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Perspective

The Role of Coastal Aquifers in Supporting Communities and Nature

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DESCRIPTION

Coastal aquifers are groundwater reservoirs located near coastlines that provide freshwater to communities, agriculture and ecosystems in coastal regions. They form an essential component of the hydrological system where land and sea meet, often supplying drinking water to millions of people worldwide. Unlike inland aquifers, coastal aquifers face unique challenges because of their proximity to seawater. The balance between freshwater and saltwater within these aquifers is delicate and human activities such as over-extraction, land development and pollution can disrupt this balance, leading to salinization and reduced water availability. Understanding coastal aquifers is therefore critical for sustainable water management, ecosystem health and climate resilience. The structure of a coastal aquifer typically consists of permeable layers of sand, gravel or fractured rock that store and transmit groundwater. Freshwater in the aquifer originates from rainfall and surface water infiltration inland. This freshwater floats above denser seawater, creating a natural interface between the two. The thickness and movement of the freshwater lens depend on factors such as recharge rates, aquifer permeability and hydraulic gradients. Coastal aquifers often discharge groundwater into rivers, estuaries and the ocean, supporting wetlands and other coastal ecosystems that rely on the steady flow of low salinity water.

One of the main concerns regarding coastal aquifers is saltwater intrusion. When freshwater extraction exceeds natural recharge, the hydraulic pressure keeping seawater at bay decreases, allowing saltwater to migrate inland. This process can contaminate wells, making water unsuitable for drinking or irrigation. Saltwater intrusion is often exacerbated by land subsidence, which may occur due to excessive groundwater pumping or natural compaction of sediments. Once intrusion occurs, restoring the aquifer to its original state is difficult and expensive, highlighting the importance of proactive management. Human activities also impact the quality of coastal aquifers in other ways. Agricultural runoff containing fertilizers and pesticides can percolate through soils and reach the aquifer, introducing pollutants. Industrial discharge, urban wastewater and improper landfill management contribute to chemical contamination. Even small concentrations of pollutants can affect water quality and human health over time, emphasizing the need for careful monitoring and protective measures in coastal regions. The hydrodynamic behavior of coastal aquifers is influenced by both natural and anthropogenic factors. Seasonal rainfall variations, storm surges and tides affect groundwater levels and the movement of the freshwater-saltwater interface. For example, heavy rainfall increases recharge, pushing the interface seaward, while drought reduces recharge and allows saltwater to advance inland. Human activities such as groundwater extraction for urban water supply, irrigation or industrial use can accelerate these natural processes and intensify salinization.

Sustainable management of coastal aquifers requires integrated approaches that account for both water demand and environmental protection. Limiting groundwater extraction to rates compatible with natural recharge is essential. Artificial recharge techniques, such as infiltration basins or injection wells, can enhance aquifer replenishment. Coastal setback zones and land use planning can help protect recharge areas from contamination and prevent development that exacerbates saltwater intrusion. Continuous monitoring of water levels, salinity and pollutant concentrations provides data needed to make informed management decisions and respond to emerging threats. Climate change further complicates the management of coastal aquifers. Rising sea levels increase the hydraulic pressure of seawater, pushing it further inland and raising the risk of saltwater intrusion. Changes in precipitation patterns can reduce recharge, while extreme events such as hurricanes can introduce contaminants and alter groundwater flow. Anticipating these impacts and incorporating climate projections into aquifer management plans is essential for long term water security in coastal areas.

In conclusion, coastal aquifers are vital resources that sustain communities, economies and ecosystems along the world's shorelines. They face pressures from over-extraction, pollution, land use change and climate change, all of which can lead to salinization and reduced water availability. Effective management

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requires a combination of careful monitoring, controlled extraction, artificial recharge and protection of recharge areas. Integrating scientific knowledge with policy and community engagement ensures that these aquifers continue to provide freshwater and ecosystem support for generations to come. Protecting coastal aquifers is not only a matter of water supply but also an investment in environmental sustainability and resilience in the face of growing coastal pressures.