Ecological impacts of reservoir dams on river ecosystems in tail waters

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Ecological impacts of reservoir dams have been reported from various aspects such as 1) barrier for migratory animals like anadromous fishes, 2) eutrophication of reservoirs by plankton blooming, 3) decreasing flow volumes in tail waters, 4) stabilization of flow regimes by flood peak cut, 4) changes in thermal regimes of river water, 5) river bed degradation and increase in substrate grain size by sediment trapping, etc. In this lecture, these impacts will be reviewed with some examples in Japanese and Asian rivers, particularly those on benthic animals and their habitat conditions in tail waters.

Figure 1. Comparison of the riverbed landscape between upstream and downstream reaches of the Yasugawa Dam in the Yasu River in central Japan. The dam is as old as 53 years and the distinctive riverbed armoring can be observed. White part of rocks indicates thick accumulation of organic matter originated from the reservoir.

If you visit a dam site and compare the river landscapes between upstream and downstream reaches of the reservoir, you will notice the drastic changes in riverbed geomorphology (Figure 1). The contrast in grain size is the most distinctive: *i.e.*, sand, gravel and cobble substrates disappear in tail waters. In addition, the rocks and stones in the surface layer of the riverbed are too fixed to remove them by hand. These phenomena observed in tail waters of reservoir dams are called as “armoring”. The armoring riverbed is characterized also by a thick epilithon composed of algae, fine particulate organic matter and silt deposited on the surface of substrates (Figure 2).

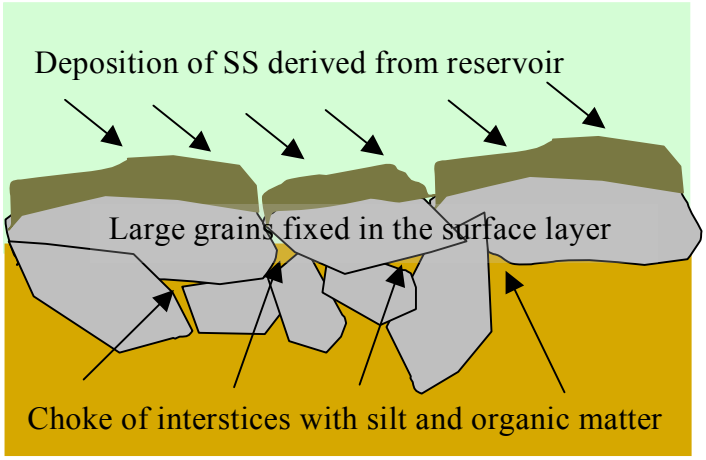

Figure 2. Scheme of armoring riverbed developed in the tail water of reservoir dams. In addition to increase in substrate grain size, deposition of silt and particulate organic matter derived from the reservoir is a common feature in the tail waters, which results in choke of hyporheic zones and anoxic conditions.

Figure 3. Changes in riverbed landscape at 2km downstream of the Ootaki Dam in the Yoshino River, a Japanese mountain stream in Nara Prefecture. The left and right picture shows just before and 3 years after the start of the dam operation.

The armoring and scouring of riverbed advance within a few years after dam construction (Figure 3). In case of Japanese rivers the maximum flows at flood exceed the capacity of dams because of high temporal concentration of precipitation in the monsoon climate. Therefore, substrates of small grain size in the tail waters will be flushed away at each flood without receiving any compensational sediment. Since values of the annual maximum flow vary stochastically, the degree of armoring in the dam tail waters will increase gradually for more than 50 years (Figure 4).

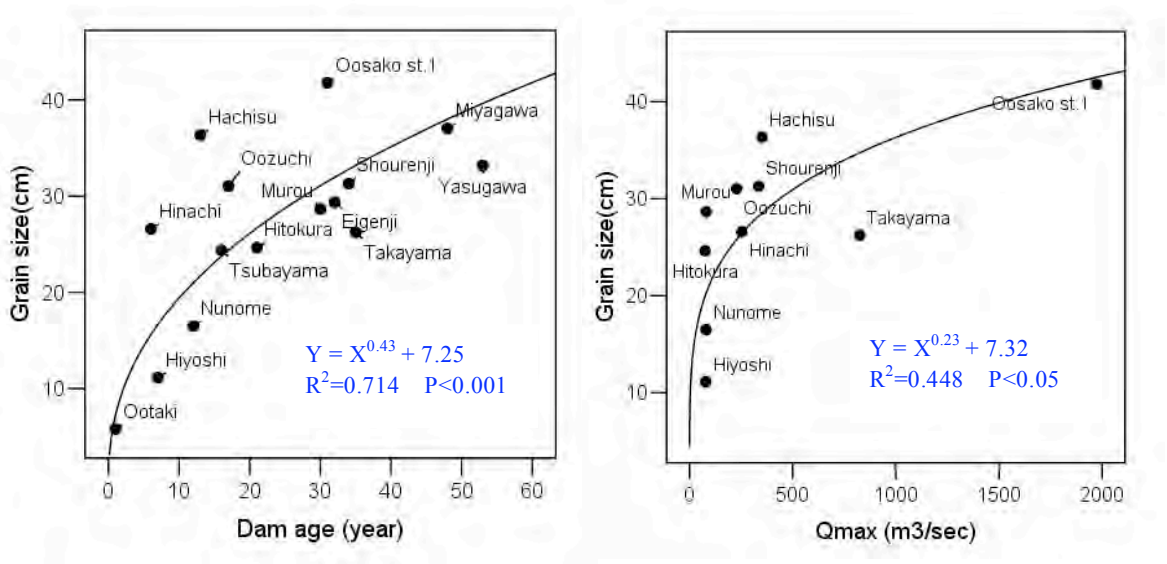

Figure 4. Relations of the degree of armoring riverbed in the tail waters to the dam age (left figure) and to the maximum flow experienced after the dam construction (right figure) based on the field measurement at 15 and 10 dam sites in Kinki district of Japan, respectively. After Hatano et al. (2005).

The armoring riverbed is connected to various ecological changes in the dam tail waters. In this lecture, channel geomorphology, physicochemical characteristics of substrate and hyporheic zone, characteristics of benthic animal communities, purification ability of riverbed will be compared among tail water reaches different in the degree of armoring and scouring of the riverbed.

Reference

Hatano K., Takemon Y. and Ikebuchi S. (2005) Characteristics benthos community and habitat structure in the downstream reaches of reservoir dams. Annuals of the Disaster Prevention Research Institute Kyoto University No.48 B: 919-933. (in Japanese with English abstract).