University of Birjand

Water Harvesting Research Vol. 6, No. 2, Autumn & Winter 2023, Original Paper p. 195-202

10.22077/JWHR.2024.7158.1124

Public Attitudes toward Environmental Impacts from Seawater Desalination: Insights from Southeast Iran

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Received: 10 December 2023/ **Revised**: 06 February 2024/ **Accepted**: 11 February 2024

Abstract

Freshwater scarcity is a growing issue in water-scarce countries, and the rising population increasingly depends on unconventional water sources, like desalinated seawater. The environmental impact of desalination is crucial, and it is equally important for stakeholders to comprehend these effects as the success of projects relies on the participation and support of local communities. However, there are varied and at times conflicting opinions regarding the environmental impact of desalination plants among the general public. This study examines public attitudes of the environmental effects of desalination plant operations through the use of questionnaires conducted along a section of the coast of Chabahar in the southeast of Iran. According to the results, there is a positive significant relationship between knowledge and factual knowledge of citizens about the environmental impact of desalination plants ($p<0.05$). It was found that males reported higher knowledge and factual knowledge than females ($p<0.05$) which can be due to their higher education and their greater role in the family economy. As long as, those with higher marine-dependent livelihood showed a higher knowledge and factual knowledge in using desalinators ($p<0.05$). In addition, Internet and TV were the main information sources that used. In general, these results can help decision-makers in public participation programs and the trade-off between freshwater need environmental sustainability. Through determining the key role of environmental education, we suggested that education to local people should be placed at the urgent priority of development of technology for desalination of sea water.

Keywords: Desalination, Knowledge, Local people, Water crisis.

1. Introduction

To gain freshwater, most of the countries in the Middle East and North Africa depend on desalination plants (Schiffler, 2004). These places represent ~50% of the total capacity of desalination plants worldwide (Eke et al., 2020). Drought remains a global challenge but is a serious problem for countries that are located in deserts or semi-arid regions. These countries possess more than 1/3 of the world's population. (Shahabfar and Eitzinger, 2013). Iran possesses a lot of deserts and semi-arid regions and represents one of the driest places on Earth (Mansouri Daneshvar et al., 2019). The country only has 1.4% of the water on Earth that can be consumed (Khatibi and Arjjumend, 2019). The population growth in the region increases the demand for water resources. The amount of water in the ground also diminishes rapidly which is due to pumping more water out of it than is replaced by rainfall, and due to climate change (Darre and Toor, 2018; Ahmed et al., 2021). Desalination is referred to removing salt from seawater so that it is suitable for drinking. The desalinated water can be used for drinking and growing crops (Shahabi et al., 2015). There are 101 desalination plants in Iran, possessing a desalination capacity of around 672.000 m^3 per day. These plants are located in northern and southern coastal provinces (National Water and Wastewater Engineering Company of Iran,

2023). In Iran, the central and southeast regions have little rainfall and are characterized as dry and semiarid (Daneshmand and Mahmoudi, 2017). There is no exact prediction of how much salt will be left following the desalination process in Iran. There is a debate about the potential negative environmental impacts of removing salt from seawater (Lesimple et al., 2020). Environmental impact serves as a challenge that constrains the sustainable development of desalination projects (Hoepner, 1999; Lattemann and Höpner, 2008; Sola et al., 2021).

The removal of salt from seawater is controversial because it is costly, and releasing the salty water back into nature may have bad consequences (Liu et al., 2013, Li et al., 2020). Given the release of large amounts of CO_2 into the atmosphere, desalination plants can contribute to climate change (Jouzdani et al., 2020; Alhaj et al., 2022). Limited cultivation and less availability of freshwater resources have resulted in extended urbanization, especially in the cities of Konarak and Chabahar. Apart from environmental risks (e.g., potential effects on marine ecosystems and mangrove forests of Chabahar), poor urban planning resulted in damage to infrastructures along coastlines, including ports and desalination plants. Individuals differ in their opinions on these issues. Many people wish to establish desalination plants (plants that take salt out of seawater) in order to solve water problems. But they are not aware that how much this will damage the environment. Not many studies have investigated the understanding the public awareness of the environmental effects of using desalination plants (Portman et al., 2022). Heck et al (2018) indicated the need for further discussion with more people so that you can find out what their opinions and potential resolutions are on issues like desalination. Heck et al (2016) conducted a study on the acceptance of desalination plant among 112,299 residents of Carlsbad, in Southern California and found strong support for the desalination plant. An awareness of local attitudes toward this technology and its impacts is crucial to get an awareness of local preferences in the development of these plants. Chabahar, as the only oceanic port in southeastern Iran, only benefits from 20% of drinking water (Esmaeilion et al., 2021). The drinking water of Chabahar is supplied from the Gulf of Oman by means of water treatment devices. Since the number of water treatment devices is less than the population and consumption of the city, Chabahar is divided into different areas, and every week there is only one or two days of water supply in each area (Emamjome et al., 2019). The citizens of Chabahar are thus forced to store water during these two days for their future uses, and this causes the water in the reservoir to become unfit for human consumption and is used only for washing purposes. This situation has made seawater desalination a feasible option. Thus, Iranian government officially regards it as a free-trade and industrial zone. In this study, a questionnaire was developed, validated, and tested for the assessment of the knowledge of the environmental impact of the desalination plant in Chabahar bay. The questionnaire aims to test people's factual knowledge of the environmental impact of desalination plant activities. The goal was to obtain stakeholders' perceptions of the Chabahar desalination plant through a quantitative questionnaire survey to explore qualitative factors and conceptual framework of them.

2. Materials and Methods

2.1. Study area and status of the desalination plant

Chabahar Bay, possessing an area of 320 km^2, is the largest bay located in the northeast of Oman Gulf, Sistan and Baluchestan Province, Iran. This area possesses no big rivers. The area is characterized by dry weather (arid climate) with a yearly rainfall of lesser than 200 mm. It has a mean yearly temperature of 18^{oC} and high solar radiation (more the 4000 sunlight hours per year) (Figure 1).

A questionnaire survey was administered in November-December 2021 in Chabahar to obtain an understanding of the local people's perceptions toward environmental factors in desalination plants. To determine the reliability of the questionnaire, 20 questionnaires were distributed among the statistical sample as a preliminary test.

Fig. 1. Location of Chabahar in Sistan and Baluchestan Province, Iran.

To check the content validity of the questionnaire, the questionnaire was developed drawing on reliable sources and literature and, several experts were consulted, and the validity was confirmed. The reliability of the questionnaire was calculated by Cronbach's alpha method and found to be 85%. Since this coefficient is higher than 70%, it shows that the questionnaire enjoyed good reliability. To determine the sample size required to complete questionnaire Daniel (1978) was used.

$$N = \frac{z^2_{1-\frac{\alpha}{2}} p(1-p)}{d^2} \quad (1)$$

The total sample size was 504 and of this 500 questionnaires had complete information. This response rate shows consistency with previous studies on public attitudes toward natural resource issues (Vaske, 2008; Perry et al., 2014; Heck et al., 2018). A four-part questionnaire with 46 questions was administered to collect data. The descriptive statistics of the studied variables in the research are shown in Table 1. The overall public perception and socio-demographic variables were analyzed using descriptive and inferential statistics. The existence of differences among the environmental awareness and self-expression of citizens on the use of desalinators and demographic variables was tested by One-way ANOVA. Kolmogorov–Smirnov pretest was used to check the normality of the samples. Following each ANOVA, we performed post hoc Tukey's multiple-comparisons tests for each variable. Pearson correlation coefficient, t-test, and linear regression at a significance level of 0.05. The questionnaire data were analyzed using SPSS 17.0.

3. Results and Discussion

We collected 500 effective questionnaires from the participants in Chabahar. The main features of the respondents including age, gender, level of education, and marine-dependent livelihood are described in Table 1. The mean and standard deviation of the age of the respondents is 27.67±7.05. Based on the classification, the majority of the subjects ranged in age from 20 to 30 (55.2%). In terms of the level of education, the highest percentage was related to Diploma education (41.2%). Also, the majority of these people did not make a living from the sea (65.6%) (Table 1). This research represents the first study addressing the impact of socio-economic and environmental factors on the desalination development.

Table 1. Frequency distribution of sociodemographic characteristics of the surveyed respondents according to demographic information.

Items		Frequency	Percentage
Age	<20	78	15.6
	20-30	276	55.2
	>30	146	29.2
Gender	Female	106	21.2
	Male	394	78.8
Education	High school	118	23.6
	Diploma	206	41.2
	associate's degree	72	14.4
	bachelor's degree	85	17.0
	Masters and Ph.D.	19	3.8
Place of residence	Resident	300	60.0
	Non resident	75	15.0
	Instructors and practitioners of diving training	16	3.2
	Those involved in kayaking and surfing	109	21.8
Livelihood dependency	Yes	172	34.4
	No	328	65.6

Table 2 organized in two sections including methods of obtaining environmental information (13 items) and questions about the use of the sea (11 items). Table 2 shows the

mean and standard deviation of the methods of obtaining environmental information and the purposes for which they used the sea. The methods most frequently used for obtaining information included the Internet, television, social media, family and friends, respectively. The main purposes for the use of the sea were having fun by the sea, walking on the beach, and swimming, respectively.

The mean and standard deviation for self-expression and environmental awareness of the respondents in using desalination are 16.67±4.53 and 5.47±2.79, respectively. Using a range of questions, the respondents' awareness and self-expression were calculated, and a score of less than 33% indicated poor awareness and self-expression; scores between 33 and 67% indicated average awareness and self-expression, and a score above 67% indicated good awareness and self-expression. The results of this survey showed that most of the respondents possessed poor levels of awareness (56%) and self-expression (44.6%) (Table 4).

According to Table 3, the independent t-test demonstrated a statistically significant relationship between the knowledge and factual knowledge of the citizens on the use of desalinations and gender and marine-dependent livelihood (p-value<0.05), and males reported higher awareness and self-expression than females. Also, those with higher marine-dependent livelihood showed a higher knowledge and factual knowledge in using desalinators (p-value<0.05).

Table 2. The mean and standard deviation of items related to the methods of environmental information collecting.

	Source	Never	Rarely	Sometimes	Often	Always	Mean	standard deviation
Information use	TV	19.6	25.2	21.8	17.4	16	2.85	1.35
	Newspaper	24	38.4	20.6	9.2	7.8	2.38	1.17
	Internet	17	22.6	19.8	21.8	18.8	3.02	1.37
	Radio	34.8	35.4	13.2	8.8	7.8	2.19	1.22
	Department of Environment	38.2	28.8	17.4	9.8	5.8	2.16	1.2
	Department of Fisheries	37.4	32.2	14.4	9.4	6.6	2.15	1.21
	Public hearings	23.2	35.8	23.6	10.2	7.2	2.42	1.16
	Scientific presentations	27	39.2	21	9.2	3.6	2.23	1.05
	Social media	24.2	23.2	20	14.6	18	2.79	1.42
	Family and friends	20.2	29.2	21	14.6	15	2.75	1.33
	NGO	29.6	37.2	14.4	9	9.8	2.32	1.25
	Pro-desalination group	42	26	14	8.6	9.4	2.17	1.31
	Anti-desalination group	50.2	27	11.8	5.4	5.6	1.89	1.15
Ocean use	Commercial fishing	48.2	19.4	16.8	6	9.6	2.09	1.32
	Recreational fishing	25.6	28.4	26.4	12.4	7.2	2.47	1.2
	Surfing	37.2	26.2	21.8	10	4.8	2.19	1.17
	Swimming	25.4	30.4	19.2	10.6	14.4	2.73	1.27
	Boating	17.6	22.8	20.8	19.2	19.6	2.58	1.35
	Seaside fun						3.00	1.38
	jet ski ride	62.6	22.8	6.4	5.6	2.6	1.62	1
	Beach walking	21	26.8	16.6	16.8	18.8	2.85	1.41
	Diving	46.4	29.6	13.2	6.6	4.2	1.92	1.11
	Aquaculture	54.4	21.4	12.4	7.4	4.4	1.86	1.15
	Sea kayaking	55.6	23.2	11.4	5.6	4.2	1.79	1.11

Table 3. Frequency distribution of awareness levels and self-expression of the residents on the use of desalinations.

		Knowledge		Factual knowledge	
variable		Mean (SD)	P-value	Mean (SD)	P-value
Gender	Female	4.83 (2.26)	0.003	15.68 (4.2)	0.011
	Male	5.64 (2.89)		16.94 (4.58)	
Age	<20	5.44 (2.46)		15.29 (3.33)	
	20-30	5.21 (2.8)	0.026	16.38 (4.47)	0.000
	>30	5.97 (2.86)		17.96 (4.89)	
Education	Lower than the high school diploma & High school	5.27 (2.77)		15.82 (4.38)	
	Diploma	5.53 (2.8)		16.64 (4.23)	0.001
	associate's degree	5.93 (3.28)	0.123	17.54 (5.12)	
	bachelor's degree	5.51 (2.39)		17.83 (4.76)	
	Masters and Ph.D.	4.1 (1.88)		13.89 (2.97)	
Place of residence	resident	5.91(2.81)		16.86(4.62)	
	Non resident	3.73(1.79)		15.04(3.68)	
	Instructors and practitioners of diving training	3.75(1.8)	0.000	16.93(4.55)	0.007
	Surfers	5.7(2.86)		17.23(4.6)	
Livelihood dependency	Yes	5.23(2.72)	0.165	15.82(4.55)	0.002
	No	5.59(2.82)		17.12(4.46)	

After calculating the respondents' level of awareness and self-expression, in each part, a score of less than 33% indicated weak awareness and self-expression; a score between 33 and 67% indicated average awareness and self-expression; and a score higher than 67% indicated a good awareness and self-expression. Similarly, a one-way analysis of variance test showed a statistically significant relationship between the environmental awareness and self-expression of citizens on the use of desalinators with age, level of education and marine-dependent livelihood (p-value<0.05). Tukey's test suggested that the mean of self-expression in the respondents over 30 years old, with master's and Ph.D. degrees, as well as residents, was higher than other groups. The average level of knowledge was also higher among the respondents over 30 years old with master's and Ph.D. degrees and those who did kayaking and surfing (Table 3). Total scores were grouped into three groups (1) score of 33 and less considered as weak attitude, (2) between 33 to 67 as moderate and (3) greater than 67 as good attitudes. The results showed that 56% of the subjects had weak knowledge, 34.6% of them had a moderate awareness and 9.4% had a good knowledge about breastfeeding. Moreover 37.6% had a moderate Factual knowledge and 17.8% had a good Factual knowledge towards breastfeeding (Table 4).

Table 4. Comparison of the mean scores of the respondents on demographic data.

		Frequency	Percentage
Knowledge	Weak (<5)	280	56
	Moderate (5-9)	173	34.6
	Good (>9)	47	9.4
Factual knowledge	Weak(<15)	223	44.6
	Moderate (15-21)	188	37.6
	Good (>21)	89	17.8

According to Table 5, the value of F (7, 492) at the 99% confidence level is higher than the critical value, which shows that there are significant multiple correlations between the environmental self-expression of the respondents in the use of desalination and the information obtained (p-value<0.05). The multiple correlations coefficient is 0.389, and the modified coefficient of determination is 0.151. Thus, 1.15% of the variance of the respondents' environmental self-expression in the use of desalinations can be explained by the information obtained. The remaining variance relates to other factors that are out of the scope of this study. The results of Table 6 show that the beta coefficients for age (0.223), gender (0.087), marine-dependent livelihood (0.119), and information use (0.29) are statistically significant (p-value<0.05). Nevertheless, the

beta coefficients for the education level (-0.03), place of residence (0.056), and ocean use (-0.038) show no statistical significance (p-value > 0.05). Among the significant variables, information use has the most impact in predicting self-expression.

Table 5. Variance analysis of multivariable regression (citizens' environmental self-declaration in the use of desalinations)

Source of change	Sum of Squares	df	Mean Square	R^2	R	F	P-value
Regression	1551.237	7	221.605	0.151	0.389	12.517	0.000
Residual	8710.275	492	17.704				
Total	10261.512	499	-				

Table 6. Multiple linear regression coefficients for citizens' environmental self-expression in using desalinations.

Model	B	S.E	Beta	T	p-value
(Constant)	5.097	1.497	-	3.405	.001
Gender	0.961	.465	.087	2.065	.039
Education	-0.119	.180	-.030	-.661	.509
Livelihood dependency	1.131	.406	.119	2.786	.006
Place of residence	0.090	.067	.056	1.343	.180
Age	1.545	.311	.223	4.964	.000
Information use	2.162	.345	.290	6.267	.000
Ocean use	-0.255	.309	-.038	-.827	.409

4. Conclusion

Water shortage is said to affect one-third of people around the world, and the situation is anticipated to be compounding considering the increased need for water along with population growth, urbanization, climate change and increased household and industrial uses (Wang et al., 2022). The regions that are vulnerable to drought are prone to water supply shortages and socioeconomic impacts. Therefore, using reservoir storage is required to satisfy future water demands. The analysis of stakeholders' views and eliciting the general attitudes toward forthcoming desalination projects and the perceptions toward established desalination systems are scarce. Our study is one of the first studies addressing public attitudes of local people in relation to desalinated water use in Iran. Population growth and maritime infrastructure at Chabahar has emphasized the significance of the need to get an awareness of coastal vulnerability and environmental risks.

Although many studies corroborated the need to use desalinators for the provision of drinking water, there is not sufficient awareness of the contribution of this technology among local communities and decision-makers. Environmental impacts on marine areas are less apparent and might be less heeded and explored by the public (Panagopoulos and Haralambous, 2020). Although many reclaimed wastewater reuse projects have been implemented in Iran, unfortunately, no research on individuals' acceptance of such projects has been done. The findings of this study imply limited knowledge about the positive contribution of desalination in general and its environmental impacts, in particular, among those who live in the area under study. Those who rely on marine resources may not show a high degree of support and trust in desalination plants. Heck et al. (2018) argued that fishermen and marine recreationalists in coastal areas hold different attitudes towards desalination and demonstrate low support for desalination and lack of trust.

In this research, it was found that the respondents with higher levels of academic education preferred more use of reclaimed wastewater for various purposes, such as cooking, car washing, flush tank, air conditioning and public consumption. Taken together, those with higher academic education enjoy more awareness on environmental issues and more often tend to take part in reuse projects. A wealth of has shown a correlation between education level and acceptance of reclaimed wastewater use. Wester et al (2015), for example, found that in the United States, less-educated people were unwilling to use wastewater. In a further study in Kuwait, Alhumoud and Madzikanda (2010) reported that more-educated people showed more willingness for wastewater reuse. While some earlier studies have shown that older people consider more risks associated with reclaimed reuse, this study found no significant differences between different age groups in

this regard. Friedler et al. (2006) also did not report a correlation between age and support for water reuse. Media advertisements, public workshops, and the establishment of information campaigns enhances public awareness about the quality of reclaimed wastewater and promote its use. Such measures may affect the use of reclaimed wastewater among those who have limited knowledge on this issue. Heck et al (2018) argued that it is essential to discuss with more stakeholders to obtain their perceptions on desalination since stakeholders hold varied attitudes toward this issue. Thus, if stakeholder-related issues left doubtful, the desalination project may be postponed or terminated due to criticism from several social groups, users' uncertainty about desalinated water, and dissent from non-governmental organizations (Fielding et al., 2018). It was found that most coastal residents believe that the desalination contribute negatively to environmental conditions by carbon dioxide emissions and brine discharge. In conclusion, compilation of appropriate laws and regulations in the field of environmental pollution and optimal implementation of existing laws, such as the integrated plan of coastal areas, is essential in improving the level of knowledge and awareness. Successful design and implementation of wastewater reuse projects, in addition to economic and technological benefits, is highly dependent on public support. Therefore, gaining public support for such projects prior to their implementation is of importance and solutions to reduce or eliminate the adverse effects of desalination facilities should be investigated.

5. Disclosure Statement

No potential conflict of interest was reported by the authors.

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