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Economic assessment of the effects of sediment replenishment to rivers and the effectiveness of sediment management

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ABSTRACT

Japan is characterized by steep mountain topography and weak geology as well as high precipitation and seasonal drastically changing temperature. As a result, sediment produced in mountain areas is frequently transported downstream and supplied to coastal areas through the river mouth which has formed many alluvial fans. In these upstream mountain rivers, many storage dams have been constructed for the purpose of flood control and water utilization. Nowadays, sediment accumulation in their active storage volume is a crucial issue both for reservoir and river basin sustainability.

In Japan, several countermeasures such as excavation, dredging, draw down flushing and bypassing have been introduced to solve this issue. This paper studies the effects of sediment replenishment with a sediment bypass project which restores sediment movement to the original condition and evaluates the project quantitatively by converting the effects to economic value to the extent possible. Additionally, the paper examines optimization of sediment replenishment by conducting sensitivity analysis to know how the effects change through implementation of sediment management.

As a case study, we have selected the Yahagi River where integrated sediment management in a river basin with a proposed sediment bypass tunnel at the Yahagi dam is undergoing. Based on several scenarios, we have conducted economic analysis considering both advantage and disadvantage points of sediment replenishment. We have also studied the effects of sediment management to control shape of reservoir sediment accumulation in the reservoir regarding the quality control in the reservoir. Additionally, based on the amount of necessary sediment excavation volume for maintenance the river channel and downstream reservoir areas after the operation of sediment flushing BP, we studied measures for effective use of sediment resources by sediment nourishment for river-mouth, estuary and coastal areas and recycling for construction materials. In the case, we considered possible site of stockyard where receiving unstable volumes of excavated sediment and delivering these recycling sites continuously.

In this study, historical study is done over dam and rivers and added with cost-benefit analysis of sediment BP over the estuary and coastal zone. Furthermore, in order to enhance the effectiveness and accuracy, estimation of sediment volume inflow of the dam using rainfall data, landslide data, etc. is included into analyzing process.

In the normal basin, sediment is produced in the bare land of landslide trace and supplied to the river channel by the action of gravity, wind, surface flow, etc. When sediment supply into river channel is abundant, talus is formed. Then, erosion of talus supplies sediment volume to the river channel. During heavy rain, bare land gets wider, then, sediment production from a new collapse area occurs rapidly which increases sediment production and supply system. These processes are added into previous model, then, applied on river case study.

Model is calculated with assumption of 50 years stabilized sediment inflow into the dam and sediment supply from eroded area along the way. Then, the result is verified with the real sediment inflow state, which shows good correlation. This includes sediment production results in the rivers, dams region, estuary to the coastal area, and sediment influx from terrain, geology, from rainfall conditions. Moreover, cost-effectiveness calculation of sediment BP can be constructed. It should be noted that aerial photographs, geological data, hydrological data for other dam are also available, thus, study to deter- mine the operation of sediment BP is possible.

From now on, the review and implementation propriety of sediment BP of dam both inside and outside Japan and case study to determine economic effect, etc. are increasing.