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Tectonic Lakes-Climatic and Anthropogenic Impacts

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In the world there are several different types of lakes: glacial, barrier, volcanic, and tectonic. The type of the lake is determined by how it is made. Glacial lakes are formed by glacial scouring, barrier by landslides, volcanic by volcanoes activity, and tectonic by natural fissures during tectonic movement. Climate changes, movement of the Earth's plates, erosion, and even human and animal activity can help in lake formation. Tectonic lakes are probable the most valuable water bodies due to their high biodiversity, socio-economic development and cultural heritage.

This paper will present the historical and present state of the three tectonic lakes: Ohrid, Prespa and Dojran. Since the watersheds and the lakes are shared by three countries, Albania, Greece and Macedonia, these water bodies are not fully investigated regarding hydrology, hydrogeology and water use. Lakes Ohrid and Prespa are located in the south-western part of Balkan Peninsula. Both lakes belong to the watershed of Crn Drim that flows into Adriatic Sea. The lakes are the largest tectonic lakes in Europe. Lake Ohrid formed in the Tertiary period between 3.5 and 4 million years ago, is one of the oldest lakes in the world. The volume of the lake is estimated to be 50.7 km3 with maximum depth 289 m and the average depth 151 m. Lake Ohrid is a resource of tremendous local and international significance. Therefore, UNESCO declared this lake a World Cultural and Heritage Site in 1980. Lake Prespa is an interesting case study as regards hydrology and hydrogeology. This lake does not have surface outflow. Prespa valley and the lake itself is located at higher altitude than Lake Ohrid for about 155 m and the waters from Lake Prespa outflow through karst underground conduits into Lake Ohrid. So, this is the reason why both lakes can not be analysed separately. Lake Prespa is much shallower than Lake Ohrid: the average depth is about 15 m and the maximum depth is 53 m. Lake Prespa during winters sometimes turns to ice; this is in contrast to Lake Ohrid, whose waters never freeze. Both lakes valleys are densely populated and are supporting by an evident human pressure. As transboundary ecosystems the last years of socio-economic development and political transition, at the lakes have been observed an overuse of biological and natural resources.

Lake Dojran is situated in south-eastern part of Macedonia and is shared by two countries, Greece and Macedonia. This is the smallest and the shallowest tectonic lake in the country. The watershed of the lake belongs to the Vardar river basin that gravitates toward Aegean Sea. The lake was formed in a karstified basin created by combination of Tertiary volcanic and tectonic activity. The volume of the lake at normal water level is 262 million m3 which corresponds to the average depth of 6.5 m: maximum depth is 10.4 m. Dojran Lake doesn't have surface outflow and the only outflow is by evaporation from the lake water surface.

This paper will present time series data on water level from Macedonian site only for the period 1951-2010. Changes in water level oscillation have been analysed in relation with the precipitation regime in the region. Water use and some other human activities that impacted the entire lakes ecosystems will be also discussed. Comments on existing and needed hydrological, meteorological, hydrogeological and biological monitoring will be also included. When all climatic, hydrological and anthropogenic impacts and/or evidences are combined, it provides a very clear picture of unique and fragile ecosystems of the three tectonic lakes that are changing significantly. Oligothrophic state of Ohrid Lake in recent times is changing due to human activities in its watershed. Human activities have aged the lake more in the past several decades than in the previous few million years. Lake Prespa is naturally more nutrient-enriched than Ohrid Lake. Agricultural activities and human wastes have greatly accelerated its eutrophication. Dojran Lake has reached its ecological catastrophe within the period 1985-2000 due to serious water level declination and water volume lost. This water level declination together with simultaneous water quality deterioration resulted with serious ecological impacts. Some results regarding environmnetal assessment and water balance modelling from KfW Feasibility Study-Transboundary Prespa Park Project (2005) and Development of Prespa Lake Management Plan (2010)) will be presented.

Keywords: tectonic lakes, water level, climatic characteristics, human impacts, ecosystems vulnerability