統合システムを用いた中国・東苕渓流域の河川環境と生物多様性の評価

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An Integrated System for Preliminary Assessment of River Environment and Biodiversity in the East Tiaoxi River, China

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Abstract: This paper presents the use of an integrated system for process-based integrated analysis and modeling of river environment and biodiversity based on spatial and ecological data from survey database of the East Tiaoxi River basin. An integrated analysis modeling was performed at the regional scale to identify the environmental contributing factors and hotspot of river environmental degradation.

Keywords: 統合システム (integrated system)，河川環境 (river environment)，生物多様性 (biodiversity), GIS (地理情報システム)

1. Introduction

With rapid economic development and increased population in the Taihu Lake Basin, many rivers have suffered increasingly from serious environment problem especially by urban and mining development (Qin, 2008). Moreover, degradation of aquatic environment in the East Tiaoxi River basin has been one of the most urgent issues, where the biodiversity has decreased in recent decades.

In this paper, based on the survey database of the East Tiaoxi River basin, an integrated research was performed to assess the river environment and biodiversity. Fig. 1 shows the flow chart of the current research. Using many apparatus such as electrofishing, water quality equipment, and Global Positioning System (GPS) logger, an integrated field survey (fishes, plants and water quality) was conducted on the whole of the rivers. A survey database was made from 108 surveyed stations in the East Tiaoxi River. For preliminary assessment, Geographic Information System (GIS) and Remote Sensing (RS) were utilized to collect significant spatial information of various environmental datasets to support the integrated analysis.

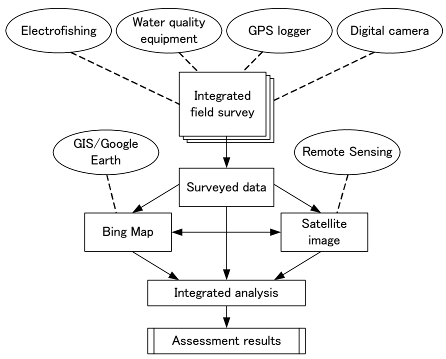

Fig. 1 The flow chart of the integrated system

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In addition, an integrated analysis at regional scale was carried out using GIS to identify the environmental contributing factors and hotspot of river environmental degradation that is important to identify the preliminary zoning areas in need of further research.

2. The study area and biodiversity data analysis

By utilizing a 30m-grid of DEM (digital elevation model), a drainage basin of the East Tiaoxi River was simulated by using a hydrologic model in GIS. Based on the model, it is estimated that the river basin has a total drainage area of 3,436 km^2 and the total river length of 220 km divided into eleven stream sections. Table 1 shows the physical characteristic of the study area calculated by the hydrologic model that described the length, elevation and gradient on each stream section.

A total of 3531 individual of fishes were sampled during the survey time from November 19th until November 23rd, 2009. 76 species of fish representing 17 families were collected. Among those species, it seems that *Rhinogobius giurinus* was distributed widely around the streams. *Rhinogobius lentiginis* and *Rhinogobius multimaculatus* was found mostly from middle stream to upstream of the East Tiaoxi River. Fig. 2 shows the distribution of species richness overlaid by the stream sections. It is found that high species richness was distributed in the stream section VII which has a length of 41 km. The stream section XI has a twice length of section VII, however; the species richness is low in the section XI.

Submerged plants are also important for most fishes as their habitat (Fasham and Turker, 2005). Therefore, it is important to assess the riverside environment in the section XI which has low of species diversity. An investigation of riverside was done in the main stream of East Tiaoxi (stream section XI) by combining the functions of Google Earth, GPS logger and high resolution of digital camera. About 3700 photographs were taken from a boat, sequence. Those photographs were attached in Google Earth and analyzed in GIS.

Table 1 Physical characteristics of the river

Section	Length (km)	Elevation (m)	Gradient (m/km)
I	5	190～94	19.2
II	2	145～94	25.5
III	8	94～34	7.5
IV	16	331～34	18.6
V	11	34～11	2.1
VI	17	209～11	11.6
VII	41	416～8	9.9
VIII	29	29～8	0.7
IX	16	11～6	0.3
X	5	8～6	0.4
XI	81	6～2	0.1

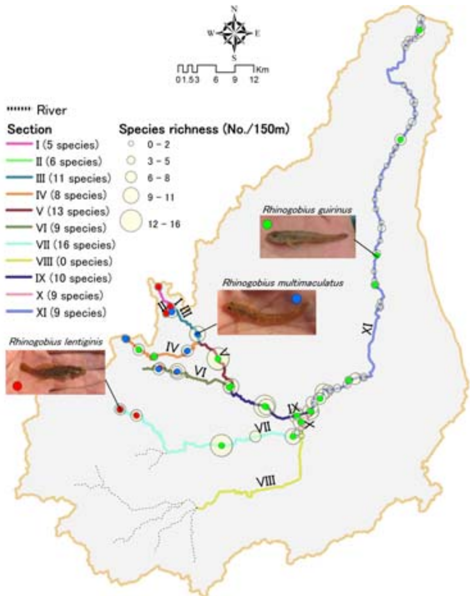

Fig. 2 Distribution of fish species by stream sections

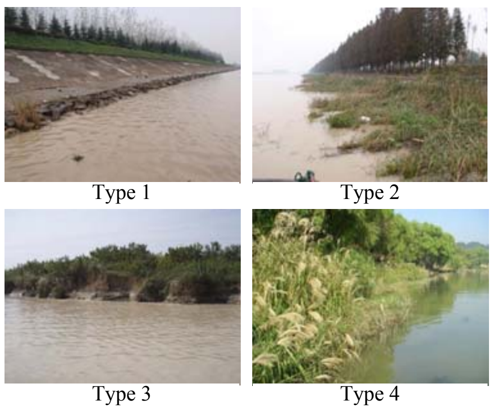

Fig. 3 The classification of riverside in the section XI

The typical classification of riverside in the section XI can be divided into four types of bank including artificial shore protection without vegetation, artificial shore protection with vegetation, natural riverside without vegetation, and natural riverside with vegetation, as shown in Fig. 3. About 40 % of the riverside at the section XI is classified as type 1, and about 25 % classified as type 2. Natural riverside with vegetation (type 4) is only can be observed mainly at the upstream in the section XI.

3. GIS integrated model and analysis

3.1 Environmental contributing factor model

High human population density directly affects river condition and water quality (Rich *et al.*, 2005). By utilizing a remote sensing data in 2005 and high resolution of digital aerialphotograph data from Bing Map, build-up area (mainly urban and mining) which has high population density can be detected by integrated model analysis (Fig. 4). In Fig. 5, the map shows the build-up area (BA) density that consists of nine colors, each indicating a range of BA density. The BA density model was derived by combining the build-up area image classification model (Zha *et al.*, 2003) and feature density model (Silverman, 1986).

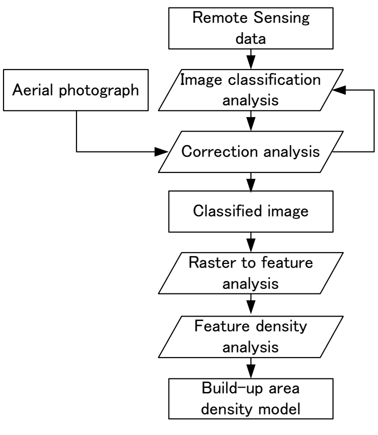

Fig. 4 The flow chart for the build-up area density model

3.2 Spatial hot spot model

For the effective investigation, it is necessary to indentify the hot spots where the in-detail survey can be carried out at a local scale. A feature with a high value is interesting, but may not be a statistically significant hot spot. To indentify relatively accurate hot spots, GIS-based Getis-Ord Gi* statistic model was used. The Getis-Ord model is given as (Ord and Getis, 1995):

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \overline{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad (1)$$

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n}; \quad S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X}\right)^2} \quad (2)$$

where: G_i^* is a *Z* score, x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature *i* and *j*, *n* is equal to the total number of features

The output from the hot spot analysis is a *Z* score for each feature. Most statistical tests begin by identifying a null hypothesis. The *Z* score is a test of statistical significance that helps to decide whether or not to reject the null hypothesis. *Z* scores are measures of standard deviation.

3.2.1 Data analysis

Deterioration of the water quality was mainly evident as increase of chlorophyll, resulting from urbanization, mining and the consequent increase in living standards in the basin (Qin, 2008). Water quality such as Chl-a concentration and turbidity was also surveyed on the whole of the streams. By utilizing the Chl-a and NTU of surveyed data, a GIS-based spatial hot spot model was carried out to identify the hot spot of the water quality deterioration.

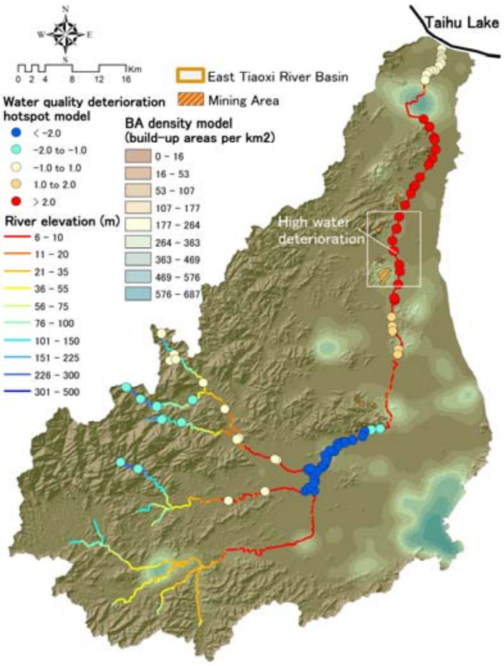

Fig. 5 Model output of the build-up area density, water quality deterioration hot spot in the East Tiaoxi River basin

Fig. 6 Photograph shows that the mining is actively conducted in the vicinity of low elevation stream

The model output of the density distribution of build-up area including urban and mining, river elevation and water quality deterioration in the East Tiaoxi River basin is shown in Fig. 5. The hot spot analysis shows that the Chl-a concentration and water turbidity is high (Z>2.0), which is mostly observed in the lowest part of river elevation. Fig. 6 shows the photograph taken in part of the East Tiaoxi where mining is actively conducted in the vicinity of the river. The rivers affected by urban and mining industry were observed in the lowlands.

4. Conclusions

In this paper, an integrated research was performed for the preliminary assessment of river environment and freshwater biodiversity. High diversity of fish species in the study area was mainly observed from the middle stream to upstream. The main stream of the East Tiaoxi has low biodiversity because of this section was affected by urban and mining development. The water with worst quality was observed in the vicinity of the mines.

Acknowledgement

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