

Perceptions of Solar Desalination in South Africa

Devesh Singh¹, Freddie L. Inambao^{1*}

¹Green Energy Solutions Research Group, Discipline of Mechanical Engineering
 University of KwaZulu-Natal, Durban, South Africa.

ORCID: ¹0000-0001-9922-5434 (Freddie Inambao), *Corresponding Author

Abstract

South Africa and the greater African continent are predicted to experience future water shortages due to a rapidly growing population and inadequate conservation of water resources. Research has shown that over the last decade desalination has become a reliable and effective means of producing potable water. This paper presents a perception study that was carried out, in which 100 participants completed a research questionnaire regarding water supply and alternative means of producing potable water in South Africa. The results and their implications for the survey are discussed. The perception study found that 85 % of respondents believed desalination was a suitable solution to future water shortages that South Africa may face.

Keywords: Desalination, perception study, potable water

I. INTRODUCTION

A perception and customer opinion study were carried out. Members of the general population were asked to complete a survey. The survey included basic information about the individual, their knowledge on water usage and scarcity in the region, alternative means of water supply and implementation within South Africa. They were also asked their views regarding the viability of desalination systems for everyday use.

II. METHODOLOGY

A. Sample Size

When carrying out a survey one of the main factors that affects the reliability of results is the sample which is the minimum number of individuals required to participate to yield a reliable result. In statistical analysis there is a recognized method to calculate this sample size, as given by [1]:

$$n = \frac{Z^2 \times p(1 - p)}{e^2} \quad (1)$$

Where:

n = Sample size

Z = Confidence level

The confidence level is generally chosen as 95 %. As such the corresponding Z-score can be taken from Table I [2].

p = Estimated prevalence

This is given as 50 % or 0.5.

e = Margin of error

Margin of error is chosen by the researcher. A smaller margin of error generally results in a more reliable set of results. A margin of error between 5 % to 10 % is acceptable [3]. Margin of error (e) was therefore taken as 10 %.

TABLE I. CONFIDENCE LEVEL: Z-SCORE

Confidence Level	Z-score
90%	1.645
95%	1.96
98%	2.326
99%	2.576

Given that:

$$Z = 1.96$$

$$P = 50 \% = 0.5$$

$$E = 7.5 \% = 0.075$$

Based on these figures, the sample size for the survey can be calculated using **Error! Reference source not found.** This sample size will be the minimum number of individuals that need to complete the survey for results to be deemed reliable.

$$n = \frac{(1.96)^2 \times 0.5(1 - 0.5)}{(0.10)^2} = 96.04$$

The result from the calculation shown above outputs a value of 96.04 which was rounded off to the next integer. The sample size therefore was set at 97 individuals; however, 100 individuals completed the survey. Snowball sampling, a nonprobability method, was utilized.

B. Research Survey

The self-administered research survey that was designed, compiled and sent to individuals can be found in the Appendix. The online platform Google Forms was utilized to distribute the survey. The link to the questionnaire was posted onto various forms of social media and survey takers were asked to share and refer the form to others. The questionnaire consisted of 29 questions in total under the following headings:

- 1) Personal information
- 2) State of water resources
- 3) Alternative sources of water
- 4) Future of desalination

III. RESULTS

The section provides the results obtained from the 100 respondents that completed the survey. The results for the perception study survey are structured as follows:

- 1) Question
- 2) Table with numerical results summary
- 3) Figure with graphical representation of results

A. Age of Respondents

Question: Age (see Table II and Fig. 1).

TABLE II. AGES

Age	Number	Age	Number	Age	Number	Age	Number
18	1	27	6	36	0	45	0
19	1	28	4	37	2	46	0
20	5	29	3	38	1	47	0
21	6	30	3	39	0	48	1
22	9	31	4	40	1	49	0
23	19	32	2	41	0	50	1
24	12	33	2	42	0		
25	6	34	3	43	1	56	1
26	6	35	0	44	0		
Average age of respondents				26.48 ≈ 26			

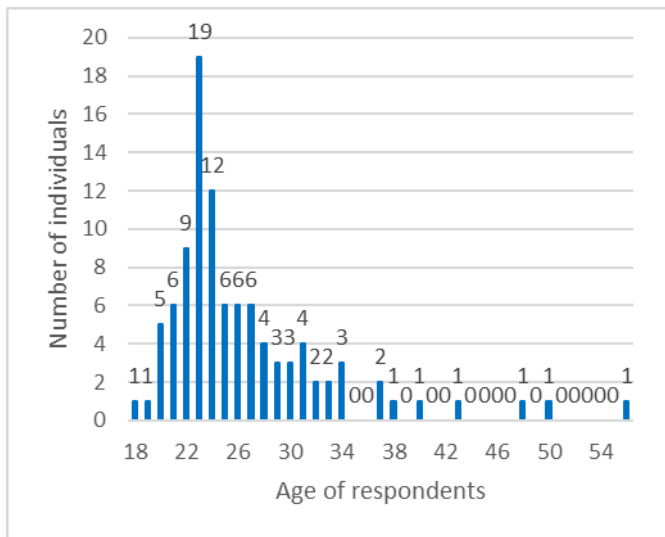


Fig. 1. Number of respondents in each age group

B. Educational Qualification

Question: Highest qualification completed (see Table III and Fig. 2).

TABLE III. HIGHEST QUALIFICATION

Highest qualification	Number/Percentage of respondents
Grade 12	22
Higher certificate / Diploma	11
Bachelor's degree (including Honours)	55
Post graduate degree (Masters/PhD)	12

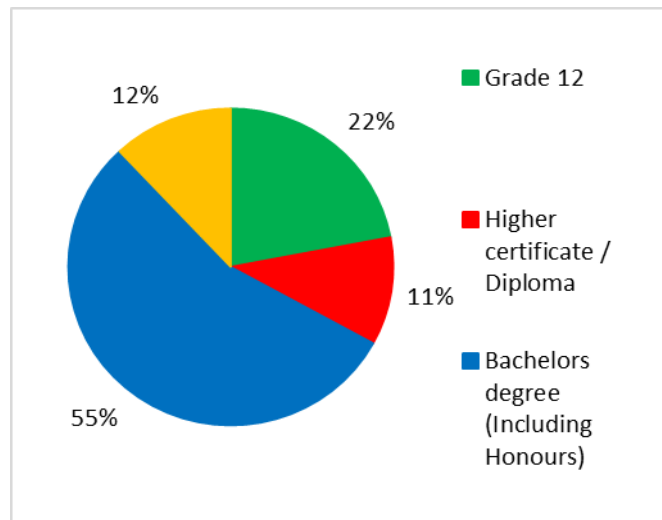


Fig. 2. Highest educational qualifications

C. Geographic Location

Question: City of residence (see Table IV and Fig. 3).

TABLE IV. GEOGRAPHIC LOCATION

City	Number/Percentage of respondents
Cape Town	5
Johannesburg	18
Durban	51
Pietermaritzburg	2
Vanderbijlpark	6
Germiston	1
Vereeniging	5
Pretoria	3
Klerksdorp	1
Newcastle	2
Vaalpark	2
Meyerton	1
Heidelberg	1
Alberton	1
Potchefstroom	1

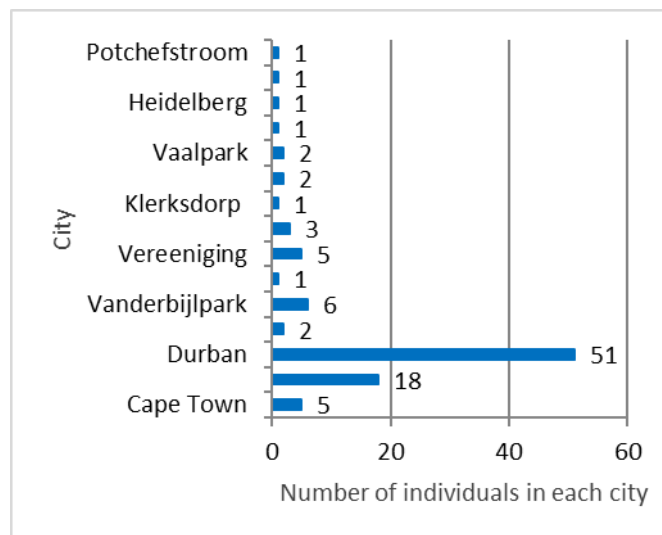


Fig. 3. Geographic location

D. Household Size

Question: Number of individuals in your household (see Table V and Fig. 4).

TABLE V. HOUSEHOLD SIZE

Number of individuals in respondent's household	Number/Percentage of respondents
1	15
2	20
3	18
4	23
5	17
6	4
7	1
8	1
9	1
Average household size	3.34 $\approx$ 4

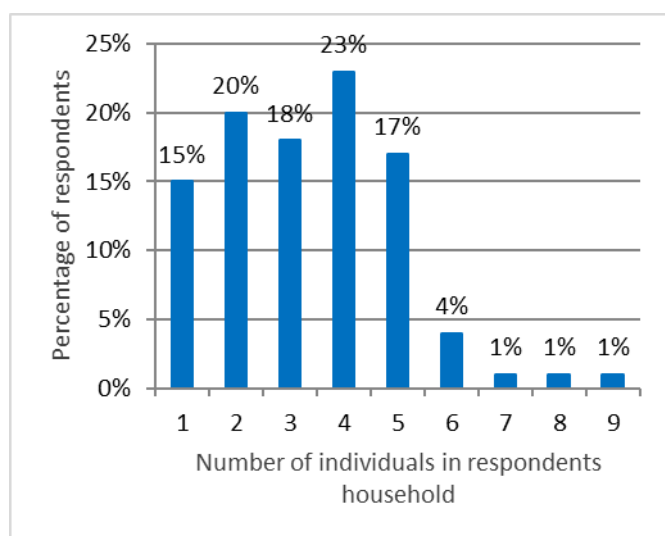


Fig. 4. Household size

E. Understanding of Potable Water

Question: What is your understanding of what potable water is? (see Table VI and Fig. 5).

TABLE VI. PERCEPTION OF WHAT POTABLE WATER IS

Understanding	Description on graph	Number/Percentage of respondents
Good understanding	Yes	49
Wrong understanding	No	14
Unclear understanding	Ambiguous	18
Does not know – No answer	Do not know	19

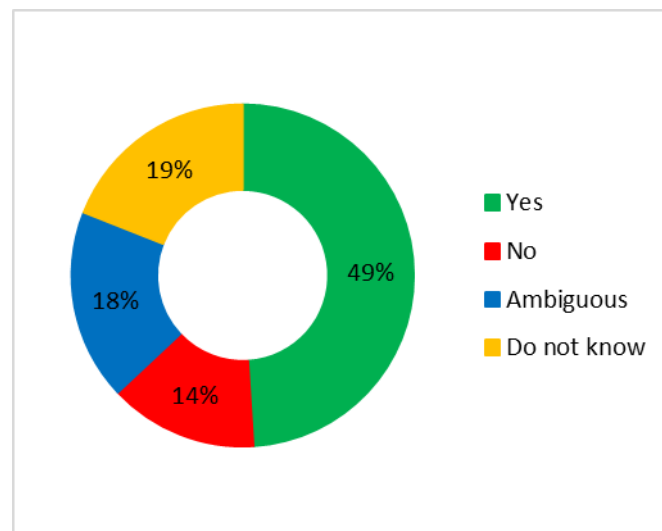


Fig. 5. Perception of what potable water is

F. Source of Drinking Water

Question: What is the primary source of drinking water at your residence? (see Table VII and Fig. 6).

TABLE VII. SOURCES OF DRINKING WATER AT RESPONDENTS' RESIDENCES

Source of water	Number/Percentage of respondents
Municipality	91
Bottled water	6
Rainwater	1
Borehole	1
River/Lake	1

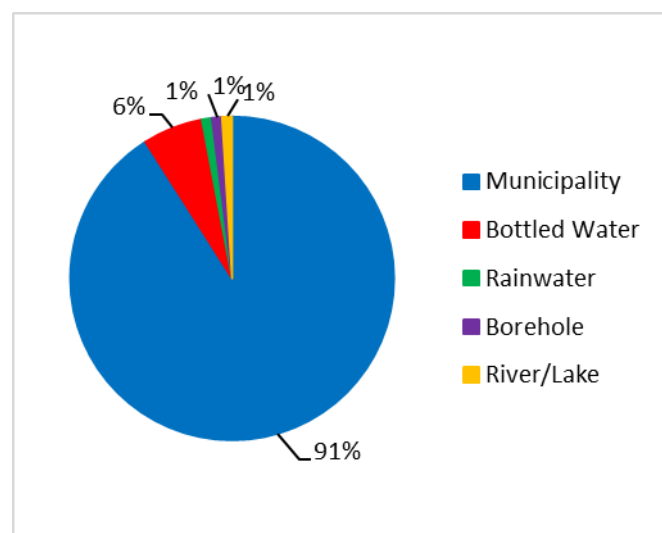


Fig. 6. Sources of drinking water at respondents' residences

G. Perception of Safety of Municipal Water

Question: On a scale of 1 to 10, how safe for consumption is the water supplied by your municipality? (see Table VIII and Fig. 7).

TABLE VIII. PERCEPTION OF MUNICIPAL WATER SAFETY

Rating	Description	Number/Percentage of respondents
1	Not safe for consumption	0
2		0
3		0
4		2
5		4
6		8
7		12
8		30
9		24
10	Extremely safe for consumption	20
Average rating of municipal water safety		8.16 $\approx$ 8

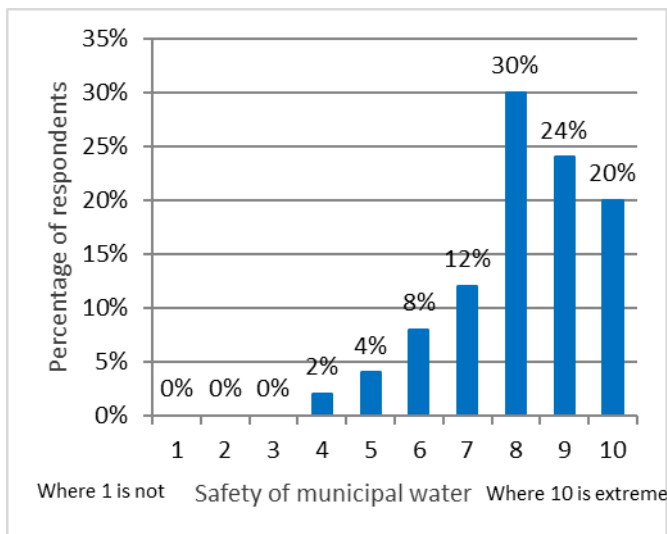


Fig. 7. Perception of municipal water safety

H. Scarcity of Water Resources in our Country

Question: On a scale of 1 to 10, how scarce are water resources in South Africa? (see Table IX and Fig. 8).

TABLE IX. PERCEPTIONS OF WATER RESOURCES SCARCITY IN SOUTH AFRICA

Rating	Description	Number/Percentage of respondents
1	Extremely scarce	1
2		1
3		12
4		27
5		23
6		11
7		13
8		5
9		5
10	Not scarce at all	2
Average rating of scarcity of water resources		5.24 $\approx$ 5

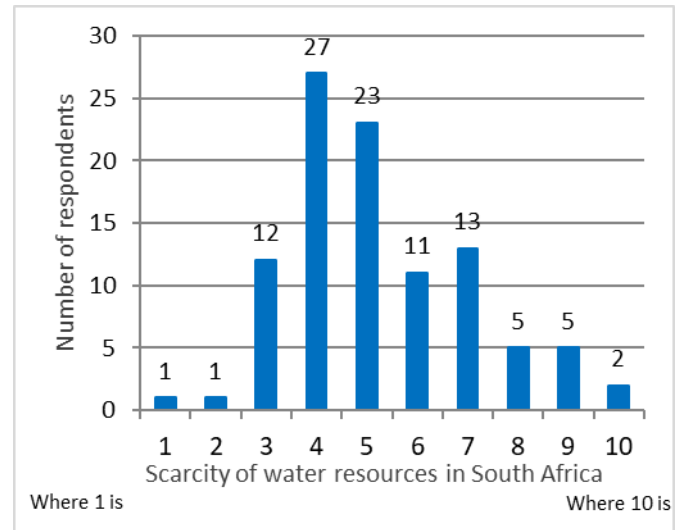


Fig. 8. Perception of water resources scarcity in South Africa

I. Daily Water Consumption

Question: How many litres of water do you drink per day? (see Table X and Fig. 9).

TABLE X. WATER CONSUMPTION PER DAY

Range of water consumption per day	Number/Percentage respondents
Less than 1 litre	11
1 litre - 1.99 litres	50
2 litres - 2.99 litres	33
3 litres - 3.99 litres	5
Greater than 4 litres	1

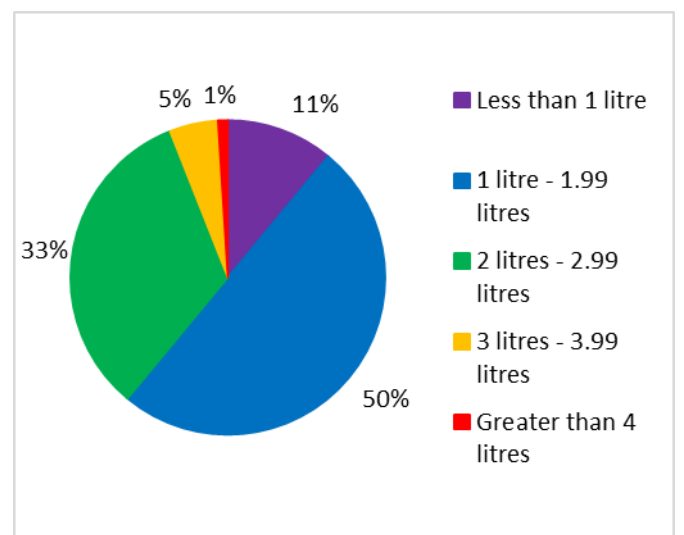


Fig. 9. Estimate of daily consumption of water

J. Daily Water Usage

Question: How many litres of water, would you estimate, do you use per day in total to complete everyday tasks? (see Table XI and Fig. 10).

TABLE XI. ESTIMATES OF WATER USAGE PER DAY

Range of water usage per day	Number/Percentage respondents
Less than 10 litres	6
10 litres - 24.99 litres	27
25 litres - 49.99 litres	21
50 litres - 74.99 litres	21
75 litres - 99.99 litres	11
More than 100 litres	14

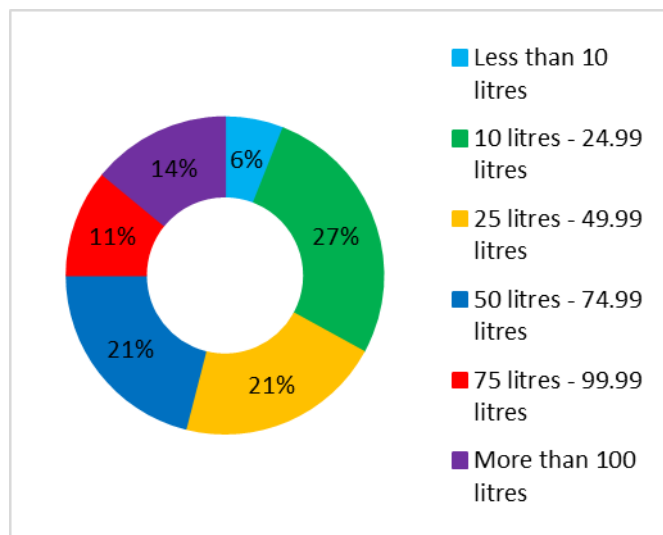


Fig. 10. Estimate of daily water usage

K. South Africans with Access to Safe Drinking Water

Question: What percentage of South Africa's population has access to a supply of safe drinking water? (see Table XII and Fig. 11).

TABLE XII. PERCEPTION OF PERCENTAGE OF SOUTH AFRICANS WITH ACCESS TO SAFE DRINKING WATER

Range of individuals access to safe drinking water	Number/Percentage respondents
Less than 30%	13
30% - 49.99%	37
50% - 69.99%	29
70% - 89.99%	17
90% - 94.99%	3
More than 95%	1

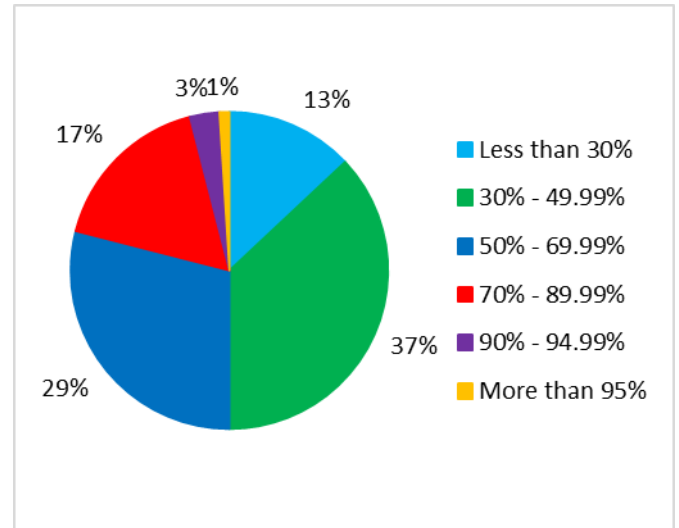


Fig. 11. Perception of number of South Africans with access to safe drinking water

L. Conservation of Water

Question: On a scale of 1 to 10, how much do you attempt to conserve water during your daily activities? (see Table XIII and Fig. 12).

TABLE XIII. ATTEMPTS TO SAVE WATER

Rating	Description	Number/Percentage of respondents
1	Not conservative at all	2
2		1
3		4
4		4
5		17
6		16
7		23
8		21
9		6
10	Extremely conservative	6
Average rating of water conservation		6.56 ≈ 7

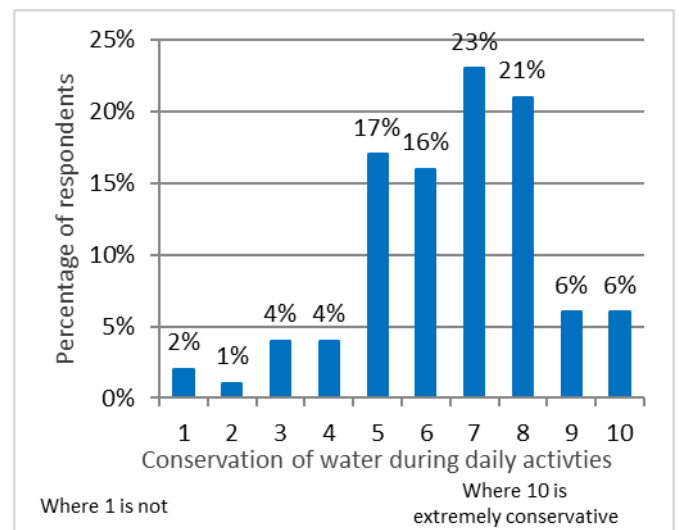


Fig. 12. Conservation of water during daily activities

M. Measures to Ensure Water Conservation

Question: Do you believe that there are sufficient measures in place to ensure the delivery of safe drinking water for current/future generations in South Africa? (see Table XIV and Fig. 13).

TABLE XIV. PERCEPTION REGARDING SUFFICIENT MEASURES TO ENSURE WATER CONSERVATION FOR THE FUTURE

Answer	Number/Percentage of respondents
Yes	16
No	84

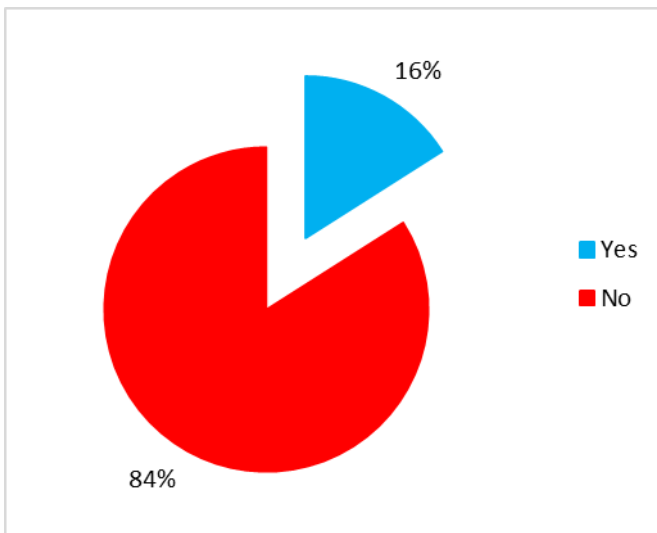


Fig. 13. Perception regarding sufficient measures in place to ensure conservation of water resources for the future

N. Best Alternative to Municipal Water

Question: Which means of water supply is the best alternative to the municipal water supply? (see Table XV and Fig. 14).

TABLE XV. PREFERENCES FOR ALTERNATIVE WATER SUPPLY

Water production method	Number/Percentage of respondents
Rainwater	24
Borehole	35
Reclaimed/grey water	4
Desalination	24
River/Lake	8
Atmospheric water generation	5

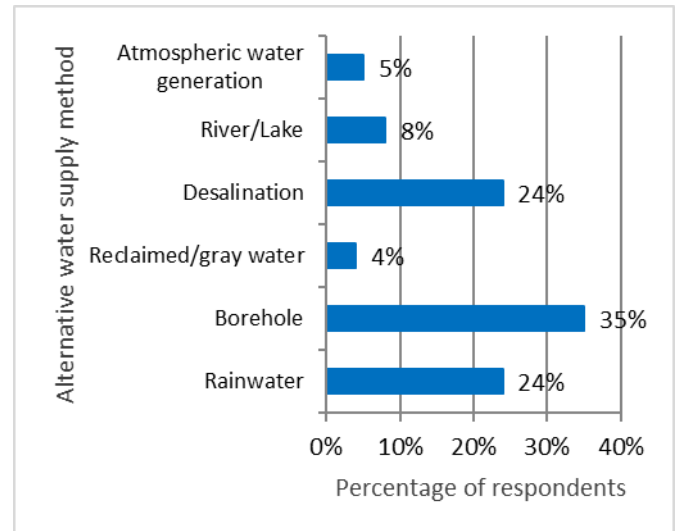


Fig. 14. Preferred alternative means of water supply

O. Potable Water Production Method

Question: Which method of potable water production do you prefer? (see Table XVI and Fig. 15).

TABLE XVI. PREFERRED POTABLE WATER PRODUCTION METHOD

Potable water production method	Number/Percentage of respondents
Filtration	34
Ultraviolet irradiation	10
Boiling	27
Chemical treatment	29

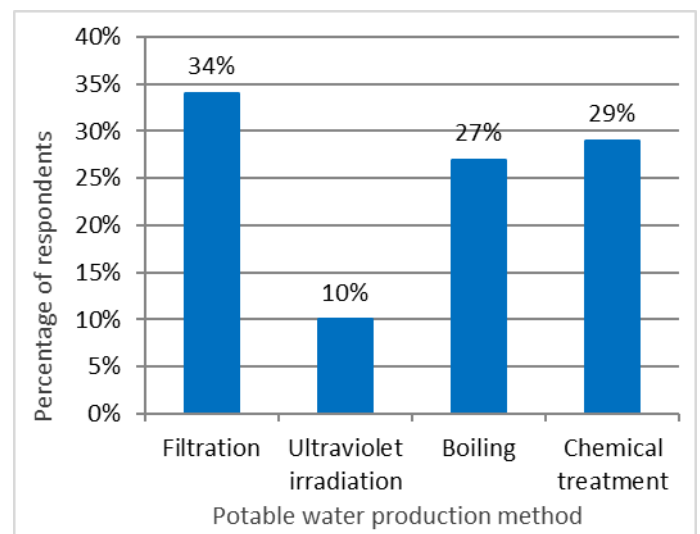


Fig. 15. Preferred potable water production method

P. Understanding of Desalination

Question: What is your understanding of desalination? (See Table XVII and Fig. 16).

TABLE XVII. SUMMARY OF RESPONDENTS' UNDERSTANDING OF DESALINATION

Understanding	Description on graph	Number/Percentage of respondents
Good understanding	Yes	56
Wrong understanding	No	7
Unclear understanding	Ambiguous	17
Does not know – No answer	Do not know	20

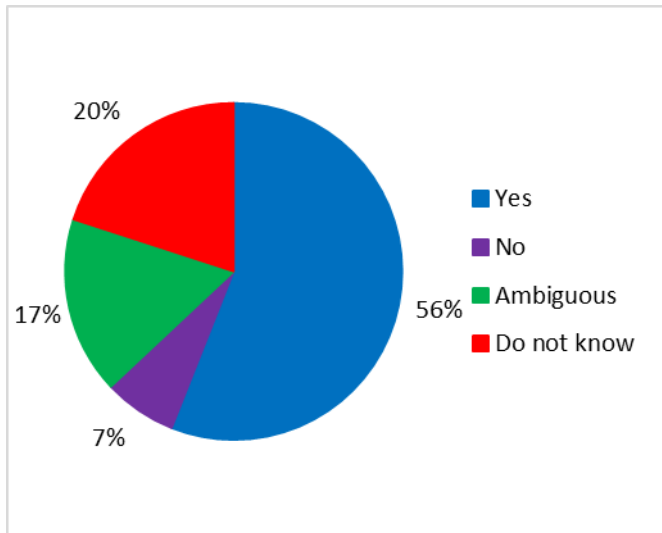


Fig. 16. Understanding of what desalination is

Q. Most Effective and Efficient Desalination Technique

Question: Which do you believe is the most effective and efficient method of desalination? (see Table XVIII and Fig. 17).

TABLE XVIII. PERCEPTION REGARDING THE MOST EFFECTIVE AND EFFICIENT DESALINATION METHOD

Desalination method	Number/Percentage of respondents
Electrodialysis	6
Solar distillation	12
Humidification-dehumidification	1
Reverse osmosis	32
Do not know	49

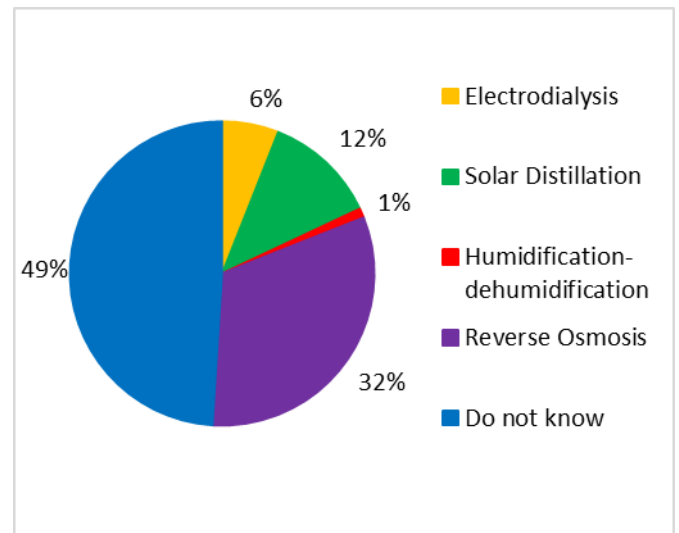


Fig. 17. Preferred desalination method

R. Awareness of Desalination Plants in South Africa

Question: Are there any large-scale desalination plants in South Africa supplying drinking water to the general population? (see Table XIX and Fig. 18).

TABLE XIX. AWARENESS OF LARGESCALE DESALINATION PLANTS IN SOUTH AFRICA

Awareness	Number/Percentage of respondents
Yes	20
No	21
Do not know	59

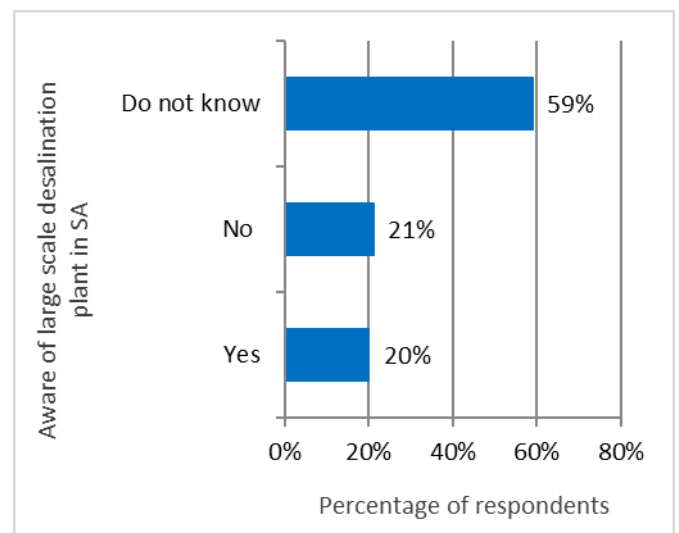


Fig. 18. Awareness of large-scale desalination plants in South Africa

S. Investment in Alternative Water Resources

Question: Do you believe there is sufficient investment in finding and implementing alternative means of supplying water in South Africa? (see Table XX and Fig. 19).

TABLE XX. PERCEPTION OF INVESTMENT IN ALTERNATIVE WATER SOURCES IN SOUTH AFRICA

Answer	Number/Percentage of respondents
Yes	12
No	88

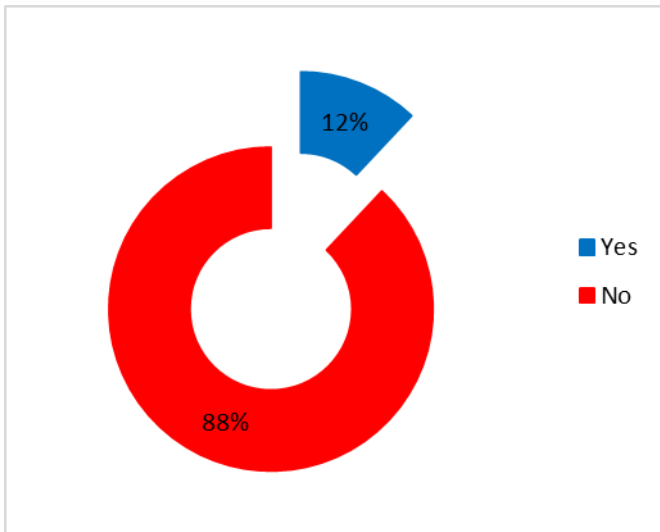


Fig. 19. Perception of investment in alternative water sources in South Africa

T. Willingness to Purchase Alternative Water Production Devices

Question: If given the opportunity, would you purchase a desalination device for your household/business to become partially or completely independent of the municipal water supply? (see Table XXI and Fig. 20).

TABLE XXI. WILLINGNESS TO PURCHASE DESALINATION DEVICES

Answer	Number/Percentage of respondents
Yes	80
No	20

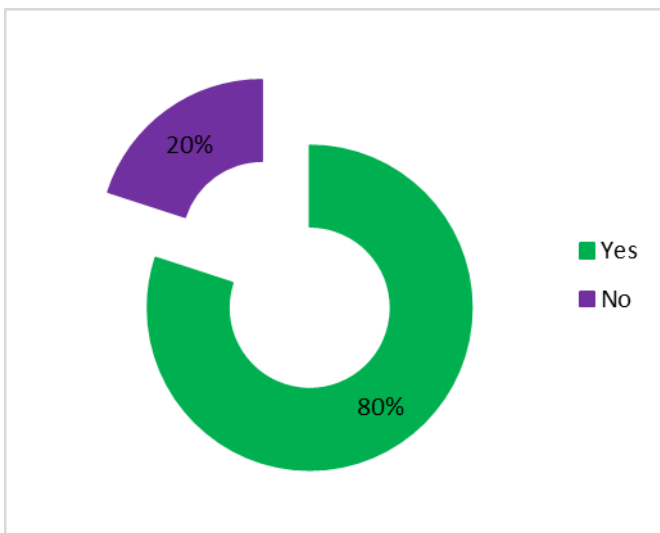


Fig. 20. Willingness to purchase desalination devices

U. Factors Guiding Purchase of Desalination Device

Question: What would be the deciding factor guiding your above decision? (see Table XXII and Fig. 21).

TABLE XXII. DECIDING FACTOR GUIDING DECISION TO PURCHASE DESALINATION DEVICE

Deciding factor	Number/Percentage of respondents
Input energy requirements	5
Start-up costs	42
Size, noise and aesthetics	4
Maintenance requirements	14
Output water quality	24
Volumetric output	3
All of the above	2
Other	6

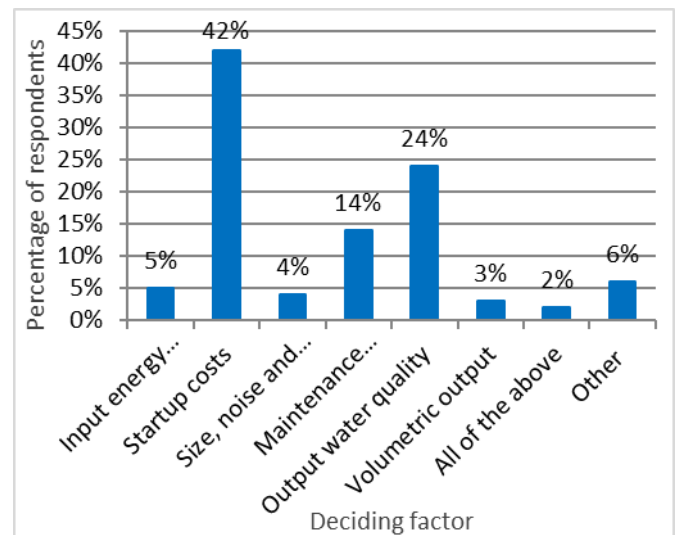


Fig. 21. Deciding factor guiding decision on alternative water production device purchase

V. Desalination is the Answer to Future Water Shortages

Question: Do you believe desalination is the answer to current/future water shortage issues that may arise in South Africa? (see Table XXIII and Fig. 22).

TABLE XXIII. PERCEPTION ON DESALINATION AS THE SOLUTION OF FUTURE WATER SHORTAGES

Answer	Number/Percentage of respondents
Yes	85
No	15

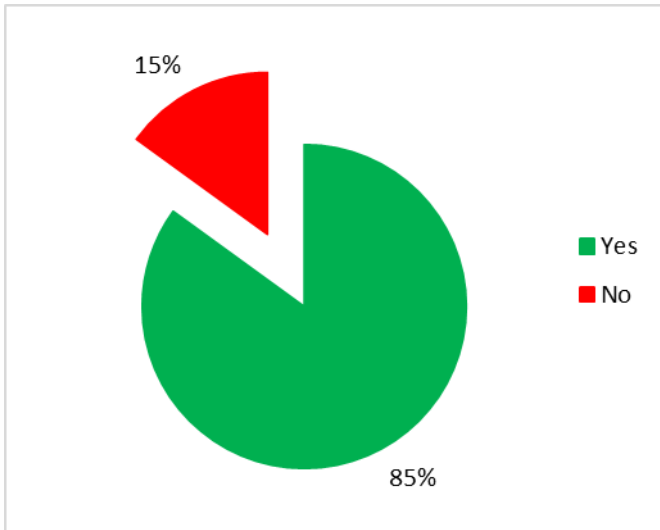


Fig. 22. Perception that desalination is the future for alternative water production

W. Powering Desalination Devices

Question: What alternative energy source do you believe is the best means of powering desalination systems? (see Table XXIV and Fig. 23).

TABLE XXIV. PREFERRED SOURCE OF POWER FOR DESALINATION DEVICE

Source of power	Number/Percentage of respondents
Solar	79
Wave	11
Wind	4
Geothermal	1
Other	5

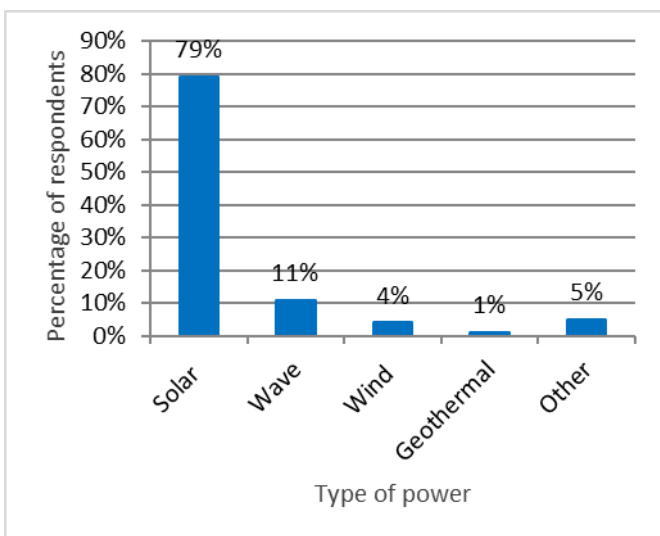


Fig. 23. Perception of the best method to power desalination device

X. Solar Energy in South Africa

Question: If solar energy was used to power a desalination system, do you believe South Africa receives sufficient solar

irradiation on average per year to make the process viable? (see Table XXV and Fig. 24).

TABLE XXV. PERCEPTION OF THE SUFFICIENT SOLAR IRRADIATION IN SOUTH AFRICA

Applicability of solar energy	Number/Percentage of respondents
Yes	74
No	9
Do not know	17

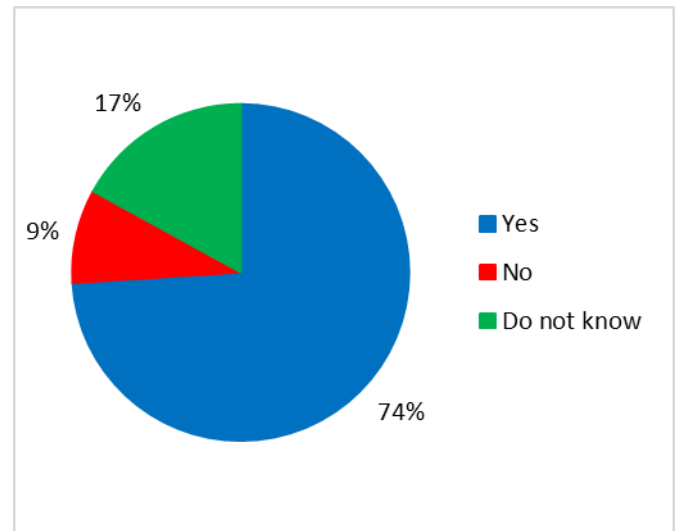


Fig. 24. Perception of sufficient solar irradiation in South Africa

IV. DISCUSSION

The survey was taken on the online platform Google Forms to aid in the data collection process. The sample size for the perception study was calculated to be 97 individuals with a margin of error of 10 %, confidence level of 95 % (as listed in Table I) and estimated prevalence of 50 %. The research questionnaire consisted of 29 questions under the headings: personal information, state of water resources, alternative sources of water and future of desalination. In total, 100 respondents completed the perception study questionnaire via the online platform Google Forms. The average age of the respondents was approximately 27 years old (Table II), with more than 66 individuals having attained a bachelor's degree or above (Fig. 2). The majority (74 %) of the survey takers were either located in Durban, Johannesburg or Cape Town (Table IV and Figure 3). The mean household size was approximately four individuals (Table V). Of the 100 responders, 49 had a good understanding of what potable water is while 14 and 19 individuals respectively either had the wrong understanding or did not know what potable was (Fig 5). 91 % of people relied on the municipality for the drinking water (Fig. 6) with others depending on other means such as rainwater, borehole water and river water (Table VII). 98 % agreed that water supplied by their municipality was safe for consumption (Fig. 7). 83 respondents used 1 litre to 2.99 litres for drinking per day (Figure 9), and 69 % used between 10 litres and 74.99 litres of water per day in total to complete everyday tasks (Table XI). Most individuals believed that a small percentage of

South Africans have access to safe drinking water, with 66 % estimating this to be between 30 % and 69.99 % (Figure 11). However, this is not the case, as in 2017 the Department of Water and Sanitation published a figure of 88.6 % having access to water [4]. On average, most respondents rated their water conservation at a 7 (Fig. 12), where 1 was not conservative at all and 10 was extremely conservative. Alarming, 84 of out 100 persons perceived that there are not sufficient measures in place to ensure the delivery of safe drinking water for current/future generations in South Africa (Table IV). Desalination placed second to borehole water as the preferred alternative to municipal water (Fig. 14). The largest proportion of respondents (34 %, Table XVI) elected filtration as the preferred means of potable water production. 56 % of survey takers had a good knowledge of what desalination was, although 27 % did not know or had the wrong understanding of desalination (Fig. 16). Reverse osmosis and solar distillation were believed to be the two most efficient and effective desalination methods (Table XVIII). Impressively, 85 % of respondents believed that desalination was the answer to future water shortages (Fig. 22), and 80 % expressed an interest in purchasing a desalination device (Table XXI) for either their household or business with 42 % noting start-up cost as the biggest deciding factor on whether they would purchase the device or not (Fig. 21). Solar energy was the most popular choice to power such desalination devices, amassing 79 % of positive responses (Table XIV). Using the perception study as a guide, it would appear that there is a great desire amongst citizens to become independent of municipal water supply and desalination devices powered by solar energy are their preferred alternative method of producing potable water.

V. SUMMARY

A perception study was carried out, in which 100 participants completed a research questionnaire regarding water supply and alternative means of producing potable water in South Africa. There were 29 questions and the results were summarised and graphed. The implications of these results were discussed.

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APPENDIX: RESEARCH SURVEY

Research Survey

My name is Devesh Singh. I am completing a Master of Science in Mechanical Engineering degree at the University of KwaZulu-Natal through a design and research project. I am tasked with designing, modelling and analyzing a Solar Powered Water Desalination System.

As part of the qualitative approach to my methodology I am attempting to survey members of the general population. The survey includes basic information about yourself, your knowledge on water usage and scarcity in the region, alternative means of water supply and implementation within South Africa and lastly, your views on the viability of desalination systems for everyday use.

Please remember that the answers you provide are your opinions and are based on your own knowledge, as such, if you do not know or are unsure of the answer there is no need to research it. I need to gauge the understanding of the general population on these key issues.

The questionnaire should take approximately 10 - 12 minutes to complete.

Thank you for your help.

* Required

1. Email address *

Personal Information

Please note that all personal information will be treated as confidential. Information will only be used for research purposes. No personal information will be supplied to or handled by any third party without attaining your prior consent.

2. First Name *

3. Surname *

4. Age *

5. Occupation *

6. Organisation *

Name of company or learning institution to which you belong.

7. Highest Qualification *

Mark only one oval.

- ☐ Did not complete grade 12
- ☐ Grade 12
- ☐ Higher certificate / Diploma
- ☐ Bachelors degree (Including Honours)
- ☐ Post graduate degree (Masters/PhD)

8. City of Residence *

9. Number of individuals in your household *

State of Water Resources

Opinions, knowledge and biographic based questions regarding water resources in your region.

10. 1) What is your understanding of what potable water is? *

Please limit your description to less than 10 words. If you are unsure, please state "Do not know" as your answer.

11. 2) What is the primary source of drinking water at your residence? *

Mark only one oval.

- ☐ Municipality
- ☐ Borehole
- ☐ River/Lake
- ☐ Rainwater
- ☐ Bottled water
- ☐ Other:

12. 3) On a scale of 1 to 10 - how safe for consumption is the water supplied by your municipality? *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not safe for consumption	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Extremely safe for consumption

13. 4) On a scale of 1 to 10 - how scarce are water resources in South Africa? *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Extremely scarce	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Not scarce at all

14. 5) How many litres of water do you drink per day? *

Include water used in beverages such as tea and coffee.

Mark only one oval.

- ☐ Less than 1 litre
- ☐ 1 litre - 1.99 litres
- ☐ 2 litres - 2.99 litres
- ☐ 3 litres - 3.99 litres
- ☐ Greater than 4 litres

15. 6) How many litres of water, would you estimate, do you use per day in total to complete everyday tasks? *

Tasks may include; bathing, ablution, laundry, garden, etc.

Mark only one oval.

- ☐ Less than 10 litres
- ☐ 10 litres - 24.99 litres
- ☐ 25 litres - 49.99 litres
- ☐ 50 litres - 74.99 litres
- ☐ 75 litres - 99.99 litres
- ☐ More than 100 litres

16. 7) What percentage of South Africa's population has access to a supply of safe drinking water? *

Mark only one oval.

- ☐ Less than 30%
- ☐ 30% - 49.99%
- ☐ 50% - 69.99%
- ☐ 70% - 89.99%
- ☐ 90% - 94.99%
- ☐ More than 95%

17. 8) On a scale of 1 to 10 - how much do you attempt to conserve water during your daily activities?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not conservative at all	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Extremely conservative

18. 9) Do you believe that there are sufficient measures in place to ensure the delivery of safe drinking water for current/future generations in South Africa? *

These measures may be put in place by the municipality or provincial/national government.
Mark only one oval.

- ☐ Yes
☐ No

Alternative Sources of Water

These questions relate to alternative sources of water and are opinion and knowledge based.

19. 10) Which means of water supply is the best alternative to the municipal water supply? *

Mark only one oval.

- ☐ Borehole
☐ River/Lake
☐ Rainwater
☐ Reclaimed/gray water
☐ Atmospheric water generation
☐ Desalination
☐ Other: _____

20. 11) Which method of potable water production do you prefer? *

Potable water is water that can be deemed as safe for consumption (drinking and food preparation).
Mark only one oval.

- ☐ Filtration
☐ Boiling
☐ Chemical treatment
☐ Ultraviolet irradiation
☐ Other: _____

21. 12) What is your understanding of desalination? *

Please limit your description to less than 20 words. If you are unsure, please state "Do not know" as your answer.

22. 13) Which do you believe is the most effective and efficient method of desalination?

If your answer to question 12 was "Do not know" please select "Do not know" as your answer for this question.

Mark only one oval.

- ☐ Reverse Osmosis
☐ Solar Distillation
☐ Electrodialysis
☐ Humidification-dehumidification
☐ Do not know
☐ Other

23. 14) Are there any large scale desalination plants in South Africa supplying drinking water to the general population? *

If your answer to question 12 was "Do not know" please select "Do not know" as your answer for this question.

Mark only one oval.

- ☐ Yes
☐ No
☐ Do not know

24. 15) Do you believe there is sufficient investment in finding and implementing alternative means of supplying water in South Africa? *

Mark only one oval.

- ☐ Yes
☐ No

Future of Desalination

Desalination is a general term for a process of removing salt and other minerals from seawater to make it suitable for human consumption (potable). Most desalination systems can produce potable water from both fresh and seawater. Given the aforementioned, please answer the following.

25. 16) If given the opportunity, would you purchase a desalination device for your household/business to become partially or completely independent of the municipal water supply? *

Mark only one oval.

- ☐ Yes
☐ No

26. 17) What would be the deciding factor guiding your above decision? *

Mark only one oval.

- ☐ Startup costs
☐ Volumetric output
☐ Input energy requirements
☐ Size, noise and aesthetics
☐ Maintenance requirements
☐ Output water quality
☐ Other: _____

27. 18) Do you believe desalination is the answer to current/future water shortage issues that may arise in South Africa? *

Mark only one oval.

- ☐ Yes
☐ No

28. 19) What alternative energy source, do you believe is the best means of powering desalination systems? *

Mark only one oval.

- ☐ Solar
- ☐ Wind
- ☐ Geothermal
- ☐ Wave power
- ☐ Other

29. 20) If solar energy was used to power a desalination system, do you believe South Africa receives sufficient solar irradiation on average per year to make the process viable? *

Mark only one oval.

- ☐ Yes
- ☐ No
- ☐ Do not know

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