**Flow rate changes, dynamism of streams, and restoring habitats**

Controlling the flow rates of streams

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**Various roles of a flood**

**Increasing flow rates**

A flood triggers fish to swim up streams and lay eggs.

1. A flooding fish to swim up streams and lay eggs:
   - In the Shin-Gakujin Stream of the Kiso River, a large number of mature-sized fish swam up the stream in the Shin-Gakujin Stream and laid eggs on the stones following a flood (April 19, 2002), suggesting a close relationship between floods and egg-laying behavior.

2. Connecting isolated backwater areas to streams:
   - During floods, otherwise isolated backwater areas can be connected to the streams. When major beds are flooded, fish enter into the beds and lay eggs. Fish and behaviors are important links to the life of the beds.

**Disturbing water**

1. Improving the streambed by washing out fine soil particles:
   - Floods wash out fine soil particles accumulated between the streambed rocks and improve streambed conditions. It also prevents stones from being buried.

2. Renewing algae growing on stones:
   - When the flow rate is increased, algae on the stones are washed away, exposing the stones to the water. This process allows new algae to grow on the stones.

3. Maintaining spaces between streambed stones:
   - When the streambed is disturbed, spaces between streambed stones are formed. These spaces are important for the survival of organisms that depend on the stream environment, such as insects.

4. Forming stream channels and micro-landforms:
   - In the Kiso River (north of Nagano Prefecture), the size of fine-water channels and sandbars is believed to contribute to the mean annual maximum discharge (large-scale floods that occur once every two to three years) and the morphological change of the stream. The stability of streamside vegetation is maintained by repeated destruction caused by flooding and subsequent regeneration, which supports vegetation functions. At the same time, disturbance by flooding enables organisms that depend on stream beaches to survive (such as insects).

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**Flow tests suggested the relationship between changes in discharge and organisms**

**Experiment on flooding and the exfoliation and reduction of production and quality as algae species, and counted the number of cells.**

**Results and Discussion**

The results are shown in Figure 1 as the mean and standard deviation. The figure shows the values just before increasing the flow to 0.25 and 0.5 m³/s as values of the 24th hour of the previous flow rate. Values accompanied by ** and * showed a significant difference among a,b,c and (P<0.05 and P<0.01, respectively) by one-way ANOVA. At 0.1 m³/s, both the dry weight and the amount of inorganic materials neither decreased nor increased but fluctuated, and no exfoliation was observed. At 0.25 m³/s, the values decreased at the 3rd hour, but the reduction was likely to be the accumulation during 0.1 m³/s. The values did not change thereafter up to the 24th hour. At 0.5 m³/s, all of the dry weight, the amount of inorganic materials and chlorophyll a decreased. This suggests that a flow rate of at least 0.5 m³/s, which is equivalent to more than 7.1 cm/s in friction velocity, is needed to remove the algae layers. Even at the termination of the experiment, there was still a large amount of algae on the rocks. The dominant algae species were: Achnanthes subfusiformis, Melosira varians, and Navicula minima (diatoms), and Chamaesiphon sp. (Cyanophyceae) before the flood. After the flood, only Navicula minima was reduced to approximately 13% of that found before the test, but the other species were not affected. The flood did not cause reductions in species other than these dominant species either. This suggests that the flood conditions used in the experiment were insufficient to exfoliate and remove algae from the rock surfaces, and so it is necessary to increase either the size or the duration of flood.

Species that grow on rock surfaces vary depending on hydrological conditions such as flow rate and water quality, and so the adhering state varies. To overcome the problem of accumulation of fine sediments on riverbeds, washing-out conditions must be determined based on the actual state of the site. More experiments will be conducted using various conditions so as to cope with various states.

**Column**

River renaturalization projects, which started in 2001, involve not only the rehabilitation of habitat structures on the scale of reaches and segments, but also restoration of the inherent natural system of rivers which is closely correlated with their watershed characteristics. Several types of project have been attempted to naturalize inherent natural systems in rivers. For example, typical projects which focused on the flow and sediments for renaturalization included: increasing the maintenance discharge for aquatic organisms, flexibly operating dams to restore part of the natural flow regime, and artificially supplying sediment to the downstream segments of dams. However, the relationships between physical and biological phenomena are not well understood, and thus we should clarify the relation via experiments and field surveys in order to effectively incorporate those solutions into a framework for watershed management.