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Development Of River Recreation Index Model Reflecting Fuzziness In Water Quality Data

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DEVELOPMENT OF RIVER RECREATION INDEX MODEL (RRIM) REFLECTING FUZZINESS IN WATER QUALITY

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The water-related recreational activities have become to gain its popularity with the expansion of personal income and leisure spaces around rivers. Sufficient information on the river should be provided to the public in order to enhance the safety and efficiency of recreational river use. The information includes various river characteristics and among them, water quality is crucial for recreational activities because poor water quality can affect human health in a bad way. In Korea, the Real-Time Water Quality Index (RTWQI) was developed by Ministry of Environment using data from real-time monitoring system. However, it overestimated the level of water quality by underestimating the effect of bad status of water quality parameters. Also, it does not consider the vagueness of distinction among the water criteria. Thus, this index could generate the imbalance and deficiency in the river recreation information due to insufficient consideration of coliform and fuzziness of water quality criteria. In this research, a River Recreation Index Model (RRIM) for the river recreation use was developed. The River Recreation Index (RRI) was calculated using daily data of important water quality parameters.

In this research, Fuzzy Synthetic Evaluation (FSE) method was selected to develop the model for its ability to express the vague concept with number. Membership value was introduced to express those fuzzy concepts. Membership value differs from 0 to 1 depending on its level of membership of certain set. Membership function shows the relation between membership value and element. FSE synthesizes several individual elements into an aggregate, which is perfect for developing index model [2]. The procedure of FSE is divided into four steps: (1) Selection of parameters which are integrated into index, (2) Set of grade and water quality criteria, (3) Design of membership function of water quality parameters to express vague criteria, and (4) Development of method of integrating membership values into index.

First, important water quality parameters for river recreation were chosen. To do this, two standard were required for water quality parameters. First standard was that parameters which are measured by auto water quality monitoring station and second was that parameters which are crucial for river recreation. As a result of selection of parameters, DO, pH, turbidity and chlorophyll a were chosen.

Second, the RI was divided into four grades such as “Excellent”, “Good”, “Acceptable”, and “Unacceptable”. “Excellent” means that the water quality is so good that people can enjoy first contact recreation such as swimming and water-skiing in rivers without any concern. “Good” is the grade that first contact recreation is feasible. “Acceptable” means that secondary contact recreation such as boating, sport-fishing is available. Lastly, “Unacceptable” means any contact recreational activities in rivers in not allowed. According to each grade, water quality criteria of chosen water quality parameters were determined. These criteria were suggested referring to Korean river and lake living criteria, Korean algae alarming system criteria (water.nier.go.kr), USA nation and state water quality criteria (www.epa.gov), drinking water quality criteria [3] and swimming water quality criteria in World Health Organization [4], UN algae outbreak water quality criteria [5].

Next, as the determined water quality criteria has the uncertainty, membership values of the each water quality parameter were assigned to different grades in order to express that. In this research, fiver rules were determined to define membership function. A curved triangular membership function was designed to satisfy five rules. As a last step of developing model, integrating method was determined. Using the defined membership functions, 4 concentrations of DO, pH, turbidity and chlorophyll a could be converted to 16 membership values. With 4 membership values which belong to same water quality parameter, parameter’s point was calculated which stand for water quality level of each parameter. Then, weighted summation equation was introduced in order to calculate RRI. To avoid underestimating effect of poor states of water quality parameters this limitation, partial minimum function was also introduced depending on range of minimum value of the parameter’s point.

The RRIM was applied to the Dasan monitoring station of Nakdong River in Korea where daily water quality data was collected. Using the data from 1st, May, 2013 to 30th, June, 2013, RRI was calculated and compared with the RTWQI. RRI was always lower than RTWQI, which meant RRIM calculated more conservative results than RTWQI. Especially, when concentration of water quality parameters measured badly, the difference between RTWQI and RRI increased. RRI reflected bad water quality parameters more sensitively than RTWQI since the developed model included membership function to express vagueness of water quality criteria, and partial minimum integrating function to prevent overestimate of water quality level.

Acknowledgments, appendices, and references

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