EFFECT OF SEWERAGE DEVELOPMENT ON THE WATER QUALITY AND INVERTEBRATE ASSEMBLAGES IN THE SHIGENOBU RIVER

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Introduction

Stream invertebrate assemblages and its habitat condition are affected by variety of natural and anthropogenic factors. Among them, wastewater input has a strong impact on stream invertebrates through increasing nutrient concentrations. (Aristi et al., 2015). The Japan Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) made mandatory that effluents of wastewater be treated by sewerage to acceptable standard.

Cities and towns in the Ehime Prefecture have been developing sewerage system significantly in recent 15 years. As a result, some evidences showed the improvement of water quality in the Shigenobu River, implying that stream community has also been restored. This study aimed to elucidate the effect of sewerage development on the water quality and stream invertebrate assemblages in the Shigenobu River in recent 13 years.

2. Methods

This study conducted every 3 month from May 2005 to November 2018. The sampling points chosen to evaluate environmental effect on Shigenobu River of point, particularly from the municipal STP and urban areas indicated without sewerage access (Fig. 1). Site Kiji (KJ) was the reference point of Shigenobu River. Site Obatake (OB) was first site impacted by settlement. Yoshihisa (YS) was upstream of Yoshihisa sewerage treatment plants (YoSTP) from Toon City sanitation system and Simohayashi (SM) was downstream site. Morimatsu (MR) was taken as an upstream point of Minamoida sewerage treatment plants (MSTP) discharged into the stream, which was sampling point conducted in Akasaka (AK) site. MSTP was Matsuyama City sewerage treatment center, which was the biggest city in Ehime Prefecture. Site Ido (ID) was a point located downstream the Yakura STP (YaSTP) from Tobe Town population. Site Nakagawara (NK) was reference point of urban area without sewerage system, which was impact to Ichitsubo (IC) and Deai (DA).

Samples for chemical analysis, nitrates, nitrites, ammonia, and phosphates were collected into 250 ml water bottles and refrigerated at low temperatures (<4º C) prior to laboratory analysis (Auto Analyzer 3, BRAN-LUEBBE). A YSI 560 stream water quality meter instrument was used to measure the water temperature, total dissolved solid, dissolved oxygen and pH. The biochemical oxygen demand (BOD) was determined using BOD5 method. Three stream macroinvertebrate sample points were collected using a Surber net sampler (0.25 m^2, 500 µm mesh size) in each study site (Barbour et all, 1999). Transect method were used in 40 m for three segments each site. All samples were stored in 70% ethanol for identification used a microscope (SZ61, Olympus).

Data on sewerage development was provided by Ehime Prefecture and MLIT. We calculated abundance of Ephemeropteran, Plecopteran and Trichopteran (EPT) taxa, and average score per taxon (ASPT) index from invertebrate data. The statistic software R was used to conduct generalized linear models (GLMs) for correlation. We applied non-metric multidimensional scaling (NMDS) based on abundance data to detect differences of macroinvertebrate taxa composition among study sites.

3. Results and Discussion

Sewerage system of cities along Shigenobu riverside increased (Fig. 2), although safely managed services have not been transported 100% to off-site system. Wastewater from urban areas along riverside was able to decrease stream water quality pollution. In 2018, BOD score showed the degradation of water quality from upstream to downstream in Shiganobu River BOD climbed gradually from KJ 0.01 mg/l to SM 0.57 mg/l, but then was going up sharply in MR 4.79

mg/l and DA 11. 09 mg/l. The result of total nitrogen (TN) and total phosphorus decreased in overall through 13-year period between 2005 and 2018 (Fig. 3). There also were significant differences in the levels of TN and TP amongst the ten study sites. BOD, nitrogen, and phosphorus used to identify freshwater contamination by wastewater pollution. Few studies have evaluated the long-term consequences of changing hydrologic regimes, also floods and droughts was impact to stream, which were occur in the last seven years.

We collected 472,514 invertebrates from 115 taxa with the high dominance of Chironomidae (72.9%). Abundance of Chironomidae appeared to be mediated by effluent concentrations. The number of individuals of Coleoptera, Ephemeroptera and Diptera, which are indicated response to pollution effluent exposure (Grantham et al., 2012) were increasing in downstream among 10 years. Nevertheless, the stability of invertebrate community metrics in the control sewerage was developing, evidenced by the high number of total and EPT taxa and biotic quality index ratings of "good status". Furthermore, EPT taxa and ASPT in each year show major deterioration in water quality. In contrast EPT taxa became high score continuously even years. In general, the correlation analyses revealed a principle problem with identifying sewerage development affecting invertebrate assemblages. The ASPT score and the number of EPT taxa increased significantly ($p<0.1$) by GLM analysis. The affecting variables identified by the regression model were similar to the result of the NMDS with a significant impact ($p<0.05$) for each sites (Fig. 4). These results demonstrate the water quality and invertebrates assemblages able to detecting and improved effecting by sewerage development.

4. Conclusion

Our study emphasizes that the development of sewerage affected the water quality with increasing of TN and TP, which was BOD showed sewerage effluent impact in Shigenobu River. We also found that invertebrates improved annually.

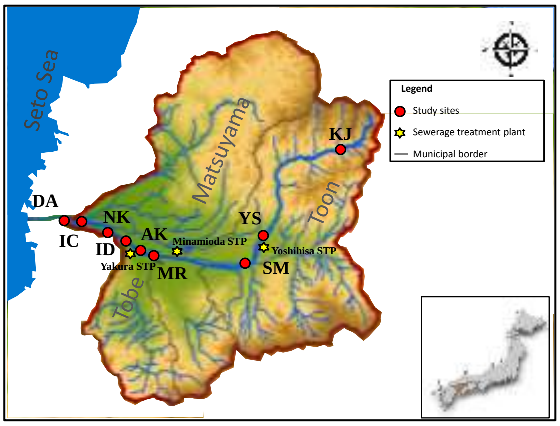

Fig. 1. Study sites of this study.

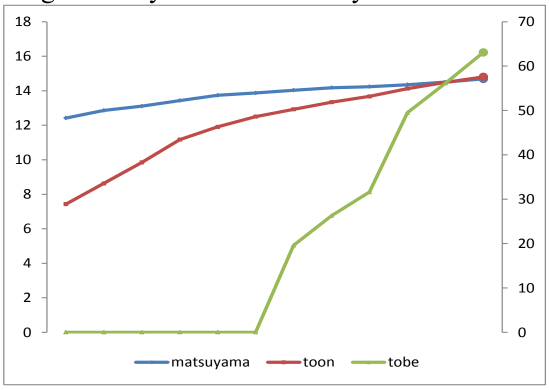

Fig. 2. Sewerage development in three municipalities of the basin.

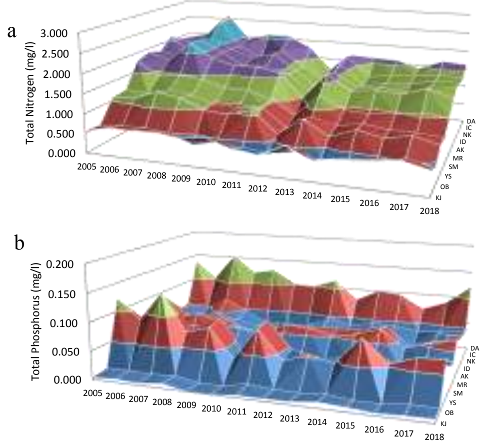

Fig. 3. Long-term changes in TN (a) and (b) TP in each study site.

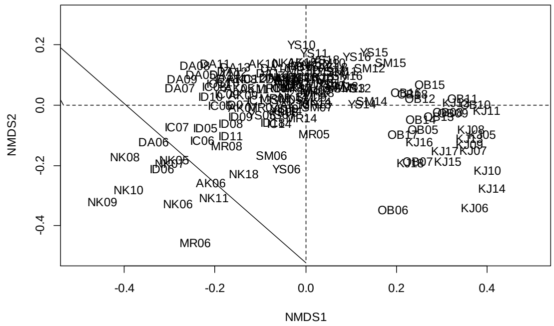

Fig. 4. NMDS biplot of study sites during study period.

References

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