EFFECT OF STOCHASTIC EVENTS AND FLOW REGIME ON THE DIVERSITY OF BENTHIC FAUNAL COMMUNITIES

MITSUKUNI TSUCHIYA[1] and KEIJI MOROTA[2]

[1]Department of civil engineering, Maebashi institute of Technology
460-1 Kamisatori, Maebashi City, Gunma 371-0816,Japan
[2]National Institute for Land and Infrastructure Management,
Ministry of Land, Infrastructure and Transport, Japan
Asahi 1,Tsukuba, Ibaraki 305-0804,Japan
(Tel: +81-27-265-7355, Fax: +81-27-265-7355, e-mail: tsuchiya@maebashi-it.ac.jp)

Benthic organisms in lotic environments are constantly exposed to a variety of natural and anthropogenic disturbances that act over a variety of scales. Species diversity is markedly dependent on the spatial attributes of the river ecosystem, extending from the level of microhabitat and river reaches, such as riffles and pools, to the level of macrohabitat, such as water catchments and river basins. Species diversity in lotic systems has been demonstrated to be a function of long-term impacts such as river engineering activities and fluctuations in river flow. Hasegawa et al. demonstrated that the diversity of benthic organisms in riffles and pools was closely correlated to the stream hydraulics at a site, and also We demonstrated that flushing due to light environments in riffles and pools influences the biomass of algae and benthic communities. Watanabe et al. emphasized the importance of studying long-term press-type impacts, such as flood disturbances and river engineering work, and conducted a study to predict recovery from artificial pulse-type impacts. In river management and conservation, the need to maintain normal flow volumes is important and considerable emphasis has been placed on Q_{60} in the past. However, the relationship between flow volume and biota in lotic systems has not been fully elucidated.

In the present study, changes in benthic communities were examined in relation to long-term press-type impacts. Furthermore, given the assumption that river flow volume is a determining factor for benthic animal communities, the relationship between flood disturbances and benthic communities was examined using discharge analysis and stochastic techniques. The objectives of the present study were thus to ascertain the differences between natural and artificial flood disturbances and to quantify a scale of disturbance appropriate for maintaining the diversity of benthic animal communities.

In previous studies, standard deviation and maximum daily flow volume have not been able to sufficiently explain the scale of disturbances. In the present study, the probability of exceeding the 95-day water level, calculated using a stochastic technique, was used as an indicator for the scale of a disturbance. Also, the probability of not exceeding the 355-day water level was assessed.

Discharge curves are used to analyze annual flow volumes of rivers based on 95-day, 185-day, 275-day and 355-day water levels. In the present study, the 95-day water level was considered to be representative of flood disturbances, and the probability of exceeding the 95-day water level was calculated to indicate the scale of disturbances. Given that the frequency distribution of daily flow volume over a 12-month period followed a logarithmic normal distribution, the probability of exceeding the 95-day water level could be calculated from the logarithmic normal distribution. This probability value

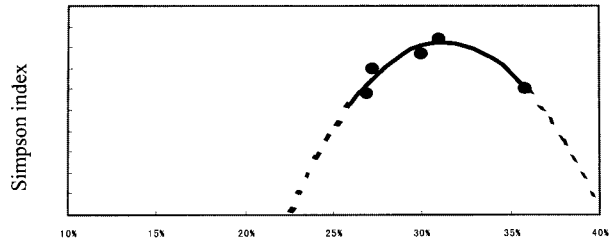
is an indicator of the frequency of medium to large-scale flood disturbances occurring in a year. Further more,not only floods, but also droughts can disturb benthic organisms. Therefore, given the assumption that the 355-day water level could also serve as an indicator for the

Frequency of disturbances, the relationship between, and an appropriate scale of disturbance maximizes diversity. Therefore, the results of the present study support the hypothesis that the probability of not exceeding the 355-day water level and the Simpson index of diversity was also analyzed.

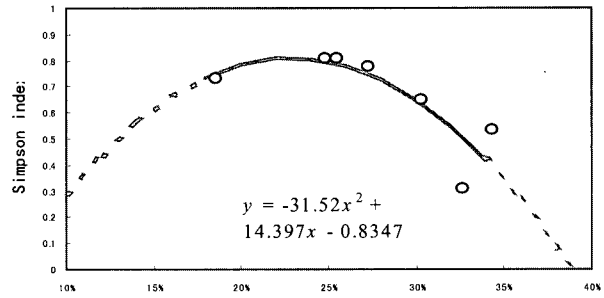
Fig. 1 shows the relationship between the Simpson index of diversity and the probability of exceeding the 95-day water level (i.e. scale of disturbance) for the Aki, Kita-Asa and Hirai rivers. The results showed a strong positive correlation between probability of exceedence and the Simpson index on the Aki and Kita-Asa rivers. In the pristine Aki River, despite insufficient flow data, a favorable correlation of 0.887 for a convex quadratic curve with a maximum value was obtained (Fig.1a). Similar results were obtained for the Kita-Asa River (Fig.1b). The level of correlation for the Kita-Asa River was not as high as that observed in the Aki River. Conversely, in the Hirai River in which several river engineering projects had been undertaken, there was no significant relationship between the biological diversity and the probability of exceeding the 95-day water level (Fig. 1c). The relationship between the probability of not exceeding the 355-day water level and the biological diversity was also investigated. The results showed that, while a significant relationship was not seen with the Aki River, a quadratic curve with a maximum value was seen in the Kita-Asa River. This relationship was not clearly seen in the pristine Aki River, and further investigations are thus necessary to identify techniques that can be applied to examine the relationship between biological diversity and drought disturbance.

These findings show that, in the pristine rivers of the Tama River catchment, the relationship between benthic animal communities and the frequency of disturbance due to the changes in flow volume can be explained by medium-scale flood disturbances in terms of the 95-day water level. This supports the medium disturbance theory proposed by Connell (1978) in which disturbances are postulated to hinder competitive exclusion, marked disturbances delay recovery in the number of organisms and lower diversity, weak disturbances cannot hinder competitive exclusion an optimal scale of disturbance does maximize the diversity of benthic communities.

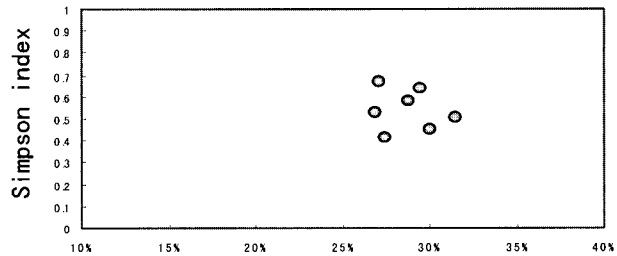
(a) Aki river



(b) Kita-asa river



(C) Hirai river



Probability of exceedence on the 95-day discharge

Fig. 1 Relationship between exceed probability of a 95-day water discharge