Authors: Espen Heen[1], Ahmed Ali Madar[2]
Affiliations: Department of Community Medicine and Global Health, Institute of Health and Society, Medical faculty, University of Oslo.[1]
Orcid ids: 0000-0001-7606-4834[1], 0000-0001-7234-2729[2]
Contact e-mail: espenheen@gmail.com

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Article

Bottled Water from National Manufacturers in Somaliland: Water Quality and Health Implications

Espen Heen (HE)[1*], Ahmed A Madar (MAA)[1].

[1]Department of Community Medicine and Global Health, Institute of Health and Society, University of Oslo.

*Correspondence: Espen Heen
Post Box 1130 Blindern, 0318 Oslo, Norway
Email: e.k.heen@medisin.uio.no
Telephone: + 47 99736353

Abstract

(1) Background: Somaliland, the breakaway republic of Northern Somalia, has a growing, commercial bottled water industry, but no available data on end-user water quality. The objective of this study was to do a public health quality assessment of popular brands of bottled water available in Somaliland. (2) Method: Between June and December 2010, 36 bottles with water from eight brands were purposefully sampled from shops in all four parts of Hargeisa city and analysed for 22 physico-chemical, five microbiological and nine informational variables. The findings were compared with international guidelines and the composition tables of the respective brands. (3) Results: The production and expiry dates on 50% of the bottles were inadequately presented. All of the physico-chemical measurements were within healthy limits; however, average pH was 5.6. Discrepancies between the physico-chemical analysis results and the composition table values provided on the bottles were large and significant ($p = .018$): Individual mineral concentrations could be as low as 1% of labelled values. Undesirable growth of total coliforms where found in 50% of all samples. (4) Conclusions: This study indicates a need for improved cleanliness in the production and distribution system, consistent production date labelling and regular physico-chemical analysis leading to accurate composition tables. There is a need for external monitoring of the quality of water delivered from the bottled water companies in Somaliland in order to prevent adverse public health effects.

Keywords: Drinking Waters; Fluoride; Iodine; Mineral Water; Somali; Water quality.

1. Introduction

Many low-income countries with limited access to potable water have a growing industry of locally manufactured and packaged water, of which bottles are most commonly used.

Similarly, Somaliland, the break-away republic of former North-Somalia, has seen a rise in the use of bottled water by her estimated four million inhabitants in recent years. By 2020, at least ten different manufacturers of bottled water operate from four main cities. Bottled water is here defined as pure and safe water in hermetically sealed bottles of various types solely for human consumption [1].

The Somaliland laws and regulations concerning water advice to use “recognized international standards” and specifically the “WHO drinking water standards” [2] when assessing drinking water quality in the sector (e.g. Somaliland National water policy, April 2002) . To our knowledge, there are to date neither official statistics nor enforced regulation of the bottled water industry.

While authorities and the public acknowledge the positive effect of making drinking water available, there is also a concern about the possibly negative impact on public health if biologically contaminated and/or chemically hazardous bottled water reaches the population [2]. The water bottle industry does not publicise internal quality control results and relevant Somaliland government bodies have so far had few means of assessing the water production in the factories. Unsafe transport, storage in high temperatures and low turnover in the individual shops might also compromise the quality for the end user.

Drinking water in Somaliland is mainly extracted from underground sources where high levels of total dissolved solids (TDS), often surpassing the threshold advised for human consumption, are encountered. A hydrogeological survey undertaken by FAO Somalia in 2012, covering Somaliland, showed that samples from more than 500 natural drinking water sources on average (mean) had unhealthy concentrations (mg/l) of chloride (601), sulphate (1653), sodium (353), manganese (0.89), fluoride (1.8) and iodine (270µg/l) [3]. The two latter elements are likely to cause disease in the population. Fluoride in the concentrations seen might produce teeth fluorosis; a brown discoloration with weakening of the enamel [4]. Excess iodine intake increases the risk of thyroid dysfunction and hypothyroidism [5, 6].

Comparative quality assessments from bottled drinking water in the region is scarce. A study by Amogne *et al.* investigated the physico-chemical quality of bottled water bought in Addis Abeba [7]. They found that 7.7 percent of bottles had properties outside of the range advised by WHO. Biadglegne *et al.* who included microbiological assessment, found that 7.4 percent of bottled water, also from the Amhara region of Ethiopia, was unfit for human consumption [8]. Bedada *et al.*recently presented microbiological data from bottled water across several regions of Ethiopia, including the Somali region, and found that around 40% of samples failed to meet either national or WHO drinking quality standards [9]. In Kenya, regular assessment of bottled water quality is done by the government, but no scientific papers have been possible to retrieve. Available data concerning the quality of bottled water in Somaliland and the wider Somalia is, to our knowledge, absent from the body of both scientific and grey literature.

The objective of this study was to assess the physico-chemical and microbiological quality of commonly consumed national brands of bottled water in Somaliland. We also wanted to compare the labelled information on the bottles with the recommended standards for commercial water products of this type. Iodine and fluoride contents in the waters were particularly in focus due to potential health risk levels in the source waters.

2. Material and Methods

2.1. Water samples

The sampling frame was all brands of bottled water available for end-users in supermarkets and shops along the main roads traversing Hargeisa city, the capital of Somaliland. The strategy was to find at least three bottles with widely different production month from the twelve national commercial water brands in distribution at the time of sampling. Forty shops were picked non-systematically along the main roads in all four parts of the city and searched for bottles by the research leader (EH) and assistant (AA) on two occasions between June and December 2010. Thirty-six plastic bottles, representing eight brands, each with different production date purchased at 15 specific shops with typical variation in storage conditions (fridged, cooled and room temperature) were obtained. The brand names were *Durdur*, *Ebyan*, *Golis*, *Maaxda*, *Saafi Mineral Water*, *Saxansax*, *Shamis* and *Xareedda*. All brands are still available in Somaliland in 2020. The remaining brands were not found, possibly because of stock-outs or only very local distribution. The volume of the bottles varied from 330 to 800 ml. Bottles were placed in refrigerator-temperature within 30 minutes of purchase and repacked for flight to the water laboratory in Kenya with ice-packs and insulation. All information on the labels where recorded.

Water source- and process information were obtained through the Ministry of Mining, Energy and Water Resources; The Hargeisa Water Agency; by searching company web-pages and by personal communication with staff at several bottled water companies.

2.2. Laboratory analyses

The Kenyan branch of SGS (formerly Société Générale de Surveillance), an internationally renowned chemical analysis provider, assessed the water quality based on their *Water potability analysis,* consisting of seven physical, 14 chemical and five bacteriological tests, performed in their laboratories in Mombasa (physico-chemical) and Nairobi (bacteriological). All tests, except total dissolved solids (TDS) and sulphates, were accredited under the ISO/IEC 17025:2005 schedule and validation data were available. This ISO specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling. The physical analyses had a precision between 2.5 and 2.7 percent and the chemical analyses 2.8 to 5.4 percent. Microbiological standard testing was performed with total (mesophilic/heterotrophic) plate count (37°C, 48 hours) by ISO 6222, and total and faecal coliform count with ISO 9308. *Streptococcus faecalis* and *Pseudomonas aeruginosa* were cultured on selective plates.

Halide concentrations were analysed in collaboration with FAO Somalia by Crop Nutrition Kenya, using ion meter/ F specific electrode for fluoride measurement and leuco crystal violet method by spectrophotometer at 592nm for iodine. Iodine recovery at three different concentrations was between 98-102%. Method coefficient of variation (CV) was two percent at concentrations of 100µg. Detection limit for iodine was 10µg/l. Additional iodine testing with inductively coupled plasma mass spectrometry (ICP-MS) were done by SGS in Belgium to verify test results. Detection limit was 2µg/l.

Due to low sample volume, three brands were not analysed on all variables, but tested based on importance from a public health perspective.

When comparing the physico-chemical properties and packaging quality of our eight brands, we have used the latest relevant guidelines from the Codex Alimentarius Commission (CAC) and WHO [2, 10, 11]. This collection of standards, guidelines and reference values are approved jointly by WHO/FAO, and constitute a good tool to assess quality in agreement with Somaliland law and regulations.

2.3. Statistical analyses

Analyses of the data were performed using Microsoft Excel 2010 and IBM SPSS statistics 25. Descriptive statistics are presented as mean with standard deviation (SD) or minimum-maximum values. With less than four data points, average deviation $\Delta\bar{x}$ was used instead of SD, calculated as

$$\Delta\bar{x} = \sum \frac{|xi - \bar{x}|}{N} \quad (1)$$

and relative average deviation instead of CV% as

$$\frac{\Delta\bar{x}}{\bar{x}} \times 100 \quad (2)$$

Wilcoxon signed rank test was used to compare ranks of paired values between composition tables and laboratory analysis for each brand. A statistical probability (p) less than 0.05 was set to reject 0-hypotheses.

3. Results

3.1. Labelled information

All examined bottles were found with a sealed cap (the little extra ring under the cap in place). Looking at production and expiry dates and longevity information, we found that three brands had sufficient information on all bottles, three had sufficient information on some bottles and two provided labels that were entirely without information (Table 1). Regardless of brand, half of the bottles lacked sufficient information. Only one brand stated a maximum usage time (three days after breaking the cap seal). Other details from the labelling can be found in Table 2.

Table 1. Assessment of production and expiry date or other longevity information on eight brands of bottled waters produced in Somaliland. Brand names are exchanged with letters.

Brand	No. bottles tested	Sufficient[1]	Insufficient[2]	Absent[3]	Sufficiency %
A	5	0	0	5	0.0
B	2	2	0	0	100.0
C	4	4	0	0	100.0
D	6	1	0	5	16.7
E	3	0	0	3	0.0
F	7	5	2	0	71.4
G	4	4	0	0	100.0
H	5	2	2	1	40.0
Total	**36**	**18**	**4**	**14**	**50.0**

1) Visible production and expiry date or longevity information

2) Dates printed, but unreadable or errors in datum print

3) Not possible to find information on the bottle

Table 2. Labelled information on bottles concerning water treatment, composition tables, water classification and environmental advice for eight brands of bottled waters from Somaliland.

Company	Type of treatment	Composition table?	Composition text, exact wording:	Same composition values for all production dates?	Bottled water classification	Environmental advice
A	UV, membrane, Ozone	Yes	Average Composition	No	Purified bottled water	Crush after use, dispose properly + sign
B	No info	Yes	Composition mg/1000ml (approx.)	Yes	pure mineral water	Recycle + sign. Keep your city tidy + sign
C	Ozone	Yes	Chemical composition p.p.m	Yes	Bottled health water/bottled drinking water	No
D	Ozone	Yes	Chemical composition (mg/lt)	Yes	Mineral water	Crush after use. Dispose properly + sign
E	No info	Yes	Composition (approx.) Mg/Ltr	Yes	Pure bottled water	PET - crushable bottle + sign
F	No info	Yes	Composition (approx.) in mg/ltr.	Yes	Pure natural mineral water	Sign of a person using a dustbin
G	UV	Yes	Composition (approx.) Mg/ltr	Yes	Pure bottled water	No
H	Ozone (1 of 4)	Yes	ppm	Yes	Purified bottled drinking water	No

3.2. Water processing information

Five companies processed their water in Hargeisa, of which three used the public water system from the Geed Deeble catchment area as source water and one used a private borehole. The remaining three companies were situated in Burco (next largest city), and used private boreholes. With the exception of one company that used a sand filter, all stated to use a membrane water filtration system as their main treatment modality. In addition, written information on the bottles stated that four companies were treating the water with ozone and two with ultra violet radiation (UV).

3.3. Physico-chemical analysis

Full potability analysis was performed with five brands (A,B,D,F and H), one in duplicate (A) (Table 3). Physical analysis was missing for two brands. On average the appearance, odour and colour where *acceptable*. Mean (min- max) pH were 5.6 (5.3-5.8); total dissolved solids (TDS) 34 mg/l (22-46) and conductivity at 25°C 48 µs/cm (31-65). All brands showed too acidic water compared to WHO guideline [2]. In the chemical analysis, no result exceeded the upper limit of the guidelines, nor the analysing laboratory`s thresholds. Mean (min-max) total hardness ($CaCO_3$) were 0.6 mg/l (0-1.2); chlorides 7.1 mg/l (4-11); sulphates 2.3 mg/l (<0.4-5); phosphate 0.09 mg/l (0.06-0.12); sodium 7.4 mg/l (1-14); calcium 1.2 mg/l (0-3) and magnesium 1.1 mg/l (0-3). Iron, manganese, aluminium, boron and copper were less than 0.02 mg/l (detection limit) in all samples tested. Residual chlorine was undetectable in all samples. Brand (A) analysed in duplicate with bottles picked at the same time from the same shop showed only minor differences in chemical composition: The mean relative average deviation of 13 variables was 5.7% (relative average deviation from 0 to 26% by individual variable), which would be within the typical analytical precision of the laboratory methods applied.

Tab 3. Physical, chemical and microbiological properties of five brands of bottled water in Somaliland compared with upper limits from investigating laboratory (SGS) and guidelines from CAC/WHO/FDA

Firm/brand Name		A		B	D	F	H			Upper limits	
	Unit							Mean	SD	SGS	CAC/WHO/FDA
Volum	ml	330	750	330	1000	750	750				
Appearence		-	-	-	Acceptable	Acceptable	Acceptable				
Odour		-	-	-	Inoffensive	Inoffensive	Inoffensive			Inoffensive	
Colour	Hazens	-	-	-	2.5	2.5	2.5	2.5	0.0	15 Max	
Suspended matter		-	-	-	Nil	Nil	Nil	Nil			
pH at 25° C		-	-	-	5.3	5.8	5.6	5.6	0.3	<8.0	6.5-9.5
Total dissolved Solids	mg/l	-	-	-	21.8	45.6	33.5	33.6	11.9	1000	1000
Conductivity at 25° C	µs/cm	-	-	-	31.1	65.2	47.9	48.1	17.1		
Total hardness as CaCO3	mg/l	-	-	-	0.0	1.2	0.7	0.6	0.6	500	
Chlorides as Cl	mg/l	4.5	7.8	3.6	6.8	10.9	9.1	7.1	2.7	250	250.0
Sulphates as SO4	mg/l	3.9	4.6	<0.4	<0.4	2.7	2.0	<2,3	1.2	250	250.0
Phosphate as PO4	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0		
Fluoride as F	mg/l	0.8	0.8	0.6	0.9	0.8	0.7	0.8	0.1	1.50	1.50
Residual chlorine	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil			
Iron as Fe	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		0.30	0.30
Manganese as Mn	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		0.10	0.05-0.5
Aluminium as Al	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		0.20	
Boron as B	mg/l	-	-	-	<0.02	<0.02	<0.02	<0.02		0.30	2.40
Copper as Cu	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		1.0	1 or 2
Sodium as Na	mg/l	11.6	13.7	1.1	3.9	8.0	5.9	7.4	4.7	200	
Calcium as Ca	mg/l	3.3	3.2	0.5	<0.02	0.2	0.1	<1.2	1.7		
Magnesium as Mg	mg/l	3.1	3.1	0.3	<0.02	0.2	0.1	<1.1	1.6		
Total plate count at 37 C	cfu/ml	>3000	Nil	>3000	100	105	Nil	3/6 cont.			100cfu/ml
Total coliform count	mpn/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil		0.00	
Faecal coliform count	mpn/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil		0.00	
Streptococcus faecalis	cfu/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil		0.00	
Pseudomonas aeruginosa	mpn/100ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil		0.00	

3.4. Comparison of analysis measurements with labelled values

The brands individual mineral composition table values indicated typical "mineral waters". All were within the WHO guideline upper values. When compared with the SGS laboratory measurements, a statistically significant difference for three of the five brands tested were revealed (z= -2.37; p =.018). A mean individual brand measurement (from the analyses of seven solutes and pH) between 18 and 65% of composition table values were found. Similarly, total dissolved solids (TDS), which can be viewed as an aggregated value for all solutes in water, were found to be 15-35% of table values. One third of the chemical analyses were below 10%, whereas magnesium and calcium were as low as <1% of the values in the composition tables. Apart from one, all measurements were on the low side of the labelled values in all brands. (Figure 1).

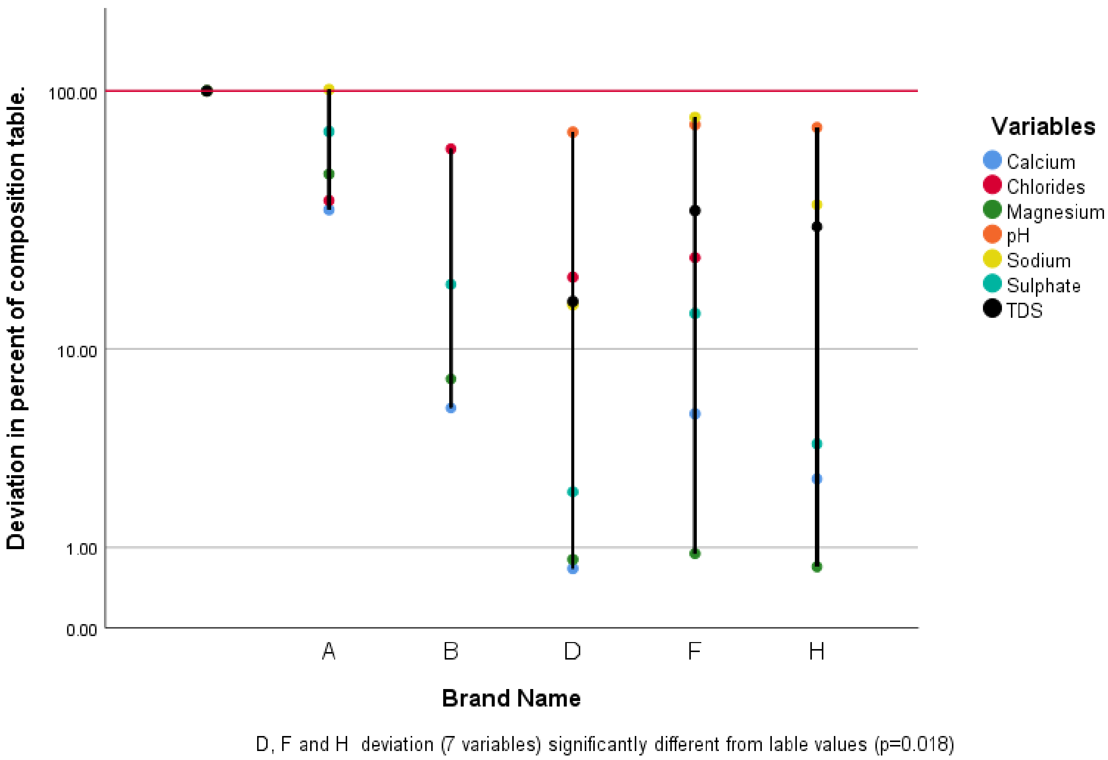

Figure 1. Percentage deviation of the mean measurements of analysed physico-chemical variables with corresponding composition table values as reference (100 percent, red line), separately for five Somaliland brands of bottled water. Logarithmic scale. Vertical lines indicate min-max range. n = 29.

3.6. Halide concentrations

Fluoride and iodine were analysed for the eight brands, each with three different bottles. Six brands had values below detection limit for the analysis (10 µg/l iodine and 0.0 mg/l fluoride). Two brands showed slightly higher mean concentrations (Table 4). Brand A had maximum fluoride concentration at 0.09 mg/l and brand C fluoride at 0.06 mg/l, while maximum iodine concentration in the latter was 29 µg/l. For the remaining brands with iodine results < 10 µg/l, additional ICP-MS testing came out with concentrations from 2 to 11µg/l with a mean value of 5.7 µg/l.

Table 4. Mean concentrations of iodine and fluoride in eight brands of bottled water (in triplicate) from Somaliland, analysed by spectrophotometric methods.

Brand	Iodine concentration (µg/l)	Fluoride concentration (mg/l)
A	<10	**0.045**
B	<10	<0.010
C	**16**	**0.037**
D	<10	<0.010
E	<10	<0.010
F	<10	<0.010
G	<10	<0.010
H	<10	<0.010

3.7. Microbiological contamination

The microbiological parameter "total plate count" surpassed the desired level with three out of six samples showing total colony forming units (cfu) per ml above 100 (Table 3). More specific growth tests with total and faecal coliform count, *Streptococcus faecalis* and *Pseudomonas aeruginosa* did not show any signs of contamination in the water from any of the bottles.

4. Discussion

Our quality analysis of eight brands of bottled water from manufacturers in Somaliland showed that only three brands displayed adequate longevity information. On the bright side, the 15 chemical variables were measured within healthy limits in all brands, despite the general ground water characteristics of the area with high TDS [3]. The actual mineral concentrations compared with the printed composition tables on the bottles were significantly lower. Half of the bottles showed undesirable growth of total coliforms.

There was a surprisingly low mean level of EC (48 μS/cm) and TDS (34mg/l) in the bottled water samples tested. The level of dissolved solids is, in fact, comparable to certain costal rainwaters [12]. Due to long periods of the year without rainfall, all regular all-year water sources in Somaliland are spring/groundwater. Across all aquifers, only 30 percent of groundwater samples have been measured to be below the safe electrolytic conductivity (EC) limit of 1500 μS/cm, with 29 percent of the samples in the range 1500 to 3000 μS/cm and 41 percent of the samples above 3000 μS/cm [3]. More specifically, conductivity in borehole water from Geed Deeble, where several companies draw their source water, typically ranges from 500-1000 μS/cm (personal communication – Hargeisa Water Agency). There is a close to linear relationship between EC and TDS, with TDS (mg/l) being 0.5-0.8 times the EC numeric value, depending on types of dissolved solids.

This confirms the information we have received that the source water for bottled water production is treated in ways that reduce the level of mineral content, mainly by membrane filtration. The most likely technique applied is reverse osmosis filtration, a purification technique widely used to desalinate and reduce TDS in water [13]. Bearing in mind that the majority of water sources in Somaliland has too high mineral content, the low levels provided by the bottled water companies is beneficial for public health, diluting the load of minerals present in household water. According to CAC [10] *natural mineral water* should not be modified in its essential mineral constituents, which give the water its properties. Three of the companies still call their product *mineral water*, which does not accurately describe its content.

The overall mineral content of the brands assessed is good for human consumption. This is reassuring and more consistent than findings from other comparable countries [7, 14, 15]. However, the composition tables for the various brands do not reflect the measured concentrations of minerals (Figure 1). Even though the labelling states *approximate* or *average* composition, finding discrepancies of hundred times the values is clearly conflicting and cannot be explained by low analysis accuracy or variations between laboratories alone. Similar discrepancies have been reported from other countries in the region [15-18] and is generally attributed to uncontrolled variation in the production line or explained by a desire to present the product in a favourable way for the potential user. We have good reasons to believe that both might be the case for manufacturers in Somaliland till date (personal communications). The practice misleads the public and might cause errors in nutritional planning for individuals and groups.

The thorough analysis of the fluoride and iodine content of the bottled water showed low levels of these halides in six out of the eight brands, in line with the trend for all the other physico-chemical measurements. Even for the brands with measurable levels, the maximum concentrations would contribute relatively minimally to an expected total intake of these elements when consuming two litres of bottled water a day. The only exception is the single measurement of 29μg iodine in one litre of water, providing 1/5 of the recommended daily iodine intake of 150 μg for adults [19].

On the other hand, one should be aware of the risk of low intake, both of fluoride and iodine, if individuals only rely on bottled water for their fluid consumption and cooking. A certain amount of fluoride is beneficial for strengthening the enamel of the teeth and reducing caries formation, illustrated by the fact that several countries have legislation for mandatory drinking water fluoridation [20]. A group vulnerable to iodine deficiency is bottle-fed babies, if the combination of bottled water and milk powder low in iodine content provides the sole form of nutrition [21, 22] As long as untreated household water and local food are consumed, these deficiencies might be rare in Somaliland.

Commercial bottled water can be the source of major water-borne epidemics [23, 24]. The microbiological analyses performed did not reveal any problem with faecal contamination, contrary to what has been found in several other studies in low- and middle- income countries [14, 25, 26]. All the same, a total plate count of more than 100cfu/ml is an indication that effectiveness of disinfection processes, as well as cleanliness and integrity of distribution systems, needs improvement [2]. Assuming that the majority of brands are treated with reverse osmosis, the membrane pores should not let protozoa, bacteria and virus pass into the treated water. The ozone and UV disinfection applied by a number of brands has an additional effect of inactivating protozoa, bacteria and virus; UV, when properly applied, is more effective than ozone [2]. The heterotrophic growth in half of the tests is therefore most likely an expression of post-filtration contamination. A number of studies also show that heterotrophic growth in bottled water is common and increases with higher storage temperatures and longer storage duration [27-29]. Since humans are exposed to many heterotrophic organisms through food and air, a high plate count does not necessarily deem the water unsafe for drinking, but it will indicate an increased risk of contaminants in general.

All the eight brands in this test used plastic bottles. Five brands provided information about proper disposal. One brand even suggested recycling their bottles, although we are not aware of any bottle recycling systems in Somaliland. The idea, though, is very much needed, since crushed plastic bottles are littered everywhere in the environment and loads are swept away into the city surroundings with every heavy rainfall and eventually might end up in the Gulf of Aden as plastic pollution. Another environmental issue is how the highly mineralized and possibly polluted wastewater from the reverse osmosis process is discarded, of which we have no information.

To our knowledge, this is the first bottled water quality assessment study from Somaliland and the wider Somalia with samples from major national water companies - a country in such need of verified clean and safe water. We also consider it a strength that all samples were picked from typical end user shops and analysed in one batch by certified, international laboratories.

The study has some limitations. The number of bottles investigated is restricted. As such the results have to be viewed with caution, not claiming to be a systematic representation of each brand throughout the year with its seasonal variations in source water solutes. Relevant assessments such as contamination by virus [30]; radiation load from radon and uranium [31, 32]; toxic metals like lead, mercury and cadmium [33]; organic chemical hazards [34] and endocrine disrupting chemicals, in particular bisphenol A and phthalates (used in a range of consumer products) [35] is yet to be studied. The widespread use of ozone as disinfectant indicates a need to assess brominated compounds [2]. The toxic metal antimony, used in the production of plastic bottles, can leach into the water [36]. Studies indicate that long storage time increases the risk of threshold levels [37].

Our data is from 2010-2011 and does not accurately reflect the current situation. Some will argue that they are out of date and no longer relevant. However, with no other scientific articles on this nutritional topic from the country available, it provides important baseline knowledge of the nutritional implications of bottled water consumption in Somaliland. Further, we have no indication that the bottled water production- and distribution methods generally have been altered since the time of data collection. Our findings highlight that regular monitoring of water production, both internal quality control and external government assessment, are needed, and provides a comprehensive overview of what is currently known and what should be done. As of 2020, water and industrial authorities in Somaliland are still in need of necessary regulatory, technical and financial means to monitor adequately.

5. Conclusion

A water quality analysis of eight national brands of bottled water, manufactured in Somaliland, did not reveal any unsafe chemical or biological properties for human consumption. Fluoride and iodine levels were in the safe range. This stands in stark contrast to the high and often unhealthy mineral content of untreated drinking water sources in the country. Still the assessment indicated several areas with a need for improvement: (1) Cleanliness in the production and distribution system; (2) Lifting water pH into the more balanced range; (3) Consistent production date labelling; (4) Correct product categorization; (5) Accurate physicochemical composition tables and (6) Systems for recycling of plastic bottles. Taking into account the limits of this study, a broader quality assessment study is needed. External monitoring of the water quality delivered from the bottled water companies in Somaliland should be followed with support to rectify pending quality issues.

Data Availability: Data files supporting the results section can be obtained on request from the corresponding author.

Author contributions: HE designed the study, carried out the data collection with AA, performed data analysis and prepared the manuscript. MAA critically reviewed the draft, contributed to the interpretation of the findings and approved the final version of the manuscript.

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