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Water Quality Index (WQI) for Main Water Treatment Plants in Basra City, Iraq

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ABSTRACT

The Water Quality Index (WQI), a paramount tool for appraising potable water quality, significantly influences human health and survival. It is an index that quantifies the cumulative effect of various water quality parameters, which are integral in the computation of the index. This study was undertaken to calculate the WQI of ten water treatment facilities in Basra city, for the period spanning January to December 2021, through an evaluation of the physical and chemical attributes of the raw and treated water. Regrettably, it was found that none of the treatment plants under study produced water deemed fit for human consumption. Notably, only the Al-Garmma 1 plant was classified as delivering water of poor quality, while the remaining facilities produced water of either very poor quality or, more alarmingly, unfit for human consumption. This constitutes a grave public health concern for the residents of Basra Governorate. The findings necessitate the exploration of alternative, superior treatment methodologies to those currently employed in these facilities. It is a stark reminder of the critical role played by water treatment infrastructure in safeguarding public health and underscores the urgent need for enhancements in treatment processes in the Basra region. This study serves as a stepping-stone towards reforming water treatment practices, ultimately contributing to improved public health outcomes.

1. INTRODUCTION

Water, an elemental resource crucial to sustaining life, constitutes approximately 71% of the Earth's surface and is indispensable to all known life forms [1]. Despite its relative abundance, around a third of the world's population endures a severe scarcity of drinkable water, a situation exacerbated chiefly in underdeveloped countries due to rapid population growth and concomitant large-scale agricultural and economic expansion [2]. With 90% of polluted water being discharged into rivers and streams [3], the mounting demand for fresh water has inevitably rendered water management a pressing global concern [4]. Regular monitoring of water quality is integral to the sustainable management of water resources [5]. Water quality information delineates the biological, chemical, and physical constituents of water and their interactions, thereby facilitating its appropriate use [6]. The purification process, necessary to render water fit for human consumption, requires removal of undesirable physical elements such as taste and odor, as well as chemical and microbiological contaminants [7]. Various treatment processes, inclusive of flocculation, sedimentation, filtration, and disinfection, are implemented in treatment plants to ensure the provision of safe water to communities [8]. The characteristics of the raw water source and the technical and operational conditions within the treatment plant units largely determine the quality of the treated water [9]. Regular evaluation of the operation of water treatment plants, via monitoring of the quality of treated water, is crucial to ensure compliance with legal requirements [10]. Assessment of raw and treated water quality typically involves physical, chemical, and biological parameters [11].

The Water Quality Index (WQI) is a mathematical tool that synthesizes a significant volume of water data (standard parameters) into a single number [12], serving as a pivotal and widely employed technique in ascertaining water quality and requisite treatment [13]. This index enables categorization of water for various uses and provides a standard for evaluating management strategies [14]. The Weighted Arithmetic Index Method (WAWQI), employed in this study, is a popular approach yielding practical and reasonable results.

Basra, a city in southern Iraq, predominantly relies on the Shatt al-Arab River for its water supply, which also caters to agricultural, industrial, and miscellaneous uses. Most of Basra's water treatment plants, classified as classic plants treating surface water via coagulation, flocculation, sedimentation, and filtration, are situated alongside the Shatt al-Arab River [15]. Numerous studies have evaluated these plants' efficacy, either by assessing the quality of water they produce or by examining the efficiency of their individual treatment units.

The primary objectives of this study include evaluating the physical and chemical properties of the river water (raw water) and the water output from the treatment plants to determine the water quality of the Shatt al-Arab River and the treated water produced by these plants, using the WQI as a benchmark.

2. STUDY AREA

Iraq's main resource is surface water. Iraq is dependent on the waters of the Tigris and Euphrates and their tributaries, as well as the Shatt al-Arab river, which is made up of the Tigris and Euphrates' confluence in the town of Qurna in the Basra province (see Figure 1). With a length of 192 km, the water from the Shatt al-Arab river is discharged into the Arabian Gulf. Depending on the amount of water originating from Turkey and Syria, as well as the amount of rain and snow that falls, the amount of water varies from year to year [16].

Figure 1. Locations of water treatment plants in Basra city

Table 1. Details of water treatment plants

Water Treatment Plant Name	Location		Water Treatment Plant Type
	Longitude	Latitude	
Mihejran	47°51'14.49"E	30°26'58.30"N	Multiple package units
Al Garmma 1	47°44'45.44"E	30°34'20.64"N	Multiple package units
Al Jubila 1	47°48'46.42"E	30°33'1.11"N	Conventional
Al Bradiah 1	47°51'20.00"E	30°30'9.18"N	Conventional
Shatt Al Arab	47°52'24.15"E	30°32'49.95"N	Multiple package units
Al Zubair	47°46'32.25"E	30°13'14.34"N	Conventional
Al Fao	48°26'53.33"E	29°59'24.62"N	Conventional
Al Nashwa	47°39'27.03"E	30°45'22.20"N	Conventional
Al Qurna	47°20'17.68"E	30°58'27.00"N	Conventional
Al Ribat	47°49'51.60"E	30°32'9.60"N	Multiple package units

All water treatment plants in Basra were constructed along the banks of the Shatt al-Arab river because it is the city's primary source of fresh water. To determine the quality of the water produced by these plants and its appropriateness for drinking [17]. The city center and all of its associated districts were represented by the ten largest water treatment plants in Basra Governorate (Table 1), which were chosen for analysis of the water's chemical and physical properties and calculation of the water quality index for each of these plants.

3. MATERIAL AND METHODS

To analyze the water provided to Basra for the time period from January 2021 to December 2021, ten water treatment plants in the governorate's center and its environs were chosen, and samples of the water leaving these plants were taken. Every month (Certain days of the month), water samples were collected for each of the stations listed in Table 1 in plastic bottles, which were then put in a cooler box and delivered to the lab.

Each sample was examined to determine 12 parameters, including pH, turbidity, Total Hardness (TH), electrical conductivity (EC), alkalinity, calcium (Ca), magnesium (Mg), chloride (Cl), sulfate (SO_4), Total Dissolved Solids (TDS), sodium (Na) and potassium (K) using guidelines from Examination of Water and Wastewater [18].

3.1 Water Quality Index (WQI)

One of the most common methods for expressing water quality is the WQI. We can determine the water quality and the necessary treatment procedures by knowing the value of the WQI [12]. A water quality index is a mathematical technique for expressing water quality by combining a lot of measurable water data into a single value. The WQI is a tool that may be used to compare the quality of water from various sources and to provide a rough understanding of any potential water issues in a given location [19].

Several national and international organizations have developed various water quality indexes [20]. In this study, the weighted arithmetic index approach of the parameter was implemented from numerous publications [21]. The most frequently measured water quality variables are used in the Weighted Arithmetic Water Quality Index Method, which categorizes the water quality according to the level of purity [22]. Twelve physicochemical factors (pH, EC, TDS, K, Na, Mg, Ca, TH, Cl, turbidity, alkalinity, and SO_4) were taken into account in a four-stage method to calculate the WQI for the suggested case study.

Step 1: Calculating the inverse of the standardized maximum concentration (C_n) to obtain the proportionality constant "K" in Eq. (1). The number of parameters used in the investigation affects the value of k [23].

$$K = \frac{1}{\sum_{n=1}^{m} \frac{1}{C_n}} \tag{1}$$

Step 2: Using Eq. (2), the relative weight (W_n) was then calculated.

$$W_n = \frac{K}{C_n} \tag{2}$$

Step 3: The third step was utilizing Eq. (3) to generate the quality rating scale (Q_n) for each parameter.

$$Q_n = \left[\frac{S_n - S_0}{C_n - S_0}\right] * 100 \tag{3}$$

where,

S_n is the measured concentration of each parameter.

S_0 is the ideal value of each parameter in pure water.

S_0=0 (except pH =7.0 and Dissolved Oxygen = 14.6 mg/l).

Step 4: Lastly, the water quality index (WQI) was calculated using the Eq. (4).

$$WQI = \frac{\sum W_n * Q_n}{\sum W_n} \tag{4}$$

A comparison is made between the value of the water quality index and Table 2, which is separated into stages based on water quality, from excellent to non-potable [24].

Table 2. Types of WQI [24]

Type of Water	WQI Range	Grinding	Possible Usage
Excellent water	0 - 25	A	Drinking, Irrigation and Industrial
Good water	26 - 50	B	Domestic, Irrigation and Industrial
Poor water	51 - 75	C	Irrigation and Industrial
Very poor water	76 - 100	D	Irrigation
Unfit for consumption	> 100	E	Restricted use for Irrigation

4. RESULTS AND DISCUSSION

In this study, Appendixes 1 and 2 display the statistical analysis of physical and chemical parameters of treated water from 10 Basra water treatment plants for the time period of January 2021 to December 2021. The parameters measured at these stations' maximum, minimum, mean, and standard deviation are displayed in Appendixes 1 and 2, along with a comparison to the WHO's [25] and Iraqi standards' [26] upper and lower bounds (Table 3).

Table 3. The classification of water based on Iraqi and WHO standards [25, 26]

Parameter	Iraq Standard	WHO Standard	Unit
pH	6.5 - 8.5	6.5 - 8.6	
Electrical Conductivity (EC)	400	400	µs/cm
Turbidity	5		NTU
Alkalinity	20	50 - 150	mg/l
Total Hardness (TH)	500	500	mg/l
Total Dissolved Solids (TDS)	1000	1000	mg/l
Calcium (Ca)	100	75	mg/l
Sodium (Na)	200	200	mg/l
Potassium (K)	12	12	mg/l
Chloride (Cl)	250	250	mg/l
Magnesium (Mg)	50	50	mg/l
Sulfate (SO4)	250	250	mg/l

Figure 2 illustrates the pH range of the water leaving the water treatment plants used in this study. The Mihejran plant had the lowest pH levels, at 6.9, while the Al-Nashwa plant had the highest pH levels, at 8.2. All pH measurements fall within the acceptable levels established by the World Health Organization and Iraqi guidelines (see Table 3).

Electrical conductivity (EC) is a measure of positive ions (cations), which greatly affect the taste and thus the acceptability and palatability of water by the consumer [27]. EC is a metric that is assessed for an indirect indication of water salinity in the water and agriculture sectors [28]. This number represents the total amount of dissolved salts [29]. EC is influenced by temperature, ionic concertation, and the types of ions that are present in water. Therefore, EC offers a qualitative evaluation of the water quality [30]. Figure 3 illustrates the EC of treated water from all water treatment plants, which is greater than the permitted limits of the Iraqi standard and the WHO (see Table 3).

Colloidal and ultra-fine dispersions in water bodies are the main cause of turbidity. Drinking water quality in the distribution network is likely to deteriorate as a result of rising microbial counts, raised iron concentrations, or rising turbidity, all of which have an impact on the taste, odor, and color of water. Pathogens and opportunistic microorganisms can find refuge in turbidity [27]. In Figure 4, the results showed a variance in the amount of turbidity in the treated water from the treatment plants in this study, with the biggest amounts coming from the Al-Fao plant (24.9 NTU) and the Al-Qurna plant (24 NTU), and the lowest amounts from the Al-Nashwa plant 1 NTU (see Appendixes 1).

Alkalinity is a sign of a water's capacity to neutralize acids that have been added to it. This parameter therefore represents the buffering capacity of waters. The three most significant substances that can influence the alkalinity of water are dissolved hydroxides, carbonates, and bicarbonates [31]. Drinking water guidelines state that a water supply should have moderate amounts of alkalinity to reduce the corrosive effects of acidity [32]. Figure 5 demonstrates that, save from the Al-Ribat plant for Dec. 2021 and the Al-Zubair plant for Sep. 2021, all of the treated water from the treatment plants has an alkalinity concentration that is higher than what is permitted by WHO and Iraqi standards (see Table 3). Since the pH did not exceed 8.3, this means that the cause of the alkalinity of the treated water from these stations are bicarbonate ions [17].

Results for the treated water in the water treatment plants in this study during the period of Jan. 2021 to Dec. 2021 showed variations in the concentrations of parameters TH, TDS, Ca, Na, K, Cl, Mg, and SO_4 (see Tables 2 and 3). The data showed that the Mihejran plant had the highest concentration of TH (1880 mg/l), while the Shatt Al-Arab plant had the lowest concentration 303 mg/l (Figure 6). In addition, the Mihejran plant's treated water had the highest concentration of TDS (7158 mg/l), while the Shatt Al-Arab plant had the lowest concentration 546 mg/l (Figure 7). In Figure 8, the Mihejran plant has the highest Ca concentration (380 mg/l), while the Shatt Al Arab and Al Ribat plants have the lowest calcium concentrations (62 mg/l). In Figure 9, the Mihejran plant has the highest Na concentration (1880 mg/l) and the Shatt Al Arab plant has the lowest sodium concentration (74 mg/l) in the treated water.

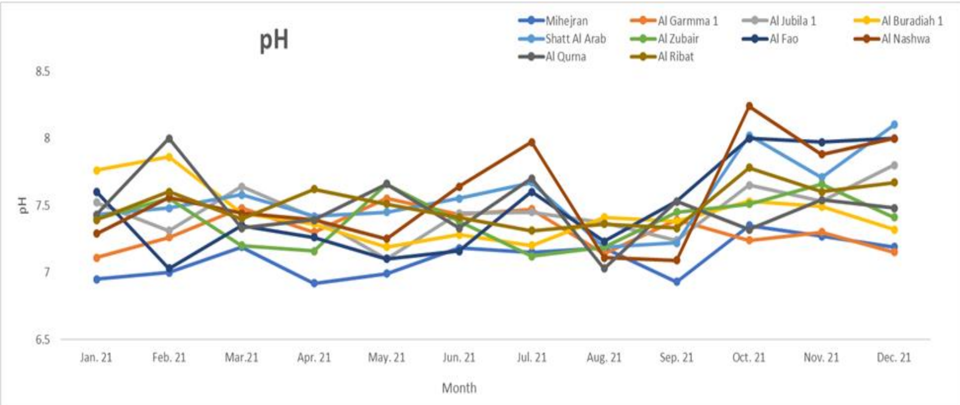

Figure 2. pH value of treated water from WTPs

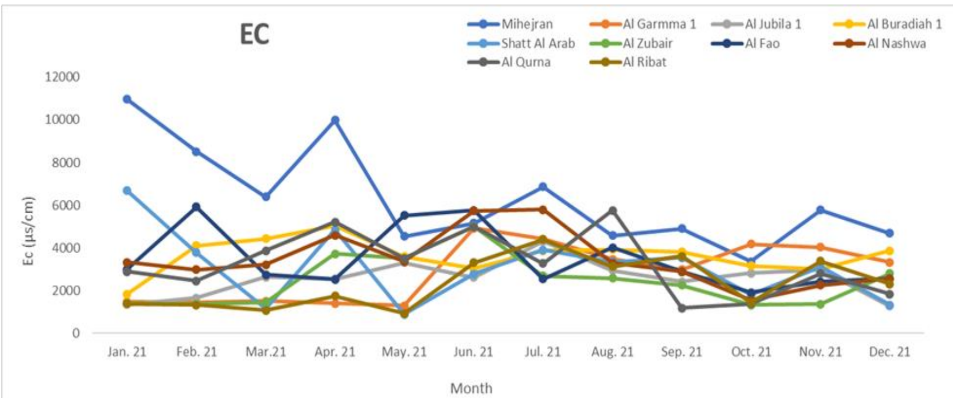

Figure 3. EC concentration of treated water from WTPs

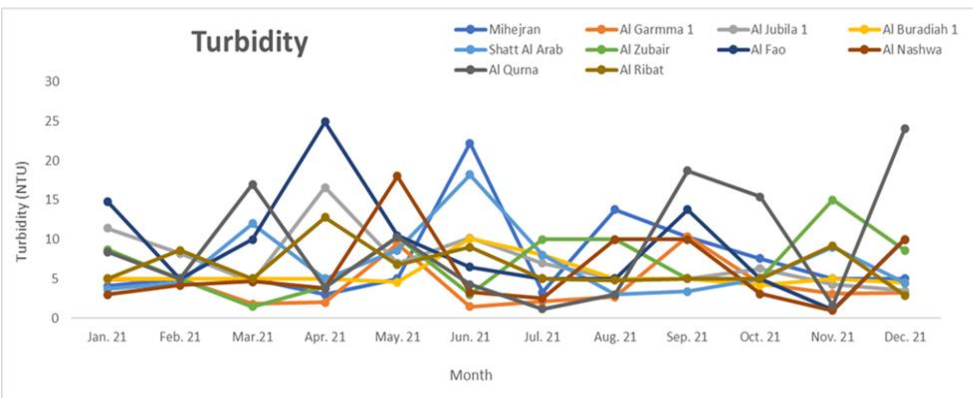

Figure 4. Turbidity concentration of treated water from WTPs

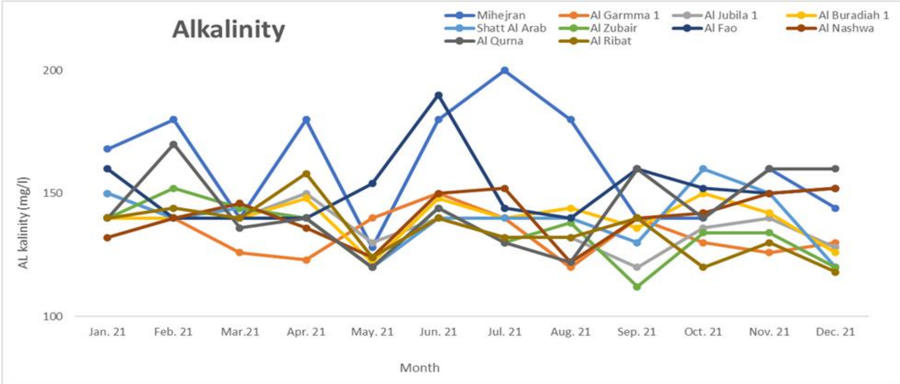

Figure 5. Alkalinity concentration of treated water from WTPs

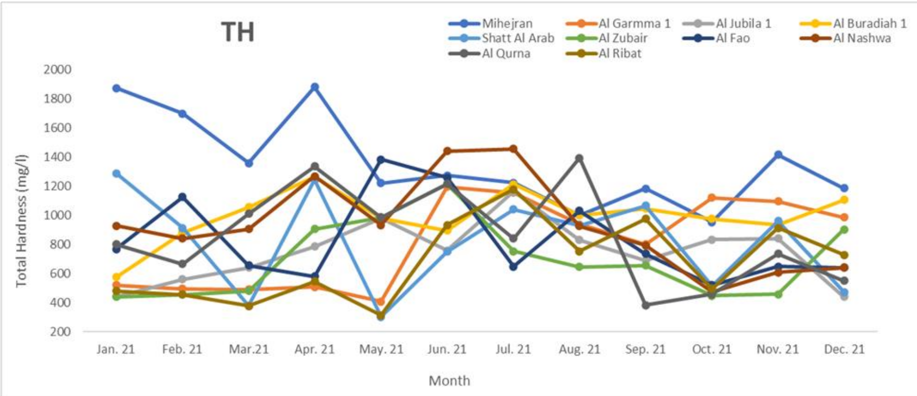

Figure 6. Total hardness concentration of treated water from WTPs

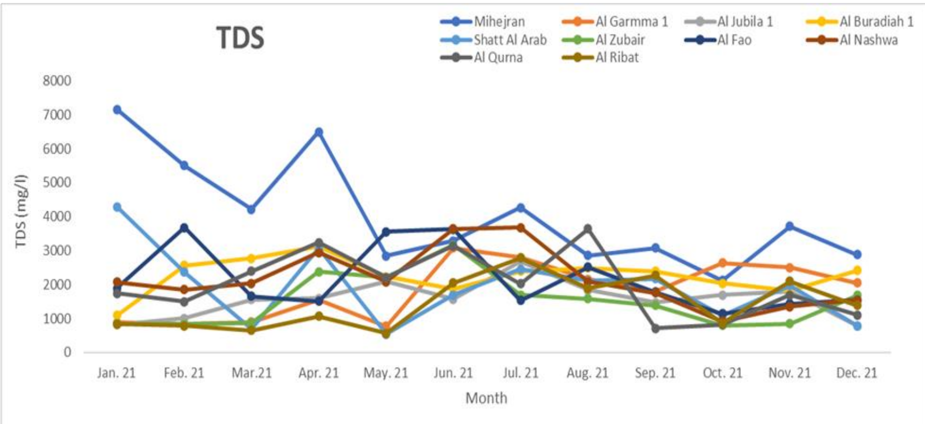

Figure 7. Total dissolved solids concentration of treated water from WTPs

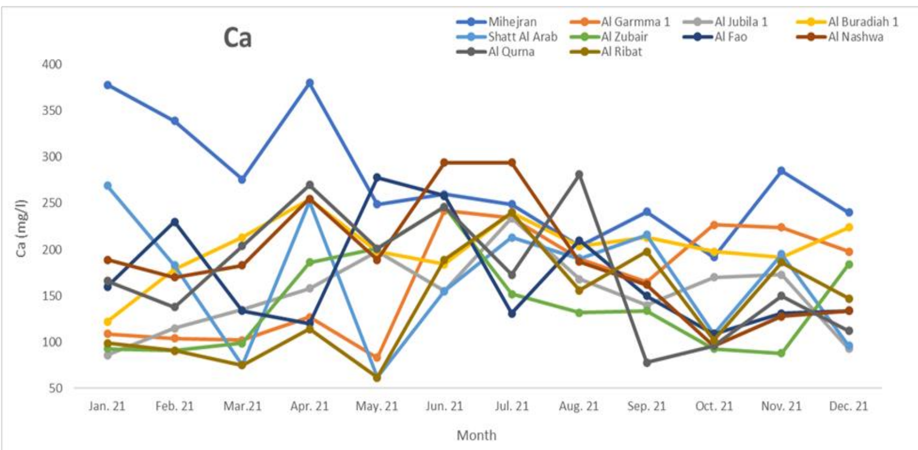

Figure 8. Ca concentration of treated water from WTPs

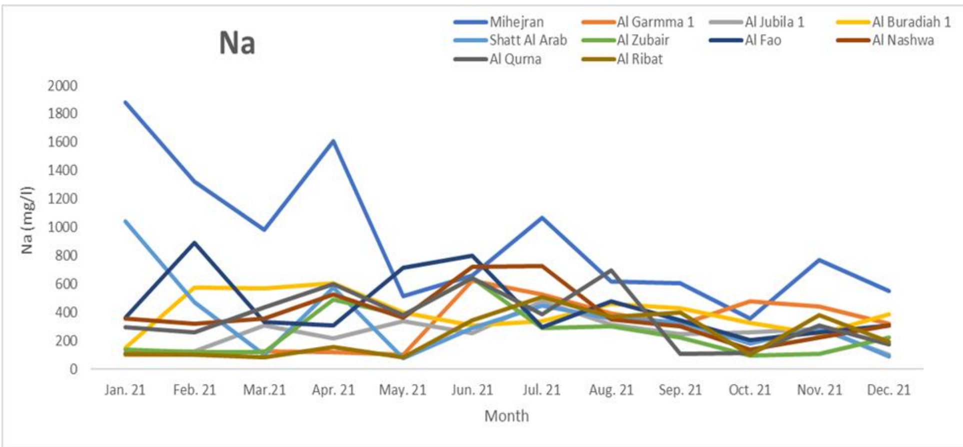

Figure 9. Na concentration of treated water from WTPs

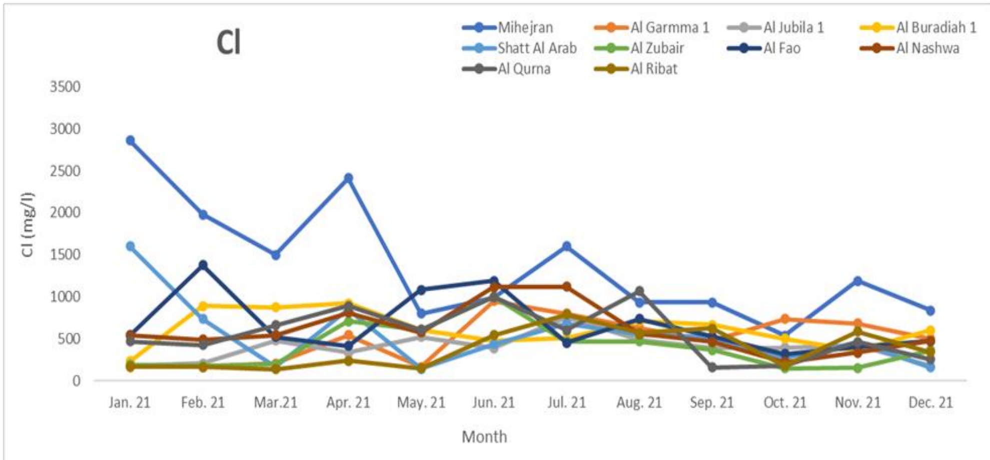

Figure 10. Cl concentration of treated water from WTPs

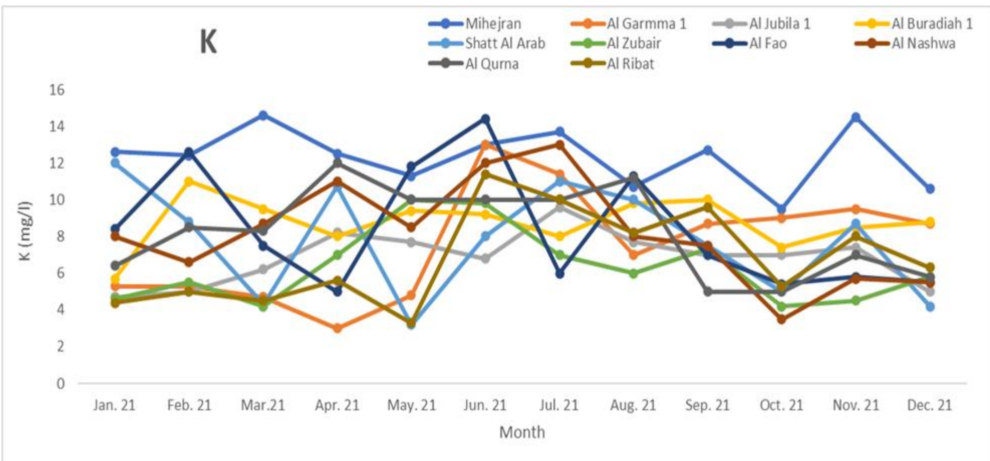

Figure 11. K concentration of treated water from WTPs

Figure 10 illustrates the difference in Cl concentrations in the treated water, with the Mihejran plant having the greatest concentration (2860 mg/l) and the Al-Ribat plant having the lowest concentration (136 mg/l). Additionally, Figure 11 demonstrates that the Al-Garmma 1 plant records the lowest K concentration (3 mg/l) and the Mihejran plant records the highest K concentration (14.6 mg/l). The treated water in the Mihejran plant has the highest level of Mg (227 mg/l), while the Mg concentration in the Shatt Al-Arab plant is the lowest (36 mg/l), according to Figure 12. The concentration of SO_4 in the water from the Al-Jubaila 1 plant has the lowest concentration (971 mg/l), while the Mihejran plant has the greatest concentration (1175 mg/l), this is demonstrated in Figure 13.

4.1 WQI analysis

As shown in Tables 2 and 3, the weighted arithmetic index method was used to calculate the water quality index by measuring a few physical and chemical characteristics of raw water (incoming water) and treated water (outgoing water) at ten water treatment plants in Basra Governorate from January

2021 to December 2021. Figure 14 depicts the value of the water quality of the treatment plants used in this study, and it reveals that none of them provide water that is potable or of high quality (excellent or good). Figure 14 demonstrates the poor water quality of the Al-Garmma 1 station's treated water. very Poor water quality is provided by the Al-Jubila 1, Al-Buradiah 1, Shatt Al-Arab, Al-Zubair, Al-Nashwa, and Al-Ribat plants. The plants in Mihejran, Al-Fao, and Al-Qurna provide water that is unfit for human consumption.

Three water quality readings were taken for each research plant, and Figure 15 illustrates the considerable variation between those values over the course of a complete year from January 2021 to December 2021. The first value shows the minimum value for the quality of treated water, the second value shows the average values (mean) for the quality of treated water, and the third value displays the maximum values for the year's treatment. If the minimum value for the quality of the treated water at these stations is used, it has been shown that the majority of the plants provide good water quality, but when the maximum value is used, we discover that all of the plants are unfit for human consumption.

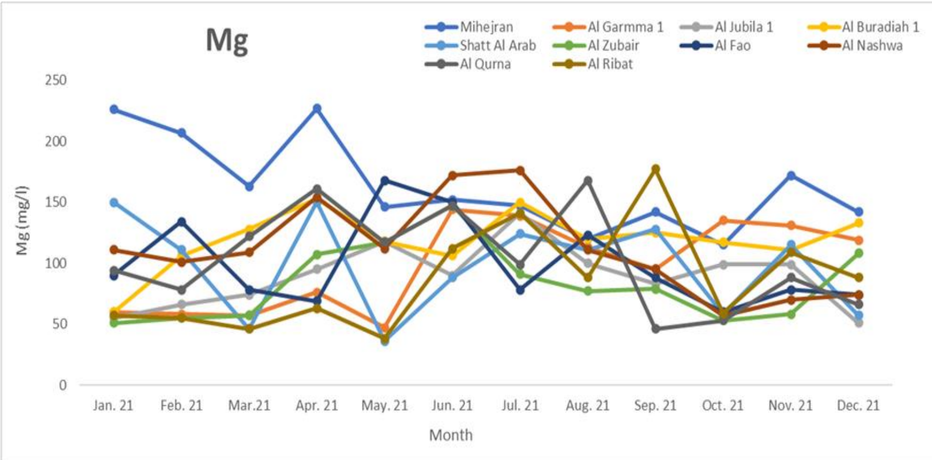

Figure 12. Mg concentration of treated water from WTPs

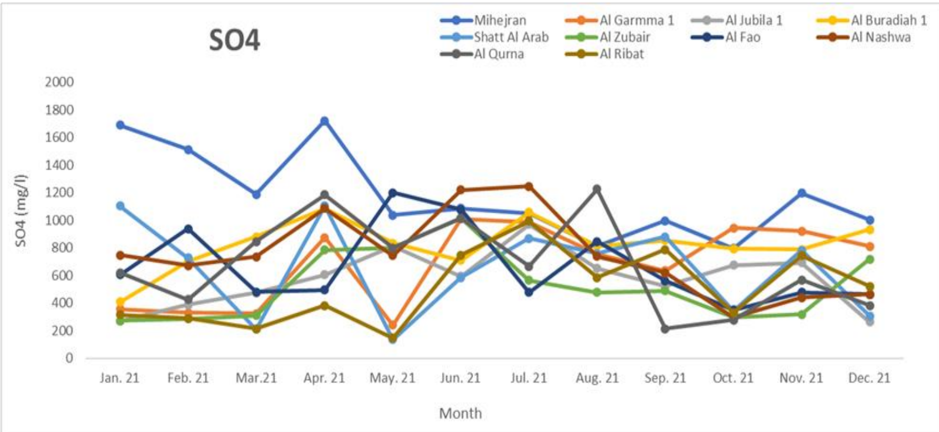

Figure 13. SO_4 concentration of treated water from WTPs

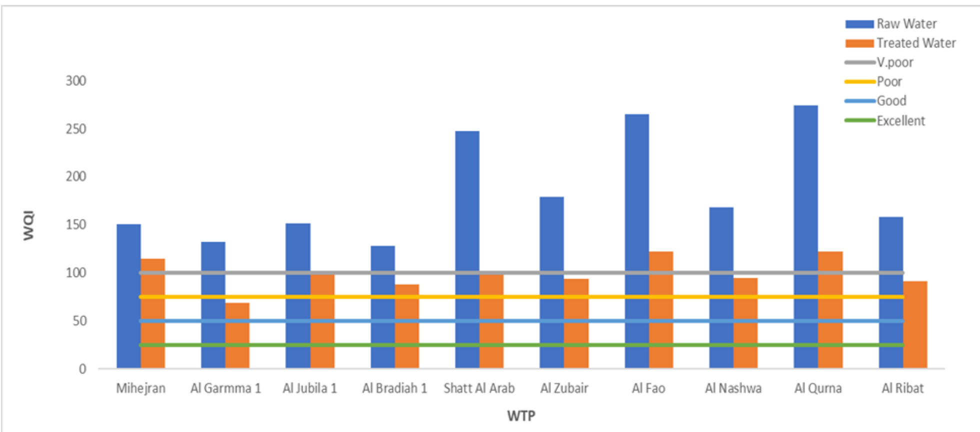

Figure 14. WQI for the raw and treated water for WTPs

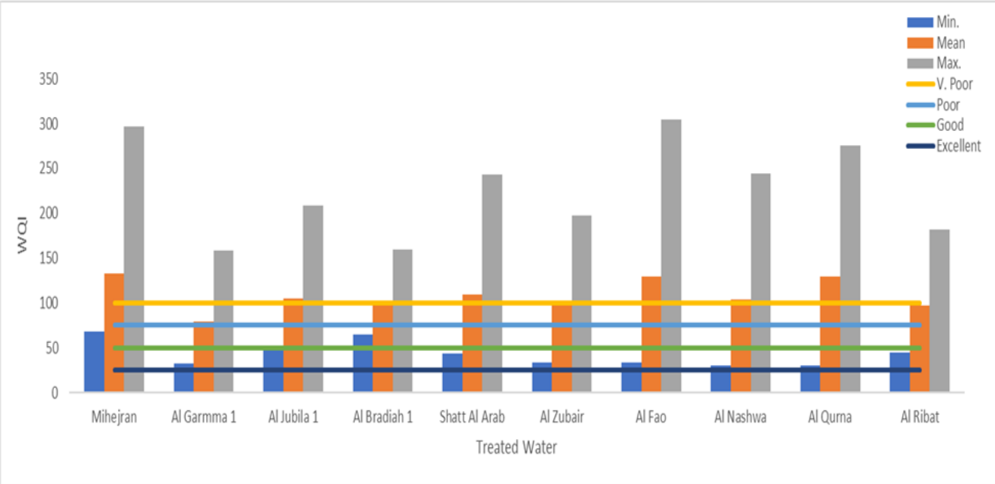

Figure 15. Variation of WQI for the treated water for WTPs

5. CONCLUSION

The current study was carried out on the primary source of raw water (Shatt Al-Arab River) and treated water for ten treatment plants in the Basra Governorate during the time period of January 2021 to December 2021. By assessing some of the raw water's and treated water's physical and chemical properties, as well as the WQI for each of these plants. The results showed that:

- By examining some of the physical and chemical properties of the water entering each plant, it was demonstrated that the Shatt Al-Arab River's water quality is quite low. The majority of these data, including total dissolved salts, salinity, turbidity, total hardness, and elevated calcium and sulfate concentrations, were discovered to be higher than those permitted by the WHO and Iraqi regulations.
- The Shatt al-Arab River's salinity and insufficient supply of water are the main causes of the river's water quality decline. The inputs of municipal, industrial, and agricultural wastes that are released onto the river bank are the main cause of the deterioration in water quality.
- The results showed that the value of the WQI for all treatment plants in this study are very poor values and do not provide potable water. This has an impact on the lives of people living in Basra Governorate. As a result, it is necessary to reevaluate the treatment strategy utilized in these plants and find more efficient remedies.
- One of the main causes of the decline in water quality produced by the water treatment plants in the city of Basra is management, operation, and lack of maintenance in these stations. As a result, these stations need to undergo routine maintenance, and continuous water quality checks are required.

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NOMENCLATURE

C_n Standard maximum concentration typically provided by WHO (Table 3).
m number of computed variables.
K The proportionality constant.
S_n The measured concentration of each parameter.
S_0 The ideal value of each parameter in pure water. S_0=0 (except pH =7.0 and Dissolved Oxygen = 14.6 mg/l).

APPENDIX

Appendix 1. Physical and chemical parameters (Minimum–Maximum) of water from WTPs

Parameter	Mihejran	Al-Garmma 1	Al-Jubila 1	Al-Buradiah 1	Shatt Al-Arab	Al-Zubair	Al-Fao	Al-Nashwa	Al-Qurna	Al-Ribat
Raw Water										
pH	7.21-7.35	7.38-7.75	7.41-7.85	7.32-7.89	7.34-8.26	7.29-8.09	7.12-8.04	7.29-8.29	7.09-8.04	7.35-8.04
EC (μs/cm)	3379-10970	1300-5446	1356-4315	1836-5199	908-6692	1337-5030	1947-5509	1551-5808	1181-5756	871-4718
Turb.(NTU)	4.2-22.2	3-27.3	5.8-20.7	5.2-17.8	4.5-90	5.8-37.2	5-95	2.1-35.5	2.7-88	10-23

Alka. (mg/l)	148-200	128-160	130-160	124-156	120-168	120-156	142-190	122-160	126-174	120-160
TH (mg/l)	968-1880	414-1379	440-1170	576-1307	303-1288	432-1232	528-1332	472-1464	382-1392	296-1239
TDS (mg/l)	2138-7158	796-3516	818-2704	1100-3248	564-4318	822-3200	1172-3456	932-3696	726-3682	526-2964
Ca (mg/l)	198-380	86-277	86-237	122-263	62-269	88-250	112-269	96-298	78-281	59-240
Na (mg/l)	363-1880	107-701	104-488	152-616	81-1056	99-655	208-840	140-728	107-703	75-542
K (mg/l)	9.7-14.6	5.2-11.8	5-10	6-10.6	3.5-12.4	4.2-11	5-13.6	3.7-13.3	5-12.4	3-12
Cl (mg/l)	540-2860	168-1065	180-760	234-930	146-1610	150-1015	320-1275	226-1125	162-1075	136-825
Mg (mg/l)	115-227	49-168	53-141	60-158	36-150	51-148	61-161	57-175	46-168	36-150
SO_4 (mg/l)	803-1723	247-1200	272-981	412-1128	141-1108	265-1033	358-1151	302-1251	216-1228	134-1074
Treated Water										
pH	6.92-7.35	7.11-7.55	7.1-7.8	7.19-7.86	7.19-8.1	7.12-7.66	7.03-8	7.09-8.24	7.03-8	7.31-7.78
EC (µs/cm)	3360-10970	1273-4908	1270-4290	1824-5022	887-6680	1325-5003	1904-5916	1538-5794	1178-5748	923-4383
Turb.(NTU)	3-22.2	1.5-10.4	3.5-16.6	4.2-10.1	3-18.2	1.5-15	1.1-24.9	43101	1.2-24	2.9-12.8
Alka. (mg/l)	128-200	120-150	120-150	122-150	120-160	112-152	140-190	122-152	120-170	118-158
TH (mg/l)	952-1880	407-1194	440-1162	576-1263	303-1288	440-1216	520-1384	472-1456	382-1392	311-1178
TDS (mg/l)	2122-7158	778-3084	782-2690	1094-3132	546-4286	804-3170	1148-3682	924-3682	718-3640	568-2782
Ca (mg/l)	192-380	83-242	86-234	122-254	62-269	88-246	109-278	96-294	78-281	62-240
Na(mg/l)	358-1880	100-622	101-478	146-607	74-1043	96-644	204-889	137-725	104-696	82-510
K (mg/l)	9.5-14.6	3-13	4.7-9.6	5.7-11	3.2-12	4.2-10	5-14.4	3.5-13	5-12	3.3-11.4
Cl (mg/l)	536-2860	160-950	172-750	230-920	140-1600	146-1000	316-1375	222-1120	159-1065	136-790
Mg (mg/l)	115-227	47-144	51-141	60-153	36-150	51-147	60-168	57-176	46-168	38-177
SO_4 (mg/l)	798-1723	242-1011	265-971	410-1087	138-1105	272-1018	351-1200	300-1247	214-1225	149-995

Appendix 2. Physical and chemical parameters (mean ± standard deviation) of water from WTPs

Parameter	Mihejran	Al-Garmma 1	Al-Jubila 1	Al-Bradiah 1	Shatt Al-Arab	Al-Zubair	Al-Fao	Al-Nashwa	Al-Qurna	Al-Ribat
Raw Water										
pH	7.4±0.1	7.5±0.1	7.6±0.1	7.5±0.2	7.7±0.2	7.7±0.2	7.6±0.3	7.7±0.3	7.7±0.3	7.7±0.2
EC (µs/cm)	6404±2402	3204±1444	2647±868	3669±836	3103±1682	2543±1228	3440±1297	3467±1302	3282±1482	2383±1366
Turb. (NTU)	10.7±6.3	10.5±6.4	12.7±4.4	9.7±3.6	22.7±22.1	15.8±9.7	24.7±25.2	13.8±11.2	25.6±24.2	13.5±3.7
Alka. (mg/l)	175±21	141±8	142±10	143±9	142±13	137±11	156±13	143±11	148±14	138±11
TH (mg/l)	1380±309	881±328	774±220	1000±183	825±336	721±265	826±266	936±316	874±332	691±322
TDS (mg/l)	4120±1610	2003±939	1640±552	2303±530	1948±1085	1592±789	2140±853	2193±862	2046±952	1477±871
Ca (mg/l)	280±61	180±65	157±44	204±35	169±68	146±54	169±53	191±63	178±66	140±63
Na (mg/l)	929±489	351±203	265±110	406±136	357±272	271±181	435±206	394±181	371±200	242±173
K (mg/l)	12.7±1.6	8.2±2.4	7.4±1.5	9.1±1.3	8.1±3.1	6.8±2.3	8.3±2.8	8.4±2.8	8.6±2.5	7±3.3
Cl (mg/l)	1400±733	540±307	410±169	618±211	548±409	416±276	658±313	608±280	570±303	380±260
Mg (mg/l)	166±38	106±40	93±27	119±25	98±40	87±32	98±33	112±38	105±41	83±39
SO_4 (mg/l)	1197±310	710±323	603±216	832±182	656±336	555±259	660±254	756±302	697±337	520±317
Treated Water										
pH	7.1±0.1	7.3±0.1	7.5±0.2	7.4±0.2	7.6±0.3	7.4±0.2	7.5±0.4	7.6±0.4	7.5±0.2	7.5±0.2
EC (µs/cm)	6309±2365	2861±1376	2562±849	3631±813	3092±1678	2450±1177	3475±1448	3456±1299	3258±1488	2325±1174
Turb. (NTU)	7.4±5.6	4.2±2.9	7.4±3.8	5.5±1.7	7.1±4.5	7.2±3.9	9.3±6.4	6.1±4.9	9.4±7.6	6.6±2.8
Alka. (mg/l)	162±23	134±9	137±9	140±8	140±12	134±12	152±14	141±10	144±16	135±11
TH (mg/l)	1355±309	809±306	746±211	993±176	821±335	695±259	833±289	934±313	864±333	678±275
TDS (mg/l)	4038±1579	1833±835	1576±536	2269±519	1937±1083	1527±757	2158±941	2166±850	2020±951	1438±747
Ca (mg/l)	274±62	167±59	152±42	202±33	168±69	142±53	170±58	190±62	176±66	138±56
Na (mg/l)	911±475	304±190	253±107	399±139	354±270	260±172	440±229	390±180	365±199	235±154
K (mg/l)	12.3±1.6	7.5±3	6.9±1.4	8.8±1.4	7.8±3	6.3±2	8.4±3.3	8.2±2.8	8.3±2.4	6.8±2.6
Cl (mg/l)	1380±714	500±274	393±164	612±215	546±407	402±265	668±351	603±278	564±302	373±234
Mg (mg/l)	163±38	98±37	89±26	119±24	98±40	83±31	99±35	112±38	103±41	86±42
SO_4 (mg/l)	1175±310	683±293	577±209	823±176	652±333	529±251	665±278	752±299	687±338	506±267