

Water supply, groundwater overexploitation, and water resources management in Cyprus.

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Water supply and distribution is a spatiotemporal problem which cannot be described solely by the supply and demand laws in economics. The water demand in Cyprus has experienced an exponential increase over the last decades while the supply (rainfall, groundwater, desalination water) has decreased. The growing population, the flourish of tourism and the economic growth in combination with physical events due to climate change increase the pressure to the authorities to cover the demand and have led to the overexploitation of groundwater resources, resulting in seawater intrusion to groundwater.

The issue of water overexploitation and its mitigation resembles the classic example of the prisoner's dilemma in game theory. Two rational "players" follow their own strategies in a game, with the outcome being influenced by each individual's actions. Each "player" realizes that they will increase profit by extracting water from wells. Since all "players" are rational and prioritize their personal interests, they all follow the same tactic of pumping water. The result is ultimately the decline of the groundwater level and, consequently, groundwater salinization. This situation, not new and referred to as the "tragedy of the commons," illustrates how individuals acting in their own self-interest can undermine the common good, maximizing their own gains.

The equilibrium that results can only change through intervention in the game, translated into measures. Such measures typically involve regulations and laws. In Cyprus, various measures have been taken in accordance with the European Union's Water Framework Directive. Specifically, actions have been taken to reduce water losses (e.g., green taxes), promote efficient irrigation and proper water usage, recycle and reuse water resources, and raise of public awareness.

Strategies for addressing quantitative water scarcity in aquifers are also implemented. In Cyprus, protective zones for water supply wells have been established, monitoring systems for spring flows have been installed, and aquifers are enriched with tertiary treated water (Ezousa, Akrotiri). Research is also conducted for precise design of managed aquifer recharge (MAR) wells, determining the properties of flow through porous media under various boundary and hydraulic conditions (e.g., soil stresses, hydraulic conductivity).

The overexploitation of groundwater resources is not only limited to Cyprus but is part of Europe's broader framework for water management. Member states are obligated to safeguard groundwater resources by adopting various solutions that could be applicable on our island. Such solutions include pumping out seawater from near the coastal aquifer, creating land artificially along the coastline, and constructing barriers to prevent the intrusion of seawater into freshwater. Specifically, barrier creation can be achieved through cementation technologies within soil formations, employing either chemical methods or nature-inspired techniques, such as microbially induced carbonate precipitation (MICP). This method has been extensively studied in the laboratory and proves to be environmentally friendly, utilizing non-toxic bacteria to deposit calcium carbonate within the soil's granular network. As a result, soil permeability and porosity decrease, forming a "wall", and consequently reducing the flow rate of seawater towards groundwater. This method has proven to be effective in reducing the flow-controlling parameters such as porosity, permeability and erodibility.

Water resources management is a vital issue that necessitates collective effort and cooperation. Through this collaboration and awareness, we can ensure a sustainable future for the next generations, preserving water resources as a precious treasure that must be cared for with love and respect.