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Effect of Irrigation System on Groundwater Resources in Harran Plain (Southeastern Turkey)

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Abstract: Irrigated agriculture is the largest consumer of groundwater resources. The interaction between agricultural irrigation and groundwater resources, both in quantity and quality, is often understood later than when the adverse effects starts. For more efficient and sustainable utilization of the limited water resources, improved understanding of how respond to irrigation is essential. The Southeastern Anatolia Project (Turkish: GAP) is a major and comprehensive initiative in Turkey. The GAP was a programme to develop water and land resources in the region and planned as a package that comprised 13 individual projects on irrigation and energy production on the Euphrates-Tigris basins. This project includes irrigation networks for an area of approximately 1.8 million hectares. One of the important project sites is Harran Plain having the biggest groundwater resources and the largest irrigation field in the GAP region. Harran Plain has 3,700 km^2 drainage area, 1,500 km^2 plain area and 476,000 hectares of irrigation area. Before this project, the irrigations could potentially lead to about 2 m/year decline in groundwater table. After this project application, hydrodynamic system of groundwater has changed. The groundwater level has risen since 1995 in plain. In addition hydrodynamic system has been effected groundwater quality. Results show that a proper irrigation rotation system can implement an efficient water management over the irrigated areas and lead smaller groundwater change and its quality.

Key words: Irrigation system, groundwater, GAP, water management.

1. Introduction

Groundwater is the primary source of water for irrigation in many areas such as Turkey. Irrigated agriculture is the largest consumer of groundwater resources as in many arid regions unconstrained use of groundwater resources may cause serious aquifer depletion and environmental degradation [1]. Basically cropping practices directly have major effect on groundwater recharge and quality. Some studies have reported more than 10 m depletion in the groundwater level in last decades in some parts of India [2, 3], China [4] and western Turkey [5]. Chen et al. [6] investigated the responses of crop productivity and water balance components to climate change in Northern China Plain using a modeling approach. This study mentioned that to obtain the minimum amount of water for sustaining the crop yield, the irrigations could potentially lead to about 1.5 m/year decline in groundwater table when other sources of groundwater recharge were not considered. The interactions between agricultural irrigation and groundwater resources are generally very close to each other. Hu et al. [7] modeled the groundwater responses to the irrigation practices and he clarified the possible groundwater depletion with the vast amount of wheat plantations. Also Mirzavand and Ghazavi [8] implemented time series models for predicting the fluctuations in groundwater levels in Iran. It is important to increase the efficiency of groundwater saving basically targets to reduce evaporation, increase the crop water use efficiency and

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protect groundwater quality. In addition several strategies may be developed to eliminate environmental degradation and groundwater depletion such as irrigation technologies and alternative cropping systems. In many cases the excess irrigation water extracted again recharges the shallow aquifers and does not leave the system such as water transmission during the peak demand [9]. Some studies have been done about recharge from irrigated cropland to shallow aquifers [2, 10-12]. Sometimes excess irrigation water can increase water levels. These situations also affect quality of water. The aim of this study is to focus on irrigated agriculture on groundwater resources of Harran Plain where are the biggest groundwater reserves in the Middle-East and the largest irrigation field in the Southeastern Anatolia Project region which is 3,700 km^2 drainage area, 1,500 km^2 plain area and 476,000 hectares of irrigation area [13].

2. Study Area

Harran Plain is located between Şanlıurfa and Syria in Lower Euphrates branch of Southeastern Anatolian Project (GAP) which is a regional development project based on irrigated agricultural modernization (Fig. 1). It has an irrigation target of about 150,000 hectares in Harran Plain that is 30 km-50 km and is located in a region of rolling hills and a broad plateau that extends south into Syria. The plain, the largest in the GAP region, has 141,500 ha of irrigable land, 3,700 km^2 of drainage area and 1,500 km^2 of plain area [14]. Irrigations have reached to over 130,000 ha up to know, but it leads to some problems such as over-use of water, salinization, alkalinization and waterlogging stimulated by over-consumption of water creates ecological and economic damages [14-16], and the unequal, insufficient and unstable supply of irrigation water leads to social unrest.

3. Hydrological and Hydrogeological Properties of Harran Plain

According to meteorological data of Akçakale, an average annual precipitation value from 1994 to 2013 is 257.49 mm. The high precipitation can be seen in January and low precipitation can be seen in August. Cillap stream is one of the important surface water of plain. This stream recharges from north of study area and discharges south of plain where is flow to Syria. This stream was converted to canal by General Directorate of State Hydraulic Works (DSI) for irrigation.

The Harran Plain located on a graben structure bordered by N-S orienting faults system. The study area is composed of Paleocene, Eocene, Miocene, Pliocene and Pleistocene aged rocks. Eocene limestone is an important geological unit which includes groundwater resources in plain (Fig. 2). Generally it can be seen deep and shallow aquifer in the plain. The deep aquifer also called a confined aquifer which comes from Eocene karstic limestones

Fig. 1 Location map of study area.

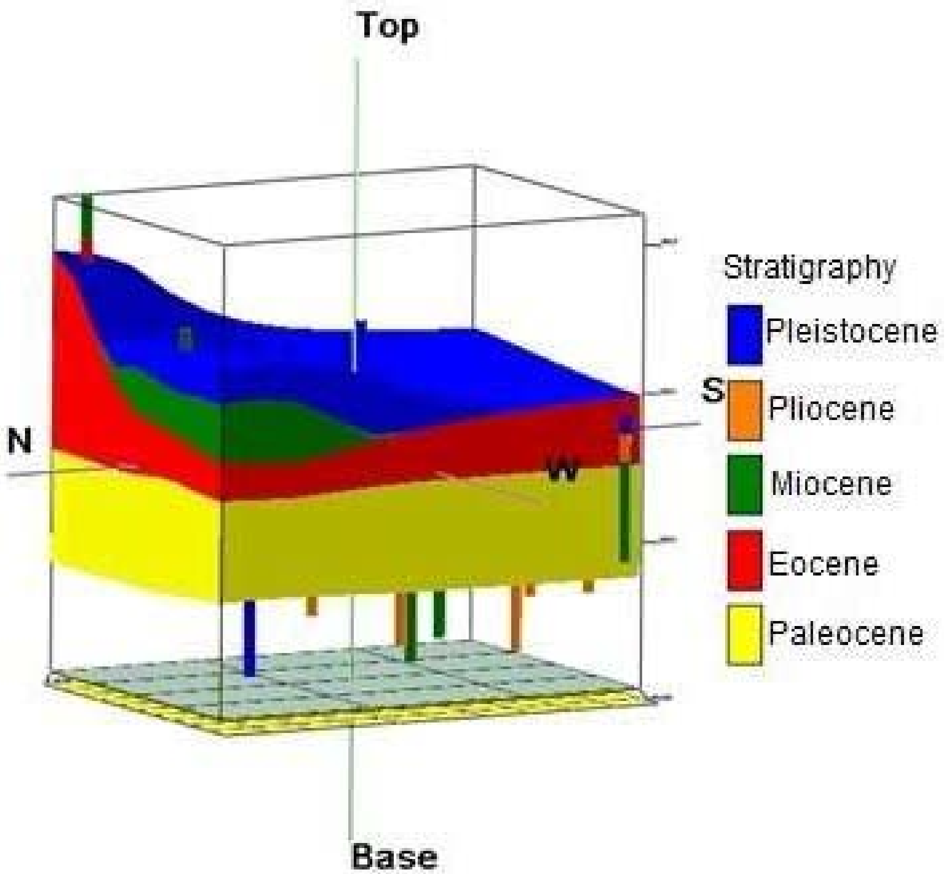

Fig. 2 3D cross section of geological units of Harran Plain.

and its thickness is about 300 m. Eocene karstic limestone can be seen in west, east and north of plain. Over 1,000 wells have been done in this aquifer. The flow rate of aquifer is range from 10 to 100 L/sn. The shallow aquifer is an unconfined aquifer. It consists of Pleistocene rocks which include clay, sand and gravel and its thickness is approximately 60 m. There are hundreds of shallow wells within this unit and its yield ranges from 5 to 30 L/s [14, 17]. Some groundwater wells, which represented plain, are selected for groundwater situation from 2014 to 2015 (Fig. 3). The results show that groundwater flows North to South of the study area. Groundwater level has annual cyclic variation depending on wet and dry seasons. (Fig. 4 and 5)

4. Irrigation Harran Plain

Turkey has developed irrigated agriculture very rapidly over the past 60 years especially around Harran Plain. For sustainability of irrigation system in this region, operation maintenance study was done by Government of Turkey for GAP. The main idea of this study is to maximize net benefits and to ensure sustainability. All GAP developments are based on the original projects identified by the DSI. Many interrelated projects are planned within the framework of the DSI projects requiring the conjunctive use of surface water resources for irrigation and power generation [18]. Additionally the conjunctive use of surface water and groundwater resources is planned for Harran Plain. Irrigation has been done by the local water cooperative in Harran Plain. Generally drip irrigation system has been used extensively in plain but still many agriculture fields have been irrigated with wild irrigation. This situation has been effected groundwater resources.

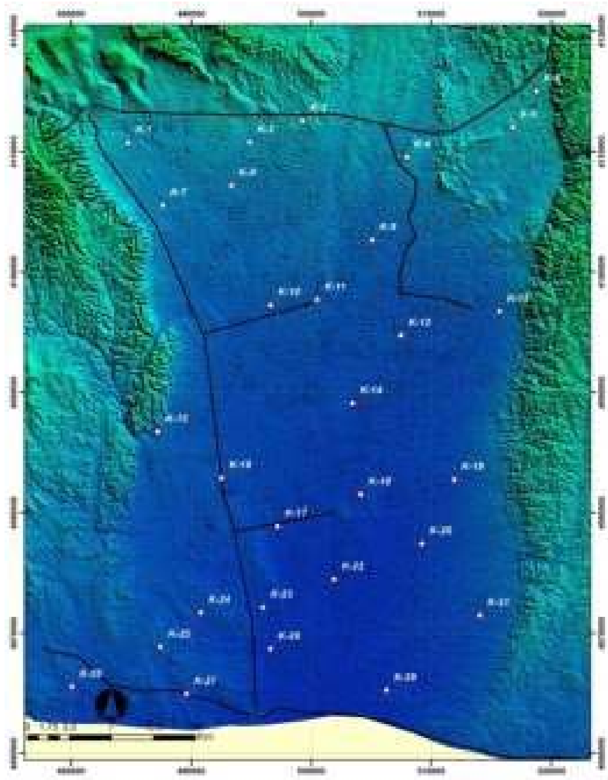

Fig. 3 Observation wells in study area.

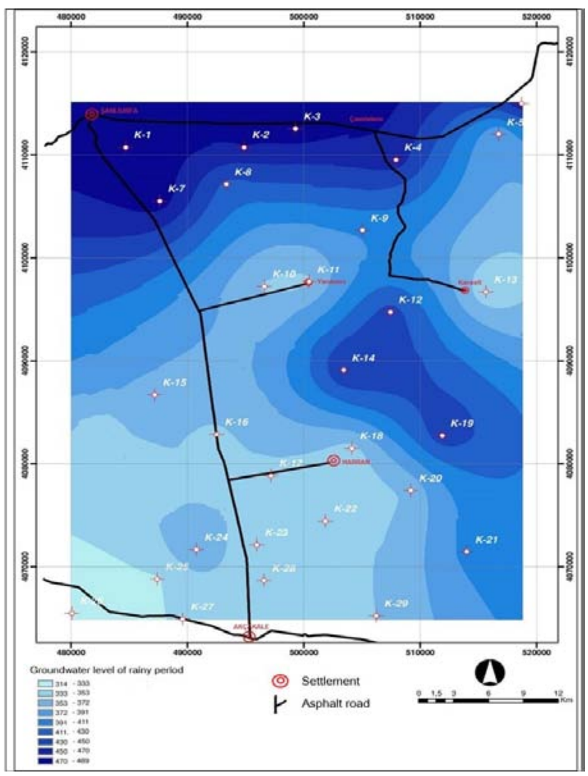

Fig. 4 Distribution of groundwater head in wet seasons.

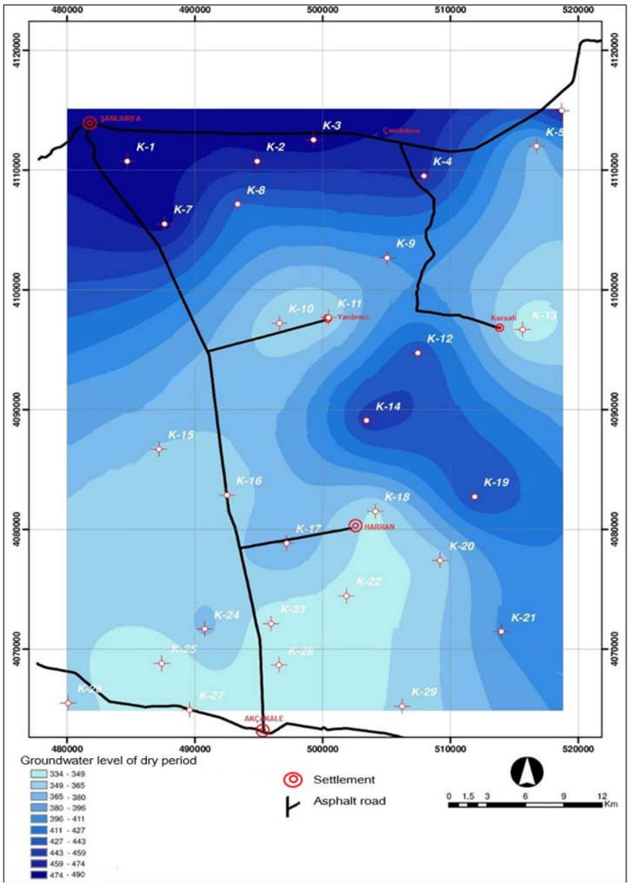

Fig. 5 Distribution of groundwater head in dry seasons.

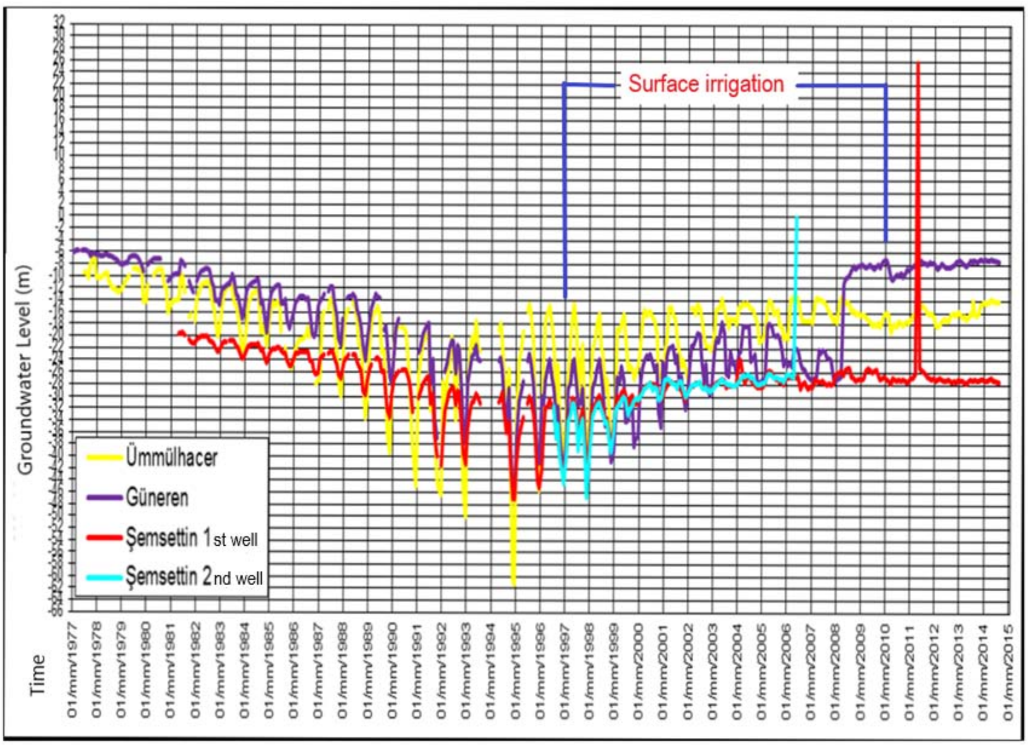

Fig. 6 Distribution of water level from 1977 to 2015 in East of Harran Plain (data from DSI).

5. Result and Discussion

GAP is one of the biggest irrigation systems in Turkey. Despite large quantities of water currently available from the Euphrates and Tigris rivers, it is becoming increasingly important to improve management of these resources [19], and in particular in the Harran Plain, faces problems of salinity, excessive and uncontrolled Irrigation, an insufficient drainage system, and an increased groundwater level caused by irrigation [20]. The government of water institute has been monitored groundwater level from 1977 to up to now in Harran Plain. Groundwater level declines from 1977 to 1995 (Fig. 6). After uncontrolled irrigation, groundwater level has been raised from 1995 up to now. Even artesian wells can be seen in plain. Because of changing hydrodynamic of groundwater system in plain, groundwater quality has undergone changes in the plain. Some studies mentioned that after application of fertilizers, excessive and uncontrolled irrigation, physical and chemical properties such as electirical conductivity (EC) and nitrate concentration in most of the wells exceed the maximum allowable value (for EC = 2,500 µS/cm and NO_3- = 50 mg/L) [21]. A huge amount of fertilizers and chemicals are used in agricultural activities, which cause high environmental risks in the area [22]. Therefore it is important to monitor groundwater resources and to develop effective management strategies for groundwater resources of the Harran Plain.

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