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Hydrogeological conditions and water resources management of Ios Island, Cyclades, Greece

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The Cyclades islands have been experiencing over time problems of water scarcity, due to limited water resources. The last decades precipitation over the south Aegean islands displays generally a larger variance and has a tendency of becoming dryer, compared to long-term climatic normal (Nastos & Zerefos, 2010) because of climate changes. Reduced precipitation can affect the sustainability, quantity and quality of water resources. The natural shortage of water resources is exacerbated by increasing water consumption for human needs, such as the expansion of irrigated land and the development of urban, industrial and touristic areas.

These conditions reinforce the necessity to improve water management in order to ensure the necessary quantity of water supply. This necessity becomes stronger in areas with complex geological setting, with relatively small aquifers and tangential (with hydraulic communication) to the sea, where overpumping and the expected minimum natural renewal due to the dry climate, leads to a significant drawdown in water table, resulting sometimes in the salinization of groundwater.

The municipal water supply of Ios Island has been reinforced by a series of projects and interventions, mainly focusing to the summer period due to tourism where water demand surpasses by far water availability, consisting of:

- New deep boreholes.
- Construction and operation of the water reservoir of Mylopotamos with a total capacity of 215,000m^3.
- Construction and operation of Mylopotas desalination plant with a total capacity of 1,000m^3/day.

Given the climate change that has taken place in recent years, there is a continuous quantitative and qualitative degradation of Ios Island water resources. Indicatively, it is reported that it has been recorded:

- Partial or total recession of springs discharges.
- Significant drawdown of wells and boreholes water tables.
- The water reservoir of Mylopotamos was totally empty in 2000 and 2018, due to the prolonged drought.

The Ios Island almost entirely comprises of metamorphic rocks and Quaternary formations unconformably cover them (Van Der Maar & Jansen, 1981). The metamorphic rocks are including the dominant unit of the Cycladic Blueschist Unit (CBU) which is located mainly in the north part of the island and in scattered outcrops in the south. The CBU is tectonically overlying the Cycladic Basement Unit which constitutes the Variscan basement and is demonstrated in the central and south part of the island.

Three main aquifer systems developed on Ios Island include (Kourmoulis, 1980; Papadopoulos & Stergiopoulos, 2000; JV of Aegean Watersystems, 2005; Giannoulopoulos & Lappas, 2010):

- The shallow aquifer system in porous Quaternary formations.
- The karstic aquifer system in the carbonate rocks of the Cycladic Blueschist Unit (CBU).
- The aquifer system (both shallow and deep) in the fractured hard rocks mainly of the Cycladic Basement Unit.

Precipitation is the direct recharge of the three aforementioned aquifer systems. It should be mentioned, that the overlying, shallow aquifer system is also indirectly recharged from the streams runoff during the winter months and from the formations of the Cycladic Blueschist Unit (CBU) and mainly of the Cycladic Basement Unit (augengneiss and garnet-mica schists). However, even this indirectly recharge depends on the precipitation.

The shallow, porous aquifer system of Mylopotas, Manganari, Psathi, Koumbara and Kato Kambos is encountering continuous quantitative and qualitative degradation, due to restriction of precipitation during the winter months and overpumping during the summer months.

The karstic aquifer system of the north part is being discharged in the Aegean Sea and therefore, it is not of particular hydrogeological interest.

The aquifer system in the fractured hard rocks mainly of the Cycladic Basement Unit occurs in the weathered zone (shallow) and in the fractured zone (deep) of the garnet-mica and the augengneiss and is encountering continuous and over time quantitative degradation since:

- The great majority of small springs which discharge the weathered zone has suffered partial or total recession through the years, due to the restriction of the precipitation and the prolonged drought.
- The time fluctuation from 1976 until today of the springs discharges, named Epano Desi, Kato Desi, Psathi and Aghia Theodoti, which discharge the fractured zone of the augengneiss shows both continuous recession and flow, covering even today the water supply of some settlements. It should be mentioned, that in the recharge areas (hydrogeological basins) of the aforementioned springs there are no wells and boreholes and therefore, their

continuous discharge recession is due to restriction of the precipitation and the prolonged drought.

- The time fluctuation from 2005 until today of the fractured zone water table of the augengneiss shows drawdown which exceeds 35 meters in the west and southwest of Kastro or Pyrgos and is almost 15 meters in the south margin of the Mylopotas alluvial basin.

In conclusion, a continuous quantitative and qualitative degradation of Ios Island water resources is being recorded which is the result of both the restriction of precipitation during the winter months and therefore of the limited recharge and the overpumping during the summer months of the three main aquifer systems. Furthermore, the direct consequence of the climate change is the often occurrence of extreme hydrometeorological phenomena that favors the runoff instead of infiltration which leads to the restriction of the recharge of the three main aquifer systems.

For the sustainable water resources management of the Ios Island new projects must be planned, such as:

- Artificial recharge for both the shallow, porous aquifer system and the aquifer system (shallow and deep) in the fractured hard rocks mainly of the Cycladic Basement Unit.
- Construction and operation of new water reservoirs.
- Construction and operation of new desalination plants.

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