Groundwater–Surface Water Interactions of Small Arid-Landscape Lakes in Khorezm, Uzbekistan

Julian Scott1, Laurel Saito1, Michael Rosen2, John Lammers3, Nodirbek Mullabaev4, Dave Decker1,5, Marhabo Bekchonova6, Diana Shermetova6, Dilorom Fayzieva4

1 University of Nevada Reno; 2 U.S. Geological Survey; 3 EF-UNESCO German/Uzbek Project; 4 Institute for Water Problems, Uzbekistan; 5 Desert Research Institute; 6 Urgench State University

I. Introduction

Little is known regarding the hydrology of hundreds of small lakes located in the arid western Uzbek province of Khorezm, and this study seeks to fill this knowledge gap. The numerous lakes present in this flat landscape may represent a valuable water resource to local people (Figure 1). These lakes are thought to have formed in natural depressions, and many receive irrigation water run off. The ultimate goal of this research is to determine a rough water budget, which would be useful in examination of possible land management options and modelling the effects of such management on the economic, ecological, and water quality of the lakes.

This poster focuses on the hydrology of two typical Khorezm lakes, Tuyrekkul (TUY) and Khodjababa (KHO), that are also the focus of concurrent aquatic ecology studies. Groundwater and surface water interaction at these lakes was assessed for the summer of 2008 using water elevations and the stable isotopes of oxygen and hydrogen (δ18O and δD) as tracers. The work presented here attempts to characterize these lakes as being of the gaining, losing, or through-flow type.

Figure 1. Location of study area. Grey areas are lakes; studied lakes are highlighted in red and the province capital in blue. River water is conveyed to Khorezm through an extensive canal network. This water is thought to constitute the majority of surface and groundwater in Khorezm.

II. Study Site Description

TUY and KHO are both relatively small and shallow lakes that have no perennial outflow (Table 1). This region receives little annual precipitation (>100 mm yr⁻¹) and experiences high summer temperatures (100-120°F) and low summer humidity. Thus, high rates of evaporation are expected during the summer months. The lakes are surrounded by small agricultural fields growing wheat, cotton, and rice, which are flooded intermittently throughout the year (note foreground in upper Figure 2).

Emergent grasses line the shores of these lakes, and local aquifer material at both lakes is primarily well sorted sand with little silt.

Figure 2. KHO and TUY, summer 2008.

III. Methods

Water elevations were determined in piezometers installed in the aquifer near the lakes, and pressure transducers continuously monitored lake level elevation. Comparison of lake and water table elevations provide groundwater and lake water interaction information. Pump and slug tests were performed on these piezometers to determine aquifer parameters.

Water grab samples were taken from lakes and nearby surface waters, including irrigation and drainage canals (Figures 3 and 4). Groundwater samples were taken from piezometers after 3 well volumes were pumped out. Samples were subsequently analyzed for δ18O (δD) and δD at the University of Nevada Stable Isotope Laboratory.

Figure 3. Simple diagram of lake area.

Figure 4. Taking grab samples and pumping groundwater.

IV. Data Analysis and Conclusions

Elevations suggest that TUY is gaining groundwater for most of the summer (Figure 5A). Decreasing lake 6D over time at TUY supports this, as groundwater 6D is much more negative than lake water. However, at the end of July, lake elevation rises above the water table. Simultaneously, groundwater 6D approaches lake 6D, suggesting that the lake is losing water during this time. At KHO, water table elevations during the summer suggest the lake is gaining groundwater. Lake inputs are clearly outweighed by evaporative losses, however, because lake stage decreases and lake 6D increases throughout the summer (Figure 5B).

The stable isotope data collected at these two lakes makes a linear evaporative trend line that deviates from the global meteoric water line (GMWL; Figure 6). This supports the hypothesis that the Amu Darya River is the original source of all sampled water bodies. Note that the two precipitation samples were taken 10 minutes apart and are from the single rain event that took place during the sampling period (Figure 6). They plot off of the GMWL and have different values because of evaporation during free fall and the preferential rainout of high 6D water.

Finally, hydraulic conductivity of aquifer material at both lakes was found to be about 6E-5 m/s through analyses of slug and pump test data (Figure 7).

V. Future Work

All water samples were also analyzed for major ion geochemistry. With the help of the geochemical model PHREEQC, these data, in addition to stable isotope data provided here, will be used to differentiate surface and groundwater inputs to these lakes. Conclusions taken from this research will be used to support ecological aspects that are the concurrent focus of two other Masters theses, as well as a limnologic and chemical study being done by a larger NATO funded project.

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