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# Pollution evaluation in the Shahrood River: Do physico-chemical and macroinvertebrate-based indices indicate same responses to anthropogenic activities?

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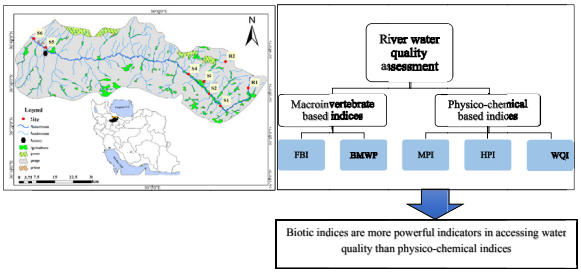
## HIGHLIGHTS

- Effects of industrial and domestic wastewaters and agricultural activities to river macroinvertebrates and water quality status.
- The water quality based on biotic indices was related to human-induced activities.
- A clear deterioration of the water quality was observed from upstream to downstream sites.

## GRAPHICAL ABSTRACT

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## ABSTRACT

This study evaluates the impact of anthropogenic activities on the Shahrood River using water physico-chemical variables and macroinvertebrates data sets obtained over a period of 12 months between February 2012 and February 2013 at 8 sampling sites. Biotic indices i.e. FBI and BMWP based on macroinvertebrates and physico-chemical indices (MPI, HPI and NSF-WQI) were employed to evaluate the water quality status in connection with natural- and human-induced pressures. Based on physico-chemical indices, water quality was categorized as low polluted level and it is suitable for drinking purposes. The water quality based on biotic indices was related to the anthropic activities; a clear deterioration of the water quality was observed from upstream to downstream sites. The water quality along the river changed from very good (class I; reference sites) to good (class II; midstream sites) and turned into moderate (class III) and poor (class IV) quality (downstream sites). These findings indicate that biotic indices are more powerful indicators in assessing water quality than physico-chemical indices. *Allocapnia*, *Glossosoma* and *Hesperoperla* were exclusively related to least disturbed sites, and Naididae, Orthocladiinae and *Ecdyonurus* were found in sites showing notable degradation. Our results recommended that the use of macroinvertebrates could be employed as a cost-effective tool for biomonitoring and controlling of polluted riverine ecosystems in the Middle East. Finally, the results from this study

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may be useful not only for developing countries, but also for any organization struggling to use macroinvertebrate based indices with restricted financial resources and knowledge.



## 1. Introduction

There is increasing pressure on rivers globally owing to human appropriation of water resources (Meybeck, 2003; Vörösmarty et al., 2010). Nutrient pollution, habitat degradation, bank erosion and alteration in hydrology are some of the most common problems that riverine systems are facing today (Vörösmarty et al., 2010). The evaluation of ecosystem pollution and the assessment of biota responses to environmental changes have received increasing attention from scientists (Azrina et al., 2006; Chen et al., 2013; Taherizadeh and Sharifinia, 2015; Mangadze et al., 2016). Biological monitoring programs are widely applied in developed countries and suggest many advantages in assessing ecological outcomes of perturbations in developing countries (Sharifinia, 2015). Currently, many indices based on macroinvertebrate communities are used as effective tools for assessment of health or pollution status in freshwater ecosystems, because they are comparatively easy and affordable to collect (Mangadze et al., 2016).

Monitoring of water quality in the running waters is required, particularly where the water be used as sources of drinking water and subjected by pollution as a result of different human activities in the river catchment (Ahmad et al., 2010; Giri and Singh, 2014). Contamination from heavy metals in surface water is one of the main quality problems in many cities with fast growth, because management and conservation of water quality and health infrastructures did not increase accompanying with the development of cities and urbanization, especially for the developing countries (Karbassi et al., 2008; Ahmad et al., 2010). Physico-chemical based indices are tools to evaluate the status of water quality and require understanding about the principles and fundamental concepts of water and its issues (Tiwari et al., 2015). Several researchers have applied physico-chemical based indices for the evaluating water quality. However, in recent years much attention has been paid to the direction of water pollution evaluation in the inland waters with applying of heavy metal pollution index (HPI), metal pollution index (MPI) and National Sanitation Foundation Water Quality Index (NSF-WQI) (Mohan et al., 1996; Tamasi and Cini, 2004; Prasad and Sangita, 2008; Sharifinia et al., 2013; Giri and Singh, 2014). The selection of the suitable indicators used to evaluate the status of water quality and environmental conditions are an essential component in water resources assessment (Lewis et al., 2007).

The Shahrood River is one of the most important mountainous rivers in the northwestern of Iran. Water quality in mid- and downstream sites is greatly impacted by industries and agricultural pesticides and herbicides. The major point sources of pollutants in these areas are industrial and domestic wastewater (Sharifinia et al., 2016). Deterioration of water quality and degradation of river health are directly and indirectly intensified by the enhancement activities of a particular catchment (Mehari et al., 2014). The Shahrood River in Iran has not been away from these developments which are connected with anthropogenic activities. There are all potentials of pollution from the use of pesticides, herbicides and fertilizers from the increasing wide-ranging agricultural activities along the river. Effects of pollution (point and non-point sources) are increasingly being noticed in water resources worldwide and will carry on for as long as development activities to address the human demand increase (Sawyer et al., 2004); and the Shahrood River is no exception.

In the present work, we tested the suitability of two biotic (Biological Monitoring Working Party: BMWP; and Hilsenhoff Family Biotic Index: FBI) and three physico-chemical based indices (HPI, MPI and NSF-WQI) to evaluate health/pollution of the Shahrood River in Iran and link them to human-induced activities. Macroinvertebrate based indices (BMWP and FBI) need identification of macroinvertebrates to genus/family level and allocate a single score to macroinvertebrates at the genus/family level that is demonstrative of the genus/family's tolerance to water pollution (Armitage et al., 1983; Hilsenhoff, 1988).

## 2. Materials and methods

### 2.1. Study area

This study was conducted along the Shahrood River, in northwestern Iran (Fig. 1). The Shahrood is the only river of the Alborz basin, which drains into the Caspian Sea. It is located between longitudes 40° 33′ E and 40° 55′ E and latitudes 36° 49′ N and 44° 75′ N. The Shahrood basin is an important agricultural area in Iran, with feed (rice and wheat) and horticultural crops (fruit and vegetables). However, the crop growth periods are the dry periods (May to September) of the year and are accompanied by high temperatures, high evapotranspiration rates and dry soils. Inevitably, these conditions result in irrigation cutbacks and overexploitation of surface water resources with significant impacts on the natural water cycle and water availability.

### 2.2. Sampling sites

The sampling sites (R1, R2 and S1–S6) were distributed along 96 km of the Shahrood River. The eight sampling sites were selected longitudinally on the basis of various forms of impacts and predominant human activities along the Shahrood River. Two sampling sites (R1 and R2) that were likely to be of a high ecological status and that were situated in the headstream of river were chosen to act as reference sites. These sites placed in the mountainous area and characterized by steep slopes, high water flow, prevailing coarse substrate, riparian vegetation and minimal external stress influence. Sampling site S3 was situated at the headwaters of the Shahrood River, with a fish farm existing between R2 and S3. Sampling sites S1, S2 and S4 were impacted by agricultural wastewater. These three sampling sites were selected to evaluate the influences of non-point pollution sources. The impacts of point pollution source were captured by sampling sites S5 and S6, both placed in downstream of leather-making factory and the city of Laoshan, respectively. Residential, industrial, agricultural and fish culture sewages are the main destructive factors in the river basin, especially in downstream sites. At each site, a sampling reach of 100 m was chosen for macroinvertebrate and water quality sampling (Fig. 1).

### 2.3. Field sampling and sample analysis

Water samples were sampled monthly from February 2012 to