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Integrated Approach for Environmental Management in Tenryu River

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ABSTRACT:

The environmental impacts on rivers are unavoidable by dam construction. The sedimentations in upstream of dams, discharges of turbidity water to downstream and changes in water temperature are typical environmental issues for dam impoundment. These impacts restricted not only near the impoundment but also on upstream and downstream. Therefore the more integrated environmental management approach has been required for the whole river system including from catchment area to sea.

The "Tenryu River Natural Resources Reproduction Committee" has been established on 2012 through three years preparation. The purpose of the committee is the preservation, and conservation for the environmental condition of the Tenryu River, especially for inland water fisheries. The committee is composed of the fishermen's cooperative association, researchers of ecology and limnology, and the dam administrators. Information about the environment of the Tenryu and the technical development for fisheries are discussed in the committee over each standing point.

The committee now gives prominence on three important issue for fishery product; "attached algae productivity of river with dams", the "spawning bed creation for "ayu fish" (sweet fish; Plecoglossus altivelis) and "information dissemination of these research to local communities. In this report, we present the outline of new approach of the committee for river environment conservation and reconstruction of inland fisheries in the Tenryu River.

Keywords: Impacts on environmental condition; Multivariate and quantification analysis; Investigation and evaluation technique; Attached algae; Productivity of river.

1. INTRODUCTION

The environmental impacts of dam impoundment on rivers are subjects which have started since dam construction. Sedimentation in impoundment discharge of cool and turbid water to downstream, and changes in nutrient concentrations caused by planktonic algal production are severe problems in the Japanese rivers which have been constructed dams. Moreover, these environmental impacts may also effect on lives and distribution of the aquatic organisms of rivers, and as results may lead to depression of fisheries and changes in human lives in local communities along the river. The influences does not restrict only near impoundment, but also wide area which includes lower and upper streams far from

reservoir. There are also many stakeholders in connection with a river, and therefore the more synthetic environmental management over the whole river from headstream to sea is needed.

In this report, we present outline of newly started actions by fishermen, researchers and dam administrators for conservation of fluvial environment in the Tenryu River, Central Japan.

2. REPRODUCTION OF THE TENRYU RIVER

2.1. Outline of Tenryu River

The Tenryu River is originated from Lake Suwa in Nagano Prefecture, and it flows through the mountain area of Okumikawa and the Hokuen, and into the Pacific Ocean (Fig. 1). It has 213 km long, and has 5,094 km^2 catchment area. In the Tenryu River, many dams were built until now for the purpose of flood control, irrigation, and power generation.

Sakuma Dam, the largest one in the river system, is the concrete gravity dam, and has 294 m length and 156 m height built in the middle of the Tenryu River and the electric power generated provides 1/3 of the potential water power. There are also two small dams for power generation and irrigation, Akiba and Funagira Dams downstream of the Sakuma Dam.

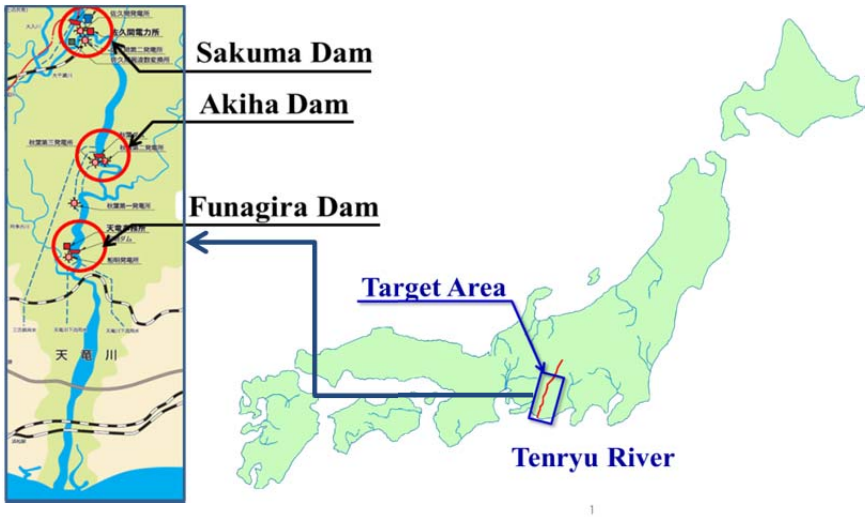

Figure 1. Tenryu River system and target area

2.2. The Tenryu River Natural Resources Reproduction Committee

The Tenryu River flows through the erodible area near the Median Tectonic Line in Japan Islands, and therefore continuously carries a lot of sediment during flood periods. The accumulative sediment in Sakuma Dam measured in 2013has reached to 37% of reservoir capacity (327 million m^3). Moreover, since the scale of the reservoir is large, discharge of the turbid water containing clay, silt and fine sand has been severe problems. The turbid water effects directly and indirectly to the main fishery resources of the sweet fish (referred later as “ayu fish”; *Plecoglossus altivelis*). There is also the tendency for the recreational fishing person to keep away to use as a fishery field because of turbid water. In recent years, it is a reason for causing the depression of inland water fisheries.

Moreover, there are also many stakeholders, and it needs a long period of time for the understanding the problems, the adjustment, and the implementation of further plan for the fluvial environment. In many rivers, the fishermen's union is the only association that has legal rights for economic activity. Under the present situation where environmental rights without economic interests are not common, unions have a strong voice against artificial interference with their fishing grounds. Therefore the more integrated environmental management by fishermen has been required for the whole river system, including not only the dam impoundment, but also up- and downstream.

The "Tenryu River Natural Resources Reproduction Committee" has been established on 2012. The purpose of the committee is the conservation of fluvial environment and recreation for of inland fisheries especially ayu fish. The committee is composed of the fishermen's cooperative association, researchers for limnology and ecology, and the dam administrators. The information about the environment of Tenryu River, and the technical problems for further development are discussed cross-boundary of the members (Fig. 2).

Figure 2. The Tenryu River Natural Resources Reproduction Committee

3. ENVIRONMENTAL CAPABILITY OF TENRYU RIVER

3.1. Environmental capability containing river ecology

The grasp of the environmental characteristics of the target river is important in the preservation and the reproduction of in fluvial environment. Instream Flow Incremental Methodology (IFIM), and Index of Index of Biological Integrity (IBI), etc. are recently proposed as the methods of evaluating the environmental characteristics including the river ecology (Nakamura 1999, and Koshimizu1997). But these evaluation methods need the detailed investigation in the rivers, even if the effective methods which is applicable.

On the other hand, ayu fish is the main fish stocks in the river from which it is distributed all over rivers in Japan. The ayu fish is the fish representing river ecology environment. Moreover, the main target of inland water fisheries is the ayu fish in Japan. The ayu fish has the special feeding habits which use a primary production (attached algae) as food is (Kitamura 2002). Production of the minute attached algae to grasp is greatly influenced by water temperature and turbid water compared with another living thing with large-scale and high mobility.

For this reason, in many rivers, investigation about the prolonged ayu fish productivity and various related environment is conducted, and it has been accumulated as official announcement data. Then, the fluvial environment of Tenryu River was positioned based on the results of an investigation about main rivers all over the country.

3.2. Relevance of ayu fish productivity and environmental capability

The 22 main rivers all over Japan are compared with Tenryu River about the environment condition. The information about ayu fish productivity, ayu fish planting, habitation range of ayu fish, land use of catchment areas, etc., were used about the ecology environment of a river. The catchment area, the river length, the river bed slope, the reservoir area of structures (dams, and weir, etc.), and the discharge flow were used about the physical environment. Furthermore, suspended solid concentration (SS), water temperature, dissolved oxygen (DO), biological need for oxygen (BOD), etc. were used about the water quality environment.

The multivariate and quantification analysis was conducted about the relation of the environmental capability of 22 rivers and the ayu fish productivity with above environment parameters (Hayashi 1993). Fig. 3 shows the mean value of ayu fish productivity (ratio of ayu fish productivity with catchment area) in Japan was evaluated to 71kg/km^2 for from 1988 to 1998. And the result of the single correlation analysis shows the relation into the centering on ayu fish productivity between the factors was investigated in Fig. 4.

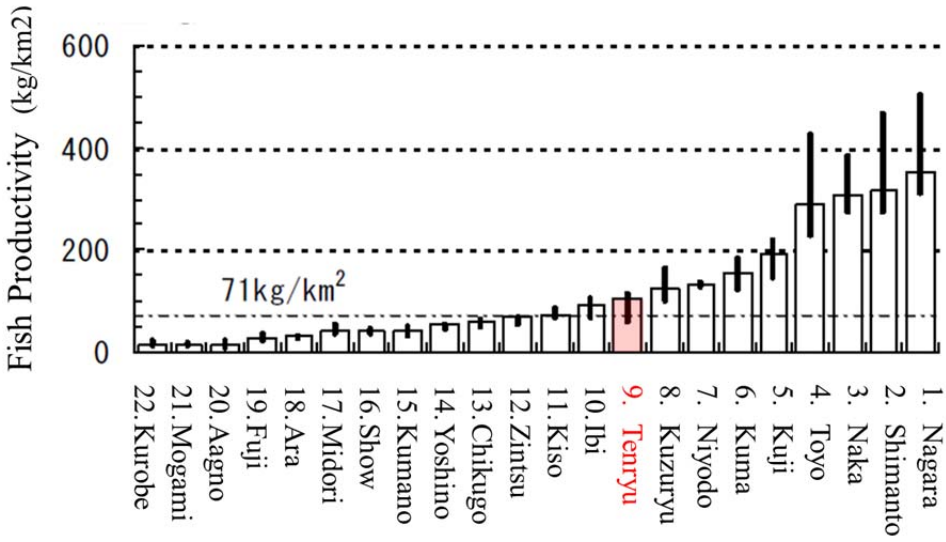

Figure 3. Comparison of ayu fish productivity of 22 rivers in Japan

Through the principal component analysis, the water temperature, the maximum discharge flow/average discharge flow, and DO have the positive correlation with the ayu fish productivity. And the river bed slope, SS, and the ratio of reservoir area and the catchment area have the negative correlation with the productivity in the factors. 22 rivers were plotted based on these main ingredients in Fig. 5. The group of high productivity (o) has been arranged on the 1st quadrant. These results show that the ayu fish productivity of Tenryu River is located near the boundary of the group of high productivity and the low productivity.

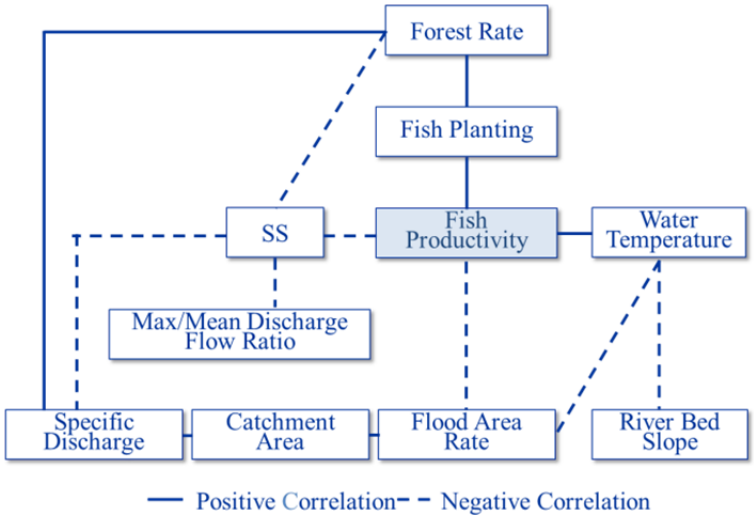

Figure 4. Single correlation of ayu fish productivity with environmental factors

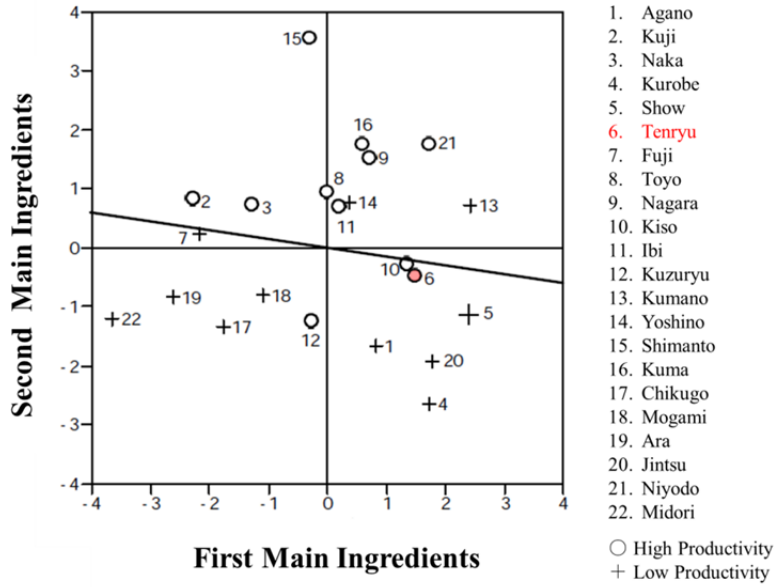

Figure 5. Position of 22 rivers with ayu fish productivity by principal component

3.3. Ayu fish productivity of Tenryu River

The ayu fish productivity, ayu fish planting, the physical environment, and the water quality environment about Tenryu River were analyzed by the regression analysis and the principal component analysis for the data. The environmental factors were analyzed about the influence for the change of the ayu fish productivity through 26 years data from 1979 to 2005. Through regression analysis, Fig. 6 shows that the annual change of ayu fish productivity has high correlation with the ayu fish planting, and is strongly influenced to the artificial influence. On the other hand, the water temperature, DO, the minimum discharge flow, and the mean discharge flow have the positive correlation with the ayu fish productivity.

Moreover, the relation between the change of ayu fish productivity and the environmental factors were examined through the principal component analysis by using the same parameter above mentioned regression analysis (Hayashi 1988). Fig. 7 shows the result of

the analysis that the 1st ingredient has the positive correlation with SS and the mean discharge flow, and the negative correlation with the water temperature. And it shows that the 2nd ingredient has the positive correlation with the fish productivity/catchment area, DO, BOD, and the ayu fish planting.

It shows that the change of fish productivity in Tenryu River becomes higher with BOD and DO which have high correlation with the main ingredients 2, and the fish planting is higher years. On the other hand, the change of fish productivity in Tenryu River has no relation with SS and the mean discharge flow. In addition, the water temperature (from January to May, and from October to December of the previous year) has small relation of the ayu fish productivity and the environment factor of river because of small loading to the main ingredients 1 and the 2nd ingredients.

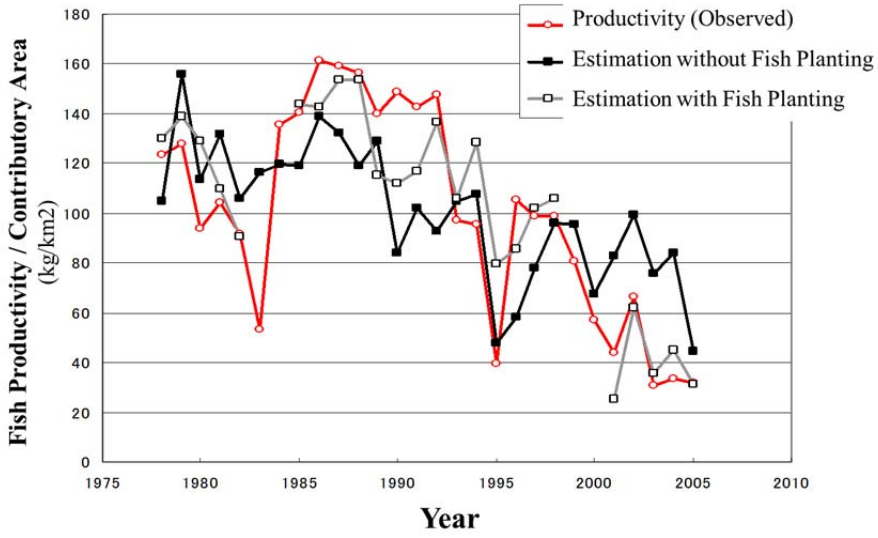

Figure 6. Estimation of ayu fish productivity by regression analysis (Tenryu River)

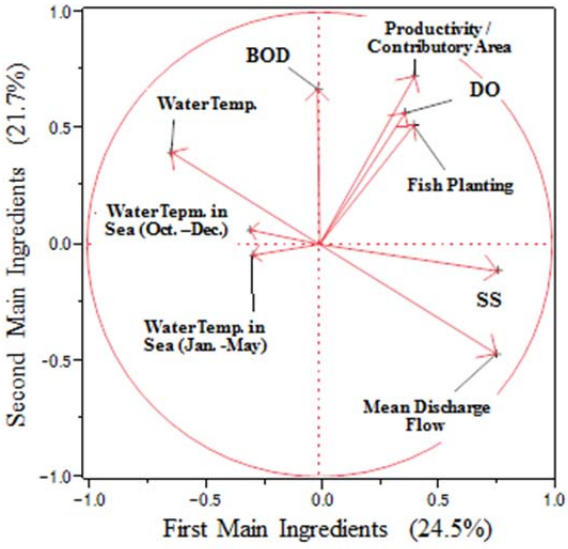

Figure 7. Relation about ayu fish productivity and other factors (Tenryu River)

4. MEASURES AND EXAMINATION METHOD

4.1. Structure of ecosystem, and improvement in fishes productivity

The recovery of ayu fish productivity in Tenryu River is related to SS, the water temperature, DO, BOD, and the discharge flow through the statistical analysis about environmental factors. It is convinced through the structure of a river ecosystem shown in Fig. 8. The quantity of attached algae on the surface of the river bed materials is influenced because of the change of the water quality, discharge flow, and the organic matter in the river, and, the fish productivity and DO change with the influences of them as the result. Moreover, the physical states in the river such as the movement of the bed material and the particle diameter changes, then the attached algae on the bed material which is the food of fishes changes, and the fish productivity also changes.

For this reason, the field investigation about the attached algae and DO gives the important key for the change of the ecology environment of the river, or the fish productivity.

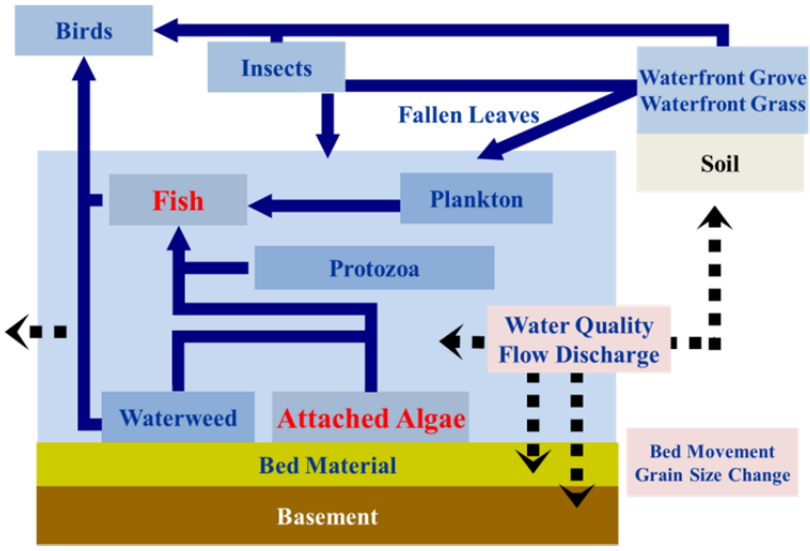

Figure 8. Structure of ecosystem in river system

4.2. Ayu fish productivity of Tenryu River

Adult ayu fish feeds on attached algae (periphytic algae) developing on gravels in the river. Algal biomass as dry weight, chlorophyll a, and species composition of attached algae were measured. The species composition of the attached organism and the biomass are not uniform, and a number of samples for statistical analyses are needed (Otani 2009). For this reason, the convenient measurement of the attached algae is required in the field. Fig. 9 shows that the results of investigation by the fluorometric method to roughly estimate biomass and species composition of the attached algae in present research (Beutler 2002).

Biomass of blue-green algae and diatoms in just downstream of the Funagira Dam are shown in Fig. 10. Dominant species was diatoms. Gravels surface was covered by clay and silt. The fed part by ayu fish on the gravel (Samples No.41 and 43) was lager biomass than other part of gravel (Sample No.42). Therefore this suggests the growth of algae will be influenced by turbid water.

Figure 9. Measurement of attached algae on gravel by fluorometric method

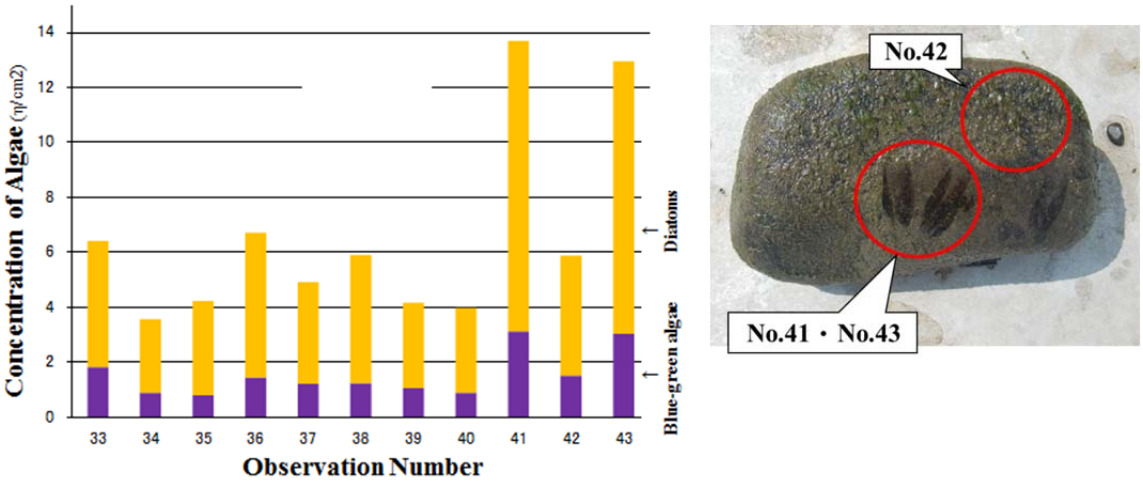

Figure 10. Algae on gravels at Shiomid bridge downstream of Funagira Dam (left: results of measurement, right: gravel after fed by ayu fish)

4.3. Production rate investigation

The quality of the ayu fish of primary production foods is influenced to the species composition of periphytic algal community and the biomass of attached algae. And the algal productivity is also important factor. The productivity of attached algae is influenced by the current. It is difficult to estimate the production in the laboratory. Therefore it is more suitable to observe directly in the open system by which the flow is maintained. We measure daily fluctuations in the DO, which is changed by algal production and respiration.

Fig. 11, 12, and 13 show the diurnal fluctuations in DO concentration. Fig. 11 shows that the daily changes in DO in just downstream of Funagira Dam (red line) and lower riffle far from the dam (blue line). It shows low productivity just downstream of the dam. On the other hands, Fig. 12 shows productivity just downstream of the dam (red line) was higher than the Keta River, a tributary without dam (blue line). Fig. 13 shows the long period investigation of DO at the downstream left bank of Funagira Dam. Algal production and respiration increased by development of algal community. Thick algal community indicated by such high productivity was not suitable food environment for ayu fish. Thick algal community was washed out after heavy precipitation and began succession of algal community again. Dam impoundment can decrease in frequency such flood event.

Moreover, from the results of the investigation shown in Fig. 13, the production rate (P) of attached algae of Funagira Dam in the downstream, changes greatly with the renewal time

and the sunshine conditions, and is estimated roughly 0-20 mgO_2/m^3/day through the DO with taking account the water temperature. The respiration rate (R) under the fine weather is same range in general, and the ratio of P/R is almost 1.0. However, the daylight hours are short, the breathing may exceed production.

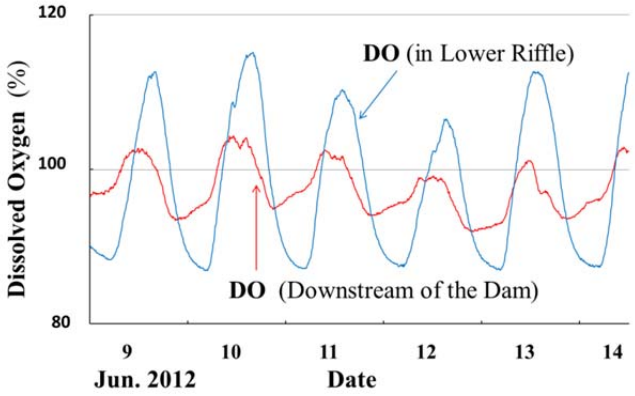

Figure 11. Change range of DO at downstream and lower riffle of Funagira Dam

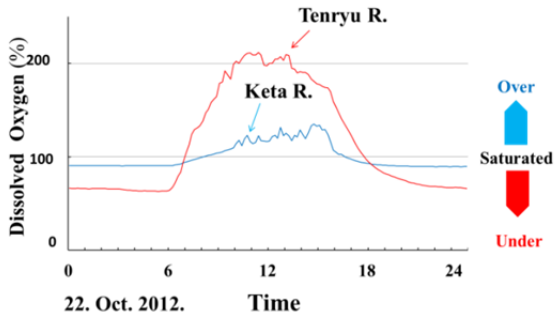

Figure 12. Daily change of DO at Funagira Dam and Keta River

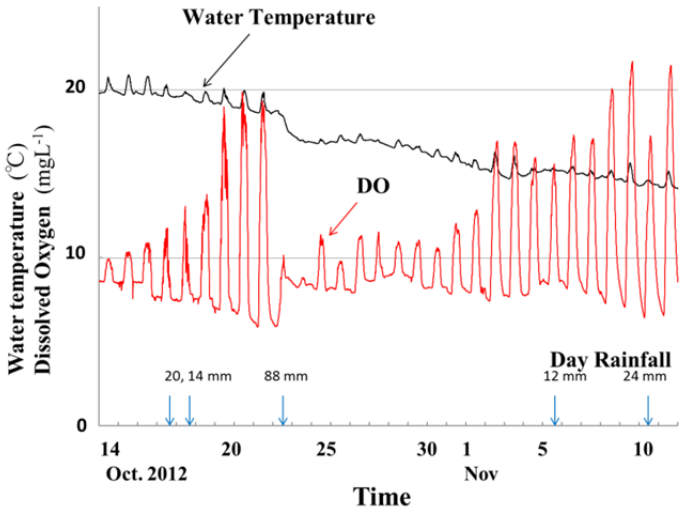

Figure 13. Long period change of DO, water temperature and rain at downstream of Funagira Dam

5. CONCLUSION

It is introduced about the outline of new approach of the committee for fluvial environment conservation and reconstruction of inland fisheries in the Tenryu River. The purpose of the committee is the preservation, and conservation for the environmental condition of the Tenryu River. In order to make reproduction of Tenryu River successful, it is important to get to know well about the environmental capability about Tenryu River. Same valuable conclusions can be drawn as followers:

(1) Through the statistical analysis about 22 rivers in Japan with the official announcement data, the fluvial environment of Tenryu River was evaluated at the boundary of the

group of high productivity and the low productivity in Japan, and has the positive correlation with water temperature, discharge, and DO.

(2) In Tenryu River, the annual change of ayu fish productivity is strongly influenced to the artificial influence of fish planting. Through the principal component analysis it is suggested the recovery of ayu fish productivity and the environment improve in Tenryu River have been necessary to SS, the water temperature, DO, BOD, and the discharge.

(3) The fluorometric method to estimate biomass and species composition of the attached algae in the field, and the growth of algae on the surface of gravel will be influenced by turbid water from the results of investigation.

(4) The productivity of attached algae was investigated through the measure of daily fluctuations in the DO concentration in the river, and changed because frequency of flood events. The production rate is estimated roughly 0-20 $mgO_2/m^3/day$

The committee gives the importance of information dissemination, therefore the environmental preservation of Tenryu River, technology, and other information are always disseminated to the various local communities and stakeholders by the homepage (URL: www.tenryugawa.jp). Furthermore, in the committee, the DNA microarray of the ayu fish has been created for the first time in the world as the new method of an environmental impact assessment. Gene expression analysis by the river water of Tenryu River was conducted, and it investigated about the influence in the gene level. We want to report at the next opportunity.

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