

Urbanization and groundwater sustainability-A case study of Lahore Pakistan

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Highlights

- ▲ Groundwater levels in the Lahore city are falling at a rate of about 1 m per year
- ▲ Consumers of groundwater in the city are domestic, industrial, and commercial users.
- ▲ Latest interventions and regulations have helped to lessen the rapid depletion.

Introduction

Groundwater over extraction due to urbanization and industrialization owing to rapid increase in population has become a critical issue for the mega cities in the world showing land subsidence and other impacts (Islam et al., 2021). Lahore, the provincial capital, is the 2nd largest city of the Pakistan having population of more than 12 million with an annual increasing rate of 3.7% in 2020. The city has gone under very rapid urbanization due to rural-urban shift owing to several factors in Pakistan. It is hub of industrial and commercial activities as well as custodian of historical and cultural values of the old Indus Valley Civilization. It lies in the Indus River Basin (IRB) on the left bank of Ravi River. Water and Sanitation Agency (WASA) is the concerned organization to supply the water for drinking and other domestic needs of the people of the city. Some private households and housing societies have installed their own pumping wells as well. Water table at many places in the city has now gone beyond 40 m or more (Zakir-Hassan et al., 2017). Drainage network of about six major drains in the city collects runoff from rainfall, domestic as well as the industrial effluents which are being disposed into the adjacent river without treatment (Hassan et al., 2017). This is resulting in the increasing volume of urban drainage water every year which is causing deterioration of quality of groundwater (Akhtar & Tang, 2013; PWOP, 2013). Major sources of contamination of groundwater in the city are River Ravi, drainage network, industrial effluents, agriculture activities in suburbs, urban solid wastes, landfills, pavements and reduced recharge (Akhtar & Tang, 2013; Hassan et al., 2016).

Methodology

An experimental layout of piezometers has been installed along and around the river at three location to evaluate the impact of pollutants in river on groundwater as shown in Figure 1. Similarly, a network of piezometers has been laid with in the city to monitor the temporal and spatial behaviour of groundwater levels as shown in Figure 2. Groundwater levels and quality are being observed twice a year i.e. pre and post monsoon season. Observed data have been analysed to depict the spatial and

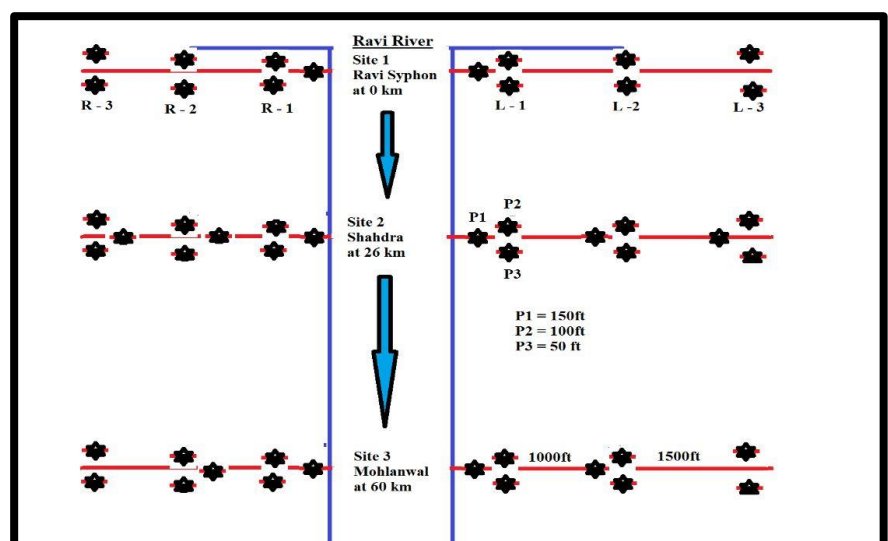


Figure 1: Experimental layout along river Ravi near Lahore City

temporal trends of groundwater. Changes in groundwater levels with respect to fluctuations in river gauge have also been monitored

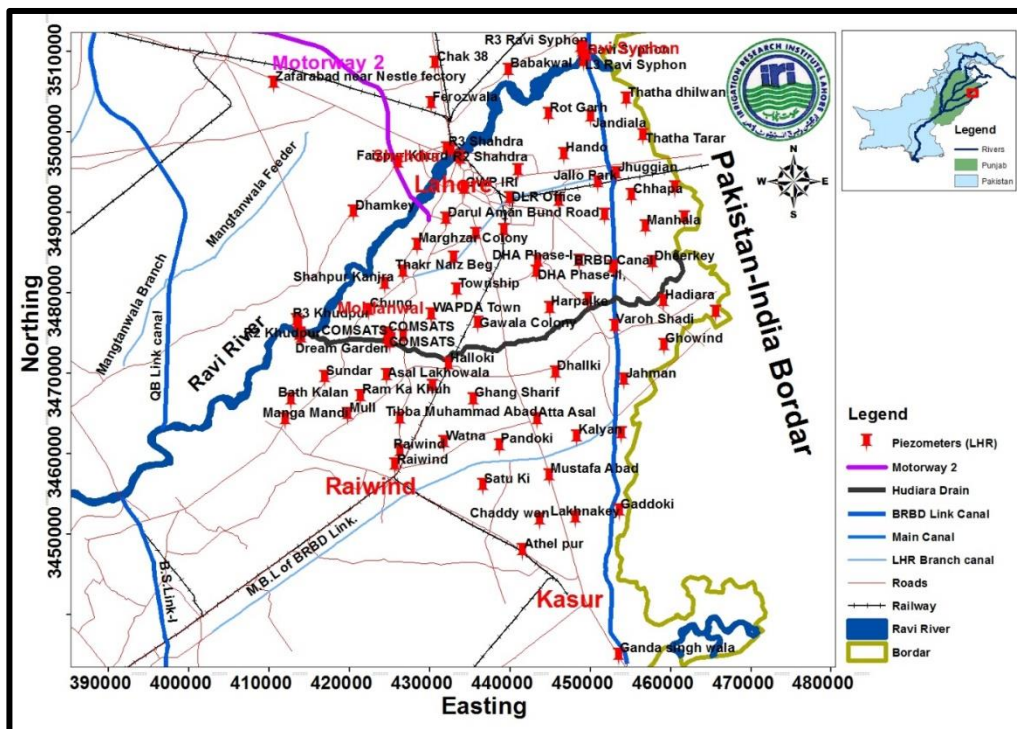


Figure 2: Network of piezometers installed in Lahore City

Results and discussion

Analysis and interpretation of observed data have revealed that groundwater levels in the city are declining at very alarming rates ranging from 1 ft to 3.8 ft per year at different locations in the city as shown in **Figure 3**. Data observed from the piezometers installed along the river in the shape of parallel and perpendicular batteries have revealed that groundwater is hydraulically connected with the river (**Figure 4**). Resultantly, effluents being thrown into the river are leaching down to the aquifer causing contamination of groundwater in the aquifer. Due to low flows in Ravi River, the recharge to aquifer has reduced and only significant source of recharge to the groundwater is Lahore Branch Canal passing through the city. Recently, on the direction of Honourable Lahore High Court some measures have been taken to lessen the presser on aquifer which include diverting canal water for parks and garden, recycling of ablution water. Different measures have been taken and regulations adopted by the government resulting in stoppage of further declining of water table in the city (**News, 2021**).

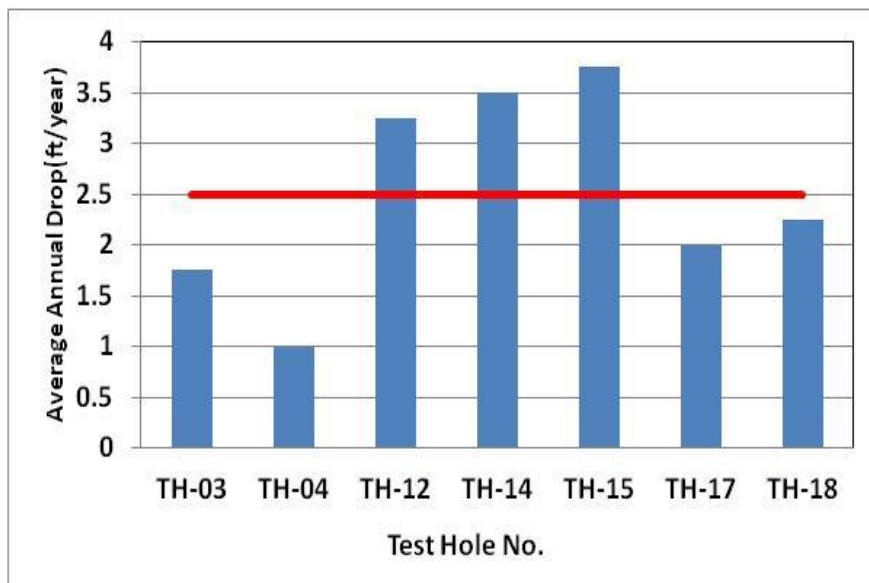


Figure 3: Average rates of depletion of groundwater in Lahore city.

Conclusions and future work

Due to tremendous increase in population, industrialization and urbanization water levels in the city are declining at the alarming rates. Quality of groundwater is deteriorating due to domestic, industrial, and agricultural effluents within in the city and from surrounding areas. River Ravi has become a source of contamination for the aquifer underlying the city. Happy news is that govt regulatory policies, recycling policies, and enhancing the recharge to the aquifer by artificial means has resulted in stoppage of further depletion of groundwater. Long-term, frequent, and accurate monitoring – by using data loggers and sensor and innovative technologies– is direly needed. Development and calibration of a groundwater flow and solute transport model for future forecast of aquifer under different scenarios is recommended.

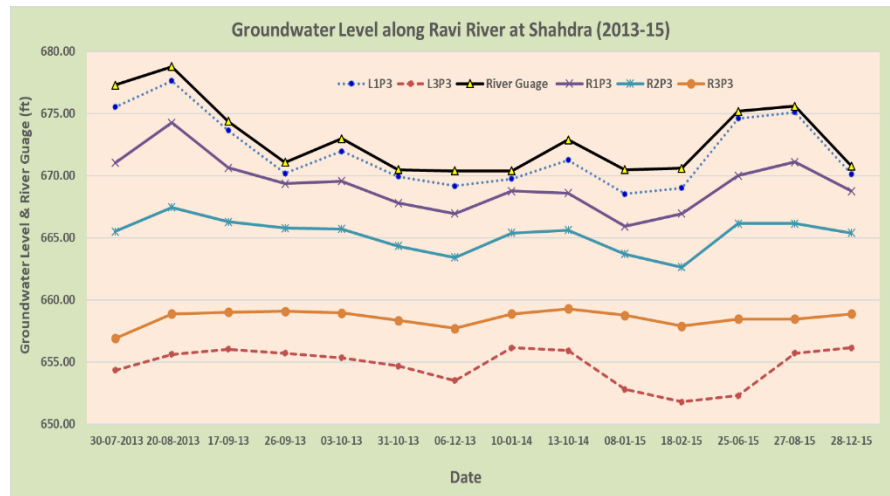


Figure 4: Fluctuation of groundwater levels with river Ravi gauge

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