BASIC FILED SURVEY AND HYDROLOGICAL SIMULATIONS FOR RIVERS IN TOYAMA PREFECTURE, JAPAN FOR HABITAT EVALUATION OF ITASENPARA

RUI ZHANG
Environmental Engineering, Graduate School of Engineering, Toyama Prefecture University, 5180 Kurokawa, Imizu-shi, Toyama, 939-0398, Japan. E-mail: z17018@st.pu-toyama.ac.jp

SHUICHI KURE
Department of Environmental Engineering, Toyama Prefecture University, 5180 Kurokawa, Imizu-shi, Toyama, 939-0398, Japan. E-mail: kure@pu-toyama.ac.jp

GUANZHEN BIAN
Environmental Engineering, Graduate School of Engineering, Toyama Prefecture University, 5180 Kurokawa, Imizu-shi, Toyama, 939-0398, Japan. E-mail: t957005@st.pu-toyama.ac.jp

BAMBANG ADHI PRIYAMBODHO
Environmental Engineering, Graduate School of Engineering, Toyama Prefecture University, 5180 Kurokawa, Imizu-shi, Toyama, 939-0398, Japan. E-mail: adhipriyambodho@gmail.com

ABSTRACT

Acheilognathus longipinnis is called Itasenpara in Japan. Itasenpara is a typical plankton feeding cyprinid that is one of endemic species in Japan. Itasenpara was found in Yodogawa River water system of Osaka Prefecture, the Nobi Plain in Gifu Prefecture and the Himi city of Toyama. However, the number of Itasenpara in Himi city has decreased in resent years. Basic field survey of water quality and river bed materials to evaluate the causes of the reduction of Itasenpara in Moo River water system and Busshoji River system in Himi city were conducted in this study. Also, a rainfall runoff model was applied to the target rivers to evaluate the impact of the historical flood disturbance and future climate change on Itasenpara.

According to the results of the survey, the DO, BOD, T-N and chlorophyll *a* of the target rivers are within the index range of normal life of the carp family. There was no relationship between the reduction of Itasenpara and water quality of the target rivers. The riverbed composition in the middle and lower reaches of the Busshoji River is likely to be unsuitable for freshwater bivalve molluscs that prefer more sand than gravel for living places. As the result of hydrological simulations, it was found that the applied model can reproduce the flood situation in the target rives reasonably well. It should be emphasized that the snow melting in February is a key point for the habitat evaluation of Itasenpara because they require the low water temperature below 5 degree Celsius to survive.

Keywords: Itasenpara, water quality, rainfall runoff simulation, Moo River, Oyabe River

1. INTRODUCTION

Acheilognathus longipinnis is called Itasenpara in Japan. Itasenpara is a nationally designated protected fish, currently living in several rivers in the Yodogawa River water system of Osaka Prefecture, the Nobi Plain in Gifu Prefecture and the Himi city of Toyama. However, in recent years, the number of Itasenpara has decreased rapidly. It is said that Itasenpara in Busshoji river in Himi city became extinct.

Itasenpara is suitable to live on the water temperature below or equal to 5 degrees Celsius, and it is for hatching and eye pigmentation (Kitamura et al., 2006) but a global warming may have been affecting a hydrologic cycle and environment such as water temperature and snowmelt in the rivers. In this study, we conducted a basic survey based on hydraulic and water quality to clarify the habitat conditions of Itasenpara in Himi City, Toyama Prefecture. Also, rainfall runoff simulations were conducted in order to evaluate the effects of snowmelt on rivers where Itasenpara live.

2. STUDY AREA

In this study, the Moo River water system where Itasenpara lives and the Busshoji River water system where Itasenpara could not find at present were selected as target rives in Himi City, Toyama Prefecture. **Figure 1** shows the location of Himi City and target rivers for the field survey. Rainfall runoff model was applied to Oyabe River for hydrological simulation because river discharge data is available in Oyabe river. There are no discharge data available in Moo River, so that the Oyabe river was selected for the evaluation of the snow impacts in the rivers. **Figure 2** shows the location of Oyabe city, Toyama prefecture, and the Oyabe river targeted for the rainfall runoff simulation.

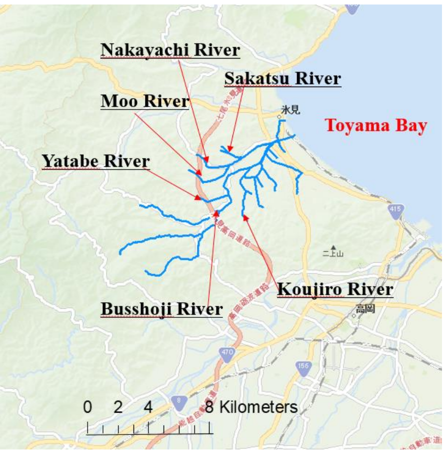


Figure 1. Study area for basic filed survey

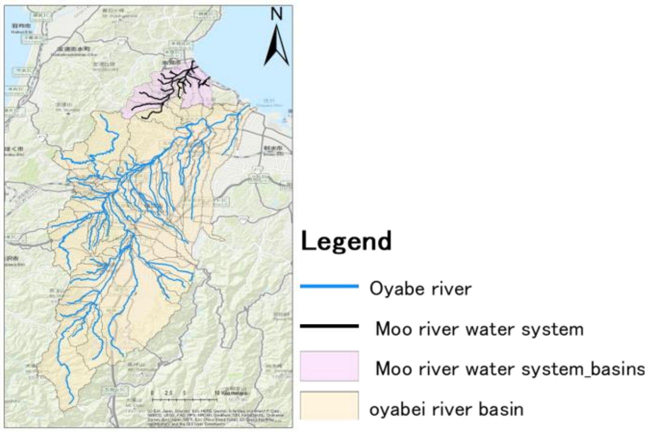


Figure 2. Study area for hydrology simulation

3. METHODS

3.1 Field observation

Field observations were conducted at the survey points shown in **Figure 3** on October 6, 2018 and June 5, 2019. The observation items were Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Nitrogen (TN), Total Phosphorus (TP), chlorophyll *a*, and Suspend Solid (SS). Also, river bed materials were collected from the rivers to investigate the differences of these materials.

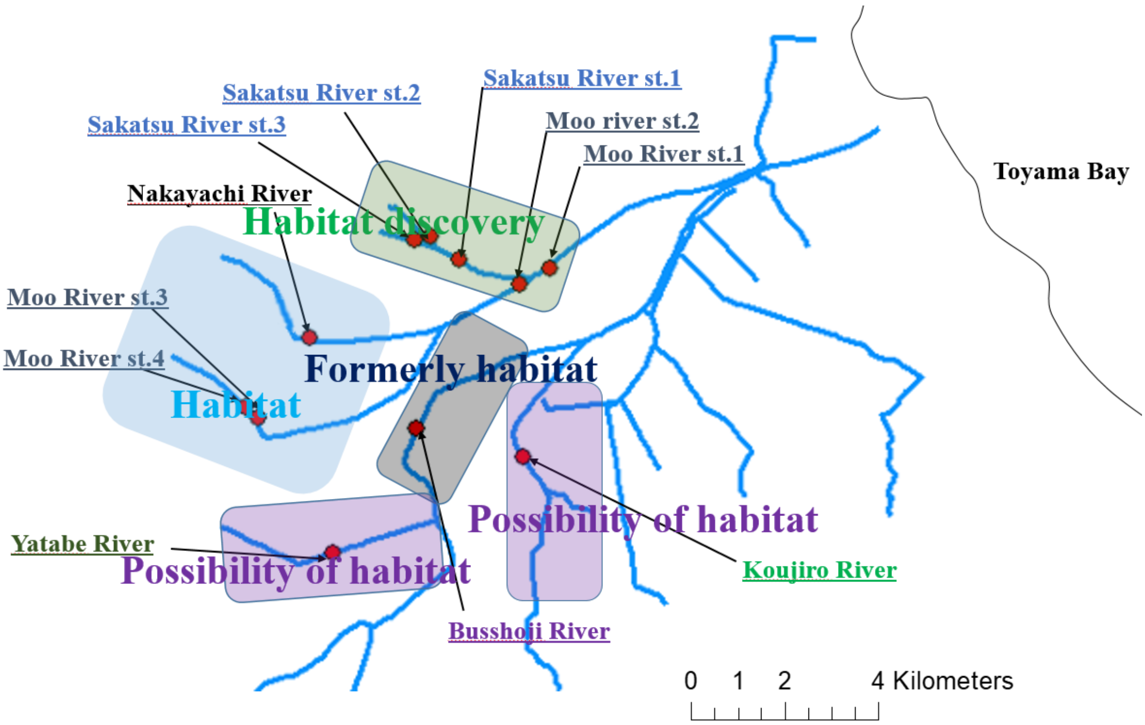


Figure 3. Assumed Itasenpara habitat and survey points

3.2 Rainfall runoff simulation

This study will investigate flood frequency and magnitude, hydrologic regime and water temperature in the target rivers in the past and future based on hydrologic modelling. A rainfall runoff model based on the lumped kinematic wave theory in a slope (Priyambodho et al., 2017) and a degree-hour model for snow melting were used for the simulations.

4. RESULTS

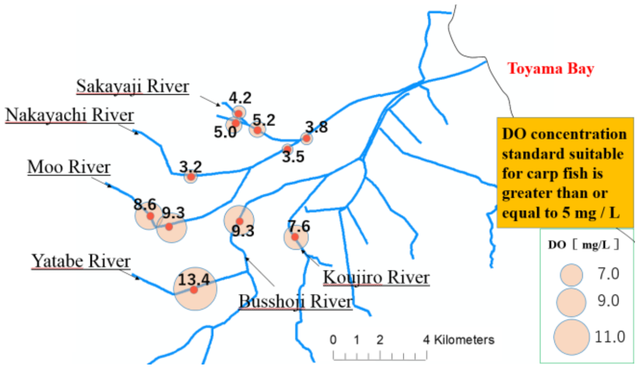
4.1 Field observation

Figure 4 and **Figure 5** show the spatial distribution of DO concentration in Busshouji and Moo River water system, on October 6, 2018 (non-irrigation season) and August 10, 2018 (irrigation season). It can be seen from the **Figure 4** that the DO value of the Yatabe River is the highest, which is 13.4 mg/L. The DO value of the upstream is generally larger than the downstream value. Except the Nakayachi and Moo River, because the DO value in downstream of the Nakayachi and Moo river is larger than the upstream. During the irrigation period, the maximum value of DO in downstream of the junction of Sakatsu River, Nakayachi River and Moo River, which is 11.8 mg/L. Generally, the downstream values of DO are larger than the upstream values of DO. During the irrigation and non-irrigation periods, almost all values of DO are larger than 5 mg/L. Yasutomi et al. (2012) pointed out that the DO concentration standard for fish of the Cyprinidae is 5 mg/ L or higher, so that the DO concentration of the Busshoji River is suitable for Itasenpara.

A comparison of the spatial distribution of BOD concentration in Busshouji and Moo River water system on October 6, 2018 (non-irrigation season) and June 5, 2019 (irrigation season) are shown in **Figure 6** and **Figure 7**. During non-irrigation season, the maximum value of BOD is 4.8mg/L in the lower Moo River. The BOD values throughout the rivers are relatively low (about 0.5 mg/L to 4.8 mg/L), and the BOD tends to be lower toward the upstream. Compared to the non-irrigation season, during the irrigation season, the values of BOD in all rivers were increased. Yasutomi et al. (2012) indicated that the BOD concentration standard suitable for carp fish is below 5 mg/L. It means the BOD concentration of Busshoji River is suitable for habitat of Itasenpara.

The results of T-N concentration in Bushouji and Moo River water system on October 6, 2018 (non-irrigation season) and June 5, 2019 (irrigation season) are presented in **Figure 8** and **Figure 9**. It is generally eutrophic (0.5 mg / L or more) during irrigation and non-irrigation seasons, the T-N concentration tends to be higher in the downstream area. During the irrigation season, the downstream of Moo River has the largest T-N value, which is 2.1 mg/L, followed by the Sakatsu River, the T-N values are all larger than 0.8 mg/L. During the irrigation season, except for the Yatabe River and Busshoji River, the T-N value of other rivers is larger than 1 mg/L.

The T-N values of the irrigation and non-irrigation seasons are larger than 0.5 mg/L. It means that the situations of the Moo and Busshoji Rivers water system are eutrophic. However, it was previously confirmed that DO is within the range of Cyprinidae, so that we concluded that Itasenpara is still acceptable to live in this eutrophic condition.



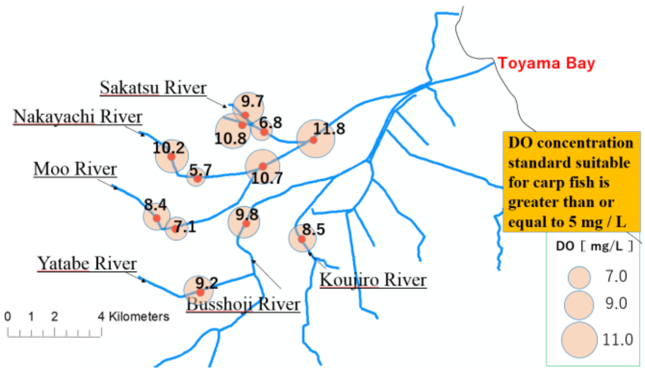
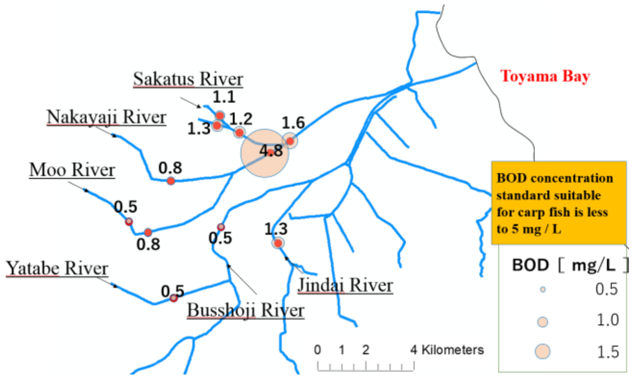


Figure 4. DO concentration on October 6, 2018(Non-irrigation) Figure 5. DO concentration on August 10, 2018(Irrigation)



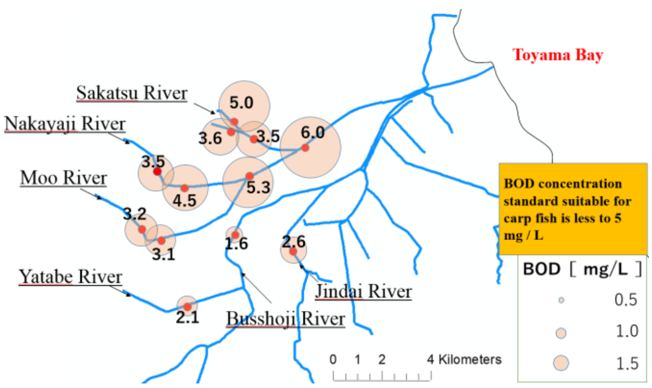


Figure 6. BOD concentration on October 6, 2018(Non-irrigation) Figure 7. BOD concentration on June 5, 2019(Irrigation)

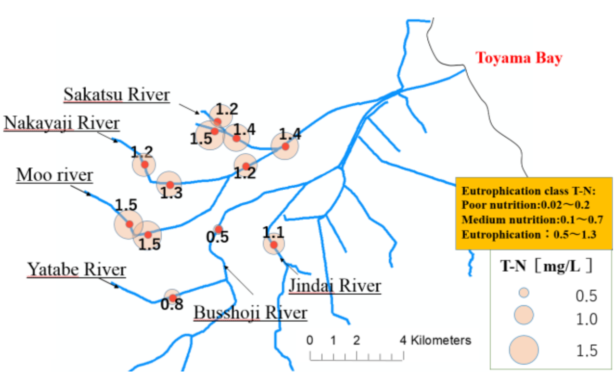


Figure 8. T-N concentration on October 6, 2018(Non-irrigation)

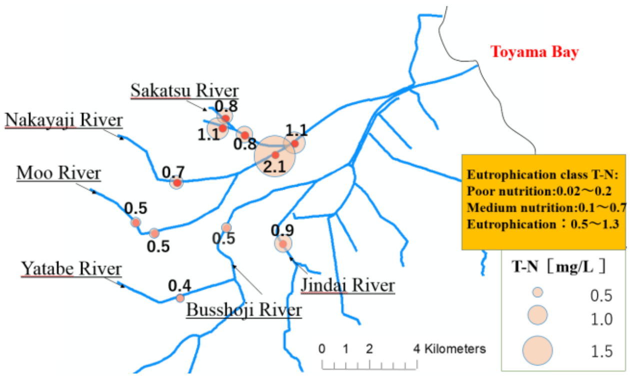


Figure 9. T-N concentration on June 5, 2019(Irrigation)

Figure 10 shows the bed material passage mass D_{50} of the target river. The sand size of the riverbed is very small overall. The river bed grain size is coarse only in the downstream area of the Busshoji River, and it is discontinuous with the upstream area due to the influence of the weir. Negishi et al., (2008) showed that freshwater bivalves prefer riverbeds with more sand than gravel. The drastic decrease in the number of freshwater bivalves in the Busshoji river might be considered to relate with riverbed materials. However, the situations should be carefully analyzed further surveys and hydrologic simulations.

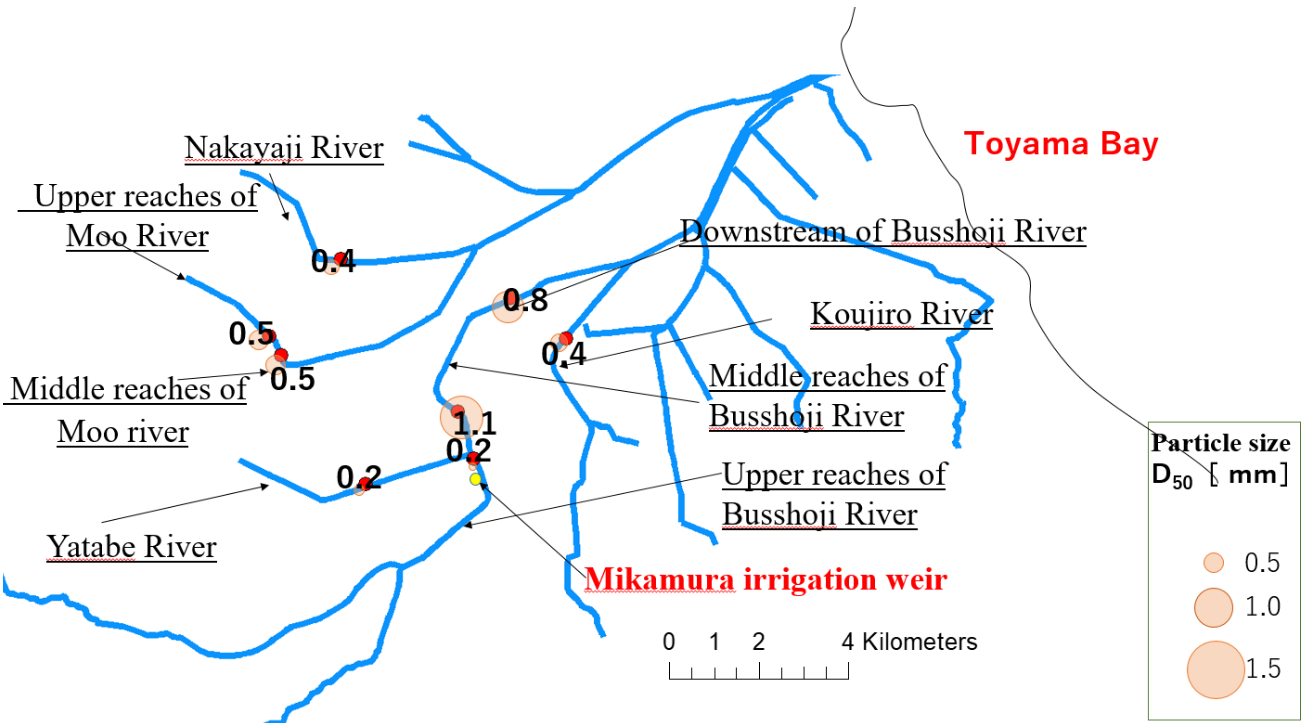


Figure 10. River bed material passing quality D_{50}

4.2 Rainfall runoff simulation

4.1.1 Calibration simulation: 8-day event simulation

Rainfall runoff model was applied to Oyabe river basin for the period (October) without snow as the first step of the hydrologic modeling. **Figure 11** shows the result of calibration. This figure shows good correlation between simulated result and observed. It means the parameters were calibrated well. So these parameters could be used for the following simulations.

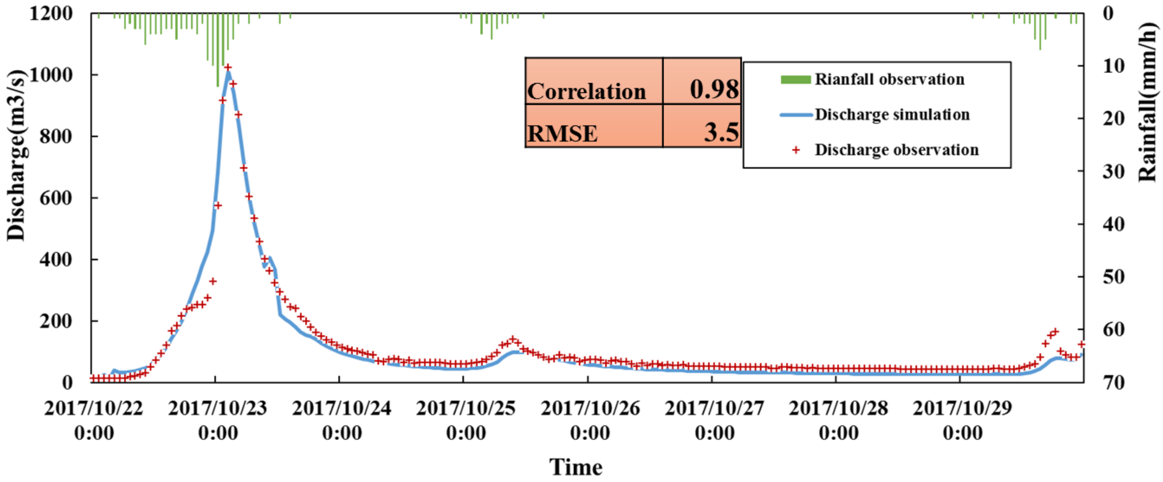


Figure 11. Hydrograph comparison between observed and simulated at Oyabe river

4.1.2 Validation simulation: Annual simulation in 2016

Figure 12 shows the comparisons between simulated and observed discharge in 2016. The model simulated the whole year discharge relatively well, but the simulation under estimated the flow discharge in February because of the snow melt. So, it is apparent that we need to consider snow melting in the simulations for habitat evaluation of the Itasenpara.

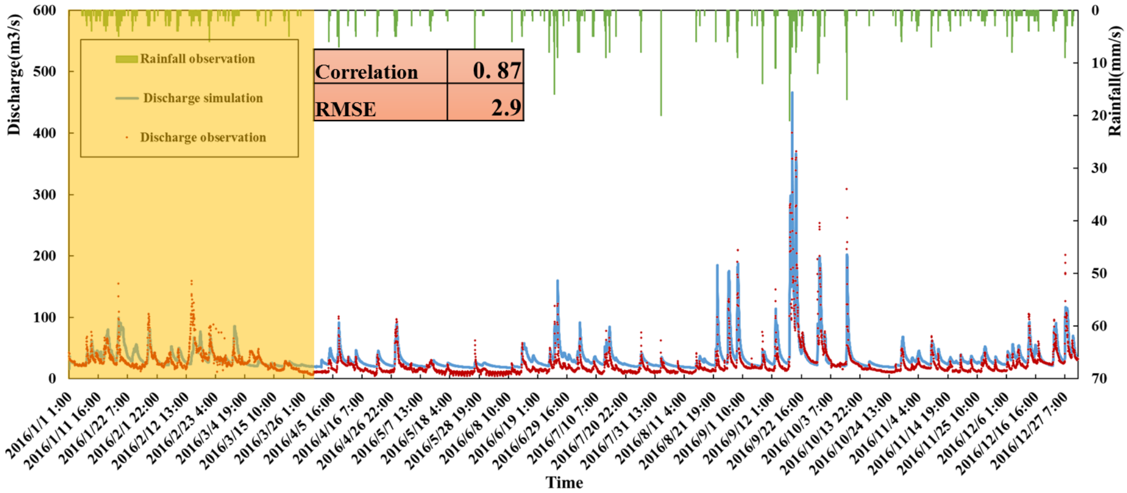


Figure 12. Annual hydrograph comparison between observed and simulated at Oyabe river in 2016

4.1.3 *Snowmelt simulation: Monthly simulation for February*

The degree hour method was used to calculate the snowmelt in February. The two comparison figures with and without snowmelt are shown in **Figure 13** and **Figure 14.** As it can be seen from **Figure 13**, the correlation coefficient without snow melting is 0.47 but the correlation coefficient with snow melting is 0.81. The correlation with snow melting is higher.

Because the water temperature of the Moo River in January and February is below 5 degrees Celsius, snowmelt may affect river water temperature. In other words, if there is a large amount of snow every year in Himi city, the water temperature may remain below 5 degrees Celsius in January and February. If the snowfall is reduced and there is not so much snowmelt, the water temperature of the Moo River might change. This situation is not acceptable for Itasenpara to live.

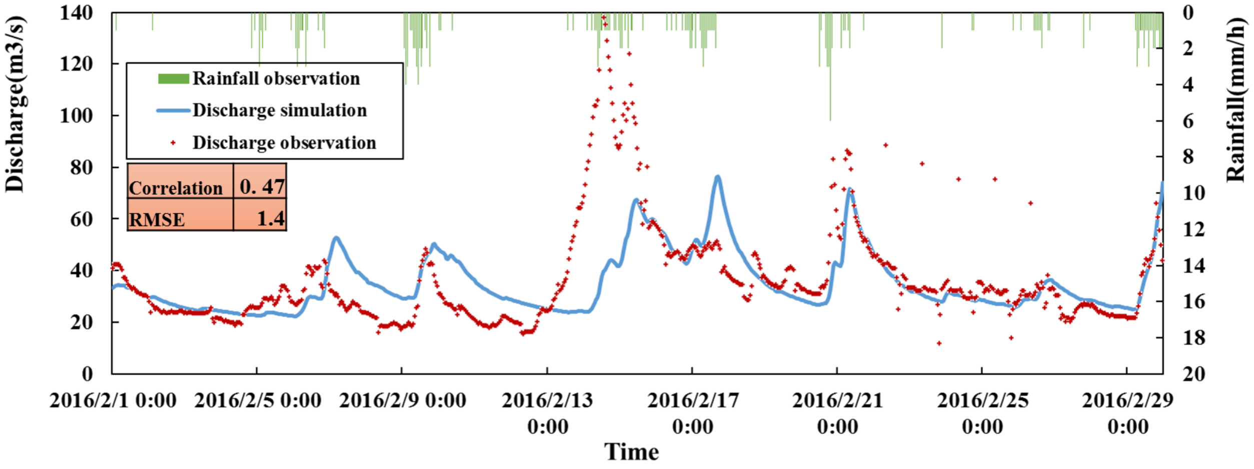


Figure 13. Simulation results without snow melting in 2016

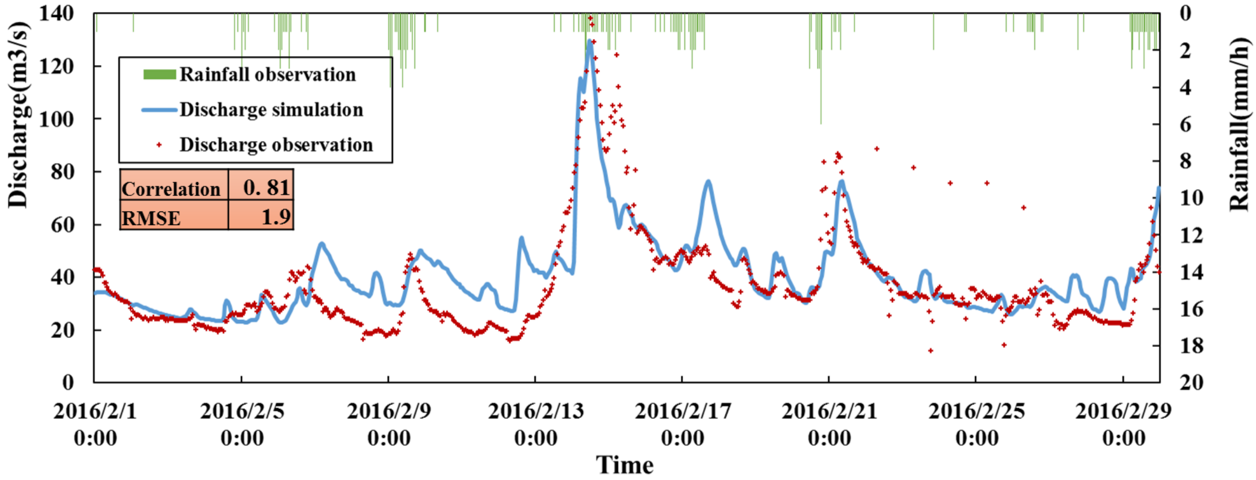


Figure 14. Simulation results with snowmelt in 2016

5. CONCLUSIONS

Through field surveys and hydrologic simulations, this paper evaluated the habitat conditions of Itasenpara in Himi, Toyama Prefecture, and clarified the changes of water quality and riverbed material composition of the target river during irrigation and non-irrigation periods. The rainfall runoff and snow melting models were applied to the Oyabe River basin.

According to the results of the field survey, DO, BOD, T-N and chlorophyll *a* of the target rivers were within the range of an index for a carp family. There was no relationship between the reduction of Itasenpara and water quality in the target rivers. However, long-term investigations are still needed. The riverbed composition in the middle and lower reaches of the Busshoji River is likely to be unsuitable for freshwater bivalve molluscs, it was required more sand than gravel for the living places.

According to the results of the hydrologic simulations, the hydrologic situations including the snow melting in February were modeled reasonably well. It should be emphasized that the snow melting in February is a key point for the habitat evaluation of Itasenpara because they require the low water temperature below 5 degree Celsius.

For the future study, historical flood situations and future flood and water temperature projections will be simulated based on the hydrologic model presented in this study and d4PDF dataset. The climate change impacts might affect for the Itasenpara habitat, and a comprehensive assessment of the habitat of Itasenpara in the future would be required.

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