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Research paper

Evaluation of the best management practices in a semi-arid region with high agricultural activity

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ABSTRACT

The arid and semi-arid regions with water scarcity are vulnerable to several stressors such as urbanization, high water demand created by agricultural and industrial activities, point and non-point pollution sources, and climate change. Hence, proactive policies and sustainable water management strategies that are based on decision support systems are crucial in arid and semi-arid regions. Because of large expenses and implementation difficulties associated with the diffuse pollution abatement plans, many authorities are hesitant to initiate, especially those that may present a financial burden on population. Lake Mogan, a shallow lake, is located in a semi-arid region dominated by dry agricultural activities and has been in eutrophic state for the past 20 years. There has been several management alternatives suggested to improve the water quality in Lake Mogan and one of the alternative is the application of BMPs that include fertilizer management, conservation/no tillage, contouring, and terracing to reduce the amount of diffuse source pollutants. In this study, Soil and Water Assessment Tool (SWAT) Model is applied to evaluate the effectiveness of agricultural best management practices (BMPs) in the Lake Mogan watershed located in a semi-arid region. The most effective BMP scenario was found as the one in which three individual BMP scenarios (30% fertilizer reduction, no tillage, and terracing) were combined. With this scenario average annual load reductions of 9.3%, 8.6%, 8.0%, and 11.1% were achieved in sediment, nitrate, total nitrogen, and total phosphorus, respectively. Even with the most effective BMP strategy, high levels of nutrient reduction will not be achieved since non-irrigated agriculture and intermittent low-flow streams accounts majority of the study area. The outcomes suggest integrated solutions should be developed to improve water quality in Lake Mogan. It is aimed that this study will aid decision makers to implement effective best management practices in watersheds showing similar characteristics (i.e. topographical, hydrologic processes, LULC (Land use land cover) characteristics, agricultural activities, meteorological etc.) with the study area.

1. Introduction

Nonpoint or diffuse source pollution is primarily related to land drainage and surface runoff (Hranova, 2006). Runoff, produced either due to rainfall or snowmelt, gathers and transports the pollutants to water bodies such as lakes and rivers. Contrary to point source pollution arising from industrial and sewage treatment plants, diffuse pollution originates from several dispersed and poorly defined sources (EPA, 2012). Diffuse pollution is affected by weather conditions, and land characteristics such as topography, soil type and land management (Ritter and Shirmohammadi, 2001). Return flow from irrigated agriculture, agricultural runoff and infiltration, wet and dry atmospheric deposition, runoff and snowmelt from roads and highways can be given as examples of diffuse pollution (Novotny, 2003). In rural areas, diffuse pollution is mainly associated with agricultural activities and animal operations. Application of fertilizers, pesticides and insecticides, irrigation return flow, irrigation with wastewater/sludge, and diffuse pollution from farmyards are some of the major cases of diffuse pollution in rural areas (Hranova, 2006).

Best management practices (BMPs) are defined as the soil and water conservation practices including social and cultural actions which have been recognized as the effective and practical ways for the environmental protection (Sharpley et al., 2006). BMPs are commonly designed with the purpose of ensuring the efficient use of agricultural chemicals; enhancing soil cover; reducing the veloc-

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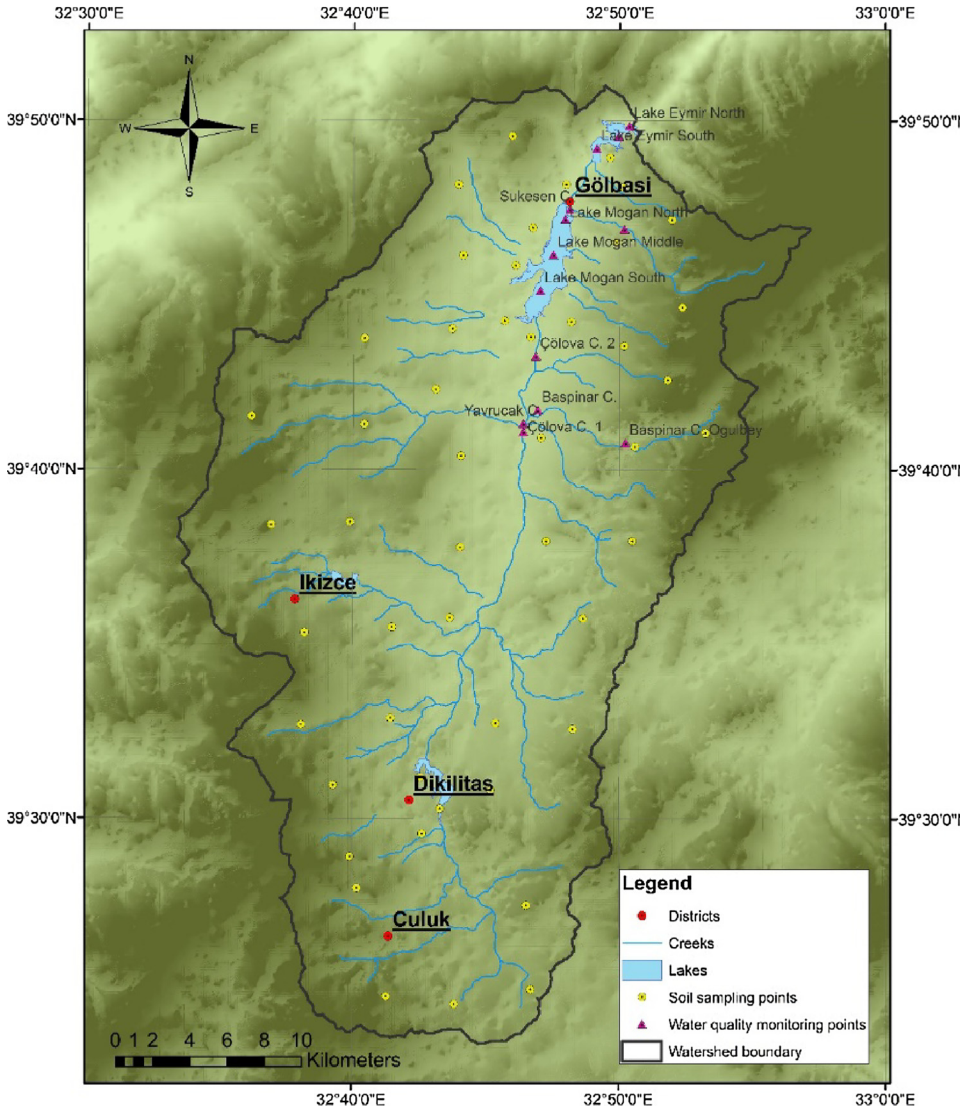

Fig. 1. Location of Lake Mogan watershed in 20 km south of Ankara, Turkey.

ity of surface runoff, and improving the management of livestock waste (Cestti et al., 2003). Troeh et al. (2004) stated that soil and water conservation methods are usually classified into two as vegetative and mechanical practices. Vegetative practices ensure denser vegetative cover for a longer period. Crop rotation, efficient use of fertilizers, and narrow row spacing can be given as examples of vegetative practices. These practices provide both improved product yield and erosion control. Mechanical practices are different from the vegetative ones in a way that they permit growing of plants which provide less soil protection but reducing the erosion at the same time. Contour tillage, no tillage, and terrace systems are some of the mechanical BMPs. Novotny (2003), on the other hand, categorized BMPs under three categories as structural, vegetative, and management. The author also added that the effectiveness of each BMP changes according to the pollutant specie in concern. Moreover, it was stated that the pollutants and the forms of them while they are transported should be taken into consideration in selecting the proper BMPs for the pollution removal. In the report prepared by Minnesota Department of Agriculture (Miller et al., 2012) the removal efficiencies of agricultural BMPs were discussed based mainly on the monitored research data but some modelling studies especially strong and practical ones were also taken into account. According to this report, the BMPs are classified as avoiding, controlling, and trapping BMPs. Avoiding BMPs aim at preventing the entry of pollutants into the environment while the controlling ones are used to control the risk of pollution if avoiding is not possible. Trapping BMPs are specified as the last step in order for catching the pollutants close to its source.

Evaluating the effectiveness of a specific BMP by field trials or by collecting monitoring data is both costly and time consuming. The amount of pollutant loads and removal rates are highly variable in every runoff event. The monitoring data should be collected repeatedly in order to successfully evaluate the performance of a BMP. Especially for large watersheds with varying land use classes and soil characteristics, intensive monitoring studies should be carried out to correctly assess the effects of a particular BMP. Consequently, such studies are not always possible at the watershed level. In this context, watershed models stand out as useful tools since they provide an inexpensive and time saving way for evaluating BMPs at the watershed level.

In this study, effectiveness of agricultural BMPs were assessed with Soil and Water Assessment Tool (SWAT), a physically based continuous-event hydrologic model, at Lake Mogan watershed dominated with agricultural lands. It is important to control the agricultural diffuse pollution to prevent deterioration of water quality in Lake Mogan. Within the scope of this study, the impacts