Sustainable and Safe Dams Around the World – Tournier, Bennett & Bibeau (Eds)

Sediment management plan in Sakawa River – the results of the first phase

Y. Fukuda, R. Akita & K. Doke
NIPPON KOEI CO., LTD. Tokyo, Japan

ABSTRACT: Many sediment management plans are being planned in Japan to manage or recover its sediment routing systems. Among many sediment management plans, one for Sakawa River is characterized by the long-term environmental monitoring which consists of biological (vegetation, fish, benthos, algae) and geological (riverbed materials, riverbed elevation, suspended sedimentation) data. These data have been accumulated in more than 10 years in normal and flood conditions and these are still being accumulated so far. These long-term data of the sediment routing system in Sakawa River are very valuable to investigate the environmental conditions in the downstream area of the dam. The results of the investigation of Sakawa River's geological and biological data monitored until 2017 indicate that coarsening riverbed was temporarily recovered by sediment deposit in upstream area, and the catastrophic damage of severe flood caused by Typhoon Malou in 2010 is recovered in the ecosystem, the condition of riverbed materials and its elevation.

RÉSUMÉ: De nombreux plans de gestion des sédiments sont planifiés au Japon pour gérer ou améliorer les systèmes de transport des sédiments. Parmi les nombreux plans de gestion, celui de la rivière Sakawa se caractérise par une surveillance environnementale à long terme comprenant des données biologiques (végétation, poissons, benthos, algues) et géologiques (matériaux du lit de la rivière, élévation du lit, sédiments en suspension). Ces données ont été répertoriées depuis plus de 10 ans dans des conditions normales ainsi qu'en crue et elles sont encore accumulées jusqu'à nos jours. Ces données à long terme sur le système de transport des sédiments de la rivière Sakawa sont très utiles pour étudier les conditions environnementales dans la zone aval du barrage. Les résultats des recherches sur les données géologiques et biologiques de la rivière Sakawa, suivies jusqu'en 2017, indiquent que l'évolution du lit de la rivière vers des sols plus grossiers a été temporairement stoppée par la déposition de sédiments dans la zone en amont. L'écosystème se remet des dommages catastrophiques causés par les graves inondations générées par le typhon Malou en 2010, tant par l'état des matériaux du lit de la rivière que par son élévation.

1 SITE DESCRIPTION AND INSTRUMENTATION

1.1 *Site Description*

Sakawa and Ayusawa River basin area is about 582km^2, its channel is about 42km, and it is administrated by Kanagawa Prefecture and Shizuoka Prefecture. Sakawa river has a main branch which is called Kawachi River at about 23km from the river mouth, and main corridor is called Ayusawa River and mainly managed by Shizuoka Prefecture.

This thesis introduces downstream environmental monitoring of sediment routing system which starts from Miho Dam located in upstream of Kawachi River.

This sediment routing system had catastrophic damage by Typhoon Malou in 2010. In the next seven years, many restoration projects were carried out, and environmental monitoring was undergone during the period, the monitoring gave us many precious data about changing river conditions.

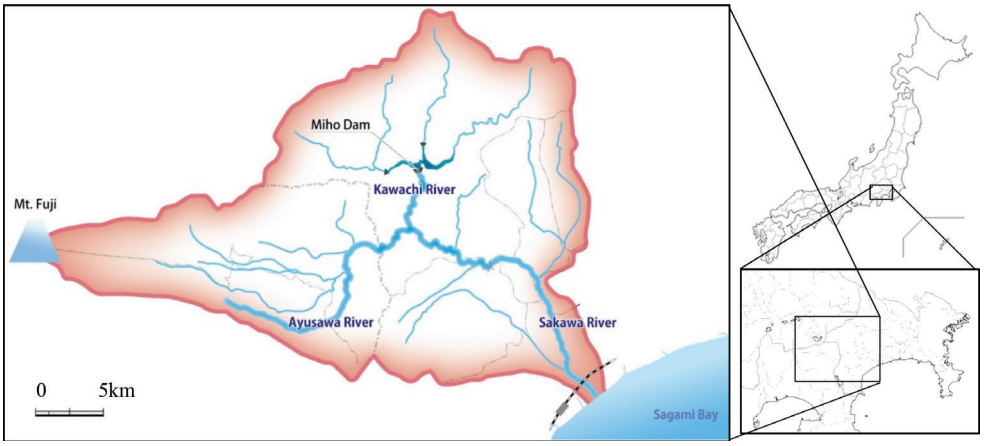

Figure 1. Sakawa and Ayusawa River basin area

1.2 *Environmental Monitoring*

After construction of Miho Dam in 1978, Kawachi River has been suffered from degradation of riverbed due to reducing the amount of sediment supply, and after Typhoon Malou in 2010, erosion and flood control project for restoration also changed natural sediment routing system. That caused many problems, for example, decrease the number of endemic species in dry riverbed due to its degradation, decrease habitats for fishes such as riffles and pools, erosion of sandy beach in coast area.

Figures 2-3 present riverbed elevation and cross sections in Kawachi river. Kawachi river is gradually decreased its riverbed elevation at the rate of 1.1cm in a year (the maximum degradation of riverbed is 2m). However, the rate was decreased to 0.4cm in a year due to sediment supply by sediment replenishment tried from 1998 to 2007, but after stooped sediment supply in 2008, the riverbed elevation started decreasing again and its materials got coarse as shown in Figure 4.

Thinking of reducing of sediment due to construction of Miho Dam, these effects such as decreasing speed of riverbed level and getting coarse of bed material are caused by decrease of sediment supply.

Therefore, "Sakawa River sediment management committee" was established with local government, river administrators, and academics, and the committee settled its principle "Sediment management plan in Sakawa River", Kanagawa Prefecture. 2018. *Sediment management plan in Sakawa River*. Its principle is "Improving sediment environment, flood control and irrigation control with caring for ecosystems.", and environmental monitoring has been conducted to realize its principle.

Environmental monitoring is divided into two kinds of monitoring, one is for sediment dynamics and the other is for environment. Its items are as shown in Table 1.

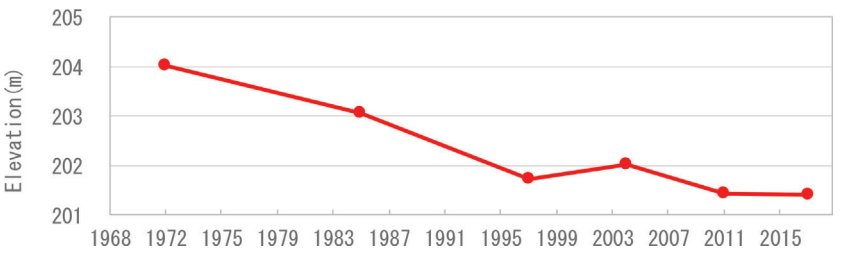

Figure 2. Riverbed elevation in Kawachi River(4.0kp)

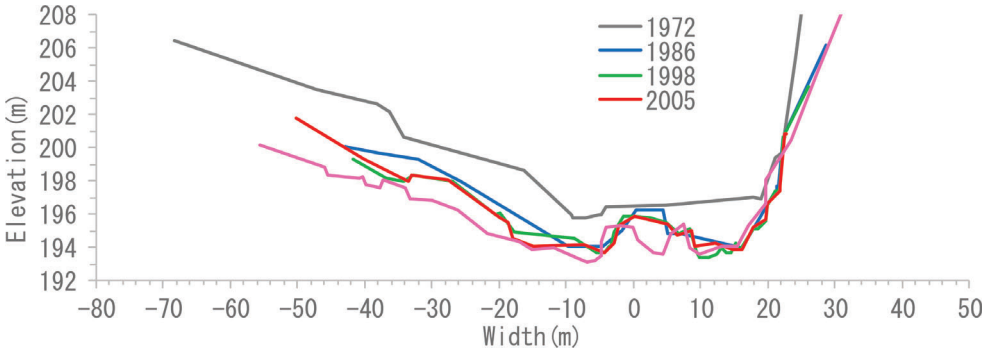

Figure 3. Historical change in Kawachi River cross sections(3.4kp)

Figure 4. Kawachi River's bed material

Table 1. Monitoring Items

Sediment dynamics monitoring items	Environment monitoring items
Suspended sediment and discharge	Benthonic animals
Bed material	Algae
Turbidity in normal and flood condition	Vegetation
	Fish, Sweet fish

2 SEDIMENT DYNAMICS MONITORING

In sediment dynamics monitoring, changes in bed morphology, sediment flow in flood condition, decrease rate of turbidity in flood condition, the effects of river maintenance projects, are conducted. Moreover, to calculate sediment yield and analyze riverbed variation, riverbed material size distribution, and turbidity monitoring are conducted.

Their sites are shown in Figure 5.

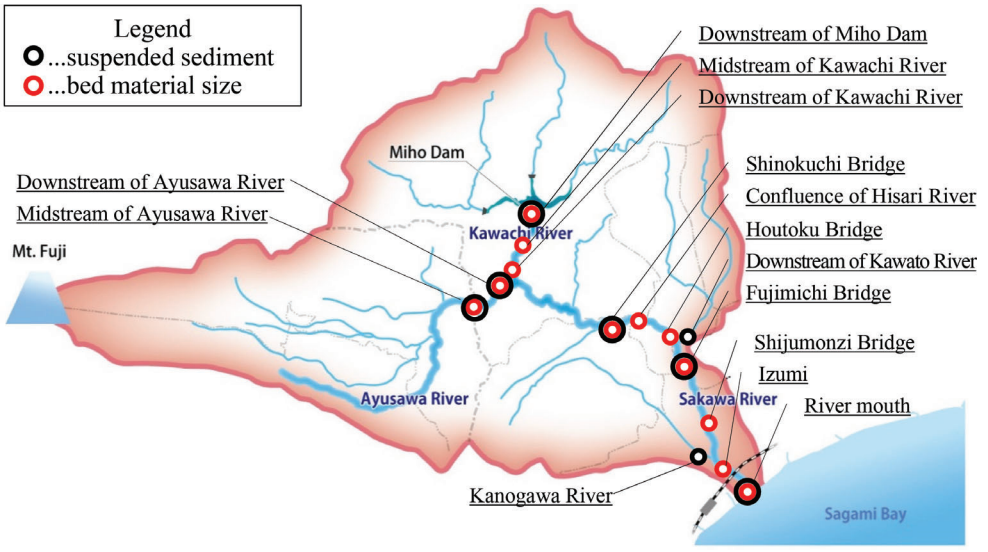

Figure 5. Monitoring for sediment dynamics sites

2.1 *Suspended sediment in flood condition*

Relationship between the amount of suspended sediment and discharge is shown in Figure 6. After Typhoon Malou in 2010, the amount of suspended sediment was increased, but in 2014 and 2015 the amount of suspended sediment got decreased at Ayusawa River, just downstream of typhoon attacked area. That indicated erosion control, for example construction of sabo dams, project well worked and the attacked area were recovered. The situations is happened at Shinokuchi Ohashi in downstream of Sakawa River.

There was a second largest flood in 2017 since Typhoon Malou in 2010. Compared with the sediment concentration in 2010, concentration in 2017 is lower. In Kanogawa River which

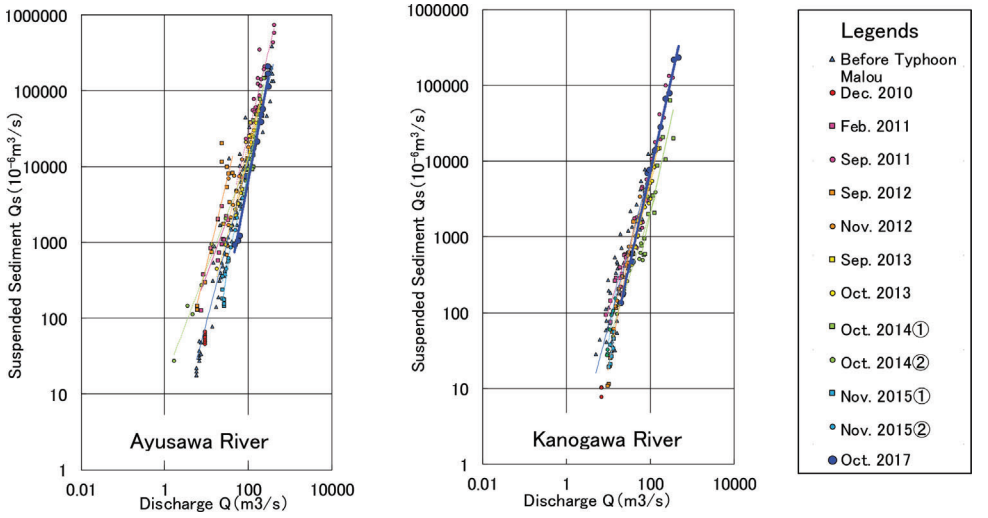

Figure 6. Annual change in relation between suspended sediments and discharge

river wasn't damaged less than other attacked area in Typhoon Malou in 2010, the sediment concentration hasn't been changed so much.

For the reasons above, upstream of Sakawa River which is sediment yield areas, were devastated by Typhoon Malou in 2010, and sediment yield and outflow were increased. Due to some restoration projects after the typhoon, sediment yield got normal conditions.

2.2 *Bed material size*

Bed material size investigation is conducted to understand the change of bed material in this sediment routing system. The investigation sites are shown in Figure 5. The investigation methods shown in Figure 5 are two ways, one is line grid for its upper layer, another is area grid for its lower layer.

Bed material at some sites in Sakawa River is shown in Figure 7. In the midstream of Kawachi River, bed material had become refined before Typhoon Malou in 2010, but in recent years it became coarse. The reason is sediment replenishment which had been tried by 2007 effects.

2.3 *Turbidity*

Fingure 8 presents turbidity monitoring result. Turbidity investigation is carried out to understand river turbidity in normal condition. High turbidity is locally occurred after Typhoon Malou in 2010, due to flood and constructions in river. That high dense turbidity had lasted

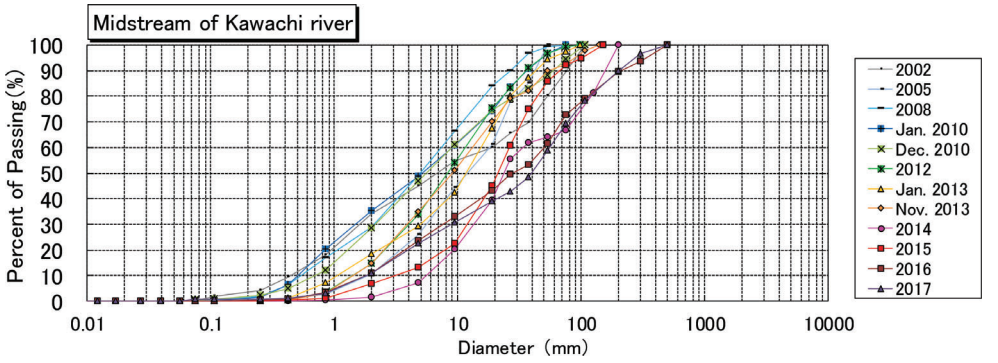

Figure 7. Midstream of Kawachi River in bed material size

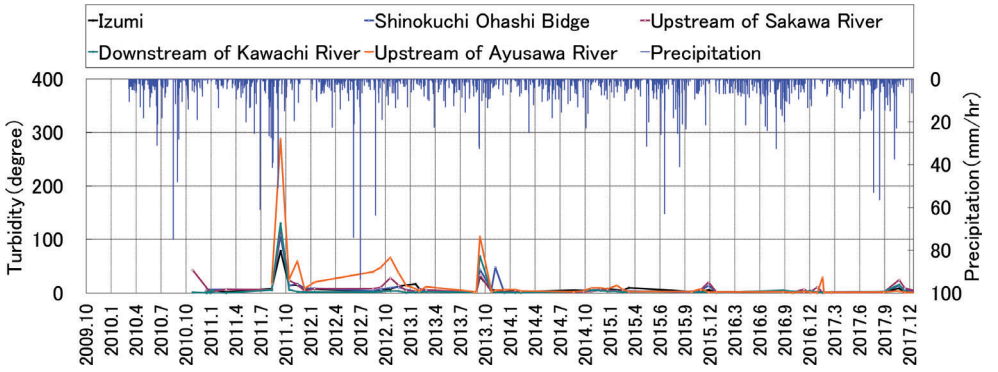

Figure 8. Turbidity in Sakawa and Ayusawa River basin

long, but it is getting low in whole Sakawa and Ayusawa River basin. For example, turbidity just after flood became lower, and the time to become normal condition is shortened. These circumstances show, fine sediment in channel is totally flown down.

3 ENVIRONMENT MONITORING

To understand the effect of change in sediment routing system on environment, some monitoring shown in Figures 9-10 is carried out. Especially fish and benthonic animals have some clear relation with sediment environment.

3.1 *Fish*

Figure 9 presents fish monitoring result. In November 2010, 2 months after Typhoon Malou, both the population and number of species in fish are fewer than normal condition. In October 2011, the population and number kept still few, but gradually recovered, and in 2016 it is nearly same as in 2008. However, in November 2017, the population was decreased due to flood and turbid water caused by Typhoon Lan. On the other hand, in Kawachi River, the population and number of species have been decreased, because coursing riverbed is not proper habitat for fish.

This sediment routing system is famous for sweet fish. Spawning bed investigation has been carried out since 2007, its site is shown in Figure 8. From 2007 to 2009, 2 or 4 spawning beds were found, but from 2010 to 2011 after Typhoon Malou no spawning bed was found. In 2012, spawning bed was rediscovered, then after 2013, 8 or 9 spawning beds were found, in 2017 4 spawning beds were found. That means spawning bed for sweet fish is recovered from Typhoon Malou's damage.

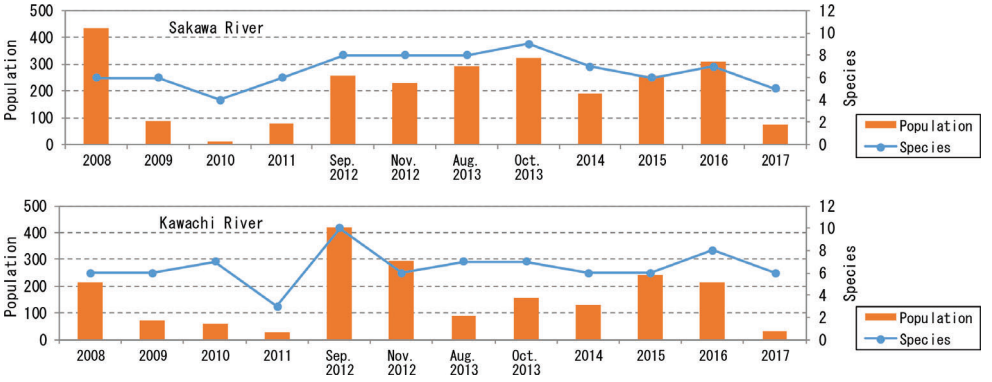

Figure 9. Fish population and species

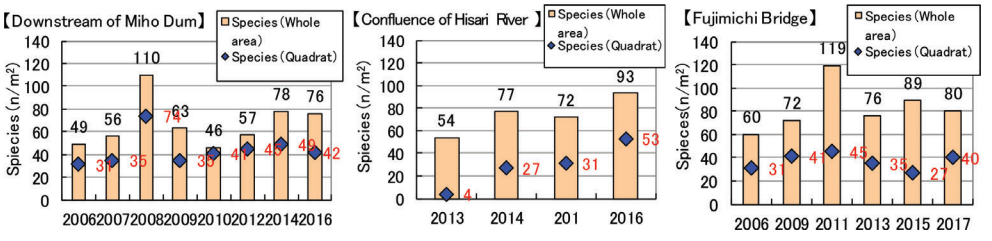

Figure 10. Benthonic animals population and species

3.2 *Benthonic animals*

Figure 10 presents benthonic animals monitoring result. The population and number of species of benthonic animals in quantitative collection after Typhoon Malou in 2010 are increasing or keeping in just downstream of Miho Dam, confluence of Hisari River, and upstream of Fujimichi Bridge1. That means its habitat is maintaining good conditions. Especially in confluence of Hisari River, the population are dramatically increased in 2016.

4 CONLUSIONS

4.1 *Conclusions*

In Japan, National Census on River Environment is held at wide interval in every 5 or 10 years, that is difficult to show the recovering process from a severe disaster like this case. Moreover, it is very rare that geological and natural environmental investigations are carried out at same time and points, and that is very important to evaluate monitoring results.

In this sediment routing system, sediment dynamics and environmental monitoring shown in previous chapter have been carried out annually at close interval in 30km since 2008. The accumulation of long term, annual and close interval monitoring data showed how the river environment, is recovered from the damage by Typhoon Malou in 2010, and the coursing riverbed is changed.

4.2 *Suggestion*

Kawachi River and Sakawa River downstream of Miho Dam have principle "Improving sediment environment, flood control and irrigation control with caring for ecosystems.". This sediment routing system is investigated very well, but still it is not good enough to aim at the principle. Annual birds and amphibians investigations are needed to evaluate gravel bar environment. Moreover, benthic animals, algae and vegetation data should be used to investigate index to protect grave bar from vegetation.

In addition to the previous suggestion, to manage this sediment routing system, evaluating correctly the amount of sediment in this system by numerical simulation is needed. Numerical simulation is under turning.

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