Land use Changes and its Effects on Water Quality (Case study: Karkheh watershed)

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Introduction

Protecting water resources is a priority issue in natural resourcs management and is essential to sustain both human and ecological communities. Both water quality and quantity influences the growth and health of human populations as well as affects ecological health of watershed systems.

Human activities has had profound effects on rivers and streams world-wide, with many freshwater systems being impacted by multiple physical (e.g. channel straightening), chemical (e.g. contamination by organic and inorganic pollutants) and biological (e.g. introduction of invasive species) stresses. The nature of anthropogenic disturbance varies within catchments affected by different land uses. For example, agricultural land use may be characterized by increased inputs of non-point source sediments and pollutants, combined with more erratic hydrology due to the increase in impervious surfaces, and restricted ecological interactions between waterways and their land margins caused by removal of riparian vegetation. Land uses change the natural functions of a watershed by impeding or altering water flow and impacting water quality. Common effects of increased human disturbances in a watershed include increases in water volume, decreases in the reaction time of stream discharge to storm events, and increases in runoff affecting stream channels, and decrease in water quality. Watershed land use impacts water quality through nonpoint sources, which are major contributors of pollution to surface and ground water that are notoriously difficult to regulate. Although individual land use activities may not appear to have immediate and significant environmental effects, the cumulative and dynamic effects can adversely impact water quality and aquatic ecosystems. Land uses effects stream channel morphology and alters the sediment and water dynamics of a watershed. Other water quality concerns include changes in pH, acidity, turbidity, thermal pollution, and dissolved chemical constituents such as nutrients, synthetic chemicals, and heavy metals. These water quantity and quality changes resulting from land use can adversely affect the aquatic organisms by increasing the stress to individual species and communities, and by reducing biodiversity.

Studies aiming at improving our understanding of the correlations between human activities and water quality such as mining, urbanization and settlements, irrigation and other land uses are important since outputs of such studies form the basis of designing measures for controlling water contamination, and water quality monitoring programs.

Materials and Methods

In the case of Iran with arid and semiarid climate and lack of fresh water, paying attention to water quality and its effective factors is necessary.

The area of Karkheh watershed is more than 5 million hectares. The construction of the Asia's biggest earth-fill dam in in this watershed shows the importance of it. It is located in the west of Iran and in the middle and southwest parts of Zagros Mountains.

The watershed is a part of Persian Gulf watershed, divided into two parts of Karkhe Olya (upper) and Karkhe Sofla (lower). Water of Karkhe River is used for different usages such as agricultural and urban uses. This shows the sensitivity of the river's water quality.

Annual rainfall is about 150 mm in the southern regions to more than 1000 mm in the northern and eastern parts of the Karkhe Olya. On the other hand, in the last decades land use has had widespread changes in the watershed. Land use changes can affect the water quality in two aspects, positively and negatively. Increase in the extent of agricultural lands due to the degradation of water quality and the relationship between increasing woodlands and water quality parameters was negative. The amount of EC and TDS of water in urban and agricultural areas are also higher. This could have happened due to unfavorable management in land use changes. Thus, the present study was carried out to survey land use changes and its effects on Karkhe river's biological traits. The watershed consists of 5 sub-basins, including Gharasu, Gamasiab, Saymareh, Kashkan and South-Karkheh.

Seven sampling stations from upstream to downstream of the river were selected including Doab, Ghorbagh, Jelogir, Paye Pol, Hamidieh, Kanal Vasileh and Hoveizeh. Information collected on water quality includes anions and cations, TDS, EC, SAR and pH. Since the aim of research was studying the effects of land use changes, a survey on land use changes in the watershed over a period of 14 years, from 1988 to 2002, was carried out. Surveying of land uses in agriculture, range, forests, etc., became possible using TM and ETM Landsat satellites. Therfore, in the Methods of study at first geometric correction of satellite images processing the image was done. The changes occurred in the 14-year period, were determined as graphs, using SPSS software.

Discussion of Results

Results showed that in the studying period, the areas of agricultural, pastures, forests and gardening land uses have reduced; on the other hand a sharp increase has occurred in the area of barren lands. The area of urban lands has also increased from 19051 to 27794 hectares. Increasing urban lands in most of the sub-basins and also increasing the gardening and agricultural lands in the two sub-basins of Kashkan and South-Karkhe were observed, which can have negative effects on water quality (figure 1).

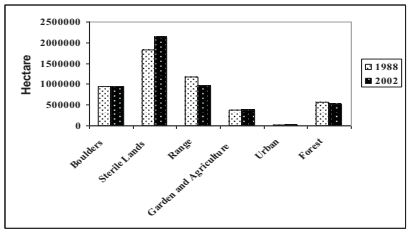

Fig. 1: Land use changes in Karkhe watershed

In the next step, the most important anions and cations including HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Ca^{2+}, Mg^{2+}, Na^+, K^+ along with other factors including TDS, EC, SAR and pH were studied. TDS is the most important factor especially in irrigation and has an important role in determining the fauna and flora. Results showed a decrease in the water quality in the 14-year period and indisputable increase in different parameters of water quality as TDS (Figure 2).

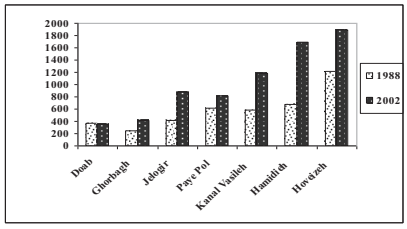

Fig. 2: TDS changes in Karkhe River

An important factor in the valuation of chemical water quality in potable and agricultural usages is pH, which did not show significant changes. This factor ranges from 6.03 to 9.3 in the Karkhe River water. Unsuitable water quality in Hamidieh and Hoveizeh stations was obvious which showed the reduction of water quality from first station to the last one. For example, changes in EC and TDS showed the increase in these factors from Doab to Hoveizeh stations (Figure 3).

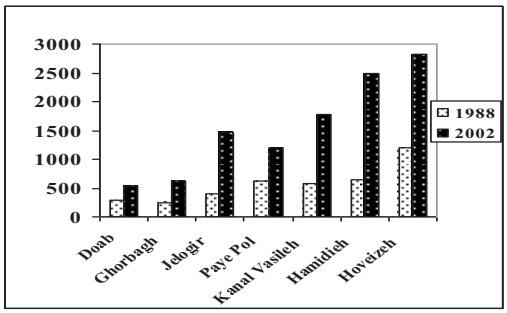

Fig. 3: EC changes in Karkhe River

Urbanization in south-eastern Australian streams can also be associated to higher salinity and nutrient concentrations.

Hessler (2004) obtained similar results. He claimed that the water quality of rivers in California State is affected by agricultural and stocks activities, so that these activities cause to reduce the water quality in most of the rivers in this state. Hatt et al. (2004) stated that the extension of urban lands has a direct relationship with the increase in TDS of rivers water. Newall and Walsh (2005) claimed that the contents of TDS and pH of rivers water are more in the watershed with extra urban lands, and less in the watershed with fewer urban areas.

We also surveyed the changes of water quality parameters by using 30 years of data which showed the abrupt changes in reduction of water quality since 1998. Another factor was also checked which can have an important effect on water quality: aridity, which affects on the volume of water and indirectly on water quality. The available data in this region showed that a drought had happened during the period of 1998-2000.

Kurunc et al. (2005) claimed that there is a negative relationship between discharge and water quality variables including EC, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+, SAR, hardness and TS. No relationship was obtained between discharge and water temperature, pH, CO_3^{2-} and B. Amirian et al. (2009) also obtained similar results. By valuating the effects of aridity on water quality of Maaroun River, they stated that water quality of the river reduced in the arid period.

Conclusions

In conclusion, land use changes have important effects on reducing the water quality of Karkheh River in the period of study. This happened because of the severe changes in the watershed land uses, especially the increase of barren lands from 1,827,739 to 2,147,773 hectares between 1988 and 2002. But we shouldn't also neglect the aridity that occurred in the period of 1998 to 2000. Therefore, we can claim that the most important parameter that caused the water quality to reduce is land use changes but aridity could have intensified this reduction.

Key words
Karkheh watershed, land use change, TM and ETM land set satellites, Karkheh River, water quality