



Perceived versus actual water quality: Community studies in rural Oaxaca, Mexico



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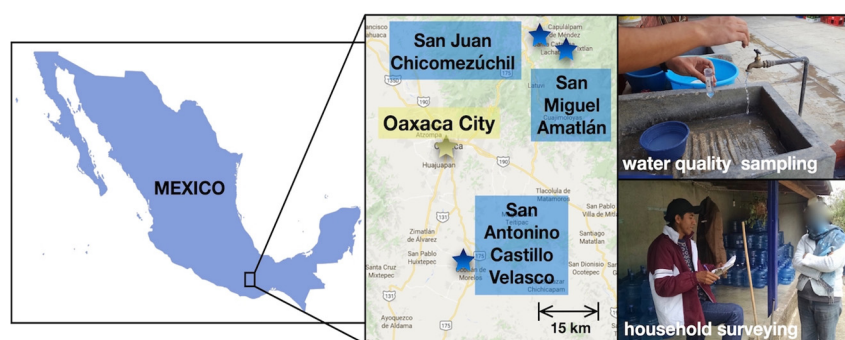
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HIGHLIGHTS

- Diarrheal diseases reported by 82% of the surveyed households for the past year.
- Microbial presence at unsafe levels in some households
- Actual and perceived microbiological water quality varies among communities.
- Many households spend a large income-fraction on bottled drinking water.
- Widespread willingness to purchase water treatment technology.

GRAPHICAL ABSTRACT



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ABSTRACT

Compromised water quality risks public health, which becomes particularly acute in economically marginalized communities. Although the majority of the clean-water-deprived population resides in Sub-Saharan Africa and Asia, a significant portion (32 million) lives in Meso- and Latin-America. Oaxaca is one of the marginalized southern states of Mexico, which has experienced high morbidity from infectious diseases and also has suffered from a high rate of infant mortality. However, there has been a paucity of reports on the status of water quality of culturally diverse rural Oaxaca. This study follows community-based participatory research methods to address the data gap by reporting on water quality (chemical and microbiological) and by exploring social realities and water use practices within and among communities. Surveys and water quality analyses were conducted on 73 households in three rural communities, which were selected based on the choice of water sources (i.e., river water, groundwater, and spring water). Statistically significant variations among communities were observed including the sanitation infrastructure (p-value 0.001), public perception on water quality (p-value 0.007), and actual microbiological quality of water (p-value 0.001). Results indicate a high prevalence of diarrheal diseases, a desire to improve water quality and reduce the cost of water, and a need for education on water

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quality and health in all the surveyed communities. The complexities among the three studied communities highlight the need for undertaking appropriate policies and water treatment solutions.

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1. Introduction

Economic inequalities in communities across the globe lead to a lack of 'basic capabilities,' among which access to clean water is considered to be essential for survival (Sen, 1992). The microbiological quality of water, when compromised, can readily transmit communicable diseases such as diarrhea, cholera, dysentery, typhoid, and guinea worm infection (Kirby et al., 2016; Mara and Feachem, 1999; Nweke and Sanders, 2009; Siya et al., 2008). Globally, diarrhea is the second greatest cause of childhood death, claiming the lives of over half a million children per year (UNICEF, 2016). The World Health Organization estimates that >663 million people put their health at risk by using unimproved drinking water sources (WHO/UNICEF, 2015). Although the majority of the clean-water-deprived population resides in Sub-Saharan Africa and Asia, a significant portion (32 million) lives in Meso- and Latin-America (WHO/UNICEF, 2015).

One of the most acute shortages of safe drinking water in the Meso-america region is in Mexico, where 8.9 million people, primarily segregated by socioeconomic standing, suffer from this social injustice (Comisión Nacional del Agua, 2014). Geographically, a distinct division in water availability and economy exists between Northern and Southern Mexico. Water quality in Mexico has been assessed and reported primarily for the more prosperous cities in the North (Cifuentes et al., 2002; Downs et al., 1999; Jiménez-Moleón and Gómez-Albores, 2011; Muñoz-Piña et al., 2016; Sánchez-Vega et al., 2006). However, Southern Mexico lags behind the North economically and also in access to safe water. The southern states of Oaxaca and Chiapas, where 40% of the population is deprived of access to any municipal water supply (Oswald Spring, 2011) are among the poorest in this country (Rivas, 2011).

Water stress is a manifestation of sociocultural complexities and economic deprivation in the region. In Oaxaca, 48% of its nearly 4 million population are indigenous to the region (Instituto Nacional de Estadística y Geografía, 2016; National Commission for the Development of the Indigenous Peoples, 2010). Nearly a quarter of the country's municipalities are concentrated in Oaxaca, and public responsibilities and sociocultural activities are administered by autonomous local leadership (*ayuntamientos*) or by indigenous local governance structures called *usos y costumbre*; however, the natural resources are owned by the federal government, a situation that often gives rise to small opposition parties (Rodríguez and Ward, 1995). The lack of safe water access becomes more acute with economic marginalization. The economic stress in the region is intense (Becerril and Abdulai, 2010); 20% of the population earns only the bare subsistence minimum wage (Rojas Miranda and Cano Cruz, 2004). Combating these challenges, the rural population of Oaxaca faces high morbidity from infectious diseases and also suffers from a high rate of infant mortality (Secretaría de Salud, 2004). Lack of access to safe water is one of the key factors for compromised health as manifested by the rampant parasitism, observed in Oaxacan children (Quihui et al., 2006).

Despite these reports of water-related diseases and fatalities, very little is known about the water quality of rural Oaxaca. In Mexico, decentralization legislation in 1983 led to each state having responsibility for water provision to its municipalities (through the State Water Commission). Oaxaca has more municipalities than any state in Mexico (570 or around one fifth of the national total), many of which are poor, relatively isolated rural communities that are not served by modern formal infrastructure networks. Oaxaca is a unique socio-cultural setting for this research with underlying complexities of the ownership of water

resources in the region. While socio-demographic reports on each municipality are automatically generated by the government, in-depth studies on communities' water quality are not available (INEGI, 2015). An extensive literature review found only three studies on microbiological water quality in the state of Oaxaca (outlined in Table S1): a water quality data report collected as a part of an educational effort (Jimenez Banuelos, 2007); data from households within Oaxaca City (Del et al., 2007); and data from a pilot study on a point-of-use (POU) water treatment device (Martín-Domínguez et al., 2005). A comprehensive study on water, health, and hygiene is lacking for rural communities in Oaxaca. The existing gap in the literature of water quality assessment in the rural Oaxacan communities needs to be filled for making policy decisions to improve water quality governance (Muñoz-Piña et al., 2016).

Water quality governance in a region is concerned with how social, political, economic, and administrative institutions operate and how regulations affect political actions and can overcome social obstacles through formal or informal channels (Kayser et al., 2015; Tortajada, 2010a, 2010b). A recent study on water quality governance in Brazil, Ecuador, and Malawi identified four key challenges, which turned out to be critical to improving the governance in these countries (Kayser et al., 2015). The challenges identified include: insufficient data sharing and coordination between government offices, lack of monitoring and enforcement of water quality laws, unclear federal policies for surveillance of water quality, and administrative and technical management of the water services (Kayser et al., 2015). These challenges are not unique to these three countries, but are important to overcome for achieving better water quality governance in general (Biswas and Tortajada, 2010; Tortajada, 2010b). These challenges become even more acute when there is a polycentric government in rural communities (Huitema et al., 2009; Neef, 2009).

In many ethnically diverse and developing economies like Mexico, decentralized governance schemes are identified as major channels through which public good (e.g., water) is managed (Müller and Chaliganti, 2016). For example, in India, one of the largest examples of decentralized governance, development activities are primarily controlled by local governance or *panchayats* (Johnson, 2003; Webster, 1990). Such a polycentric governance structure usually competes with formal leadership in the region and can introduce acute complexities and even barriers to data acquisition in such regions (Neef, 2009). Thus, integrating the informal autonomous local leadership (*ayuntamientos*) in Mexico into any study is essential for gaining access to the communities and collecting information on local practices. Data on water quality and water use practices collected from such communities is therefore particularly valuable.

This research was designed to investigate three related aspects of water supply in the Oaxacan region: (a) study the overall water quality status, both chemical and microbiological, of understudied rural Oaxacan communities, (b) explore social realities and water use practices within and among communities in the region, and (c) report diarrheal frequency among the population of the chosen communities. However, attempting to establish a direct correlation between water quality and health implications was beyond the scope of this study. To accomplish these objectives, a community-based participatory research (CBPR) method (that involves community members, organizational leaders, and researchers as equal participants) was utilized to design and implement this research, which allowed for integration of the community members into the study (Minkler and Wallerstein, 2008). By involving the community leaders and members as stakeholders, this study is valuable to initiate action from the rural Oaxacan communities. Surveys and

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