

SPATIO-TEMPORAL ANALYSES OF 100-YEAR HEAVY METALS POLLUTION IN THE WATARASE RIVER AND BIOLOGICAL RESPONSES OF JAPANESE DACE, *Tribolodon hakonensis*

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Introduction

Due to Ashio mining activities (mainly from 1610 to 1973), the Watarase River basin is contaminated by copper and other heavy metals (Figure 1). In response to the metal pollution, in 1902, the construction of Watarase-yusuichi (Watarase Retarding Basin) was laid a plan in the wetland area (the confluence of three rivers, the Watarase, Omoi and Uzuma Rivers; Figure 2). After World War II, Watarase-yusuichi has established (construction period: 1963–1998) officially for flood control and has a total area of approximately 3,300 ha. During the construction, much of contaminated soils was removed and/or under the control. In addition, Watarase-yusuichi, was registered under Ramsar Convention in 2012 (Ramsar Site no. 2061). In this study, we aimed to investigate spatio-temporal changes of heavy metal concentrations in the Watarase River, and biological responses of Japanese dace, *Tribolodon hakonensis*, to the metal pollution.

Methods

Based on water quality monitoring data (1960-2010) published by Ministry of Land, Infrastructure, Transport and Tourism, the spatio-temporal change in heavy metals in the Watarase River was modeled using generalized additive models (GAM). The river water and Japanese dace (muscle, liver and gonad) were sampled from the Watarase River and the Omoi River (a reference river) and the concentrations of heavy metals were measured by ICP-MS. Metallothionein (MT) expressions in liver of fish were estimated by qRT-PCR.

Results

In 1897, Cu concentrations in sediment and water of the Watarase River were reported 2,130-4,630 mg/kg-sediment and 13.95–22.81 mg/L-water at upper sites, and 200–3,540 mg/kg-sediment and 0.12-0.16 mg/L-water at lower sites. The spatio-temporal analysis showed Cu concentrations in river water of the Watarase River from 1960 to 2010 decreased to less than one-tenth of those in 1897. Estimated annual mean concentrations of total Cu at upper and lower sites were 0.5–2.0 mg/L in 1964 and decreased to 0.02–0.05 mg/L in 1970s (Figure 3). In 2010, mean Cu concentrations at lower sites were below the USEPA water criterion (0.005 mg/L). However, our water samples taken in 2015 showed that the Watarase River had higher dissolved concentrations of heavy metals than the Omoi River. In contrast to metal concentrations in

water, tissue residue concentrations in liver of Japanese dace collected from the Watarase River were significantly lower than those from the Omoi River.

Conclusion

Heavy-metal contamination is still present in the Watarase River. Lower metal concentrations in liver of dace sampled from the Watarase River and the higher MT expression may be a result of an adaptive strategy to the long-term heavy metal contamination. We will present results of the population structure analysis using a set of microsatellite markers for Japanese dace.

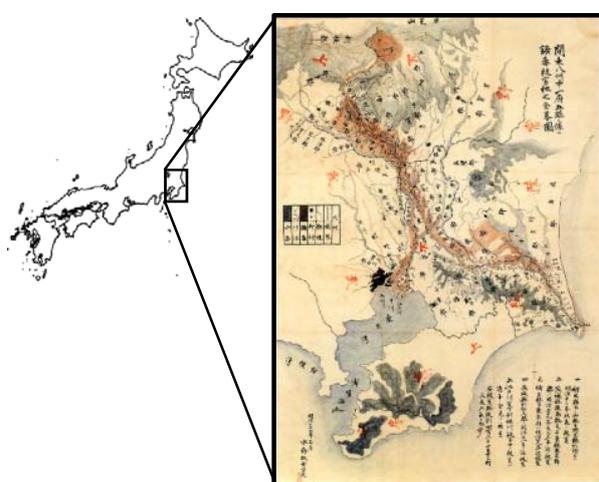


Figure 1. Brown colors indicates heavy metal polluted areas from the Ashio mining. The polluted area of >460 km² was widely distributed along the Watarase River and its downstream rivers (including Tokyo area) Reported in 1899.



Figure 2. Location of the Watarase River and Watarase-yusuichi, and the Omoi River.

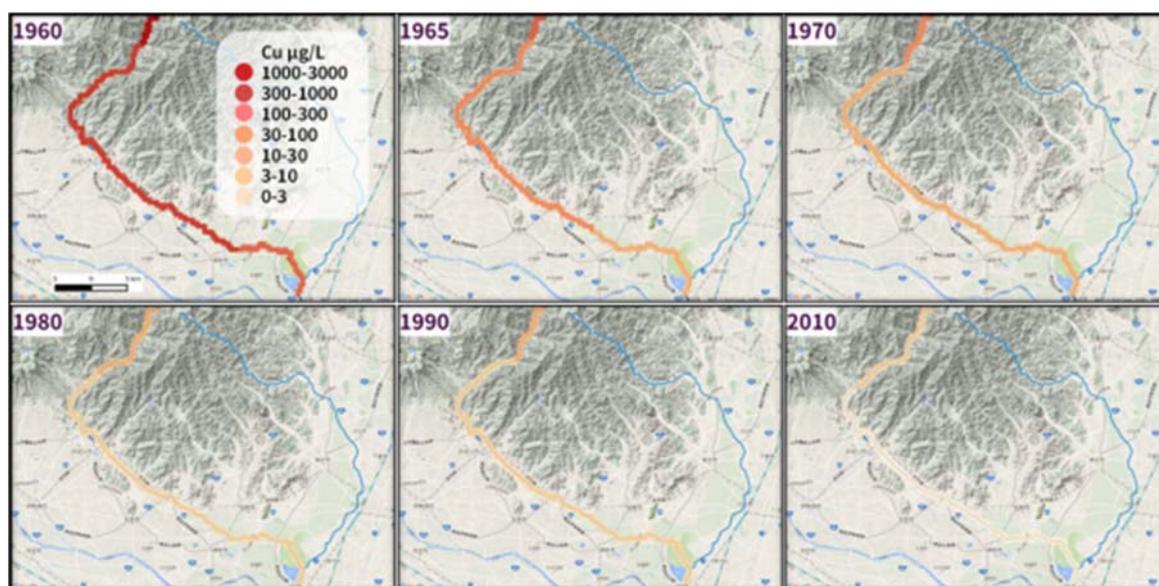


Figure 3 Spatio-temporal visualization of Cu concentrations ($\mu\text{g/L}$) in the Watarase River from 1960 to 2010