thrive because coralline algae secretes allerobasic substances which destroy their zoospores adhered to the rocks or rock beds[16]. The reason for coralline algae dominance is assumed to be reduced flux of humic substances derived from forest soil into the sea because they act as an inhibitor of coralline algae

spore germination [15]. As mentioned above, humic substances play a significant role for photosynthetic organisms in the sea.

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