



Contents lists available at ScienceDirect

## Physics and Chemistry of the Earth

journal homepage: [www.elsevier.com/locate/pce](http://www.elsevier.com/locate/pce)

## Water ecological function zoning in Heihe River Basin, Northwest China

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## ARTICLE INFO

## Article history:

Received 21 May 2016

Received in revised form

10 July 2016

Accepted 17 August 2016

Available online xxx

## Keywords:

Water ecological function

Functional zoning

Spatial clustering

Heihe River Basin

## ABSTRACT

Rapid urbanization coupled with increase in population growth rate in recent years has accelerated economic pressure on the ecological environment leading to a gradual deterioration of global and regional environment. This has particularly resulted into water contamination and shortage of water resources thus posing a great threat to human survival. How to guaranteeing sustainable use of basin water resources has attracted more and more attentions. The Heihe River Basin is the secondary longest river inland China and the significantly water source of Hexi Corridor, the problem of water pollution, ecological environment deterioration and the shortage of water has seriously threatened the ecological system of the Heihe River Basin. In this study, through depicting the characteristics of natural environment, human activities, water ecosystem services and other factors in Heihe River Basin we delineated the water ecological function in Heihe River using the principal components analysis and the K-means clustering method. In the study, Heihe River Basin is divided into 3 primary level areas and 8 secondary level sub-areas. Water ecological characteristics analysis showed that the spatial distribution of the water ecological function of Heihe River Basin was not uniform, which are mainly showed in three aspects, function of windproof and sand fixation, function of soil erosion prevention and function of water sources conservation. The results of this study can provide effective and scientific theoretical references for the integrated water sources management and the ecological function optimization of the Heihe River Basin.

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## 1. Introduction

Rapid urbanization coupled with increase in population growth rate in recent years has accelerated economic pressure on the ecological environment leading to a gradual deterioration of global and regional environment. This has particularly resulted into water contamination and shortage of water resources thus posing a great threat to human survival. Hence, the Integrated Water Resource Management (IWRM) have drawn the attention of numerous scholars and government of every country on ways of ensuring a sustainable management of the water resource (Bryce and Clarke, 1996; Crowley, 1967; Jenerette et al., 2002; Olson et al., 2001). The Heihe River Basin, located in a typical arid region of Northwest

China, is the secondary longest river inland China and the significantly water source of Hexi Corridor. It traverses three major topographic unit of China and has all the basin features of inland river in arid region. However, the ecological system of the basin is seriously being threatened by the problem of water pollution, ecological environment deterioration and the shortage of water (Wu et al., 2015a,b; Yan et al., 2015).

Although previous studies have proposed different management strategies for the basin water resources, most of these studies focused on individual indicators such as the administrative region zoning study, the water demand zoning study and the water quality zoning study (Jamshidi and Heidari, 1977; Kolo and Haimes, 1977; Wood, 1978). However, due to the complexity and openness characteristics of the river basin, the basin water resources ecological function can be more coordinated by proposing corresponding solutions for the various ecological functions of the diverse environment system. But the fact is that complexity and openness characterize river basin. Under the situation, only do we propose corresponding solutions for the variously ecological functions of

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diverse environment system, the basin water resources ecological function can be more coordinated development. Ecological function zoning, for this reason, plays an important role in the whole basin water management (Deng et al., 2014; Deng and Zhao, 2015; Shi et al., 2014). Therefore, appropriate development and planning of water resources allocation must be taken into account in accordance with the present differentiation of natural geographical environment, ecosystem diversity and the inharmonious development between economy and society. In addition, according to the sustainable development theory, it's significant to show respect to the evolution mechanisms of the renewable whole basin water resources, the relationship between water protection and sustainable use as well as the interaction mechanism for water resources and economy (Wu et al., 2015c; Yan et al., 2014; Zhang et al., 2014; Wang et al., 2016; Deng et al., 2016).

Water resources problems prevalent in the Heihe River Basin have become the focus of the contradictions between ecosystem service functions and the key topic about sustainable development and water-ecological interaction. On this occasion, the research of water resources ecological function zoning in Heihe River Basin becomes critically important in order to come up with policy recommendations that will ensure sustainable management of the water resources. It is a significant typical example for studying the river basin eco-system service functions among the inland rivers.

In this paper, we use grid as the smallest partition unit conducted an ecological function zoning of study on the Heihe River Basin. Firstly, the basic information of Heihe River Basin is presented. Secondly, this study combined with principal components analysis, explores the key indicators of natural environment, human activities and water ecosystem services and other factors which affect water environment in Heihe River Basin, then using K-means clustering

method to carry out the water ecological function zoning. Thirdly, the results of water ecological regionalization in Heihe River Basin are analyzed and put forward the countermeasure of environment protection and recovery. Finally, a concise conclusion and discussion is provided. Therefore, our division results can provide effective and scientific theoretical references for the basin integrated water sources management and the ecological function optimization of the Heihe River Basin, as well as the other inland rivers.

## 2. Study area

The Heihe River Basin ( $98^{\circ}$ – $101^{\circ}30'$  E,  $37^{\circ}50'$ – $42^{\circ}40'$  N) rises in the North of Qilian Mountains and flows into the South Inner Mongolia (Fig. 1). It is the second longest river in inland areas with a total length of about 821 km and a catchment area of about  $14.2 \times 10^4$  km<sup>2</sup>. It is located in the middle of Hexi Corridor, Northwest China, which is a typical arid region of inland areas that suffers from serious water scarcity. The geography is higher in West and South while lower in East and North. Elevation difference caused ecological landscape and climate condition has obviously vertical zonation law (Van Ty et al., 2012; Wu et al., 2015a). The dry and arid climate makes wind stronger, plenty of sunshine, but it has large temperature difference between day and night caused by the unique geographical location (Wu et al., 2014). The seasonal rainfall and temperature has a large variation, for example, it has an abundant precipitation in the rainy season while a major lack of rainfall in the spring (Shi et al., 2015). The annual precipitation in the upper stream is between 300 and 500 mm in Qilian Mountains, and in the middle reach is 100–250 mm in Hexi Corridor while the amount of rainfall in the downstream is less than 45 mm in Ejin Banner, which is a typical natural oasis in the desert area (Li et al., 2015).

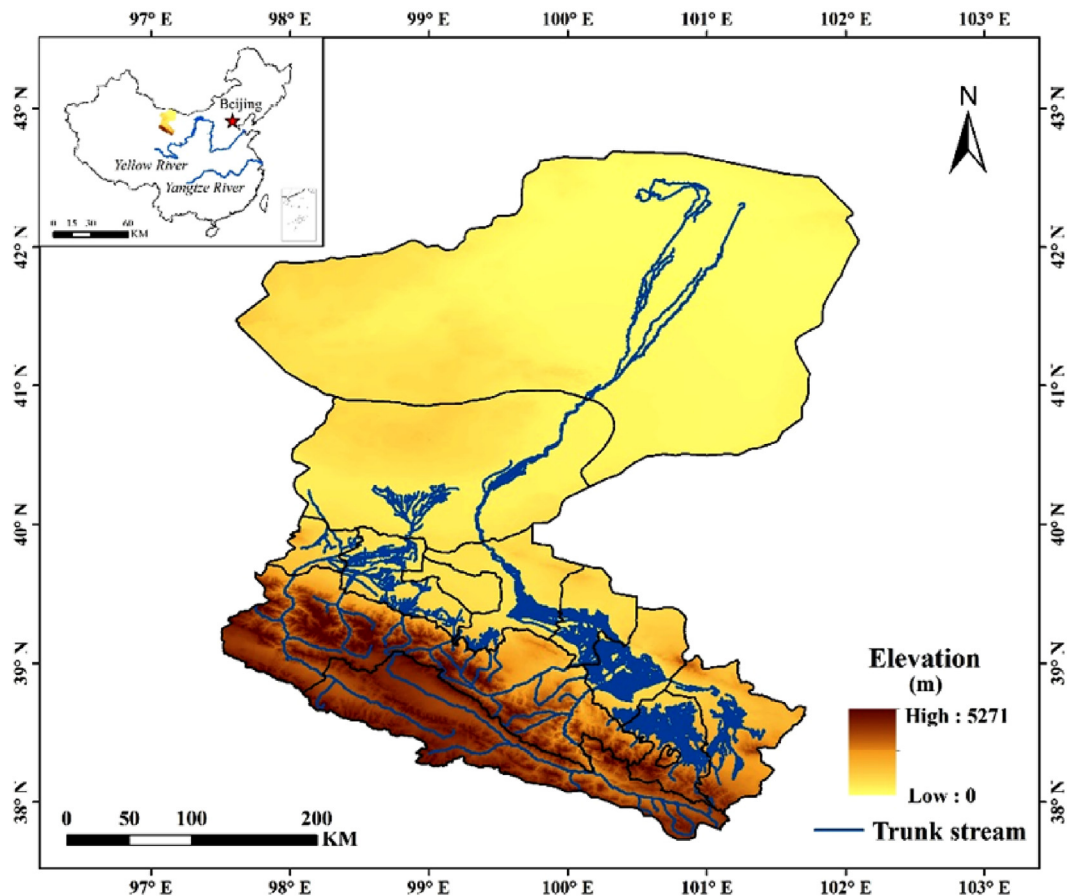


Fig. 1. Geographical location of study area: Heihe River Basin.

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