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OPINION

Increasing the visibility of transboundary groundwater

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Making the invisible visible

Released on World Water Day 2022, the 2022 United Nations World Water Development Report, *Groundwater*: *Making the invisible visible* [1], highlights the importance of groundwater in meeting water demands globally. Noted ominously in the report's short summary is that "this natural resource is often poorly understood, and consequently undervalued, mismanaged and even abused." Hence, the need for increasing the visibility of a critical water resource that, unlike rivers, lakes, and oceans, cannot be seen.

Assessment of aquifers, the formations that contain groundwater, can characterize groundwater quantity and quality, but assessment methods can be lengthy, expensive, and poorly understood. Yet, assessment is necessary for improving groundwater governance and management [2, 3]. Groundwater governance can be defined "the overarching framework of groundwater use laws, regulations, and customs, as well as the processes of engaging the public sector, the private sector, and civil society" [4]. Groundwater *management* consists of the actions of groundwater users in the context of the governance framework. An example is where the governance framework allows for aquifer recharge, but the decisions of water managers determine if aquifer recharge is undertaken.

Groundwater characterization is never an easy exercise, but assessment of aquifers that cross jurisdictional borders–transboundary aquifers–can be particularly challenging. When multiple countries are involved, data analysis may require harmonization across differences in methods of collecting and representing data, languages, cultures, and governance systems [2, 5, 6]. Yet this work is necessary to develop a common understanding of the shared resource. Monetary and human resources must be available to conduct assessments jointly. A platform for cooperation, such as a formal working group, committee, or commission, may need to be established. Many large aquifers worldwide are transboundary [2]. Transboundary aquifers cover around 40% of the continents of Africa and South America, and approximately 30% of Africa's population and 20% of South America's live in such areas [2]. Because meeting the food and water needs of the globe's growing populations reliably and safely is increasingly dependent on groundwater [2], assessment and management of transboundary aquifers require our urgent attention. Though assessment of transboundary aquifers has been ongoing (see, for example, Rivera et al. [7]), agreements to manage groundwater in transboundary settings are fewer in number [8, 9].

About transboundary aquifer assessment along the Mexico-United State border and prospects for groundwater management

Experience with transboundary aquifer assessment and the status of binational groundwater management along the border shared by Mexico and the United States (US) is highly illustrative of both successes and challenges associated with management of shared groundwater. Since the signing of the 1944 Water Treaty Regarding the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, the International Boundary and Water Commission (IBWC) has functioned admirably as the mechanism for border cooperation on water and wastewater issues [10]. IBWC focus, however, has been mostly on surface water and wastewater. Until 2009, transboundary cooperation on groundwater was limited to the Colorado River border region. The 2009 signing of the Joint Report of the Principal Engineers Regarding the Joint Cooperative Process United States-Mexico for the Transboundary Aquifer Assessment Program (TAAP) paved the way for cooperative assessment of agreed-upon transboundary aquifers. The cooperative framework established through this concise, three-page agreement, however, is for assessment only. It explicitly states: "The information generated from these projects is solely for the purpose of expanding knowledge of the aquifers and should not be used by one country to require that the other country modify its water management and use." Though a record of successful cooperation has been established [5] and much learned about priority shared aquifers, only a few of the many shared aquifers along the border have been subject to shared investigations [11, 12]. Moreover, to date, the investigations have largely focused on the physical aquifer characteristics and have not included assessment of socioeconomic conditions of the studied regions. (See papers in [13] and their references.)

Importantly, with many border communities relying wholly or primarily on groundwater, the prospects for binational groundwater management in this semi-arid region are largely unexplored [12, 14]. Lack of concerted efforts on the part of agencies and water users to cooperate on binational groundwater management could suggest that the need for binational groundwater management does not yet exist [15]. The challenges of working through overlapping and asymmetrical groundwater governance could be another contributing factor to lack of binational groundwater governance. Whereas the federal government of Mexico oversees utilization of all waters in the country, the role of state governments in groundwater management is significant in the US [6].

Climate change impacts are being experienced by the growing Mexico-US borderlands region. Temperatures are increasing, precipitation patterns are changing, and there are documented decreases in groundwater in storage [16]. A key question is whether the actors in border communities will tackle border groundwater management proactively or instead wait until wells run dry?

Concluding observations

The December 2022 UN-Water Summit on Groundwater focused on the following requisite factors for groundwater management: data and information; capacity development; innovation; finance; and governance [17]. That the multiple jurisdictional setting of transboundary aquifers introduces additional challenges was recognized by a plenary conference session dedicated to transboundary groundwater. Along with recognizing that groundwater flow conditions vary by aquifer, specific governance frameworks will vary as well, even within a geographic area, such as the United States- Mexico border [6]. Inclusive and extensive stakeholder engagement is another factor [18, 19 pc]. And while the need for more study will usually remain, one should take care not to suffer from paralysis of analysis! A critical condition for groundwater management in the transboundary setting is a functioning mechanism for

cooperation, one that is built upon trust and mutual respect. The Mexico-US region has one, but other regions may need to establish a platform for cooperation.

Reliance on groundwater is increasing. Careful management of this vital but invisible resource is essential to the water security of regions throughout the world. The work can be particularly challenging in transboundary settings, but water professionals must lead the way so that communities can benefit from their efforts to make the invisible visible.

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