Hydrogeology of India: Aquifer Systems, Groundwater Resources, and Management Challenges

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Abstract

India is a country with diverse geological, hydrological and climatic conditions, making it complex for hydrogeologists to study groundwater occurrence, movement, and quality. India's aquifer systems can be classified into unconsolidated and consolidated types, and recharge sources include precipitation, surface water, and lateral flow. India is the largest user of groundwater in the world, with about 25% of the global groundwater extraction, and groundwater resources are used for a variety of purposes. However, the overexploitation of groundwater resources has resulted in challenges related to its use and management, including depletion, deterioration of water quality, climate change, lack of governance, and inefficient irrigation practices.

Introduction

India is a country with diverse geological, hydrological and climatic conditions. The country has a long history of groundwater use for domestic, agricultural and industrial purposes. Hydrogeology is the science of water in the subsurface, which includes the study of groundwater occurrence, movement, and quality. In this article, we will discuss the hydrogeology of India, including its aquifer systems, groundwater resources, and challenges related to groundwater use and management.

Geological Setting

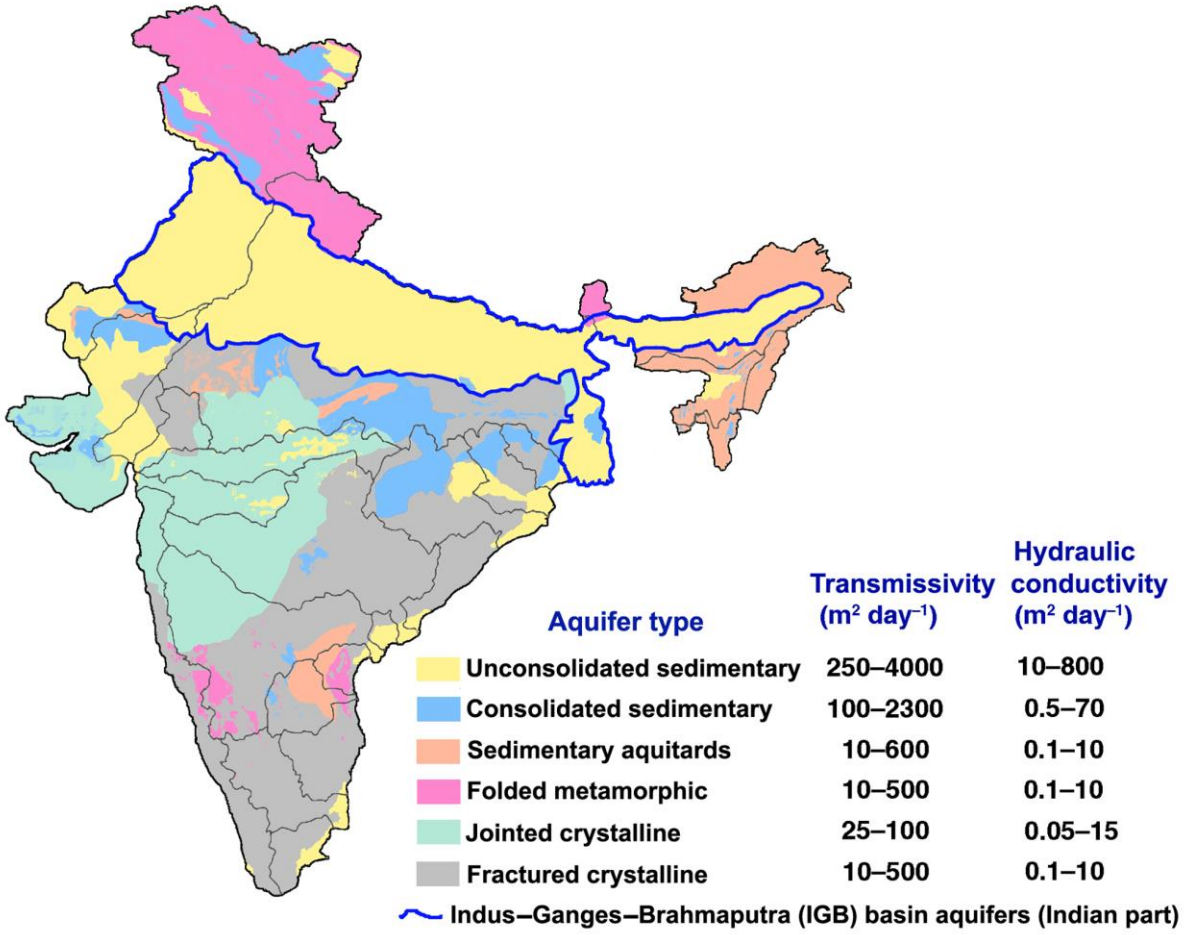
The geological setting of India is complex and varied, with different rock types and geological structures. The country is divided into six major physiographic regions: the Himalayas, the Indo-Gangetic Plain, the Peninsular Plateau, the Western Ghats, the Eastern Ghats, and the Coastal Plains and Islands. The Himalayan region is characterized by young folded mountains with a variety of rock types, including metamorphic, sedimentary, and volcanic rocks. The Indo-Gangetic Plain is a vast alluvial plain that covers a significant portion of northern and eastern India. The Peninsular Plateau is an ancient block of stable continental crust that covers most of southern and central India. The Western and Eastern Ghats are mountain ranges that run parallel to the west and east coasts of India, respectively. The Coastal Plains and Islands are low-lying areas along the coastlines of India and its islands.

Aquifer Systems

The aquifer systems in India can be classified into two broad categories: unconsolidated and consolidated. Unconsolidated aquifers are composed of loose sediments such as sand, gravel, and clay. These aquifers are found in the alluvial deposits of major rivers, coastal plains, and deltaic regions. Consolidated aquifers, on the other hand, are composed of hard rock

formations such as granite, basalt, limestone, and sandstone. These aquifers are found in the Peninsular Plateau, the Western and Eastern Ghats, and the Himalayan region.

The aquifer systems in India can also be classified based on their recharge sources. The three main sources of groundwater recharge in India are precipitation, surface water, and lateral flow. Precipitation recharge occurs when rainwater infiltrates the ground and replenishes the aquifers. Surface water recharge occurs when surface water bodies such as rivers, lakes, and ponds recharge the aquifers. Lateral flow recharge occurs when water moves laterally from high rainfall areas to low rainfall areas and recharges the aquifers.



Groundwater Resources

India is the largest user of groundwater in the world, with about 25% of the global groundwater extraction. Groundwater is used for a variety of purposes, including irrigation, domestic and industrial water supply, and mining activities. The groundwater potential of India is estimated to be around 432 billion cubic meters (BCM). However, the utilizable groundwater resources are estimated to be around 395 BCM.

The groundwater availability in India varies greatly from region to region, depending on the rainfall and geological conditions. The major groundwater basins in India are the Indo-Gangetic Plain, the Deccan Plateau, the Coastal Plains, and the Himalayan region. The Indo-Gangetic Plain is the largest and most productive aquifer system in India, providing irrigation water to the agricultural lands in northern and eastern India. The Deccan Plateau is another

important aquifer system that provides water to the agricultural lands of central and southern India. The Coastal Plains are also significant sources of groundwater for irrigation and domestic use. The Himalayan region, although less productive, is an important source of drinking water for the people living in the foothills and mountainous regions of northern India.

Challenges of Groundwater Use and Management

The growing population, urbanization, and industrialization have led to increased demand for groundwater in India. However, the overexploitation of groundwater resources has resulted in several challenges related to its use and management. Some of the major challenges are discussed below:

Groundwater depletion: The uncontrolled extraction of groundwater has led to the depletion of aquifers in several parts of India. The depletion of groundwater resources has resulted in a decline in water levels, reduced well yields, and deterioration in water quality.

Water quality deterioration: The indiscriminate use of fertilizers, pesticides, and other chemicals in agriculture has led to the contamination of groundwater with nitrates, phosphates, and other pollutants. The discharge of untreated industrial effluents and sewage into groundwater has also contributed to the deterioration of water quality.

Climate change: Climate change is expected to have a significant impact on groundwater resources in India. The changing rainfall patterns and increasing temperatures are likely to affect the recharge rates of aquifers and increase the demand for groundwater.

Lack of governance: The lack of governance and regulation of groundwater use and management has led to the overexploitation of groundwater resources. The absence of a comprehensive legal framework for groundwater management has resulted in unregulated extraction, especially in the agricultural sector.

Inefficient irrigation practices: The use of inefficient irrigation practices, such as flood irrigation and unlined canals, has resulted in the wastage of water and increased demand for groundwater.

Conclusion

The hydrogeology of India is diverse and complex, with different aquifer systems and groundwater resources. The country is the largest user of groundwater in the world, but the overexploitation of groundwater resources has led to several challenges related to its use and management. To ensure the sustainable use and management of groundwater resources in India, there is a need for a comprehensive legal framework, efficient irrigation practices, and effective governance and regulation of groundwater use. Additionally, there is a need for research and development of technologies for the recharge of aquifers and the conservation of groundwater resources.