Study on River Health Assessment Method of the Urbanized Area in Eastern Plain of China

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Abstract. River health assessment is an important decision-making basis of ecological protection and watershed management. In this study, we established the river health evaluation method of the urbanized area in eastern plain of China. In recent years, Shanghai city has carried out many comprehensive river rehabilitation and ecological restoration projects. Two small rivers with different health condition background were taken as examples to reveal the river health status before and after their rectification. The assessment result shows that the health status of river A restored from Sick (RHI=0.074) to Sub-healthy (RHI=0.510), and river B from Sub-healthy (RHI=0.585) to Ideal (RHI=0.956). This conclusion is consistent with the actual situation, and the evaluation results are reasonable.

1. Introduction
Ecosystem health of rivers is the goal of water environmental management, and river health evaluation is an important bond and basis of water environment and ecosystem management [1]. The U.S. Environment Agency (U. S. E. P. A) proposed RBP (Rapid Bioassessment Protocol) incorporated the characteristics of the stream, including width, flow, matrix type and size, into the assessment [2]. ISC (Index of Stream Condition) in Australia, RHS (River Habitat Survey) in England, ISG (Index of Stream Geomorphology) in South Africa, RCE (Riparian, Channel, and Environmental Inventory) in Sweden, all of them emphasize the significance and importance of river landscapes, river morphology, including river cross-sectional patterns, and the depth ratio of sections, which are important to river ecosystems [3-5].

Since 2010, Chinese government has paid more attention to the ecological protection of rivers and watersheds, and important policies, systems and opinions on the ecological protection and water environment clearly required regular assessment of river health. Somedifferent river health evaluation index systems were put forward to some important rivers such as The Yellow River, the Yangtze River, and the Pearl River.

However, the domestic and foreign evaluation of river health mainly focuses on large river basins, barely on the urbanized areas or small rivers of the eastern plain. The existing index system is not suitable for small urbanized rivers, as the representation and availability of indicators are very different from large watersheds and small rivers. Therefore, it is necessary to carry out research on the rivers in the urbanized areas of the eastern plain in China, which are numerous, insufficient hydrodynamics, dense river networks and high environmental pressure.

In this paper, a river health evaluation system was put forward to this area, and two small urbanized rivers were used as examples to study the river health status changes in this area.
2. Index System and Classification Standards

2.1 Index system
Following the principles of scientific, operable, systematic, independent and complete, reference to domestic and foreign literature and the Shanghai River Ecological Governance Design Guide and other guiding documents, an index system of 3 levels, 4 dimensions, a total of 9 basic indicators was defined, shown in Table 1.

2.2 Weight distribution
Using the expert scoring method, 30 experts answered the questionnaires and the scores were analyzed to determine the weight of the indicators, shown in Table 1.

Table 1. Index system and indicator weights of river health index

| Goal layer                  | Effect layer          | Layer | Meanings of index                  | Weight | Data source          |
|-----------------------------|-----------------------|-------|------------------------------------|--------|----------------------|
| River Health Index          | Water safety          | Flood control | Embankment compliance ratio        | 0.144  | Field investigation  |
|                            | Water environment     | Water quality | quality standards for surface water | 0.179  | Water analysis       |
|                            |                       | Water Liquidity | Connectivity to near water         | 0.151  | Field investigation  |
|                            |                       | Transparency   | Transparency                        | 0.094  | Water analysis       |
| Water Ecology               | Ecological shore protection ratio | Ecological shore protection ratio | 0.106  | Field investigation  |
|                            | Riverside zone vegetation | Vegetation cover in riverbank zone | 0.117  | Aerial/remote sensing |
|                            | Large aquatic plant cover | Total plants coverage in water     | 0.129  | Aerial/remote sensing |
| Human-water relations       | Hydrophilic accessibility | Walkwayalongtheriver       | 0.082  | Field investigation  |
|                            | Resident satisfaction | Resident satisfaction           | 0.104  | Questionnaire         |

2.3 Evaluation criteria
Based on local realities and a large amount of literature, the evaluation criteria for indicators are developed, shown in Table 2.

Table 2. Evaluation criteria of river health index

| Index layer                       | Evaluation value          |
|-----------------------------------|---------------------------|
|                                  | 1            | 0.8          | 0.6          | 0.3          | 0           |
| Flood control/%                  | [95,100]   | [85,95)     | [65,85)     | [50,65)     | [0,50)     |
| Water quality *                  | III and above | IV          | V            | Inferior V   | Black stench |
| Water Liquidity                  | CONNECTED BOTH ENDS | CONNECTED&TUBE CULVERT | CONNECTED&SEVERED TUBE CULVERT&SEVERED | CONNECTED&SEVERED & SEVERED | CONNECTED & SEVERED |
| Transparency/cm                  | [80,100]   | [50,80)     | [30,50)     | [10,30)     | [0,10)     |
| Ecological shore ratio/%         | [90,100]   | [70,90)     | [50,70)     | [30,50)     | [0,30)     |
| Vegetation coverage/%            | [75,100]   | [40,75)     | [10,40)     | [10,0)      | 0          |
| Large aquatic plant coverage/%   | [75,100]   | [40,75)     | [10,40)     | [10,0)      | 0          |
| Hydrophilic accessibility         | UNIMPED                    | UNIMPEDIFIED                                       | PARTLY-THROUGHLY                         | ONLY ON SOME SPOTS | COMPLETELY ENCLOSED |
Resident satisfaction/% [90, 100] [80, 90) [60, 80) [40, 60) [0, 40)

+Environmental quality standards for surface water, Ministry of Ecological Environment of China

2.4 River Health Grading Standard
River Health index (RHI) is classified as 5 levels: Ideal (0.8 \( \leq \) RHI \( \leq \) 1.0), Healthy (0.6 \( \leq \) RHI < 0.8), Sub-healthy (0.4 \( \leq \) RHI < 0.6), Unhealthy (0.2 \( \leq \) RHI < 0.4) and Sick (0 \( \leq \) RHI < 0.2).

3. Case study
3.1 Project Overview
River A (Xihuangtong River) is in Pudong District, amongst the residential areas. River A is about 720m long and 15m wide. The water was turbid and green, the transparency was below 10cm, NH3-N content was as high as 19.1 mg/L, an unpleasant smell was obvious, and river sludge was floating, mixed with oil to oil-stained zones. After the treatment, the NH3-N content is below 2.0 mg/L, the transparency reaches 40cm, and the aquatic plant cover reaches 30%.

River B (Waihuanlindai River) is in the outer ring forest shelterbelt of Baoshan District, about 800m long and 15m wide. The main problem of this river was eutrophication, with a NH3-N content of 2 to 3 mg/L. After the measures including shore slope dressing, greening, building culverts to link the near river and walkway transfixion, the flood risk is eliminated, water quality is improved, water connectivity is strengthened, and the river has become a scenic landscape.

3.2 Results and discussions
Basic data was collected and assessed by the river health index system established above, and the result shows that the health status of river A restored from Sick (RHI = 0.074) to Sub-healthy (RHI = 0.510), and river B from Sub-healthy (RHI = 0.585) to Ideal (RHI = 0.956).

4. Conclusion
In this paper, a complete river health assessment system was established, the method is intuitive and simple. This system was used to assess the health of two small rivers of Shanghai, before and after the
water environment improvements. And the health of both them was improved significantly. This conclusion is consistent with the actual situation, and the evaluation results were reasonable.

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