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A Study in the Contamination of Desalinated Water with Microorganisms, and Analysis of Chemical and Physical in Western Libya

Ayman Zwaghi[1], Qutaiba al-Rawi[2], Amira Khaled Abdulla[2], Maryam Aboajela Khalifa[2], Aisha Salem Abdelmola[2], Fatima Farag Bashir[2], Retaj Ramadan aljaghmani[2]

[1]Lecturer, Surman Medical Technology College, Sabratha University, Libya
[2]Assistant Professor, Surman Medical Technology College, Sabratha University, Libya

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Abstract: Monitoring the changes that occur to water during distribution is vital to ensure water safety. The biological stability of reverse osmosis (RO) produced drinking water, characterized by low cell concentration and low assailable organic carbon, in combination with chlorine disinfection was investigated. Water quality at several locations throughout the existing distribution network was monitored to investigate whether microbial water quality changes can be identified. Libya is located in an arid and semi-arid region of Africa with no permanent rivers or true freshwater lakes and average annual rainfall of less than 100 mm. Limited access to surface water resources has led to a heavy reliance on groundwater. Extensive use of conventional water resources such as groundwater, poor awareness of how to optimally use and save water, and seawater intrusion into coastal aquifers have all contributed to a severe water crisis in Libya. The water crisis issues in Libya are exacerbated by the population distribution relative to available water resources. 75% of Libya's population is concentrated in only 1.5% of the total land area in the western coastal centers of Jufra and Misrata, and the eastern coastal area of Jebel Akhdar. The results from this study highlight the importance of implementing multiple barriers to ensure water safety. Changes in water quality detected even when high-quality disinfected reverse osmosis (RO) -produced water is distributed highlight microbiological challenges that chlorinated systems endure, especially at high water temperatures. The aim of this paper is to shed light on the conventional and non-conventional water resources in Libya. In this context, the research aims to provide an overview of seawater desalination technology in Libya and why desalination should be embraced as a strategic and ultimate solution to the water shortage problem. In addition to the bacterial contamination of desalinated water in western Libya. This study was investigated the quality of drinking water supplied in Some Commercial Water Purification Systems at Sabratha area. Water samples were collected from five stations at Sabratha region. The physicochemical parameters were mainly, pH, Alkalinity, Chloride, Nitrate, Sulfate, Magnesium, Calcium, Sodium, Potassium and TDS. The result shows that all these parameters were fall below WHO guidelines, except pH. The bacteriological result revealed that one of the studied stations was contaminated by *E. coli* bacteria.

Keywords: Reverse osmosis (RO), groundwater, seawater, bacterial contamination, Commercial Water, Total dissolved solid's part per million (TDS ppm).

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INTRODUCTION

Drinking water is vital to human existence, and its bacterial contamination poses a serious public health threat worldwide. Despite the continued efforts to maintain water safety, waterborne outbreaks are still reported globally [1]. While drinking water quality can deteriorate through contaminants, such as toxic chemicals and microbes during transport, storage, and handling, distribution lines and systems may also influence the quality of drinking water [2]. Approximately 2 billion people globally are obligated to utilize contaminated drinking water with excreta, while 1.2 billion people lack basic drinking water services, and more than 829,000 people die each year from contaminated drinking water [3]. Although the quality of tap water (TW) in most high-income countries is stringently regulated and monitored, the demand for bottled and dispensed water has been on the rise worldwide [4-6]. The consumption of bottled water has been increasing by at least 10% every year since 2008, with the fastest growth observed in Asia and South America [7]. In the United States, bottled water consumption has grown as much as 44% since 2010, with 9 out of 10 Americans wanting bottled water to be available whenever other drinks are sold, turning a $36.3 billion profit in 2020 [8]. The use of different drinking water sources for human consumption instead of TW has been increasing [9].

Examples of two new sources of drinking water are self-standing microfiltered water vending machines (WVMs) and drinking water from soda fountains (SFs). These are commonly preferred alternatives to bottled water, and appear to be environmentally friendly, overcoming bottled water disposal and pollution drawbacks. These sources are typically equipped with reverse osmosis or activated carbon filters that can remove chlorine taste, odors, and organic and inorganic contaminants [1].

SFs are commonly used to dispense beverages in most fast-food establishments where consumers either dispense their own beverages in a purchased cup, or employees use SFs to dispense purchased beverages for customers. SF machines dispense carbonated soft drinks and drinking water. The global soda water dispenser market was valued at $1.0 billion in 2018 and is expected to grow at a compound annual growth rate of 5.4% from 2019 to 2025 (GVR 2022). The majority of reports of water contamination from SFs come from mass media sources (Cox 2010; Park 2010). Water quality studies of drinking water from SFs in fast-food restaurants are scarce [10,11] despite the rapid growth and use of these devices.

Self-standing WVMs (or simply WVMs) are generally located inside or outside grocery stores, pharmacies, and convenience stores where consumers are able to purchase drinking water while shopping or eating. WVMs are connected to TW from the local water district and make use of various filtration systems. The use of water from WVMs has considerably increased due to its affordability compared to bottled water. WVMs can dispense 5-gallon, 3-gallon, and 1-gallon units of water, depending on the funds inserted into the machine. The largest WVM provider in California is the Primo Water Company, which owns the Glacier vending machine network. In 2001, the non-profit organization, Environmental Working Group, released a report in which it verified that the Glacier Water Company reported over 60% of its sales went to Latino or Asian customers [2,3]. It has been demonstrated that WVMs are generally located in low-income and immigrant communities [12]. Although microbial contamination of drinking water from WVMs is understudied [13] reported the presence of genetic material from *Salmonella spp*, *Listeria monocytogenes*, and other pathogenic microorganisms from WVM in the Coachella Valley of Southern California. Of these samples [13] found that 32% had coliforms and 21% had heterotrophic plate counts (HPCs). Although outbreaks related to the consumption of bottled water are rarely reported, they nevertheless do occur [14]. In Italy, a study by Arnal J. *et al.* [15] found that HPCs counted at 22 °C were 71 and 86% higher than the allowable values in non-carbonated water and carbonated water, respectively, and at 37 °C, HPCs counted were 81 and 88% for non-carbonated and carbonated water, respectively. The United States has several federal-, state-, and county-level drinking water regulations, although there is only limited regular monitoring and unenforced authority for drinking water from WVMs and SFs [16].

Waterborne pathogens and their related diseases are a major public health concern worldwide. The presence of pathogenic microorganisms in drinking water is a serious public health concern and cannot be overemphasized. Although waterborne outbreaks have considerably declined over the past 20 years [17,18], waterborne microbial agents, such as *Salmonella typhimurium, Vibrio cholerae, Legionella, E. coli O157:H7, and Pseudomonas* have been implicated in acute gastrointestinal illnesses, acute respiratory illnesses, hepatitis, and several deaths. In the United Kingdom, and many other developed countries, *Campylobacter jejuni* is the cause of most rapid onset of gastrointestinal infections resulting in acute morbidity and mortality, with an estimated 2 million cases per year, and mortalities estimated to be greater than 2,000 people annually. In these cases, the majority of infections are sporadic and the sources of infection are rarely determined [19].

It has been demonstrated that water quality deterioration may often be related to biofilm formation [20]. In devices such as WVMs and SFs, high surface-to-volume ratios, the absence or low concentrations of residual chlorine, and stagnation periods are all factors that influence bacterial growth and proliferation [20]. Biofilms are organized communities of organisms widely present in nature that represent serious problems in environmental, industrial, and medical settings [21]. They also play an important role in bacterial persistence in water lines and water systems, shielding them from disinfectants and adverse environmental conditions [20]. Additionally, these films can also harbor pathogenic microorganisms, causing serious public health concerns.

There is a well-known disparity [22] in drinking water monitoring where urban high-income areas have better monitoring and water quality than rural areas. This disparity exists in the rural and unincorporated communities known as Thermal, Oasis, Mecca, and North Shore located in the Eastern Coachella Valley (ECV) of Riverside County, Southern California, USA. In these communities, the water contamination issue is well known among community members and stigmatized due to previous reports of arsenic contamination in groundwater. This contamination is present for many of the rural residents who live in mobile homes that are supplied with untreated well water [23].

Given the importance of drinking water safety, this study was conducted to assess the quality of drinking water from WVMs and SFs in the ECV and compare them to TW collected in the community. We hypothesized that drinking water from WVMs and restaurants in the ECV is contaminated with pathogenic bacteria and that our swab samples from the machine spigots contain more bacteria than samples from the corresponding bulk water samples. We also postulated that drinking water from SFs is contaminated with elevated bacterial colony-forming units (CFUs) and pathogenic microorganisms. We hypothesized that TW samples from the ECV have fewer bacteria than water samples from WVMs and SFs.

Because our overall aim is to improve the quality of drinking water in this community, we adopted a problem-solving method that characterized the physico-chemical parameters that influence the microbial contamination. We focused on identifying the presence of DNA of select microbes with parallel assessments of pH, electrical conductivity (EC), free chlorine, and total dissolved solids (TDS). This problem-solving focus recognizes that microbial contamination could be exacerbated by other water quality issues. We used quantitative polymerase chain reaction (qPCR) for the identification of the six selected microorganisms.

Inadequate water supply is still one of the major challenges in developing countries [24]. Access to sufficient quantities of safe water for drinking and domestic uses and also for commercial and industrial applications is critical to health and the opportunity to achieve human and economic development [25]. Water Purification Systems is an important and rapidly growing source of drinking water in the world originating from sea water or brackish water. Bacteriological analysis the microbiological analysis of water samples revealed the presence of *E. coli* one of the stations contaminations for stations, trains of *E. coli* that cause gastroenteritis in humans can be grouped into six categories: enteroaggregative *Escherichia coli* (EAEC) (often referred to as EAEC) is a pathotype of *Escherichia coli often* associated with diarrheal illness. The defining characteristic of EAEC compared to other pathotypes of *E. coli* is a "stacked brick" pattern of adhesion to the human epithelial cell line humane Epithel-2-Zellen (HEp-2).

Escherichia coli are gram-negative bacteria that live in the gastrointestinal tract. Most strains do not cause illness. Pathogenic *E. coli* are categorized into pathotypes based on their virulence genes.

The pathogenesis of EAEC involves the bacteria aggregating and colonizing the intestinal mucosa, releasing enterotoxins and cytotoxins that damage host cells and inducing inflammation - resulting in diarrhea and other gastrointestinal symptoms, enterohemorrhagic *E. Coli* (EHEC), enter invasive *E. Coli* (EIEC), enteropathogenic *E. Coli* (EPEC), enterotoxigenic *E. Coli* (ETEC), and diffuse adherent *E. Coli* (DAEC). Pathogenic *E. Coli* the contaminated samples are also categorized according to the risk grade for natural source, reservoir and tap samples. The data describes that there is very high risk in taps. Most strains of *E. coli* are harmless and live in the intestines of healthy humans and animals. However, the O157 strain produces a powerful toxin that can cause severe illness.

The six pathotypes of diarrheagenic *E. coli* are:

1.Enteropathogenic *E. coli* (EPEC)

1. Enterotoxigenic *E. coli* (ETEC)
2. Enter invasive *E. coli* (EIEC)
3. Shiga toxin-producing *E. coli* (STEC)
4. Enteroaggregative *E. coli* (EAEC)
5. And possibly diffusely adherent *E. coli* (DAEC)
6. *E. coli* O104:H4

(Pathotypes that cause urinary tract infections, bloodstream infections).

Serotypes of *E. coli* are determined by surface antigens (O and H), and specific serotypes tend to cluster within certain pathotypes. Rarely, an *E. coli* strain has virulence factors of more than one pathotype. An example is the strain of *E. coli* O104:H4 that caused a large outbreak of serious illnesses in Germany in 2011; it produced Shiga toxin and had adherence properties typical of EAEC.

Shiga toxins are a family of related toxins with two major groups, Stx1 and Stx2, expressed by genes considered to be part of the genome of lambdoid prophages. The toxins are named for Kiyoshi Shiga, who first described the bacterial origin of dysentery caused by Shigella dysenteriae. The most common sources for Shiga toxin are the bacteria *S. dysenteriae* and the shigatoxigenic group of *Escherichia coli* (STEC), which includes serotypes O157:H7, O104:H4, and other enterohemorrhagic *E. coli* (EHEC).

STEC are also called verotoxigenic *E. coli* (VTEC), and the term enterohemorrhagic *E. coli* (EHEC) is commonly used to specify STEC strains capable of causing human illness, especially bloody diarrhea and hemolytic uremic syndrome (HUS), which can result in kidney damage.

Other pathogenic bacteria like Salmonella serotypes can be divided into two main groups—typhoidal and nontyphoidal. Typhoidal serotypes include *Salmonella Typhi* and *Salmonella Paratyphi A*, which are adapted to humans and do not occur in other animals. Nontyphoidal serotypes are more common, and usually cause self-limiting gastrointestinal disease.

The desalination system is equipped with a chemical treatment system for the water produced, and then bacteria filtration may not be needed as part of the system. If the system has no chlorination, ozonation or similar process the water is stored and distributed with no chemical protection against bacteria [26].

The mineral composition of the water is significantly altered and then partially reconstituted to achieve a stable product that can be distributed in pipes [27]. This water differs from natural waters in the sense that its composition is controllable whereas natural waters vary over a very wide range of composition that is a matter of geology and chance [28].

A logical question is whether the ultimate composition of this and other 'manufactured' water may have some positive or negative impact on the health of long-term consumers [29]. Water produced by Water Purification Systems methods has the potential for contamination from source water and from the use of various chemicals added at the pre- treatment and Water Purification Systems and post treatment stages [30].

Natural water resources are more likely to be impacted by contamination when they are receiving waters of wastewater discharges and surface runoff [31]. Therefore, some Water Purification Systems couldn't care about drinking water quality in terms of international standards, which may endanger the public health [32]. More than 12,000 commercial water purification systems are in operation throughout the world producing about 40 million cubic meters of water per day [33].

The number is growing rapidly as the need for fresh water supplies grows more acute and technologies improve and unit costs are reduced [34]. Water Purification Systems use waters impaired with salts (seawater or brackish water) or other contaminants as their sources [35]. Libya is one of the countries suffer intense deficit of fresh water [36]. One of the basic sources of water supply is the underground water [37].

The health and well-being of humans strongly depend on adequate access to microbiologically safe drinking water [34]. Considerable time and money is invested in treating available water resources to remove undesirable microorganisms in drinking water systems [38]. Depending on the water source, water goes through various treatment steps until it becomes adequate for human consumption. After the treated water leaves the treatment plant, it has to flow through the drinking water distribution system (DWDS) and network of pipes before reaching the consumer taps. The DWDS, with its unique environment, can lead to deterioration of the microbial water quality if the appropriate environment for bacterial regrowth is created [39-41]. Two primary approaches are often pursued to prevent bacterial regrowth in DWDS: (i) limiting the nutrients available for bacterial growth or (ii) the use of disinfection residuals. In the first approach, water utilities emphasize the removal of readily biodegradable, low-molecular-weight compounds that are considered as food for bacteria to grow. Water utilities put additional efforts to optimize treatment schemes to enable better removal of slowly biodegradable, high-molecular-weight compounds as these compounds degrade at a slower rate leading to bacterial regrowth at farther locations in the distribution network [41,42]. Disinfection is another common approach to prevent bacterial regrowth by using disinfectants such as chlorine, chlorine dioxide, and monochloramine before distributing the water and maintaining a disinfectant residual in DWDS [43]. Water utilities globally preclude distribution without a disinfectant residual and disinfection is implemented in most countries and usually allows the distribution of biologically stable water. However, one cannot ignore the carcinogenic disinfection by-products that form when disinfectants react with organic compounds present in the water [44,45]. Many groups of disinfection by-products are regulated in drinking water guidelines, and water utilities have to limit the production of these by-products, monitor and measure their concentration to make sure they abide by the guidelines [46].

Previous study in Libya

1- Drinking Water Quality of Some Commercial Water Purification Systems at Sabratha Area, Libya [47].

This study was investigated the quality of drinking water supplied in Some Commercial Water Purification Systems at Sabratha area. Water samples were collected from five stations at Sabratha region. The physicochemical parameters were mainly, pH, Alkalinity, Chloride, Nitrate, Sulfate, Magnesium, Calcium, Sodium, Potassium and total dissolved solid's part per million TDS. The result shows that all these parameters were fall below WHO guidelines, except pH. The bacteriological result revealed that one of the studied stations was contaminated by *E. coli* bacteria.

Physicochemical parameters

The data in Table 1 showed that all parameters (from Water Purification Systems At Sabratha) analyzed, drinking water quality parameters of all water samples were found to be less than WHO guidelines, except pH was found to be within WHO guidelines. pH values were found to lie within WHO standard only. According to WHO standards pH of water should be 6.5 to 8.5 Hence, in study area the pH values were between 7.68 to 8.0, the values were not exceeded the standard limit however these were falling in basic or Alkaline range. Current study revealed the concentration of Bicarbonates ranges, 19.52-39.04 mg/l, and hence these were more than the standard values. The chloride value in the study ranges from 17.75-142 mg/l. Thus, all the samples have lower concentration of standard chloride. The concentration of Sulfate range from 5.7- 8.34 mg/l, the results exhibit that concentration of sulfate in Water Purification Systems was lower from standard limit. In study area magnesium was ranges from 1.2-6 mg/l, Such a low may cause some long term public health problems and could be associated with health risks of residents. In study areas, results show that the concentration of calcium ranges from 26-40 mg/l, Calcium quality in the study was less than the limit by WHO and case may effect on public health for human. Finding shows that sodium and Potassium concentration ranges were 0, No values sodium and potassium in the study area, Lack of potassium and sodium may cause diseases associated for human. AS well, results clear that the concentration of nitrate ranges from 0-0.068 mg/l, these results indicate that the quantity of nitrate in study sites is less than WHO standard, that may threat on the health of inhabitants. TDS range is 18.7-146.3 ppm in the study area. Hence, these ranges were acceptable and concentration of TDS is not harmful. The analytical data of commercial cater purification systems showed that water samples less than the WHO guideline value of pH but the value lies within the WHO standard. Most of parameters were found to have less than WHO guidelines especially in tap water, which is not to say safe to drink. If quality of water is not improved, it may exert serious health hazard for consumers. It is a tragedy that infants and young children are the innocent victims of failure to make safe drinking water and basic the study explained that all Water Purification Systems not care WHO standard.

Table 1: Laboratory Analysis of Physical and Chemical Parameters of Study Areas and WHO Standards

Parameter	Unit	Stations					WHO guideline
		1	2	3	4	5	
pH	Ppm	7.78	8	7.70	7.68	7.67	6.5-8.5
TDS	Ppm	74.25	18.7	146.3	69.85	69.85	500-1000
$NO^{3-}{}_N$	mg/1	0.068	0.058	0.036	0	0.033	10-45
CL^-	mg/1	17.75	142	71	71	142	200-600
$SO4^{2-}$	mg/1	6.16	8.34	5.7	6.07	6.88	200-400
HCO^{1-}	mg/1	39.04	29.28	39.04	28.28	19.52	10
K^3	mg/1	0	0	0	0	0	12
Mg^{2+}	mg/1	3.6	6	4.8	1.2	1.2	30-150
Na^+	mg/1	0	0	0	0	0	200-400
Ca^{2+}	mg/1	20	14	8	12	20	75-200

Bacteriological analysis

The microbiological analysis of water samples revealed the presence of *E. coli* one of the stations contaminations for stations, the contaminated samples are also categorized according to the risk grade for natural source, reservoir and tap samples. The data describes that there is very high risk in taps. The 2011 WHO guidelines for drinking water give a tolerance range for *E. coli* in drinking water as shown in Table 2. The number of bacterial colonies in station 4 exceeded 5600 per 100 mL this mean Very High Risk in station as shown in Table 3. This might be due to infiltration of contaminated water and sewage through cross connection and leakage points. Also filtered carelessness' in station may be the reasons for contamination with *E. coli*, while anther stations were conformity with WHO guidelines.

Table-2: WHO (2011) classification and color-code scheme for *E. coli* colonies per 100 mL water sample

Color	Blue	Green	Yellow	Orange	Red
Risk Level	In Conformity	Low Risk	Intermediate Risk	High Risk	Very High Risk
E. Coli	**0**	**1-10**	**10-100**	**100-1000**	**>1000**

Table-3: Bacteriological results in the of the Study Areas

Station	Count/100 ml	Remarks
1	0	Inconformity with WHO guidelines
2	0	" " "
3	0	" " "
4	5600	**Very high risk**
5	0	**In conformity with WHO guidelines**

MATERIAL AND METHOD

The beginning of water samples collection started at 18.3.2024 until 20.8.2024. The samples were collected from different resources of Water desalination plants with different area from inside Libya. Like Alharsha, Sabratah, Sourman, Alajelat. In our research for analysis our water samples we used ***Compact dry EC method*** for our research study.

EC Medium is a broth used for the detection of *Escherichia coli* and coliform contamination in water, milk, and other food products. EC Medium contains peptones for nutrient and vitamin sources. Lactose provides a carbohydrate component for the growth of lactose-fermenting coliforms.

Figure-1: *Esichrisia Coli* [48]

The work stages beginning as following:

1- Before starting disinfect the area and instruments.
2- Open incubator until 37C˚befor preparing the samples.
3- Remove the cover of the slide.
4- Deposit 1 ml (1000µl) of water sample in the center of the surface of each circle in the Compact Dry plate. The slide got from Al-Sadeem Laboratory Technology Company. The sample is automatically and homogeneously dispersed on the film and transforms the dry film into a gel in a few seconds.
5- Replace the cover on the (EC compact dry media), then incubate for the prescribed time inside the incubator at 37 C˚ for 24 hours, then read the slides results, see the microorganism's growth, in case of no any results of microorganism's growth must be return back the slides inside incubator and incubate again for 24 horses.
6- After 48 hours from incubation, if there is no growth of baceria inside the circles of (EC compact dry media), the results mean negative, while if the growth appears that means positive results.

The next pictures illustrate the steps of processing inside laboratory.

Figure 1 showing the deposit 1 ml (1000µl) of water sample in the center of the surface of each circle in the Compact Dry plate.

Figure-2: Water samples

Figure-3: preparing of the samples

Figure-4: prepare of incubator at 37C°

Figure-5: deposit 1 ml (1000µl) of water sample in Compact Dry plate

Figure-6: Autoclave for the sterilization of the tools and media

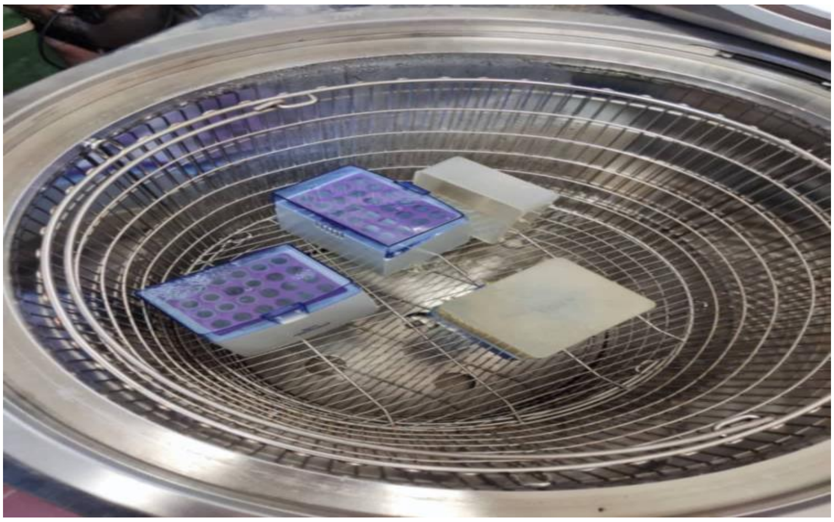

Figure-7: Autoclave for the sterilization of the tools and media

Figure-8: Insert Compact Dry plate inside the incubator

Figure-9: Insert Compact Dry plate inside the incubator

RESULTS

16 - Samples of water were subjected with Compact Dry plate inside the incubator at 37C°, we got the results as explorer in the table number (4). The results focused at EC TEST "Colony, PH, T.D.S PPM and EC. All the results of EC TEST "Colony were normal (Nil) except the *E. Coli* positive in Sourman 1 gave of 14 Positive samples, Sourman 2 of 2 positive, and Al ajelat- Quot Aldes of 2 positive samples. The results of PH with rang from 6.60 - 8.00. While the results of T.D.S PPM ranged from (23- 5030) PPM. And the last the results include *Electricity* (EC) from (44- 7860).

Table-4: The results of 16 water samples were analyzed in petroleum laboratory

No.	Sample name	EC TEST "Colony "	PH	T.D.S PPM	EC
1	Anaby Mosque	Nil	6.96	23	44
2	Alzzawiya	Nil	7.09	59	110
3	Alsharef school	Nil	7.05	55	100
4	Alttaqwa Mosque	Nil	6.86	101	212
5	Alharsha 4	Nil	8.00	84	160
6	Alharsha 5	Nil	7.67	115	222
7	Sabratah 1	Nil	7.06	73	114
8	Sourman 1	14	6.84	52	105
9	Sourman 2	2	7.01	53	101
10	Sabratah 2	Nil	7.81	124	231
11	Sabratah 3	Nil	7.10	5030	7860
12	Sabratah 4	Nil	6.86	142	262
13	Alajelat -Alkhatab Mosque	Nil	6.60	143	290
14	Alajelat -Azzramqua	Nil	7.80	30	55
15	Alajelat- Treq Asseka	Nil	6.88	73	147
16	Al ajelat- Quot Aldes	2	6.87	33	65

EC= *E. Coli* colony bacteria: PH=Water acidity: **TDS=** Total dissolved solids part per million**: EC=** Electrical Conductivity

Table-5: The results of 20 water samples were analyzed in petroleum laboratory

No.	Sample location	EC TEST Colony	PH	T.D.S PPM	Conductivity in water (EC)
1	Bin Omran Mosque (Al-Harsha)	2	7.3	90	55
2	Dhi Al-Nurain Mosque (Al-Harsha)	179	6.80	17	341
3	Al-Shaabiya Mosque (Al-Harsha)	3	6.9	120	76
4	Abnaa Wahida Store (Next to the Refinery Road)	NILL	6.3	50	89
5	Bu Hamira South Mosque (Next to Bin Youssef Forest)	6	7.2	600	129
6	Al-Sabria (Next to the Coastal Road)	8	7.6	960	324
7	Al-Yaqeen Mosque (Abi Shamata)	162	6.44	30	47
8	Al-Zawiya Teaching Hospital (The Well)	NILL	7.4	1200	49
9	Al-Zawiya Teaching Hospital (The Tank)	9	7.5	1250	49

10	Al-Zawiya Teaching Hospital (Al-Fasakiya)	NILL	7.4	1220	48
11	Al-Zawiya Refinery Company Restaurant	NILL	7.8	1300	56
12	Ali Al-Amir Mosque (Al-Harsha)	NILL	6.7	60	274
13	Al-Bu Hamiriya School	NILL	7	1233	85
14	Dijlah Drinking Water	NILL	6.54	80	204
15	Youssef Shaaban Farm Next to Bir Al-Ghanam Bridge	NILL	7.4	400	67
16	Harsha (Bin Rajab Intersection)	12	7.9	2300	97
17	Drinking Water (Shaimaa)	NILL	7.74	122	270
18	Al-Zawiya Company Desalination Plant	NILL	7.48	320	225
19	Al-Maqouz Farm	NILL	6,6	2400	160
20	Abi Shamata Mosque	NILL	7.44	1700	452

EC= *E. Coli* colony bacteria: PH=Water acidity: **TDS=** Total dissolved solids part per million**: EC=** Electrical Conductivity

In table (5) Twenty of water samples were collected from different Mosques, schools, shopping stores, farms, and hospitals, from Alzawia and Alharsha. The analysis focused at EC TEST "Colony, PH, T.D.S PPM and EC and the results were:

-The results of EC TEST Colony ranged from (2-179).

- The results of PH value ranged from (6.3- 7.74).

-The results of T.D.S PPM ranged from (17- 1300) PPM.

- At last, the results of Conductivity in water *Electricity* (EC) ranged from (47-452)

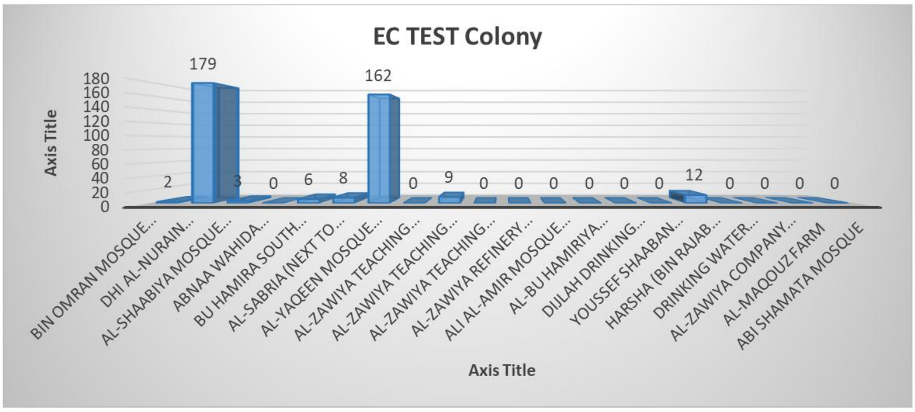

Figure-10: The results of 20 water samples were analyzed in petroleum laboratory for *E.C* TEST Colony

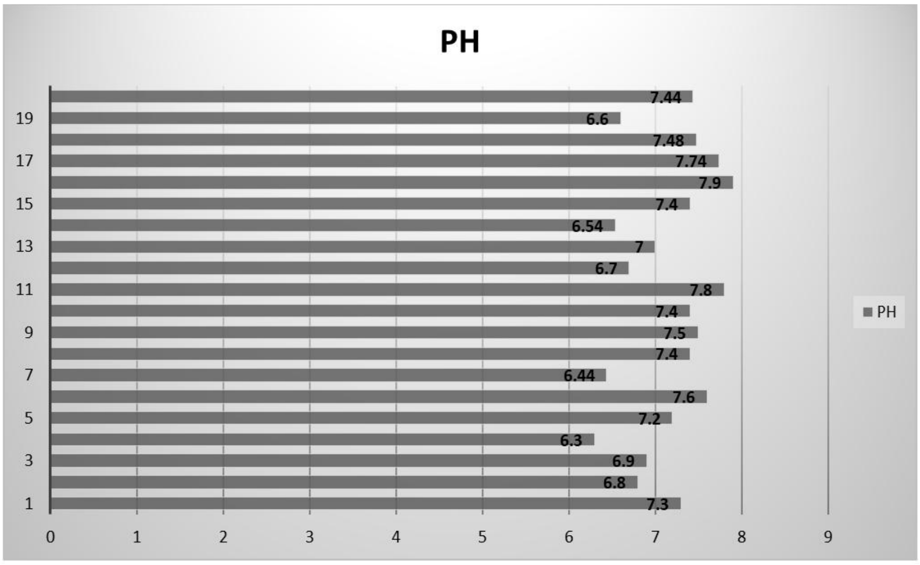

Figure-11: The results of 20 water samples were analyzed in petroleum laboratory for PH value

Total dissolved solids TDS (milligram / Deciliter):
TDS stands for total dissolved solids, and represents the total concentration of dissolved substances in water. TDS is made up of inorganic salts, as well as a small amount of organic matter. Common inorganic salts that can be found in water include calcium, magnesium, potassium and sodium, which are all cations, and carbonates, nitrates, bicarbonates, chlorides and sulfates, which are all anions. Cations are positively charged ions and anions are negatively charged ions. When water TDS read (more 9000 milligram / Deciliter) regards not fit for human consumption.

Table-6: Explain the standard rating of the TDS level (milligram / Deciliter) according to (WHO)

Level of TDS(milligrams per liter)	Rating
Less than 300	Excellent
300-600	Good
600-900	Fair
900-1200	Poor
Above 1200	Unacceptable

http://www.water-research.net/index.php/water-treatment/tools/total-dissolved-solids [56]

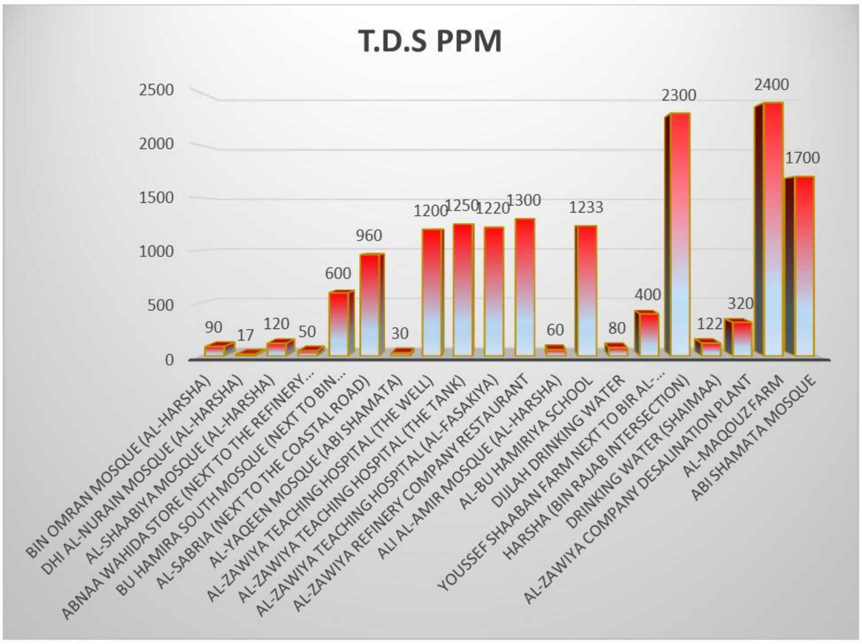

Figure-12: Comparative value of standard rating of the TDS level (milligram / Deciliter) according to (WHO) with 20 water samples.

However, a very low concentration of TDS has been found to give water a flat taste, which is undesirable to many people.

Increased concentrations of dissolved solids can also have technical effects. Dissolved solids can produce hard water, which leaves deposits and films on fixtures, and on the insides of hot water pipes and boilers. Soaps and detergents do not produce as much lather with hard water as with soft water. As well, high amounts of dissolved solids can stain household fixtures, corrode pipes, and have a metallic taste. Hard water causes water filters to wear out sooner, because of the amount of minerals in the water. The picture below was taken near the Mammoth Hot Springs, in Yellowstone National Park, and shows the effect that water with high concentrations of minerals can have on the landscape. The same minerals that are deposited on these rocks can cause problems when they build up in pipes and fixtures [50].

What is PH:
The pH value of a water source is a measure of its acidity or alkalinity. The pH level is a measurement of the activity of the hydrogen atom, because the hydrogen activity is a good representation of the acidity or alkalinity of the water. The pH scale, as shown below, ranges from 0 to 14, with 7.0 being neutral. Water with a low pH is said to be acidic, and water with a high pH is basic, or alkaline. Pure water would have a pH of 7.0, but water sources and precipitation tend to be slightly acidic, due to contaminants that are in the water.

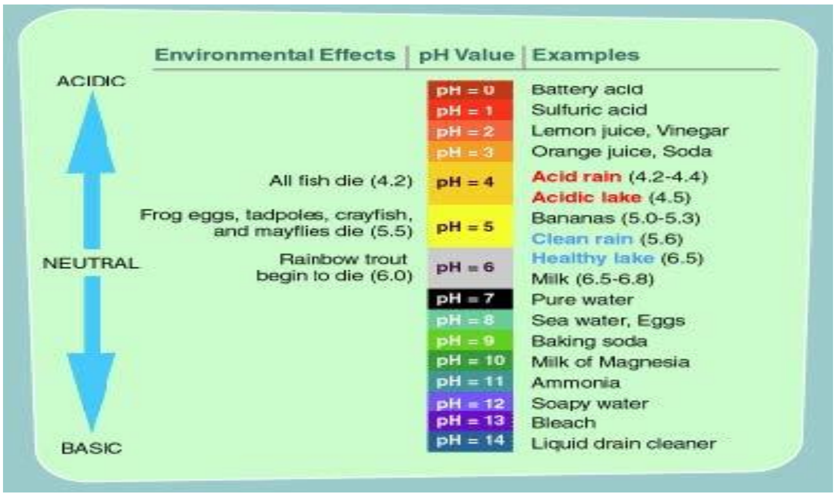

Figure 13: The standard pH value [51]

pH Scale

The pH scale is logarithmic, which means that each step on the pH scale represents a ten-fold change in acidity. For example, a water body with a pH of 5.0 is ten times more acidic than water with a pH of 6.0. And water with a pH of 4.0 is 100 times more acidic than water with a pH of 6.0.

Normal PH between 6.5 and 9.5

According to figure 10, The pH is a measure of the acidity or alkalinity. The water quality regulations specify that the pH of tap water should be between 6.5 and 9.5.

Table-7: Normal range value of Electricity Conductor (EC) in different types of water

Types of water	Conductivity Value
0.05 µS/cm	Pure distilled and Deionized water
50 mS/cm	Seawater
200 to 800 µS/cm.	**Drinking water**
2 to 100 µS/cm	Rain or Snow water

Normal range (EC) value of drinking water (200 - 800 µS/cm): µS = microsecond: mS/cm =micro siemens per centimeter

Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current.

On the other hand, if EC is too high, this can cause a number of issues, such as nutrient or salt burn as well as nutrient toxicities. An extremely high EC may also prevent your plants from being able to get enough water to cover their basic needs, and your plants could start to wilt and die.

Table-8: Normal range value of Electricity Conductor (EC) in different types of water

Water Type	Conductance Range (µS/cm)
Distilled Water	0.5-3
Snow (Melted)	2-42
Tap Water	50-800
Potable Water (US Standard)	30-1,500
Freshwater Streams	100-2,000
Industrial Wastewater	10,000
Seawater	55,000

https://atlas-scientific.com/blog/water-conductivity-range/

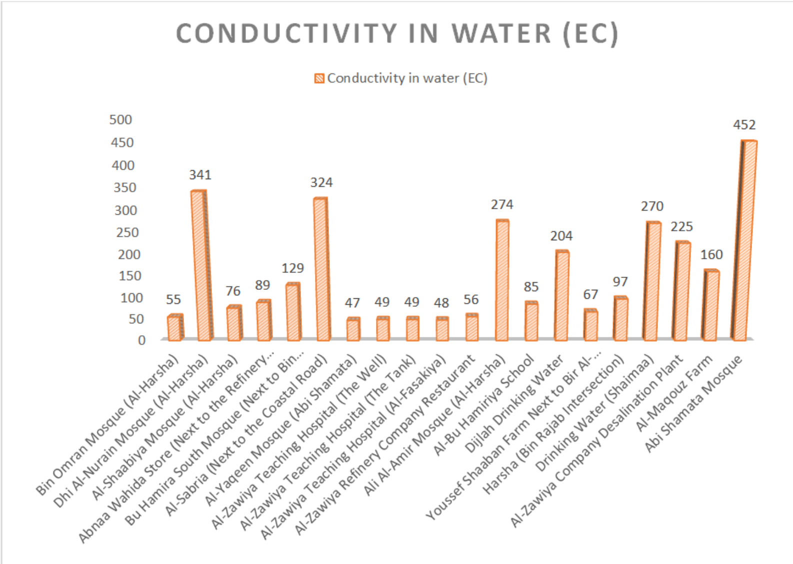

Figure-14: The value of conductivity (EC) in water for 20 water samples

Statistical Analysis instruments

To evaluate the responses of the study sample, descriptive statistics were used to analyze the data using the Statistical Package for the Social Sciences (SPSS V27), which includes: frequency tables, bar charts, mean, standard deviations, and one sample T test.

Table-9: Distribution of *E. Colli* Colony Bacteria Risk Levels

E. Colli Colony Bacteria	Count	%	Normal Range	Mean	Std	P-value
In WHO Range	25	69.4	0-1	11.08	39.426	0.134
Low Risk	7	19.4				
Intermediate Risk	2	5.6				
High Risk	2	5.6				
Total	36	100.0				

The distribution of E. coli colony bacteria risk levels (Table 1) indicates that the majority of samples (69.4%) fall within the World Health Organization (WHO) recommended range. Low-risk samples account for 19.4% of the total, while intermediate and high-risk samples each represent 5.6%. The mean colony count (11.08) exceeds the normal range (0-1), with a high standard deviation (39.426), suggesting considerable variability in the data. However, the p-value (0.134) indicates that these results are not statistically significant at the conventional α = 0.05 level.

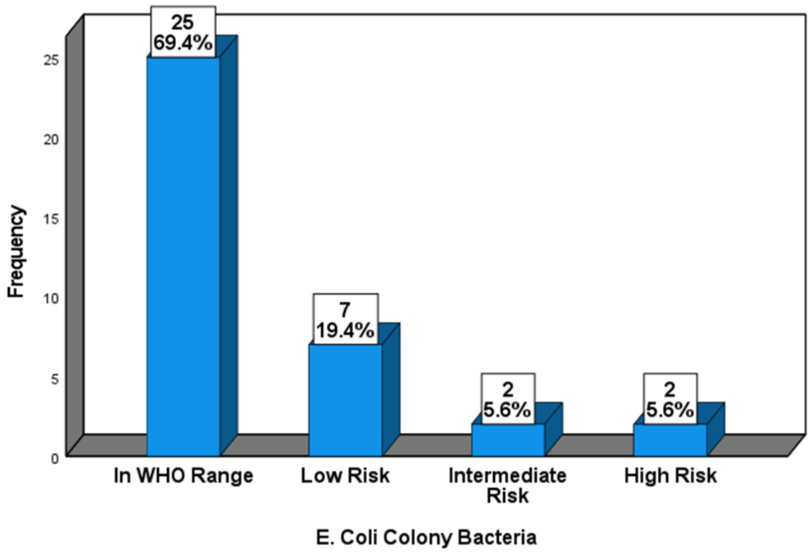

Figure-15: Comparison between normal (WHO) *E. Coli* Rang with level risk in analysis water

Table-10: Water pH Levels Distribution and WHO Range Compliance

PH level (Water Acidity)	Count	%	Normal Range	Mean	Std	P-value
Off WHO Range	2	5.6	6.5-8.5	7.16	0.448	0.398
In WHO Range	34	94.4				
Total	36	100.0				

Table 2 presents the distribution of water pH levels and their compliance with WHO standards. The majority of samples (94.4%) fall within the WHO recommended range of 6.5-8.5. Only 5.6% of samples are outside this range. The mean pH level (7.16) is well within the normal range, with a relatively small standard deviation (0.448), indicating consistent pH levels across samples. The p-value (0.398) suggests that these results are not statistically significant at the conventional α = 0.05 level, implying that the observed distribution could occur by chance.

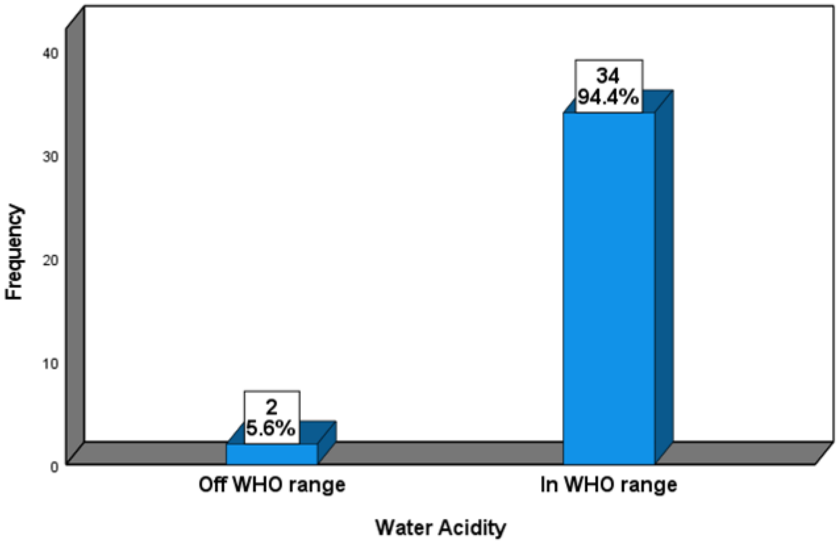

Figure-16: The range of PH water according to WHO

Table-11: Distribution of Total Dissolved Solids (TDS) Levels and Water Quality Categories

TDS level	Count	%	Normal Range	Mean	Std	P-value
Excellent	23	63.9	500-1000	601.17	1009.078	0.551
Good	2	5.6				
Fair	1	2.8				
Poor	2	5.6				
Unacceptable	8	22.2				
Total	36	100.0				

Table 3 illustrates the distribution of Total Dissolved Solids (TDS) levels and corresponding water quality categories. The majority of samples (63.9%) fall within the "Excellent" category, while 22.2% are classified as "Unacceptable." The remaining samples are distributed across "Good" (5.6%), "Fair" (2.8%), and "Poor" (5.6%) categories. The mean TDS level (601.17) is within the normal range (500-1000), but the high standard deviation (1009.078) indicates substantial variability in TDS concentrations. The p-value (0.551) suggests that these results are not statistically significant at the conventional α = 0.05 level, implying that the observed distribution could occur by chance.

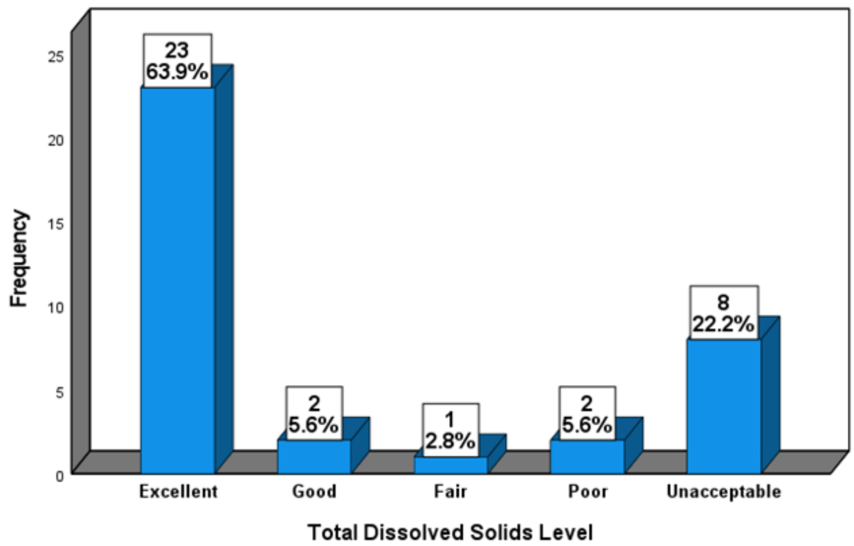

Figure 17: Distribution of Total Dissolved Solids (TDS) Levels and Water Quality Categories

Table-12: Distribution of Water Conductivity (EC) Levels Relative to Normal Range

Conductivity in water (EC)	Count	%	Normal Range	Mean	Std	P-value
Less than normal range	23	63.9	200-800	365.97	1288.735	0.875
In normal range	12	33.3				
More than normal range	1	2.8				
Total	36	100.0				

Table 4 presents the distribution of water conductivity (EC) levels relative to the normal range. The majority of samples (63.9%) fall below the normal range of 200-800 while 33.3% are within the normal range, and only 2.8% exceed it. The mean conductivity (365.97) is within the normal range, but the high standard deviation (1288.735) indicates substantial variability in EC levels across samples. The p-value (0.875) suggests that these results are not statistically significant at the conventional α = 0.05 level, implying that the observed distribution could occur by chance.

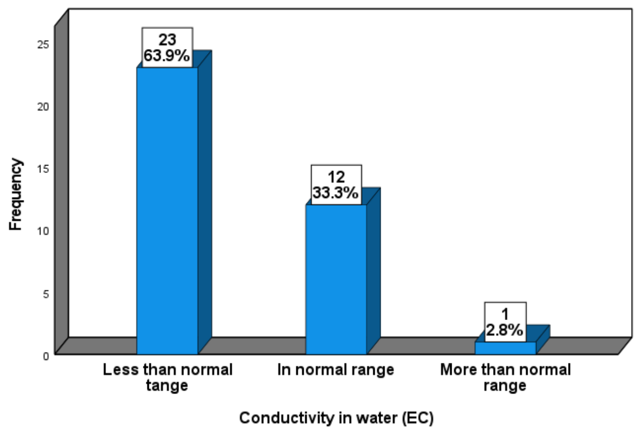

Figure-18: Distribution of Water Conductivity (EC) Levels Relative to Normal Range

DISCUSSION

According to our results in table (4) including EC TEST "Colony, PH, T.D.S PPM and EC.

All the results of EC TEST "Colony were normal (Nil), except the positive infection of E. *Coli* in Sourman -1 gave of 14 Positive samples which regards as intermediate infection, Sourman -2 have 2 positive, and Al ajelat- Quot Aldes have also 2 positive samples, The estimation of both stations according to WHO regards as low risk of infection.

This might be due to infiltration of contaminated water and sewage through cross connection and leakage points.

The results of PH in all water resources with rang from 6.60 - 8.00, this mean our results are under the normal PH rang depending on the standard rang in figure (10) found to lie within WHO standard only, which limit the normal pH of tap water should be between 6.5 and 9.5.

While the results of T.D.S PPM In table (4) ranged from (23- 5030) PPM. According to standard value in table 6, our results all regard as excellent TDS range in the study area. Hence, these ranges were acceptable and concentration of TDS is not harmful (under 300 PPM), except one result in Sabratha- 3 with value (5030-PPM) as regards over the normal value and exceed value of (1200 PPM) which regards not fit for human consumption (unexpectable).

And the last results include *Electricity* (EC) ranging from (44 - 7860). While the normal range of (EC) as in table (7) between (200-800) µS/cm, so all our results was normal except (7860) µS/cm in Sabratah- 3, regard abnormal with very high value.

The results of table (5) include
EC. test Colony, PH, T.D.S (TOTAL DISOLVID SOLIDS) PPM and **EC** Conductivity in water:
1 -The results of EC TEST Colony ranged from (2-179).
2- The results of PH value ranged from (6.3- 7.74).
3-The results of Total dissolved solid's part per million (T.D.S PPM) ranged from (17- 2400) PPM.
4- At last, the results of Conductivity in water *Electricity* (EC) ranged from (47-452).

- According to the WHO normal rang value in tape water of (EC) from (50-800) µS/cm Conductance Range, so ours results regards in the normal range of (WHO).
-The results of PH value ranged from (6.3- 7.74) which regard near to range values of WHO from (6.5-9.5)
-The results of Total dissolved solid's part per million (T.D.S PPM) ranged from (17- 2400) PPM. While the normal range and acceptance range value of (WHO) under (300) mg/L. So, some of our results regard excellent and good water for human consumption as in the results from table (5) which includes:

-Dhi Al-Nurain Mosque (Al-Harsha) = 17
-Abnaa Wahida Store (Next to the Refinery Road) = 50
-Al-Yaqeen Mosque (Abi Shamata) =30
-Ali Al-Amir Mosque (Al-Harsha) = 60
-Dijlah Drinking Water =80

While the rang of (300=600) as mentioned in WHO regard as good water like in our results of table (5) includes:
Bu Hamira South Mosque (Next to Bin Youssef Forest) = 600
Youssef Shaaban Farm Next to Bir Al-Ghanam Bridge = 400

While the range value between (900- 1200) regards as poor water in quality like in our results in table (5) which includes:
-Al-Sabria (Next to the Coastal Road) = 960
-Al-Zawiya Teaching Hospital (The Well) = 1200 (maximum poor)

The last range value according to WHO was unacceptable regards any value over (1200) as in our results from table (5) which includes:
-Al-Zawiya Teaching Hospital (The Tank) = 1250
-Al-Zawiya Teaching Hospital (Al-Fasakiya) =1220
-Al-Zawiya Refinery Company Restaurant = 1300
-Al-Bu Hamiriya School = 1233

The range value of poor drinking water from (900 until more than 1200) because of Total dissolved solid's part per million (T.D.S PPM).

Total dissolved solids (TDS) represents the combined total of all organic and inorganic substances found in drinking water. The total dissolved solids present in water is one of the leading causes of particles and sediments in drinking water, which give water its color, odor, and flavor, and can be a general indicator of water quality, so when the (TDS) becomes in rage from (900 until over 1200) becomes poor or unacceptable and not fit for human consumption because the TDS were exceed the limit of WHO.

Normal range (EC) value of drinking water (200 - 800 µS/cm): µS = microsecond: mS/cm =micro siemens per centimeter

CONCLUSION

In this study, the quality of drinking water was evaluated in desalination plants in different areas in Sabratha, Surman, AjLeilat, AL-Zawiya, Al-Harsha and a number of desalination plants for some mosques. The physical, chemical and biological standards were examined and compared with the World Health Organization standards. In general, most of the values were consistent with the World Health Organization standards, except for a few of them, as shown in Table 1. Also, the presence of coliform bacteria in three stations in small proportions, may be due to pollution in some of them due to the leakage of polluted water and sewage water through the connection and leakage points.

RECOMMENDATION

We suggest that the maintenance of the water stations be emphasized continuously and that water samples be sent to accredited laboratories for examination from time to time, provided that the examination includes chemical, physical and biological analysis. Also, water sources must be far from heavy water streams.

REFERENCES

1. Ramírez-Castillo, F. Y., Loera-Muro, A., Jacques, M., *et al.*, (2015) Waterborne pathogens: detection methods and challenges. *Pathogens*. 4 (2), 307–334.
2. Bitton, G. (2005) Wastewater Microbiology. John Wiley & Sons, *New York*, NY, USA.
3. World Health Organization (WHO) 2022 Drinking-Water Geneva. WHO, Geneva, Switzerland. https://www.who.int/news-room/fact-sheets/detail/drinking-water.
4. Hu, Z., Morton, L. & Mahler, R. (2011) Bottled water: United States consumers and their perceptions of water quality. International Journal of Environmental Research and Public Health 8 (2), 565–578.
5. Patel, A. I., Grummon, A. H., Hampton, K. E., *et al.*, (2016) A trial of the efficacy and cost of water delivery systems in San Francisco Bay area middle schools, 2013. *Preventing Chronic Disease* 13, E88-E.
6. Praveena. S. M., Huyok, N. F. K. & de Burbure, C. (2018) Public health risk assessment from drinking water from vending machines in Seri Kembangan (Malaysia). *Food Control* 91, 40–46.
7. Gleick, P. H., Allen, L., Christian-Smith, *et al.*, (2012) The World's Water Volume 7: The Biennial Report on Freshwater Resources. Island Press, Washington, DC, USA.
8. Association IBW 2021 Bottled Water Consumption Shift – U.S. Consumption by Beverage Type 2010–2020 Virginia. IBWA. [updated 2021; cited 2022 1/31/22]. Available from: https://bottledwater.org/bottled-water-consumption-shift/
9. Girolamini, L., Lizzadro, J., Mazzotta, M. *et al.*, (2019).Different trends in microbial contamination between two types of microfiltered water dispensers: from risk analysis to consumer health preservation. *International Journal of Environmental Research and Public Health* .16 (2), 272.
10. Hertin, K. J. (2011) A comparative study of indicator bacteria present in ice and soda from Las Vegas food establishments. UNLV Theses, Dissertations, Professional Papers, and Capstones. 1282. http://dx.doi.org/10.34917/2825979.
11. Godard, R. D., Sharma, P., Wagner, C. J., et al., (2013) Repeated detection of microbes in beverages dispensed from soda fountain machines and the effect of flushing on microbial density. *International Journal of Food Microbiology*. 163 (2), 218–222.
12. Cardaci, R., Burgassi, S., Golinelli, *et al.*, (2016) Automatic vending-machines contamination: a pilot study. *Global Journal of Health Science* .9 (2), 63.
13. Hile, T. D., Dunbar, S. G. & Sinclair, R. G. (2020) Microbial contamination of drinking water from vending machines of Eastern Coachella Valley. *Water Supply*. 21 (4), 1618–1628.
14. Centers for Disease Control and Prevention. (2020) Commercially Bottled Water2020 Sept 08 2021: https://www.cdc.gov/healthywater/drinking/bottled/index.html
15. Arnal J., García-Fayos B., Sancho M., Verdú G. & Lora J. 2010 Design and installation of a decentralized drinking water system based on ultrafiltration in Mozambique. Desalination 250 (2), 613–617.
16. White, A. S., Godard, R. D., Belling, C., *et al.*, (2010) Beverages obtained from soda fountain machines in the U.S. contain microorganisms, including coliform bacteria. *International Journal of Food Microbiology*. 137 (1), 61–66.
17. Jacobsen, K. H. & Koopman, J. S. (2004) Declining hepatitis A seroprevalence: a global review and analysis. Epidemiology & Infection. 132 (6), 1005–1022.
18. Levy, K.., Smith, S. M. & Carlton, E. J. (2018) Climate change impacts on waterborne diseases: moving toward designing interventions. *Current Environmental Health Reports.* 5 (2), 272–282.
19. Cowden, J. (1992) Campylobacter: epidemiological paradoxes. BMJ: *British Medical Journal* .305 (6846), 132.
20. Farhadkhani, M., Nikaeen, M., Akbari, Adergani B., *et al*., (2014). Assessment of drinking water quality from bottled water coolers. *Iran Journal of Public Health*. 43 (5), 674–681.
21. Szymanska, J. (2003) Biofilm and dental unit waterlines. *Annals of Agricultural and Environmental Medicine*. 10 (2), 151–157.
22. Madison, C. (2019) Rural America's Drinking Water Crisis Chicago. American Bar Association. 44 (2) Housing. from https://www.americanbar.org/groups/crsj/publications/human_rights_magazine_home/vol--44--no-2--housing/rural-america-s-drinking-water-crisis/.
23. Pierce, G. & Jimenez, S. (2015) Unreliable water access in U.S. mobile homes: evidence from the American housing survey. *House Policy Debate* .25 (4), 739–753.
24. Henry, R. K., Yongsheng, Z., & Jun, D. (2006). Municipal solid waste management challenges in developing countries– Kenyan case study. Waste management, 26(1), 92-100.
25. Zhao, X., Zhou, Y., Min, J., Wang, S., Shi, W., & Xing, G. (2012). Nitrogen runoff dominates water nitrogen pollution from rice-wheat rotation in the Taihu Lak region of China. Agriculture, ecosystems environment, 156, 1-11.
26. Amy, G., Ghaffour, N., Li, Z., *et al.* (2017): Membrane-based seawater desalination: Present and future prospects. *Desalination*, 401, 16-21.

27. Cotruvo, J. A. (2005). Desalinations guidelines development for drinking water background. *Nutrients in Drinking Water*, 13.
28. Wang, M. H. S., & Wang, L. K. (2015). Environmental water engineering glossary. In Advances in water resources engineering (pp. 471-556). Springer, Cham.
29. Fuchs, G., & Reichel, A. (2011). A exploratory inquiry into destination risk perceptions and risk reduction strategies of first time vs. repeat visitors to a highly volatile destination. Tourism Management, 32(2), 266-276.
30. Lattemann, S., & Höpner, T. (2008). Environmental impact and impact assessment of sea water desalination. Desalination, 220(1-3), 1-15.
31. Morrison, G., Fatoki, O. S., Persson, L., & Ekberg, A. (2001). Assessment of the impact of point Source pollution from the Keiskammahoek Sewage Treatment Plant on the Keiskamma River-pH, electrical conductivity, oxygen-demanding substance (COD) annutrients. Water Sa, 27(4), 475-480.
32. Haneya, O. K. E. D. (2012). Evaluation of microbiological quality of desalinated drinking water at Gaza city schools, Palestine. Evaluationof icrobiological Quality of Desalina Drinking Water at Gaza City Schools, Palestine.
33. Diawara, C. K. (2008). Nanofiltration processefficiency,inwater desalination. Separation & purificationreviews, 37(3), 302-324.
34. Shannon, M. A., Bohn, P. W., Elimelech, M., *et al*., (2010) Science and technology for water purification in the coming decad In Nanoscience and technology: a collection of reviews from nature Journals (337-346).
35. Elimelech, M., & Phillip, W. A. (2011). The future of seawater desalination: energy, technology and the environment. science, 333(6043), 712-717.
36. Wheida, E., & Verhoeven, R. (2007) An alternative solution of the water shortage problem in Libya. Water resources management, 21(6), 961-982.
37. Brika, B. (2019): The water crisis in Libya: causes, consequences and potential solutions. Desalination and Water Treatment,351-358.
38. Plappally, A.K. *et al.* (2012) Energy requirements for water production, treatment, end use, reclamation, and disposal Renew. Sustain. Energy Rev.
39. LeChevallier, *et al.*, (1996) Bacterial glutathione: a sacrificial defense against chlorine compounds *J. Bacteriol.*
40. Liu W. *et al.* (2002)Investigation of assimilable organic carbon (AOC) and bacterial regrowth in drinking water distribution system Water Res.
41. Schurer, R., *et al*. (2019) Enhancing biological stability of disinfectant-free drinking water by reducing high molecular weight organic compounds with ultrafiltration posttreatment. Water Res.
42. Hijnen, W.A.M. et al. (2018) Slowly biodegradable organic compounds impact the biostability of non-chlorinated drinking water produced from surface water. Water Res.
43. Farhat, N.M., *et al.* (2018) Application of monochloramine for wastewater reuse: effect on biostability during transport and biofouling in RO membranes. *J. Membr. Sci*.
44. Garcia-Villanova, R.J., *et al*. (1997) Formation, evolution and modeling of trihalomethanes in the drinking water of a town: II. In the distribution system. *Water Res*.
45. Shanks, M., *et al.* (2013) Spatio-temporal variability of non-regulated disinfection by-products within a drinking water distribution network Water Res
46. Guilherme S., *et al.* (2014) Occurrence of regulated and non-regulated disinfection by-products in small drinking water systems. Chemosphere.
47. Flafel, HM., Kaeebah, A., Fadel, M., *et al.* (2020) Drinking Water Quality of Some Commercial Water.Purification Systems at Sabratha Area, Libya. *Libyan Journal of Ecological & Environmental Sciences and Technology*. (LJEEST) 2,2,2020.
48. Guo, A. C., Jewison, T., Wilson, M., Liu, Y., Knox, C., Djoumbou, Y., ... & Wishart, D. S. (2012). ECMDB: the E. coli Metabolome Database. *Nucleic acids research*, *41*(D1), D625-D630.
49. http://www.water-research.net/index.php/water-treatment/tools/total-dissolved-solids
50. https://www.safewater.org/fact-sheets-1/2017/1/23/tds-and-ph
51. http://www.water-research.net/index.php/ph