Water safety in drought: an indigenous knowledge-based qualitative study

Azadeh Fatehpanah, Katayoun Jahangiri, Seyed Hesam Seyedin, Amir Kavousi and Hossein Malekinezhad

ABSTRACT

The indigenous knowledge of our ancestors provides valuable information on how to prevent negative health impacts on water hygiene in the event of drought. The present study aimed to explore the role of indigenous knowledge in maintaining water safety in drought conditions. A qualitative content analysis method using in-depth semi-structured interviews was used to collect and analyze the data. The current research was carried out from April 2017 to June 2018. A purposive sampling method was used to select 15 participants. Trustworthiness was applied with the Lincoln and Guba approach and data were analyzed using Graneheim and Lundman's method. Two categories including drinking water storage and water collection were extracted from the data. Each category includes different strategies to deal with water. Water storage includes water quantity and water quality. Water collection consists of collection methods and rules. Indigenous knowledge is an indispensable component of community disaster resilience. It can be transferred to other communities and employed to empower affected communities. But using the knowledge without scientific considerations cannot guarantee peoples' health throughout the drought periods.

Key words | disaster, drought, indigenous knowledge, resilience, water shortage

HIGHLIGHTS

- Indigenous knowledge is a rich source of knowledge in all communities.
- Indigenous knowledge of water health need to be compatible with modern knowledge.
- Using indigenous knowledge of water health without scientific considerations cannot guarantee the peoples' health over the drought periods.

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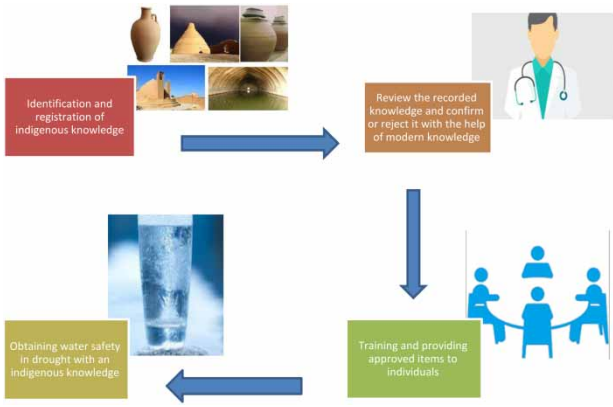
GRAPHICAL ABSTRACT



INTRODUCTION

Disaster is a part of human life and no region of the earth is safe regarding natural disasters (Hogan & Burstein 2007). Generally, the incidence of disasters in terms of frequency, severity, and damage is increasing worldwide (Alirol *et al.* 2011; Sayah mofazali & Jahangiri 2018). Iran is amongst the 21 most disaster-prone countries in the world (Jahangiri *et al.* 2011; Asefzadeh *et al.* 2016). The Intergovernmental Panel on Climate Change studied the management of severe dangers to the world in the form of natural disasters to prevent climate change and reported that drought was identified as one of the major challenges of climate change (Orlowsky & Seneviratne 2013). Analysis of soil moisture and drought indices showed an increase in the risk of drought in the 21st century (Dai 2013). Drought is a complex natural disaster and has widespread effects on aquatic resources, agricultural crops, ecosystem performance, the environment, as well as indigenous and worldwide economies (Guo *et al.* 2018). However, the information in hand with respect to drought is much less than the knowledge we have about other natural disasters. Drought causes water scarcity, desertification, dust storms, as well as air dryness in rural and urban areas (Carrão *et al.* 2018). This phenomenon in Iran has a strong impact on water resources (Zarch *et al.* 2011).

Given the history of drought in the Iranian plateau, over time people have used different techniques successfully to adapt to water shortages (Miyan 2015). Indigenous knowledge, the valuable knowledge of our ancestors (Green *et al.* 2010; Hiwasaki *et al.* 2014; Audefroy & Sánchez 2017), is a precious national source of information that can facilitate disaster prevention and response in a cost effective, collaborative, and sustainable manner (Keramat *et al.* 2011). As stated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) indigenous knowledge is 'the local knowledge that is unique to a culture or society. This knowledge is passed down from generation to generation, usually by word of mouth and cultural rituals, and has been the basis for agriculture, food preparation, health care, education, conservation and a wide range of other activities that sustain societies in many parts of the world" (Nakashima *et al.* 2000). The growing awareness about the value of indigenous knowledge has increased its application in reducing and coping with hazards (Shaw *et al.* 2008; Mercer *et al.* 2010; Codjoe *et al.* 2014; Iloka 2016). In addition, high emphasis on the transfer of technology to villages has had adverse effects on the environment and natural resources. Consequently, the use of new methods to deal with natural disasters has left increasing side-effects in local communities (Mertz *et al.* 2009). Therefore, there is a need to take this valuable and precious knowledge into account in order to deal with the current water scarcity (Pandey

et al. 2003; Habane 2011; Pareek & Trivedi 2011; Castleden et al. 2017). By considering the above-mentioned points and the fact that few studies have dealt with indigenous behaviors with respect to water in Iran, the current study was carried out to identify the role of indigenous knowledge in maintaining water safety during drought.

METHODS

Study design

This research was carried out from April 2017 to June 2018. A qualitative content analysis method (Graneheim & Lundman 2004; Mayring 2014) was used to obtain insight into personal experiences. Through this method, we achieved a deeper understanding (Denzin & Lincoln 2008; Naderifar et al. 2017; Pakjouei et al. 2018) as well as the meaning and concepts that were not possible with other methods (Silverman 2013).

Setting

This study was conducted in Yazd, which is located in a dry region of Iran (Figure 1). A large part of this province (85%) has a hot desert climate (Keshtkaran 2011). Yazd is one of the provinces of Iran that has faced water scarcity throughout its history. Considering the location of Yazd in the desert region, and the arid and warm climate, people have first-hand knowledge on how to adapt to existing conditions.

Participants

The research population consisted of the native villagers who lived in rural areas near the three main plains of Yazd

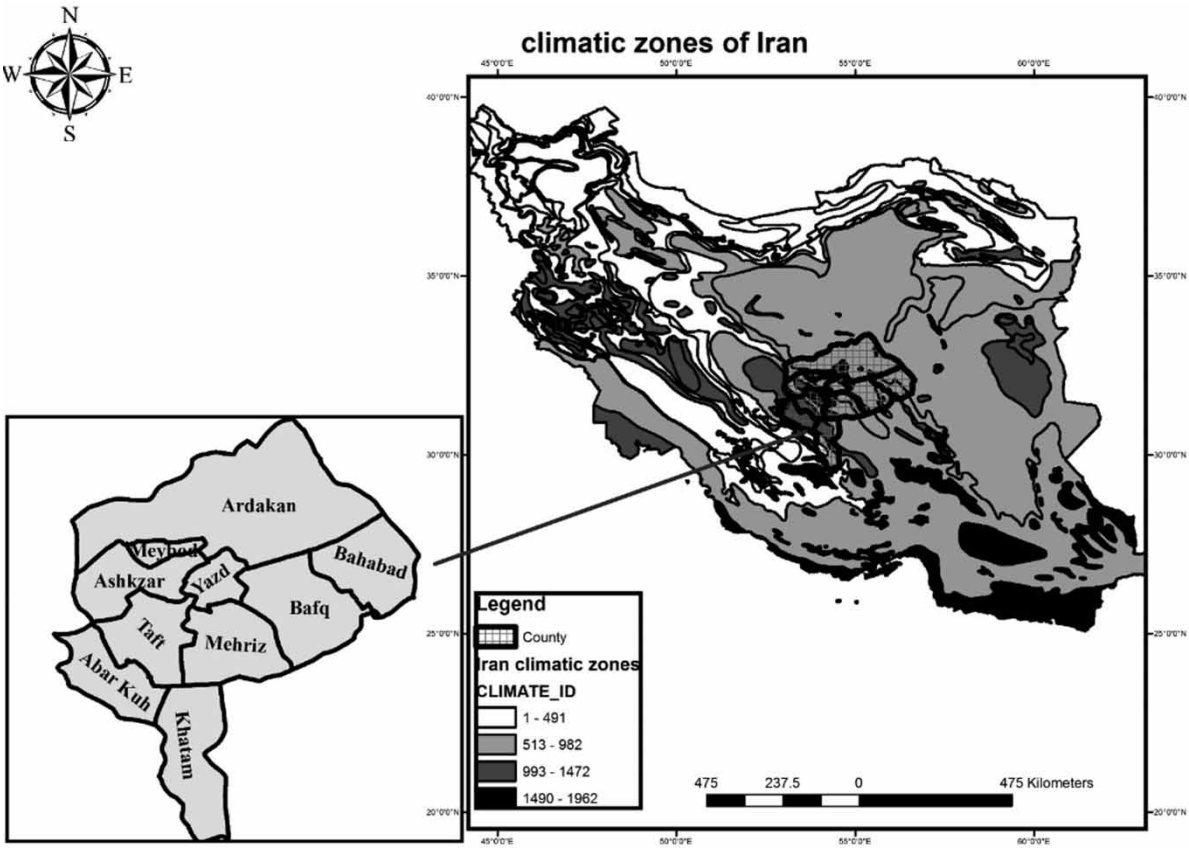


Figure 1 | Climatic zones of Iran and Yazd climatic position.

province (Yazd-Ardakan plain, Abarkouh plain, as well as Herat Va Marvast plain). The inclusion criteria consisted of being native residents of the village, being 50 years and older, without considering gender and educational level, living in the village since childhood, ability to recall the memories and methods, as well as being able to retell them and having a willingness to participate. Sampling continued until data saturation was achieved through interviews.

Data collection

Data were collected through semi-structured in-depth interviews as well as field observations (Braun *et al.* 2019). For the collection of the samples, we continued purposive sampling (in order to access appropriate participants) until the information saturation was reached (Naderifar *et al.* 2017). Each interview lasted between 15 to 55 minutes. The participants were asked for permission to record their interviews with a voice recorder. The place of interview was determined according to the arrangement made with the participants. All interviews were recorded, transcribed verbatim and analyzed using the constant comparative method. In this method, data were collected and analyzed simultaneously. After each interview, the texts were extracted from the recorded interviews and the data were coded before the next interview (Boeije 2002; Corbin & Strauss 2014).

Data analysis

Qualitative content analysis was used to analyze the data using Graneheim and Lundman method for data collection and analysis (Graneheim & Lundman 2004). After transcription of each interview, codes, sub-categories, and categories were extracted via open coding through line by line reading of the text. All of the interviews were conducted by a principal investigator (AF). Then, two researchers (AF and KJ) transcribed and analyzed the data independently. Then, the meaning units, as the phrases related to the participants' experiences, were identified. Subsequently, the data were summarized as condensed meaning units, labeled with codes, and sorted into categories and sub-categories based on their similarities and differences. When the codes or categories were different according to two researchers, a third author helped us in data analysis. The categories were identified through the constant comparison process. In the constant comparative method where data collection and analysis occur simultaneously, the new data are constantly compared against that which has been analyzed previously.

Trustworthiness

The study made use of the four criteria strategies recommended by Lincoln and Guba (Guba 1981) for trustworthiness of the data. These strategies included credibility, dependability, confirmability and transferability of data. To increase data creditability, the researcher engaged with data and the environment for months during the study period. In addition, triangulation, which involves the use of multiple and different methods, investigators, sources and theories to obtain data, was used (Safarpour *et al.* 2020). We also employed member checking, expert check, and peer check to ensure the credibility of the results. Dependability was established using an audit trail, a code–recode strategy, and peer examination. To ensure confirmability, the background and personal interest of the researcher on the subject were used. To improve transferability, demographic information of the participants and the topic of interest were described in detail.

Ethical considerations

The present study has been approved by the Ethics Committee of the Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1396.1151). According to the written consent form, approved by the ethics committee, all participants were informed about the confidentiality of their names and other personal information in the related reports and field notes. The written consent form was read out aloud to the participants who were illiterate or unable to write. In total, informed consent was obtained from all individual subjects included in the study.

RESULTS

A total number of 15 individuals with an average age of 71.5 years participated in this study. All participants were over 50 years of age and their educational levels ranged from being

illiterate to having a PhD (Table 1). In total, 12 final codes were obtained from the interviews, which were divided into two categories and four sub-categories (Table 2). The indigenous knowledge on water safety was divided into two categories of drinking water collection and water storage. Each of these categories contained sub-categories that are explained as follows: water collection consists of collection methods and rules; water storage includes water quantity and water quality.

Drinking water collection

The collection of drinking water was divided into two sub-categories: collection methods and collection rules.

The findings showed that individuals who lived near springs had easy access and could take advantage of the spring water round the clock.

'When I was a kid, we drew water from the river as our house was close to the river. We did our laundry there; the river always had water. Back then, there were no wells. Now that they have dug wells the rivers have dried up. We get water from fountains' (P3).

Table 1 | Demographic characteristics of participants

Code	Gender	Age	Education	Village
P1	Male	60	Diploma	Dehbala
P2	Male	69	Diploma	Dehbala
P3	Female	85	Illiterate	Dehbala
P4	Male	87	Fifth grade in elementary school	Dehbala
P5	Male	69	Diploma	*Shahr Asb*
P6	Female	80	Illiterate	Abarkuh
P7	Male	87	Illiterate	Abarkuh
P8	Female	75	Sixth grade in elementary school	Mehriz
P9	Female	64	Fifth grade in elementary school	Hajiabdollah
P10	Female	65	Sixth grade in elementary school	Mehriz
P11	Female	75	Illiterate	Mirokabad
P12	Female	50	Fifth grade in elementary school	Tajadab
P13	Male	65	PhD	Yazd
P14	Female	70	Elementary school	Zarch
P15	Female	70	Elementary school	Manshad

Table 2 | Categories, sub-categories derived from coding of interviews

Category	Sub-category	Code
Water collection	Collection rules	Collection frequency
		Access method
	Collection methods	Non-stagnant water
		Access time
		Access location
		No restriction on collection of drinking water
		Free drinking water
Drinking water storage	Water quantity	Using special containers at house level
		Using special buildings at urban level
	Water quality	keeping water soft and tasty
		maintain the hygiene of water
		Water cooling system

And elsewhere, villagers used urban and household Ab Anbars; they sometimes had to stand in lines for water. People, who had Qanat streams inside or near their houses, drank water at certain times.

'The Ab Anbar has cold and clean water and the spring of the Qanat was clean too. Early in the morning and before sunrise and at midnight the water in the streams was clean' (P14).

The above interview refers to all three methods of obtaining drinking water; people could go to an urban Ab Anbar during the day to drink water and get water from there, or go to a spring and bring water as they needed it. And when it was difficult to access these two because of the long distance, they had to obtain water at midnight or early in the morning when people had not yet woken up and before starting work.

The residents of villages also drank water from the covered wells at home. Therefore, depending on the type of access to a water source, the ancient people kept water at home for daily use or drew water as needed.

'In wells that were not covered, it was possible for a chicken to fall into the well and drown, or dust and

debris settle on the surface making the water dirty. But those who had covered wells drank from the water' (P7).

The researchers came to understand the unwritten rules that people felt obliged to obey, from the conversations with the subjects. These included consumption of non-stagnant water, the time of access, the location of access, unrestricted access, and free collection of drinking water.

'*Benefactors built water reservoirs. This Qanat was built 700 years ago; water used to overflow on to the ground It overflowed on to the streets and once everyone had used what they needed, it was used in agriculture; any water left over was used for farming. Farmers took advantage of the water and contributed money to promoting the endowment. The money was spent on the Qanat again and this system always ran itself economically' (P13).*

'People only drank water from the springs and they never did their laundry there. They used the water from the wells to wash the dishes or their clothes, and the water that was stored in the pool was used for agriculture. They used to say it was sinful to pollute the spring water' (P1).

'We didn't wash the dishes and do the laundry at the source where people got their drinking water. For washing and stuff, people did it in their own houses or by the pool' (P6).

Drinking water storage

For household water usage, the volume of drinking water was maintained using special containers, pools, ponds, tanks, and wells. Throughout the interviews, the interviewees referred to Khomrehs and jars, and below, two interviews are presented:

'We had an earthenware jar in which we kept water for up to 2 or 3 days …' (P14).

'For their drinking water, which came from a well or Qanat, there were various earthenware jars called Khomrehs containing 20 to 30 liters of water' (P5). (Qanat chains were intelligent solutions for water supply in the past in Iran. Underground water channels.)

In order to maintain the quantity of drinking water in the neighborhood and urban level, buildings with specific architectures were constructed including Ab Anbars (Meaning 'water storage' in Persian) and ice houses (Persian Yakhchāl). These two buildings were used for storing water, whilst keeping it cool for the people due to their own special architecture in the absence of electricity and electrical appliances.

'Throughout the year we brought water from the Qanat, which had a lot of steps and 4 windbreakers' (P14).

'There was also an ice house (a historic building at the entrance to the city of Abarkuh). In winter, people collected and poured snow into it. Later, in the summer, it melted or they took ice from the ice house to consume' (P6).

According to the findings, the solutions used to maintain the quality of water were methods to keep it soft and retain its good taste, ways to maintain the hygiene of water and keep it cool. In order for water to retain its taste, people paid particular attention to the following points: the water should have no particular smell or taste; it had to be kept in clay jars and the water had to be fresh and that is why fresh water was supplied every day.

'*How could one make sure that the drinking water was clean and safe? We said that the water should be as clear as teardrops; no smell, no unusual taste' (P11).*

'We used to get drinking water from Ezzat Abad Qanat, because it was clean and it floated down the steps, beside the street, untouched. It was as clear as glass …' (P6).

'People used to fill up two jars with water, at midnight, around 12, and they kept them by their houses and used it …' (P7) … 'water was kept no longer than a day and it never went stale' (P10).

'Water will remain fresh if you put it in the jar, and it stays cool too. We had Khomrehs too; we filled them up so as to have a reserve at all times. Water kept in the jars tastes better, and stays cool too, and the residue

settles. Water doesn't smell either, no matter how long it is stored' (P3).

The findings showed that the methods indigenous people adopted to eliminate pathogens included: making sure water was untouched, that it was fresh, that the water containers such as jars and wells were sealed or covered (to protect the water from dust or insects). Attention had to be paid to the water taste, color, and smell and water should not be stagnant. Another idea to keep the quality of water up to standard was to kill the pathogens by boiling or adding salt stone to the water reservoirs.

'The jars they made prevented water from smelling. They made them with special clay and sealed the top with stiff cloth' (P6).

… 'We brought this jar and kept it in the shade, there were also Yuka mats and we would put them on top of the jars so that snakes and scorpions wouldn't be able to get in there. We always had to seal the top' (P3).

'Once they filled the Ab Anbar, and put 2 or 3 whole pieces of salt stone in it so that it wouldn't attract worms and germs…' (P9).

'It is said, if the current (water) is weak and it's still you can't drink it, because if something falls in it the current can't take it away. We boiled the water before consumption by newborns and infants' (P1).

The findings showed that in order to keep water cool which has been referred to in all of the interviews, jars and *Khomrehs* were used. One of the interviewees mentioned stools on which the jars were placed and water was kept cool because of the exposure to air from the bottom. Another way was using ice obtained from the mountains and natural ice houses. Another method for cooling the drinking water was using glass containers consisting of two vessels one placed within the other; one vessel was filled with ice and the other with water, hence leading to clean and cool water.

'People used to have wooden stools in their houses, and they used to fill four 30-liter jars with water and put them on these stools, and cover them with wet cloths to keep them cool…' (P5).

'In Tazarjan ice was carried by donkeys and sold at night, because of the lower temperatures at that time. In the houses, ice was poured into double-walled containers to cool the water' (P13).

'They had Khomrehs and they covered them with sacks and poured water on them to keep them cool all the time' (P8).

DISCUSSION

As indicated by the results, people's behavior regarding drinking water is categorized into water collection and water storage categories. Each category included various behaviors as subcategories.

The findings showed that ancient people had rules for collecting water; they did not keep water for a long period of time, they collected water daily or several times a day from safe places, such as the untouched streams or water flow at specific times, such as late at night or at dawn.

All in all, these methods had a positive role in obtaining healthy drinking water. Momba & Notsche (2003) showed that the most significant source of water pollution and microbe quality is the type of water supply used, followed by the time of storage and the jars used (Momba & Notshe 2003). Latchmore *et al.* (2018) noted that not all water obtained from natural sources is trustworthy water. Rather, trustworthy water comes from high-speed sources such as springs, streams, and rivers. They also stated that collecting and consuming water from natural sources such as springs, streams, rivers, and lakes is a common practice among indigenous people (Latchmore *et al.* 2018). Although the findings have similarities, in order to prevent health problems, the organizing bodies need to monitor and train people on how to prevent health problems. Water collection was free and unrestricted because the water system was based on philanthropy and endowment in the old days. Therefore, people just paid for their share of agricultural water. Furthermore, they did not pollute the water at the source and prevented the loss of water, which are habits derived from their religious beliefs.

The results have also shown that water extraction was free and without limitations. Since Qanat water supply system was part of the charity systems and people's endowment in the past, no fees were taken from people for extracting water used for drinking and payment was only made for agriculture shares of water. They would not pollute water at its source and would prevent water from being wasted because of their religious beliefs. It goes without saying, considering the type of rural lifestyle in the past, the fact that drinking water was free is completely justifiable. However, doing the same thing today would not prove beneficial and could also result in overuse and waste of hygienic water. In recent studies, it has been suggested that a reasonable price be assigned to water as a solution to save drinking water resulting in appropriate water consumption (Dawadi & Ahmad 2013; Khodarahimi *et al.* 2014; Sağlam 2015).

As can be seen, water supply systems in the past were highly dependent on Qanats, which are now not in use to a large extent and not accessible to most people.

Manuel referred to the role of Qanats as one of the great examples of indigenous knowledge in Iran and defined it as an economical irrigation system. They stated that 'the reinvigoration of Qanats can play an important role in supporting the sustainable use of water across what is a climatically, and often politically, an unstable region' (Manuel *et al.* 2017).

Since villagers used stream water, they needed to pay considerable attention to the time and place of water collection in order to ensure the quality and healthy benefits of the water. According to the findings, we can classify water quality into five sub-categories; water with the highest quality for drinking and cooking, water with lower quality for washing the dishes, washing clothes, taking a bath, and farming. In other words, the quality of water decreases with drinking water being of the highest quality to water of the lowest quality being used in farming, respectively. The low-quality water was collected from open Qanat streams and was a kind of recycled water derived from the first uses. Since the agricultural sector is the biggest consumer of water in the world, and the increasing water shortage and mismanagement of water supplies are fundamental threats for sustainable development (Hamdy *et al.* 2003) taking water recycling in drought conditions of today into consideration is of great importance (Hurlimann 2011; Khodarahimi *et al.* 2014; Kumar *et al.* 2016), a point which was found in the indigenous knowledge mentioned in our study and is quite remarkable. Hogland also addresses the importance of not wasting water and educating individuals and children on how to use drinking water properly, reporting that recycling contributes to reducing water demand in society and recycled water could be used in agriculture and industry (Hogland *et al.* 2019).

In order to maintain water quantity, special clay jars, pools, domestic ponds and domestic wells like the Ab Anbar and traditional ice houses were used. As we know, poor hygiene results from lack of sufficient domestic water (Howard *et al.* 2003). The indigenous people maintained quantities of water in domestic and urban scales. Aside from the quantity, various measures were taken to ensure safe water quality (keeping it soft and retaining a good taste, and ways to maintain the hygiene of water and keep it cool). In order to preserve the taste of the water, the following items were identified. Water should have no particular smell or taste. It should be kept in clay jars. Water had to be fresh and be supplied on a daily basis. Water hygiene and lack of taste and smell is discussed under Drinking water collection. The clay jars were used to cool water and maintain the quality of drinking water. In order to prevent pollution, the openings of the jars were always kept closed or covered. Trevett also pointed out the significance of the jar type and the emphasis on avoiding touching the water, and the role of polluted drinking water in waterborne diseases in infants and immunocompromised people (Trevett *et al.* 2005). The current study has shown that water was kept cool by keeping the jars wet and the jars being exposed to wind. Using these jars was so commonplace, to such an extent that all of the interviewees referred to them. Tan found that using these jars protects the environment, and they have the feature of controlling engineering of urban rainwater non-point pollution (Tan *et al.* 2008).

The following study shows results similar to our findings. Kenya uses indigenous knowledge to produce reservoirs in the form of clay pots for drinking water storage. They found that due to the cooling effect of these pots in warm weather, less water evaporated. As a result, the local government provided the sanitary versions of these pots for their people (Shaw *et al.* 2008). Due to the cultural acceptability in the area, these containers should be protected and recommended in the current drought conditions.

Noteworthy findings of the current research include the point that a number of interviewees mentioned they boiled water before consumption by newborns and infants. The findings also indicated that the native people used salt stone and also twigs and leaves in order to purify drinking water. Marobhe *et al.* (2007) also stated in their research that less than 20% of the villages under their study had water supply coverage and others stored and consumed water in traditional ways such as using water from dams, charco dams, traditional wells, windmill and boreholes. Moreover, they used local seed powder to purify the water coming from charco dams. They indicated that local plants produced for water purification have great potential for social, economic and environmental development in semi-arid areas (Marobhe *et al.* 2007).

In addition, Mkwate also stated in their study that among 204 families under research, 72% of them used shallow wells and rivers as their sources of drinking water, and 95% of them purified and stored domestic water by boiling it or adding chlorine to it and keeping it in enclosed containers (Mkwate *et al.* 2017). Both of the studies mentioned before refer to the indigenous methods used by people all over the world to obtain clean water. Comparing the results of those studies in the literature with the current study depicts the fact that with the development of modern methods of water purification, if old methods are to be applied it necessitates caution, although they are something to be admired whether still in use or not. It is recommended that the relevant authorities become familiar with such indigenous methods, compare them with the modern approaches and if necessary, provide the necessary training for people to avoid jeopardizing their health due to wrong behaviors. This is in line with Rufener *et al.* (2010) who argued that in the absence of proper training, the domestic water disinfection interventions cannot guarantee hygienic water (Rufener *et al.* 2010). Another method mentioned in the study was using the ice from mountains and building natural fridges to be used in the summer. These ice houses had a particular kind of architecture. Also, since horses and mules carried the ice, in order to avoid direct contact of the ice with water, double-paned glass containers were used. So, the ice provided a cooling effect on water. Nevertheless, some of the interviewees did not refer to these containers and reported the carrying of ice on mules without any reference to the containers. Since all of the drinking water was stored away, this could have led to diarrhea (Copeland *et al.* 2009). This accuracy regarding the hygiene and health of the drinking water is considerable.

If we compare the current drought conditions with the living conditions of the past, we can see some similarities between them. In the event of a possible hazard, the urban infrastructure may be damaged, water supply may not be possible through the urban plumbing systems for a while, electricity and gas supplies may be cut off, and even simple hygiene may not be possible and cleansing materials not available. In the old days, people did not have access to tap water and lived without electricity and modern cooling facilities. So, it is possible to use some of their methods depending on the local conditions of each area. The indigenous knowledge can be used in the current droughts and other crises. However, it should be noted that, just as identifying and recording indigenous knowledge is valuable, making it compatible with the modern-day knowledge is also crucial since using unhealthy methods might lead to illnesses. For example, if the original source of water is polluted, storage water in houses, even under hygienic conditions is not likely to prevent disease. Along the same lines, Mercer *et al.* (2007) also pointed to the insufficiency of indigenous knowledge per se in decreasing disaster hazards. In order to prepare the indigenous people in the event of natural disasters and decrease the vulnerability of the indigenous communities in natural hazards, this form of knowledge needs to be integrated and unified with the strategies for decreasing disaster hazards (Nyong *et al.* 2007). Accepting certain local and cultural ideas about the health and the quality of drinkable water should be taken into account so that hygienic water supply projects for societies would have successful outcomes (Marino *et al.* 2009). Vuorinen *et al.* (2007) reported that when we tend to propose a solution for problems, local conditions, native methods and people should be at the core of our decision making. According to history, it is obvious that regardless of political systems, good local solutions could be found on the basis of local conditions, local needs and native methods. Although water and its related services depend to a great extent on local conditions, useful comparative studies can be conducted between various areas and cultures in order to identify applicable and reusable methods (Vuorinen *et al.*

2007). McGregor (2012) also pointed out in his research that one of the most important and essential attempts at solving the water crisis which is being increasingly felt throughout world, is the necessity of reviving and preserving native people's access to their own native ways and lifestyles as well as mutual cooperation between native knowledge and Western sciences (McGregor 2012). Yet the findings showed that indigenous knowledge entails worthwhile points which the modern world can identify with and record to prevent loss, and apply them for improving health in society, once they have been made compatible with the modern knowledge.

CONCLUSION

Indigenous knowledge is a rich source of knowledge in all communities. However, as some of the old ways might not secure health for people, they need to be made compatible with modern knowledge, and then people need to be trained in how to work with the new methods. Indigenous knowledge can be reliable and effective in times of drought, only if it is identified and integrated with modern knowledge, and then put into practice. Although indigenous knowledge contains some innovative methods which are applicable today, using them without scientific considerations cannot guarantee the health of communities throughout periods of drought.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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