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Water Balance and Quality Management in the Interrelated Aquifers Systems

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Abstract: The water balance calculation and water quality are very important matters in the groundwater management. The water balance includes two parameters: input and output parameters. The input parameter is consisted from surface recharge (precipitation, irrigation return water, surfaces runoff recharge) and underground inflow (flow from adjacent aquifers). The underground inflow is an important factor in almost aquifers. It could form an important part of the water balance and could have major effects on the water quality. Although, when the underground inflow water quality is different whit the aquifer water quality, it can affect the aquifer water quality. Therefore, identifying this parameter is very important in the groundwater management. This research shows the aquifer interrelation's roles in the water management by considering a real case study. In this real case there are two aquifers, an unconfined aquifer overly on a confined aquifer. An impermeable layer isolates these two aquifers. This layer is deleted in some area and causes connection between two aquifers. This relationship affects the unconfined water quality and its sustainability. In the dry seasons, when the water table is low and hydraulic gradient is upward, high quality water moves from confined aquifer into upper unconfined aquifer. This improves the unconfined aquifer water quality in the dry seasons and deeps layer. Also, it makes the unconfined aquifer very sustainable.

Key words: Groundwater · Precipitation · Irrigation · Unconfined aquifer

INTRODUCTION

In most fields, aquifer systems are leaky, multilayered and large areal extent [1]. Groundwater basins usually are consisted from several aquifers that are related hydrologically. This can cause water movement from one aquifer to another [2]. The law of conservation of mass is the base of the water balance principal. Recharge and discharge are the balance parameters. Recharge could take the form of water infiltrating down through the soil zone or lateral subsurface flow from adjacent geohydrological units [3]. Also, recharge could be from lower aquifers.

Water balance calculation and water quality are very important matters in the groundwater management. The water balance includes two parameters: input and output parameters. The input parameter is consisted from surface recharge (precipitation, irrigation return water, surfaces runoff recharge) and underground inflow (flow from adjacent aquifers). The underground inflow is an important factor in almost aquifers. It could form an important part of the water balance and could have major effects on the water quality. When, the underground inflow water quality is different whit the aquifer water quality, it can affect the aquifer water quality [2]. Also, the subsurface flow is an important parameter that affects the water balance calculation. An understanding of the behavior of a groundwater system and of its interaction with the environment is required to formulate a sustainable management plan [4].

The study area (Kavar Plain) is situated in the South-east Shiraz city, in Zagros Mountain Range of Iran (Figure 1). Zagros Mountain Range, with NW-SE direction, forms the extreme western boundary. The Southeast end of this mountain range terminates by a broad discontinuity known as Oman Line [5]. In Kavar Plain the irrigation water which is supplied from an unconfined aquifer, is used for agriculture (mainly wheat and corn plants). This unconfined aquifer consists of alluvium with average thickness of 105m, where its thickness varies from about 300 meters in the middle part

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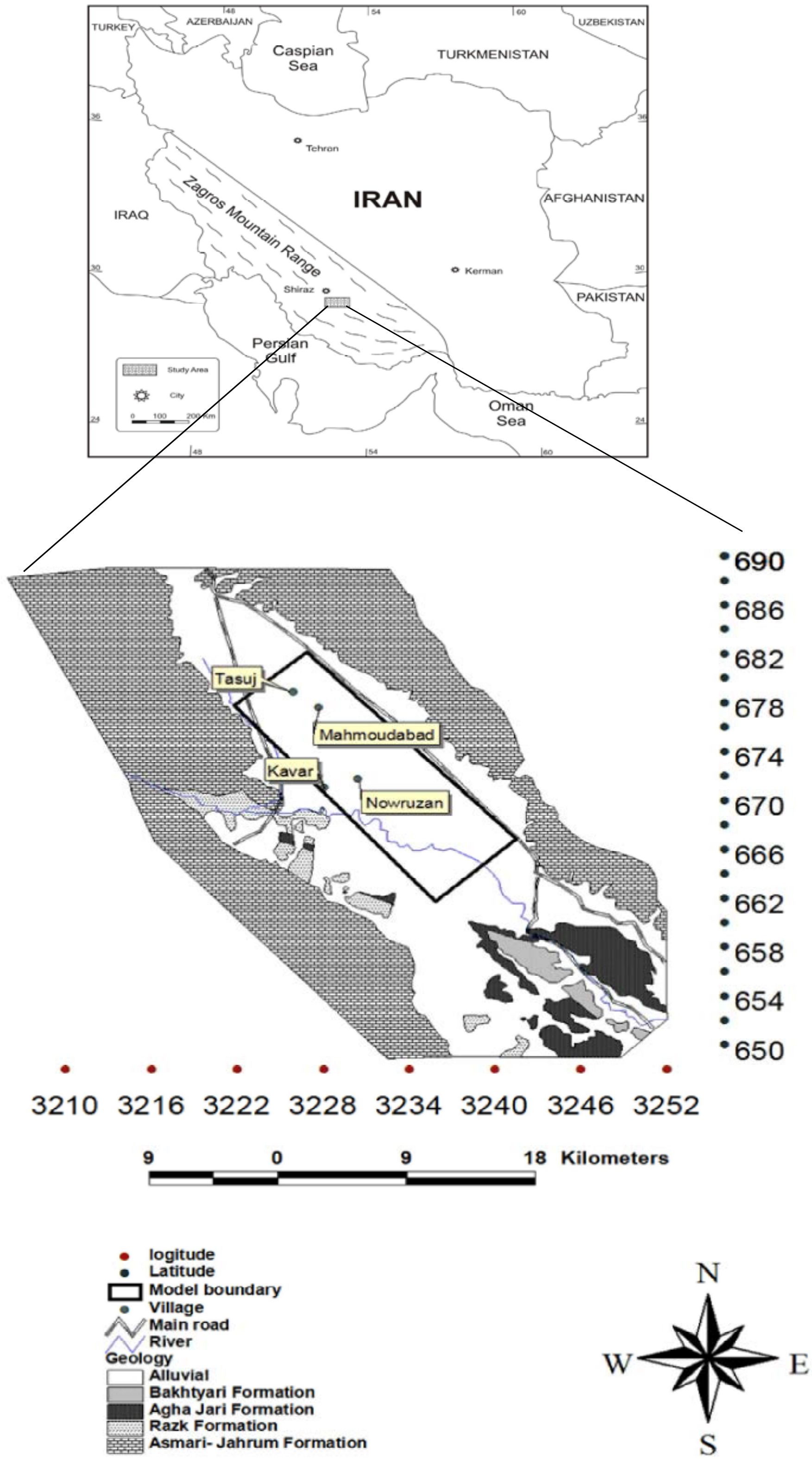

Fig. 1: Study area location

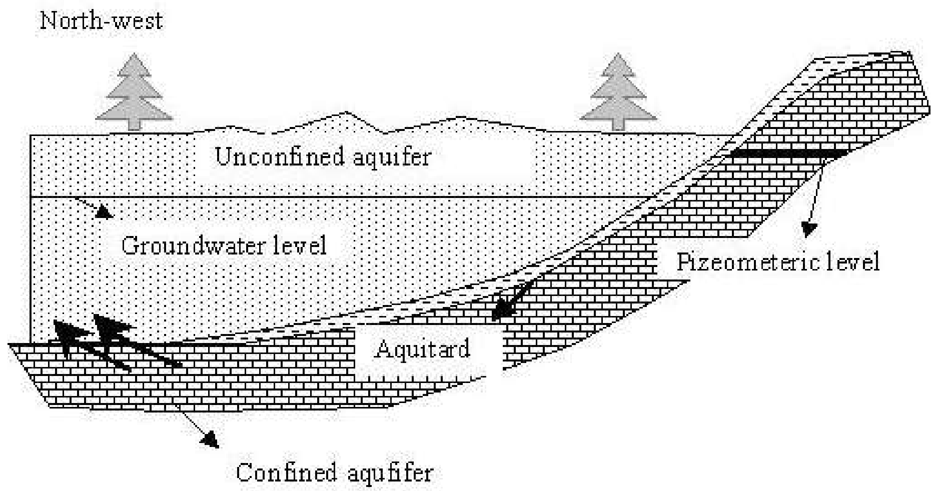

Fig. 2: Kavar unconfined and confined aquifers relationship.

to 50 meters in north and northwest parts of Kavar Plain. Razak Formation, a predominately red and some green marl with inter-bedded red sandstone, grey limestone and occasional gypsum and thin limestone, makes the bedrock. Also, there is a confined aquifer that underlies the unconfined aquifer. The confined aquifer is consists of Asmary-Jahrom Formation, a karstic limestone formation. Since there isn't Razak Formation in some area, water can move between two aquifers respects to hydraulic gradient [6, 7]. Figure 2 illustrates the Kavar Plain aquifers relationship.

MATERIAL AND METHODS

Water Balance: The annual amount of discharge from the unconfined aquifer was 119.8 million cubic meters in 1984. 575 deep wells, 12 Qantas and 8 spring extracted water from the unconfined aquifer. More groundwater exploitation were restricted or totally banned due to negative critical water balance in 1984. But, the amount of discharge has been increase since 1984. The amount of discharge increased to 231.3 million cubic meters in 1996 (the amount of wells increased to 1275). Therefore, the amount of discharge increased nearly 2 times (112 million cubic meters per year) during 12 years. if the specific yield were 0.08(based on porous media properties) and the amount of discharge had been increased linearly, the water table would be declined 21 meters (in the balance domain) due to increasing water discharge(the water balance were critical in 1984). But, the water level didn't decline during this period. This could be describe refer to Figure 2. When the hydraulic head is decreased due to overexploitation, the hydraulic gradient will be toward unconfined aquifer and force more water into it. And reversely, when the hydraulic head is increased due to recharge (wet seasons), the water movement will be inversed. Really, the unconfined aquifer acts as a buffer.

Water Quality: Overexploitation can decline groundwater level. The groundwater level decline can cause several environmental impacts, including water intrusion and water quality degradation [8-11].

Usually groundwater systems are consisted from multi interrelated aquifers. Water movement could be happen respect to hydraulic gradient. Therefore, it can cause water quality degradation [2].

In the study area water intrusion causes water quality improvement. There are some unusual water quality data in the study area. This data are as fallow [7]:

- In some parts of the unconfined aquifer, Water quality in the deeper portion of aquifer is better.
- The water quality improved in direction groundwater movement (Figure 3).
- The water quality improved in the dry seasons.

As mentioned, there are two interrelated aquifer in the Kavar plain. Groundwater can move between them respect to hydraulic gradient. Figure 4 illustrates the water movement into unconfined aquifer and its effects on water quality. This model can explain the mentioned unusual data. High quality water move into unconfined aquifer in places that aquitard layer (Razak formation) is deleted. Therefore, water quality improves in groundwater direction. Also, water quality improves in the deeper portion of aquifer in this area.

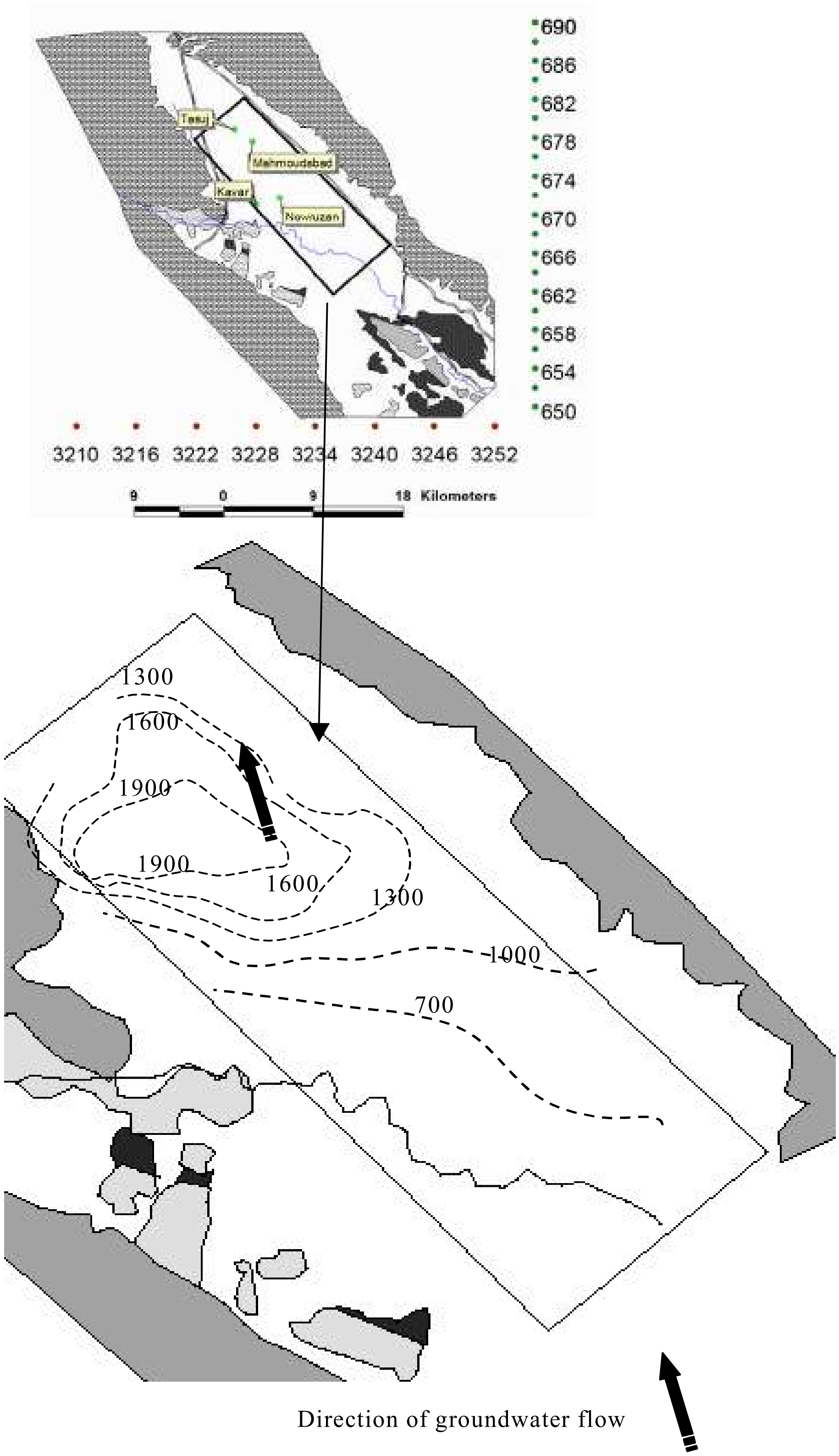

Fig. 3: Water quality improvement in the groundwater flow direction [7].

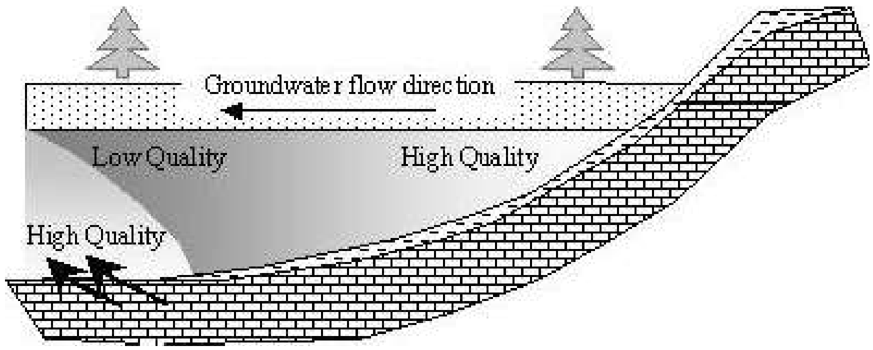

Fig. 4: Water quality improvement due to water movement from confined aquifer into unconfined aquifer

Water moves into unconfined aquifer respect to hydraulic gradient. In dry seasons hydraulic gradient is upward to unconfined aquifer, since the amount of groundwater discharge is high (for irrigation purpose) and the amount recharge is low. Therefore, high quality water move into unconfined aquifer and improve its quality. Inversely, in wet season hydraulic gradient is downward to confined aquifer due to groundwater level rising. Therefore, water movement into unconfined aquifer will reduce or eliminate.

RESULTS AND DISCUSSION

Most of groundwater quantity management models consider ideal and hypothetical conditions. Practical applications have been limited to single-aquifer system for short periods of time. In real situation, aquifer systems are leaky, multilayered and large areal extend. Therefore, an efficient approach to simulate the response of multiaquifer system and considering the system response is needed for management modeling [1]. Our results confirm firmly with Gupta *et al* [1, 4]. Also, our results confirm firmly with Ndambuki *et al*. [12]: "In the planning of most water resource systems, there are many possible objectives to consider and the future performance of each alternative is uncertain as a result of uncertainty in input parameters".

To properly manage groundwater resources, accurate information about the inputs (recharge) and outputs (pumpage and natural discharge) within each groundwater basin is needed [13]. The underground water flow from adjacent aquifers is one of the most important parameter that affects water balance and water quality. Here, water movement from unconfined aquifer affects the unconfined aquifer hydrogeological properties. It changes its water balance equations and water quality. The water management aspects would be different, if only the unconfined aquifer considered. For example, for achieving to high quality water, the drinking supply wells have to install where water move into unconfined aquifer. Also, deeper wells yield better water. On the other hand, concentrating discharge wells in this area can affect the confined aquifer. For example, it can affect its user's rights.

CONCLUSIONS

Groundwater management needs overall information, since groundwater systems are very complex. Groundwater systems often make a complex interrelated network that any stress can affect overall network. While, these effects are positive in some places, they can be very serious in other parts. Therefore, for achieving effective management for groundwater, a complete conceptual model that explains all parameters and theirs roles are essential.

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