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Comparison of FE and FLS model for Surface water quality Assessment

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Abstract

Fresh water scarcity ranks among the most urgent environmental challenges in this century, its quality increasingly being threatened by man, necessitating continuous monitoring of this valued resource. The present study focuses on the development of a methodology for surface water quality assessment incorporating uncertainty in the data, by defining fuzzy sets and an objective assignment of weightages to water quality parameters by Entropy theory. Fuzzy comprehensive evaluation was used to generate membership functions and in turn fuzzy relationship matrix was developed. The weight of each associated parameter was computed using Entropy concept which was combined with the so developed fuzzy relationship matrix to define assessment coefficient which led to overall water quality and station-wise quality assessment. The newly developed Fuzzy-Entropy (FE) model is compared with the traditional method of Fuzzy Logic system (FLS) model. The developed FE and FLS models were applied to Keno Reach of Klamath River, Central Oregon, USA.

*Keywords:*Fresh water; fuzzy sets;membership function; comprehensive evaluation; entropy; weightages

1. Introduction

Fresh water scarcity ranks among the most urgent environmental challenges in this century which enhances the necessity for continuous monitoring of water quality. Most of the surface water bodies have deteriorated over the years due to rapid urbanization and industrialization and hence water quality assessment is of utmost important.

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Water quality assessment of a water body is generally characterized by different types of uncertainties such as lack of clear boundary distinctions of parameters, various water quality standards used and so on.

Non-statistical approaches such as the fuzzy comprehensive evaluation methods address the uncertainties using the fuzzy set theory. Water quality assessment using fuzzy comprehensive evaluation by developing various types of fuzzy membership functions were carried out by Jihong Zhou et al (2012), Geng Yani et al (2011), Zhiguang Zhu et al (2009), Pan Zheng-Wei et al (2009) in their studies. The major drawback of this method is that subjective weightage is given based on expert's opinion/judgement to all the parameters. In the conventional Fuzzy Logic System (FLS) model, the uncertainty is incorporated using membership functions, but the limitation of this method in regard with fuzzy comprehensive evaluation is that weights cannot be allotted to the parameters to highlight their importance. Twinkle Tayal and Prema (2013) presented FLS model to access the drinking water quality.

In the present study, a new modelling procedure has been evolved to incorporate the imprecision associated with the observed data using fuzzy comprehensive evaluation combined with an objective weight determining approach. The weight of parameters associated with water quality assessment was computed using entropy concept. The newly developed Combined Fuzzy-Entropy (FE) model is also compared with the traditional FLS model. The models so developed are applied at the Keno Reach of Klamath River, Central Oregon, USA for surface water quality assessment. The methodology, analysis, results, discussions and the conclusions derived from the study are given in the subsequent sections.

2. Methodology

The modelling strategy involves in the development of a Fuzzy-Entropy model which consists of three phases: Phase-1: Fuzzy comprehensive evaluation, Phase-2: Entropy weighing method and Phase-3: Evaluation of assessment coefficient using Fuzzy- Entropy combination (combination of Phase-1 and Phase-2). **Phase-1: Fuzzy comprehensive evaluation** approach is used for developing membership functions for selected water quality parameters in order to incorporate the uncertainty by converting crisp input data to fuzzy inputs. The key to this method is to determine the weight set. The weight can be determined by subjective method and objective method. **Phase-2: Entropy weighing method** is an objective approach in which the weight values of individual indicators are determined by calculating the entropy and thereby the entropy weight. The evaluation of assessment coefficients using Fuzzy- Entropy combination was made use of in the assessment of overall water quality assessment and station wise quality assessment for a river system. The sequential steps involved in the development of Combined Fuzzy-Entropy model is described below:

Step-1: Selection of assessment parameters

An evaluation factor set U was determined based on the data of monitored water quality parameters

$$U = \{u_i\}, \ i=1, 2\ldots m \qquad (1)$$

where m is the number of parameters, u_i is the i^{th} water quality parameter.

Typically U can be the set of water quality parameters namely Temperature, DO, BOD, pH, conductivity and so on.

Step-2: Establishment of assessment criteria

An evaluation criteria set V was built based on the selected water quality criterion

$$V = \{v_j\}, \ j=1, 2\ldots n \qquad (2)$$

where, n is the number of evaluation criteria categories,

v_j is the j^{th} evaluation criteria category

Typically V can be the set of assessment criteria namely Poor, Good, Worst, Acceptable and so on.