

Comparative Quality Analysis between Tap Water and Bottled Water: A Case Study of Koya City in Iraq

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Abstract—Recently, bottled water consumption has been increasing significantly, even when the quality of tap water is considered excellent, which contribute for plastic pollution. Besides, reducing the use of plastic generally is recommended world widely, as its consumption is in an alarming rate. Therefore, this study aims to compare between the tap and bottled water and manifest the reasons behind choosing the bottled water which is less comfortable and often more expensive over the tap water. In this study, samples have been taken from both bottled and tap water in Koya city from November 2020 to May 2021 to test their quality using potential hydrogen, dissolved oxygen (DO), electrical conductivity, and total dissolved solids (TDS) meter, hardness was determined by complexometric titration method at 21°C, and X-ray fluorescence spectrometers. According to the quality standards, most of the variables were in a permissible range, except for DO and aluminum content in both types of water and TDS for two types of bottled water. However, the quality of tap water was much safer to be used, as compared with the bottled water.

Index Terms—Dissolved oxygen; Total dissolved solid; Electrical conductivity; Potential hydrogen; Total alkalinity

I. INTRODUCTION

Water is vital for human survival and existence of life on earth, therefore using it is imperative; 70% of humans' body is water, urine and sweat are the main cause of losing much of this water, hence hydration is crucial at all times. Besides, flushing bacteria out of a bladder, carrying oxygen and nutrient to the cells, aiding digestion, preventing constipation, maintaining the electrolyte balance, etc., are all carried out by water, thus it helps improve health (Qian, 2017). The aim of providing potable water was successful by the majority of the governments in the world, nonetheless, bottled water consumption has risen globally, for example, Asia which was the largest regional market in 2001 (Ferrier, 2001).

As stated by Qian in 2017, there are two main reasons behind concerning about bottled water consumption, which are: Production and distribution energy requirements; and plastic pollution, therefore it is better to be replaced by filtered or tap water. In this study, drinking water choices of Koya city has been explored and examined the factors that determine their choices. Empirical study has been carried out in four different places throughout the city for tap water, and four samples from different companies of making bottled water. Despite the fact that the quality of the municipal tap water is potable, yet the choice as major drinking water source was personal to choose between tap and bottled water. Hence, this comparative study was conducted to address the current behaviors of drinking water choices in Koya city; factors that determine the drinking water choices of people; and motivating people to consume less bottled water and concern about the environment by manifesting the quality test of the water samples from both types.

II. MATERIALS AND METHODS

Four samples from Tap water have been collected from different stations throughout the city (General Hospital, Iskan, Hamamok, and Koya University campus); in addition, samples from four different companies of making bottled water which were frequently consumed by the citizen of Koya city were taken from November 2020 to May 2021.

Laboratory tube has been used during collecting the samples and kept under a temperature of 4°C, then these samples directly were taken to the laboratory to quantify the following variables at 21°C: Potential hydrogen (pH), total alkalinity (TA), electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), and dissolved oxygen (DO). Besides, X-ray fluorescence (XRF) has been used to indicate the existence of some other minerals in the samples.

III. RESULTS AND DISCUSSION

A. pH

pH takes the lead in clarification process and disinfection of clean water. PH of the tap water samples was ranged from



6.4 to 7.7; however, it was from 6.1 to 6.6 for the bottled water samples as it is shown in Table 1. Therefore, most of the water samples were found to be in the permissible range of pH value that recommended by the World Health Organization and Environmental Protection Agency in 2006 which is from 6.5 to 8.5 except for the one type of bottle water samples which was just under 6.5.

B. TA

Alkalinity of water is a measure of how much acid it can neutralize (EPA, 2006). For this test, phenolphthalein and methyl red have been used as an indicator. In general, all the samples from both bottled and tap water as it has been demonstrated in Table 2, were in a permissible range which is from 84 to 110 mg/l of CaCO₃. Based on Trick et al.'s research in 2018, the alkalinity of water is due to only bicarbonate (HCO₃⁻) when the presence of hydroxyl (OH) is zero, which is the case here for all the samples of both Tap and Bottled water.

C. TH

TH is the existence of minerals that dissolved in water. Besides, the levels of Ca²⁺, Mg²⁺, and HCO₃⁻ ions increase if the water passes over or through deposits, for instance, Limestone or Gypsum which consequently turns the water into hard water (WHO, 2011). For this test, ammonium purpuras have been used as indicator. Depend on WHO standard in 2006 all the samples were considered to be soft (from 40 to 65 mg/l) except for the University area which

was fluctuating from 70 to 77 mg/l (Table 3). They are all in a suitable range for a good quality of water though.

D. EC

Water pollution can be detected when the value of EC is high (Xianhong, et al., 2021). EC of the tap water was fluctuated between 297 to 570 uS/cm, whereas it ranged from 136 to 340 uS/cm for the bottled water (Table 4). Therefore, the conductivity value is considered to be safe as for both types of water except for the University as the range should not exceed 400 μS/cm based on the WHO slandered in 2006.

E. TDS

It shows the sum of dissolved solids and minerals which is entered to the water naturally or artificially (Hayashi, 2004). In spite of the water of Hamamok and Iskan (which starts from 190 to 198 mg/l respectively), University and Hospital water contain higher amount of TDS (ranges from 202 to 365 mg/l respectively). Besides, the same difference has been noticed among the bottled water samples. B4 contains the most amount of TDS (about 217.1 mg/l), whereas the rest were fluctuated from 88 to 102 mg/l (Table 5).

Depend on the WHO in 1996, the rate of TDS should be <1000 mg/l, yet a very low rate (<100 mg/L) gives a flat, insipid taste to the water. High concentration of TDS may

TABLE I
ILLUSTRATES PH FOR THE SAMPLES OF BOTH TAP AND BOTTLED WATER

Samples	November	December	January	February	March	April
Bottled water						
B1	6.2	6.31	6.32	6.30	6.1	6.0
B2	6.5	6.54	6.6	6.55	6.5	6.43
B3	6.51	6.52	6.52	6.5	6.5	6.4
B4	6.45	6.46	6.5	6.44	6.48	6.5
Tap water						
General	6.6	6.67	6.7	6.61	6.6	6.5
Hospital						
Iskan	7.6	7.7	7.7	7.47	7.45	7.4
Hamamok	6.43	6.45	6.5	6.5	6.5	6.4
Koya	6.5	6.5	6.55	6.5	6.5	6.45
University						

TABLE II
SHOWS TOTAL ALKALINITY IN MG/L FOR THE SAMPLES OF BOTH TAP AND BOTTLED WATER

Samples	November	December	January	February	March	April
Bottled water						
B1	90	90	91	92	92	93
B2	85	84	86	87	86	86
B3	88	89	90	90	90	90
B4	88	88	89	89	90	90
Tap water						
General Hospital	92	91	95	96	98	98
Iskan	108	108	101	109	109	110
Hamamok	98	90	91	99	99	100
Koya University	100	100	101	100	102	101

TABLE III
DEMONSTRATE THE TOTAL HARDNESS IN MG/L, FOR THE SAMPLES OF BOTH TAP AND BOTTLED WATER

Samples	November	December	January	February	March	April
Bottled water						
B1	55	55	50	56	56	56
B2	40	41	41	41	41	41
B3	41	40	40	42	43	43
B4	42	42	44	45	45	45
Tap water						
General	48	48	48	50	50	49
Hospital						
Iskan	60	60	61	65	64	65
Hamamok	60	62	60	60	60	64
Koya	70	71	71	72	76	77
University						

TABLE IV
REPRESENTS EC IN US/CM FOR THE SAMPLES OF BOTH TAP AND BOTTLED WATER

Sample	November	December	January	February	March	April
Bottled water						
B1	160	158.5	158	159	159	160
B2	140	138.1	138	139.7	140	140.5
B3	140	136	135.6	137.9	138	138
B4	341	336	335	338	338	340
Tap water						
General	320	316	316	317	320	322
Hospital						
Iskan	310	305	305	308	308	309
Hamamok	300	298.1	297	299	301	301
Koya	568	568.1	567	569	569	570
University						

TABLE V
DEMONSTRATES TDS IN MG/L FOR THE SAMPLES OF BOTH TAP AND BOTTLED WATER

Samples	November	December	January	February	March	April
Bottled water						
B1	102.4	101.4	101.12	101.76	101.7	102
B2	89.9	88.38	88.3	89.4	89.5	89.5
B3	89.6	87.1	86.8	87.68	87.8	90
B4	218.2	215.1	214.4	216.32	217	217.1
Tap water						
General Hospital	204.8	202.2	202.3	202.88	203.45	203.67
Iskan	198.4	195.2	195.2	197.2	198.3	198.5
Hamamok	192	190.8	190.1	191.36	190.6	192.3
Koya University	363.5	363.6	362.8	364.16	364.3	364.8

TABLE VI
SHOWS DO IN MG/L FOR THE SAMPLES OF BOTH TAP AND BOTTLED WATER

Samples	November	December	January	February	March	April
Bottled water						
B1	2.5	2.6	2.5	2.48	2.3	2.29
B2	0.6	0.65	0.7	0.61	0.5	0.5
B3	2.4	2.4	2.5	2.23	2.2	2.2
B4	2.4	2.5	2.4	2.35	2.35	2.33
Tap water						
General Hospital	5.3	5.4	5.5	5.45	5.4	5.2
Iskan	5.5	5.5	5.6	5.56	5.56	5.3
Hamamok	6.5	6.6	6.6	6.56	6.55	6.44
Koya University	5.7	5.8	5.7	5.60	5.55	5.53

cause problems whom suffer from kidney and heart diseases, (Meride and Ayenew, 2016). Thus, it is considered to be lower than the permissible range for both B2 and B3

F. DO

The high concentrations of oxygen in water indicate good quality. DO is temperature and somewhat on atmospheric pressure dependence, similarly, EC, TDS, Salinity, and oil and grease decreases the rate of DO exponentially (Sen Gupta and McNeil, 2012). Based on the measurements, DO from the tap water samples were fluctuated from 5.2 to 6.6 mg/l whereas its range for the bottled water was from 0.6 to 2.6mg/l as it represented in Table 6. Despite of the tap water, bottled water considered being under the standard limit of EPA (Chapman, 1986) (5–9 mg/L) this might be due to the Biochemical oxygen demand (BOD) that occurs from the beginning of preserving water inside the bottle. Whereas, aeration helps the rivers reoxygenate that mostly tap water comes from.

G. Element Contents

The WHO in 2006 declared that the concentration of some minerals is crucial to life, for instance, the high concentration of Arsenic, Fluoride, and aluminum leads to many different type of disease, such as, cancer, teeth mottling, and Alzheimer. For this test, XRF has been used to determine the amount of the minerals that exist in the water (Fig. 1). Samples from both B1 and B2 as the bottled water, and General Hospital (Tap 1) and the university area (Tap2) as

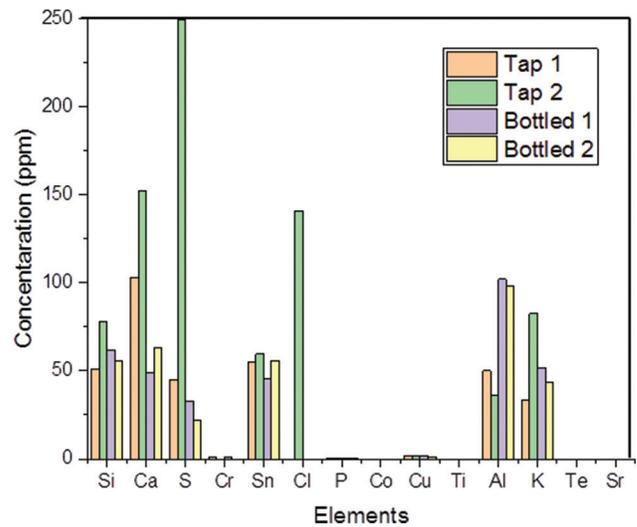


Fig. 1: X-ray fluorescence for the element concentration in ppm for the samples of both tap and bottled water.

the Tap water have been taken as they were found to contain higher amount of TH, EC, and TDS compare to the rest of the samples. In this test, Al was found to be present in a high concentration in both bottled and tap water; however, its concentration is much higher in a bottle water. This might be due to the use of the aluminum salt as coagulants for reducing the level of organic matter, color, turbidity, and microorganism (WHO, 2006)

IV. CONCLUSION

Since scientists developed water quality criteria to provide basic scientific information about the effects of pollutants in water, and to describe the requirements to protect and maintain an individual use (Enderlein, Enderlein and Williams, 1997). Therefore, testing the water that uses by the consumers or residents is essential.

Recently, plastic pollution in both land and water is a colossal concern world widely, which contributed by bottled water. To tackle this problem, this study has been done which could enhance raise awareness to reduce the usage of bottled water and return back the trust of tap water.

Based on the results from tests that were required for this comparative study between four different stations for the tap water and four different companies of making bottled water samples throughout Koya city, the quality of tap water is much higher compare to the bottled water. For instance, the amount of Al and TDS were too high for the bottled water which could cause a real damage to health, beside the low amount of DO existed in them.

Hence, the tap water is of a higher quality, environmentally friendly choice, and cheaper option, why would people still use the bottled water? Is it because of the taste and/or Personal and Family Habits, easy to get mostly everywhere? Or is it due to the quality that they have been objected to it through the media? To deal with these questions and answer them properly, it's crucial for

the government to educate our nation by schooling them about the water quality which mainly depends on these variables: pH, total alkalinity, T.H, TDS, EC, DO, and mineral content, and the damage they may cause to the environment through the plastic pollution.

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