Evaluation of Water Quality at The Rumaila Combined Cycle Power Plant: Effects, Challenges, And Management Approaches

Mariam S. Nasser[1*], Jinan S. AL-Hassany[1], Monim H. AL-Jiboori[2]

1. Department of Biology, College of Science for Women, University of Baghdad.

2. Department of Atmospheric Science, College of Science, University of Mustansiriyah.

*Corresponding author E-mail: mariam.salah2202m@csw.uobaghdad.edu.iq

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ABSTRACT

This study evaluates Rumaila Combined Cycle Power Plant water quality using physicochemical characteristics at three locations: Abu Abdullah Canal is the inlet, the Power Plant exit is pre-emptive, and Shatt Al-Basrah Canal is the outlet. The Iraqi Water Quality Index (IWQI) was used. Water quality is best at the Rumaila Combined Cycle Power Plant, but the Shatt Al-Basrah Canal has severe degradation, with TDS, EC, and chloride concentrations exceeding limits. High salinity, contamination, and depleted dissolved oxygen (DO) and higher BOD_5 and COD values indicate organic pollution. Iron (Fe), lead (Pb), nickel (Ni), and chromium (Cr) have also exceeded safety levels, indicating industrial pollution. Coliform bacteria counts in Shatt Al-Barah are over the limit, indicating sewage contamination. The IWQI considered all sites unsuitable for human use, although the power plant's water quality was excellent, proving that its treatment units and turbines prevented Siemens equipment corrosion.

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1. Introduction

Water resources are essential for human survival, agricultural productivity, economic development, and environmental sustainability. However, water pollution remains a global concern, driven by both natural processes such as climate change and geological interactions and anthropogenic activities including industrial discharge, agricultural runoff, and urban wastewater [1]. The contamination of surface water, particularly in rivers and streams, is attributed to the urbanization of the country, the production of effluents, and agricultural runoff. This pollution is caused by the introduction of pollutants like heavy metals, pesticides, pathogens, and nutrients [2]. Additionally, thermal pollution from power plants adversely affects aquatic ecosystems; additionally, industrial and municipal waste contains hazardous substances, including lead, mercury, cadmium, and arsenic. These pollutants are seep into groundwater systems, which increases the risk of contamination [3,4]. In Basrah, Iraq, the Shatt al-Arab and Shatt al-Basrah rivers are critical water sources for domestic, agricultural, and industrial uses. Yet, they face serious pollution threats due to unregulated wastewater discharge, oil contamination, and inadequate sewage infrastructure. These issues have resulted in elevated salinity, heavy metal accumulation, and microbial contamination, which have significantly impacted aquatic ecosystems, fisheries, and public health [5-7]. Water treatment is crucial to the operation of thermal power plants, this affects the efficiency of turbine maintenance, corrosion mitigation, and efficiency [8]. With the increasing importance of global energy demand, the significance of water management in power generation systems has increased [9]. Advances in water treatment technology increase effectiveness, increase the lifespan of infrastructure, and promote environmental sustainability [10]. Many tons of water are employed in the cooling systems of steam generators, this can lead to the release of heavy metals due to fatigue and stress corrosion cracking (SCC) [11]. In Iraq, the quality of surface water is typically determined by measuring the concentration of contaminants to determine if it is suitable for drinking, agriculture, aquatic life, or other purposes. The Water Quality Index (WQI) model, which is based on physical, chemical, and biological properties, is commonly employed to assess and improve water quality [12]. A new Iraqi Water Quality Index (IWQI) was created in 2020. This index evaluates the water's capacity to be used for multiple purposes while also incorporating an Environmental Risks Index (ERI) that calculates the risk of violating national regulations and potential environmental dangers [13].

The Rumaila Combined-Cycle Power Plant has been primarily evaluated for its effects on the air of the city, demonstrating that it met regulatory requirements [14]. However, the effect of this technology on water quality is still unknown despite the technology's reliance on surface water for power generation via steam. This investigation aims to determine the quality of water near the facility, identify the sources of pollution, and assess the environmental risks associated with it. Findings will have a significant impact on the sustainable management of water in the Iraqi energy sector, this will involve policies that have a long-time horizon.

2. Rumaila Combined-Cycle Power Plant (RCCPP)

The Rumaila Combined-Cycle Power Plant (RCCPP) is a powerful power plant that combines the Brayton and Rankine cycles to maximize the production of energy. It has five gas generators that operate on the Brayton cycle; the exhaust gases from these generators are used to power two additional Rankine cycle units that have heat recovery steam generators (HRSGs). These HRSGs take advantage of the Abu Abdullah Canal (Garmat Ali River)'s water to generate steam; this increases the efficiency of the system through the recovery of wasted heat. Commissioned by the Ministry of Electricity in 2015, it was later expanded in 2018 under a contract with the Kar Company, RCCPP was located in Al-Zubair, Basra Province (30.5444375°N, 47.4049375°E), 50 kilometers west of Basra City, on a 1,000 × 900-meter presage plot in the oil-rich desert. The power plant's total capacity is 3,180 million watts (1,460 million from combined-cycle units plus 730 million from steam turbines). The water from the Abu Abdullah Canal (30.5699°N, 47.6985°E) is considered the primary source (Inlet) for power plant, while the treated water is released into the Shatt al-Basrah Canal (30.5184231°N, 47.7215795°E) is considered outlet point (Figures 1 and 2).

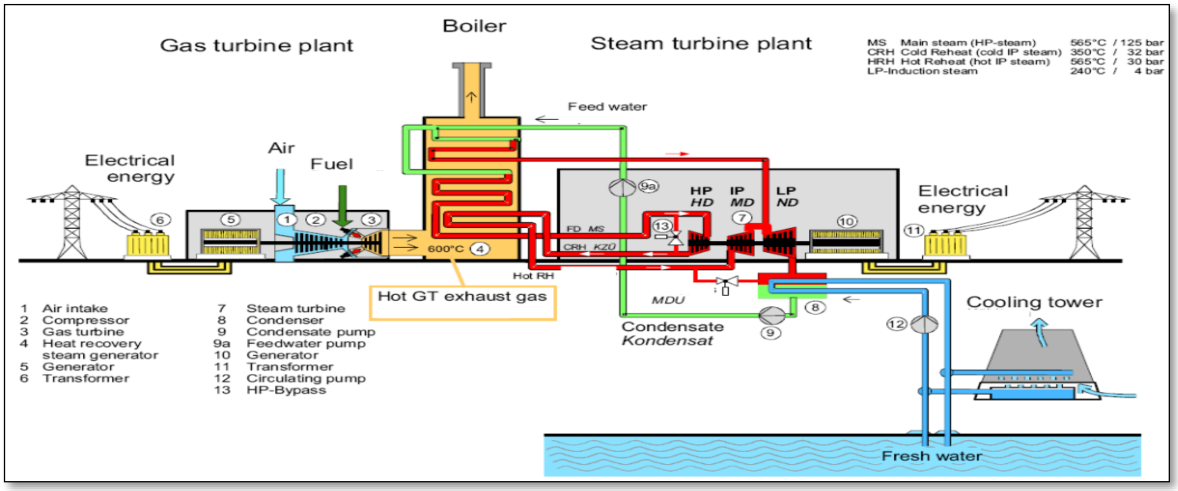

Figure 1: Basic diagram of a combined cycle power plant [15].

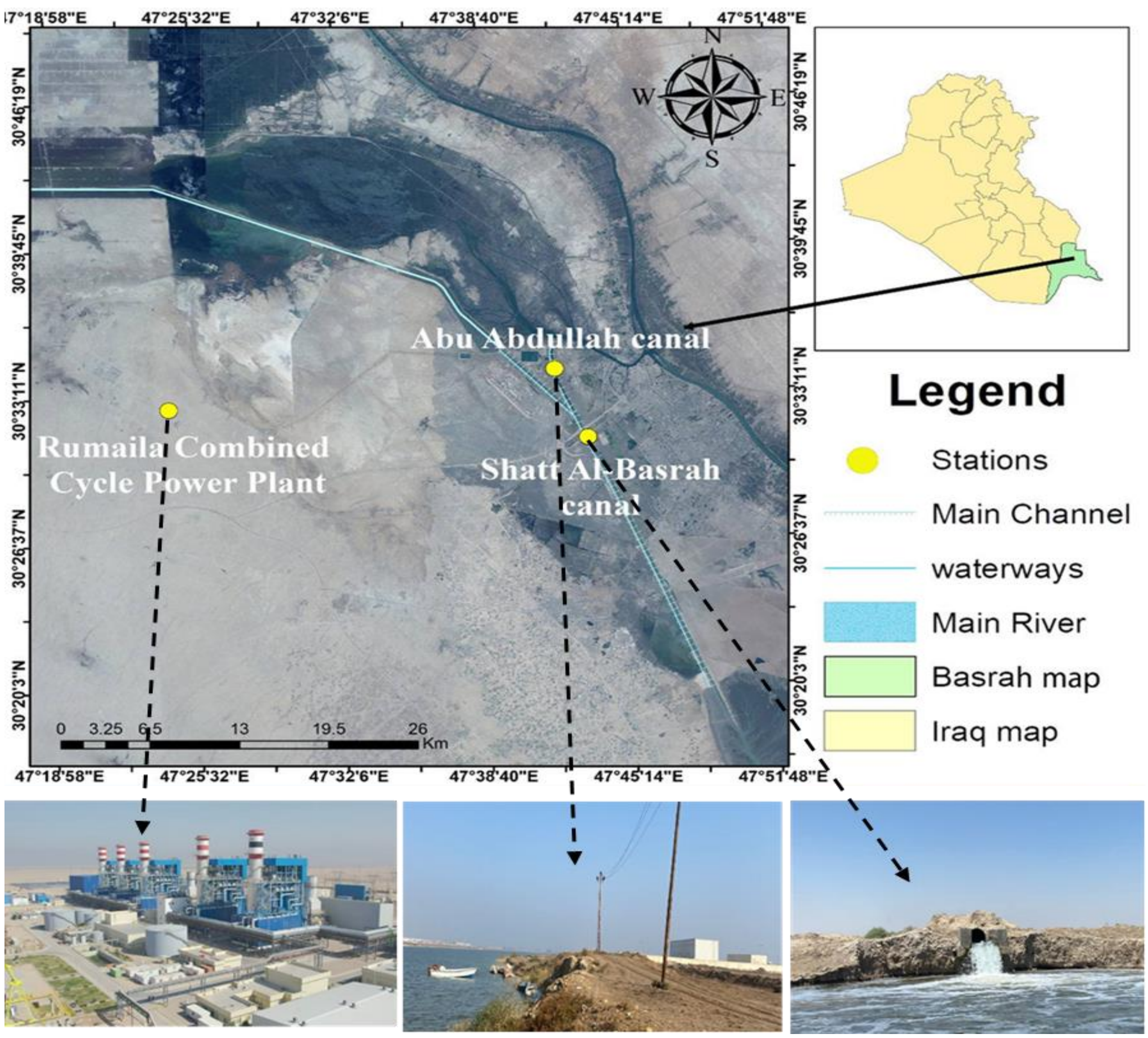

Figure 2: Location of the RCCPP: Photograph of the RCCPP facility, showing its five stacks; Abu Abdullah Canal, serving as the physical inlet unit; Shatt Al Basrah Canal, representing the outlet.

2. Materials and Methods

2.1 Sampling sites, strategy and procedure

Evaluated the three locations during both the wet and dry seasons (September, December of 2023, February, May, June, July of 2024 (Table 1), Samples were collected between 7:00 and 11:30 AM from a depth of 20-30 cm, with containers previously filled with river water before being placed in. To preserve the integrity of the sample, the sample was stored in ice-filled coolers for analysis in the laboratory. Heavy metal concentrations were measured in the Marine Science Center, University of Basrah, Iraq, following the American Public Health Association's protocols. The investigation covered Iraq's two primary seasonal classifications: wet and dry which corresponded to the climatic framework of [16], who documented a decrease in the average relative humidity of Basrah over the course of time, this was supported by a seasonal classification based on humidity data from the Al-Burjisiya Agricultural Meteorological Station (Table 2), with values greater than 50% meaning the wet season, and less than 50% meaning the dry season.

Table 1: Geographical Positions of sampling sites.

No.	Site	latitude	longitude
1	Abu Abdullah Canal (inlet)	30.5709775	47.6985960
2	RCCPP discharge (before effluent)	30.5575625	47.3930625
3	Shatt Al-Basrah Canal (outlet)	30.5186438	47.7224535

Table. 2: The monthly temperature during the study period (source; a meteorological station that is part of the Iraqi Ministry of Agriculture, is located in Burjesia, Al-Zubair district).

Season	Year	Months	RH%	Season	Year	Months	RH%
Wet	2023	December	61.54	Dry	2023	September	17.63
	2024	February	58.5		2024	June	14.76
	2024	May	52.88		2024	July	10.54

2.2 Iraqi Water Quality Index (IWQI)

This investigation evaluated water quality using the Iraqi Water Quality Index (WQI) framework of Aljanabi [14], which incorporated parameters, weights, observed values and standard metrics, and sub-indices, these were then converted into cells. The WQI formula calculates weights based on the significance of the parameters, normalizes the observed values, and combines the sub-indices to create a water quality score. This method was validated and guarantees the assessment and communication of information. The calculations of IWQI were derived from the following equations:

$$\mathbf{Final\ Wi = \sum tW / \sum tW} \text{……………..} \ (1)$$

where **tw** is the temporary weight.

$$\mathbf{SIi\ =\ final\ wight\ \times\ Qi} \text{…………..} \ (2)$$

$$\mathbf{Qi\ =\ (Ci - Cideal\ /\ Si - Cideal)\ \times\ 100\ for\ PH\ and\ DO} \text{………} \ (3)$$

$$\mathbf{Qi\ =\ (Ci\ /\ Si\ )\ \times\ 100\ for\ other\ parameters} \text{……………..} \ (4)$$

In this context, SIi is the subindex of each parameter, Wi is the final weight associated with the parameters, and Qi is the quality rating of the parameters based on their concentration. Ci is the actual value, while Si is the typical value. The optimal concentration of dissolved oxygen (DO) is 14.6 mg/L, and the ideal pH is 7.

$$\mathbf{IraqiWQI = \sum SIi\ /\ Wi} \text{…………..} \ (5)$$

As outlined by Tyagi et al. (2013), the optimal rating aligns with the Weighted Arithmetic Water Quality Index model presented in Table (3-8).

For Sodium Absorption Ratio (SAR) [16], as equation below:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}} \text{……..} \ (6)$$

Table 3: water quality rating as per NIWQI [18].

Water Quality Rating		
WQI value	**Rating**	
0-25	**Excellent**	**Blue**
26-50	**Good**	**Green**
51-75	**Poor**	**Yellow**
76-100	**Vary poor**	**Orang**
Above 100	**Unsuitable**	**Red**

Water quality parameters were selected based on their relevance to aquatic life and agriculture, following the Irrigation Water Quality Index (IWQI). Standard values are in Table 4. Equation 6 identified key parameters affecting Sodium Adsorption Ratio (SAR), particularly sodium hazard. The selection aligns with Law 25 (1967), CCME (2007), CCMME (2005), Ayers and Westcot (1985), and Malaysia (2000) [19] [20] [21] [22] [23].

Table 4: Water Quality Parameters for WQI Assessment

N.	**Aquatic life**	**Ref.**	**Agricultural**	**Ref.**
1.	WT 15	[20]	SAR 18	[22]
2.	TDS 500		pH 6.5-8.4	
3.	Turb. 5		Zn 5	
4.	DO 5.5-9		TDS 1500-3000	
5.	pH 6.5-9		Cr 0.008	[21]
6.	Cl^- 250		Cl^- 100	
7.	NO^{3-} 13		Ni 0.2	
8.	PO_4^{2-} 0.10		Pb 0.2	
9.	Cr 0.001		Fe 5	[23]
10.	Fe 0.3		$SO4^{2-}$ 250	

11.	Pb 0.01		-	-
12.	Ni 0.15		-	-
13.	Zn 0.03		-	-

3. Results and discussion

3.1 Physical Properties

The investigation revealed that their values were vastly different, and these changes were caused by changes in time and space. This distribution of information is illustrated by the mean, standard deviation, minimum, and maximum (Table 5).

Table 5: Physical Properties During Study Period in all sites

Physical Properties	Inlet (S1)		RCCPP (S2)		Outlet (S3)		Standard
	Mean ±SD	Mini-Maxi	Mean ±SD	Mini-Maxi	Mean ±SD	Mini-Maxi	
A.T.^{0}C	25.230 ±12.33	19 - 37	27.65 ±6.53	21-39	25.392 ±14.915	20 - 42	**-**
W.T.^{0}C	19.383 ±10.37	17.8 - 32.667	19.7 ±2.312	19 – 22.8	21.272 ±11.825	19-34.233	**15 [24]**
Turb.	28.177 ±23.45	12.6 - 31.7	5.85 ±2.31	3.19-8.95	52.962 ±36.135	19.653-98.4	**50 [25]**
TSS (mg. L^{-1})	95.334 ±146.3	22.667-393	43.42 ±4.73	40-50	242.375 ±112.14	74.33-145	**-**
Salinity %	4.105 ±0.429	3.233-4.3	5.150 ±0.251	4.7 - 5.3	37.939 ±10.242	31.333-51.833	**-**
TDS (mg. L^{-1})	3526.3 ±633.4	2698.1-4285.7	4538.35 ±626.93	3896-5318.4	36171.2 ±5881	31317.333-45776.333	**500 [19]**
EC µS/cm	1116.841 ±2722.11	4.287-6673.3	9.767 ±1.2	8.31-11.31	13456.4 ±32828.3	48.933-80466.7	**500 [19]**

The quality of water at each site was markedly different. The average air temperature (A.T.) was between 25.230°C and 27.65°C, with fluctuations between 19°C and 42°C. No universal norms are defined. Water temperature (W.T.) varied from 19.383°C ± 10.37 (S1) to 19.7°C ± 2.312 (S2) and 21.272°C ± 11.825 (S3), which is greater than the 15°C-24°C range at S3, The turbidity level was 28.177 ± 23.45 (S1), decreased to 5.85 ± 2.31 (S2), but increased at S3 (52.962 ± 36.135, max 98.4 NTU), exceeding the 50 NTU threshold, Total Suspended Solids (TSS) was 95.334 ± 146.3 mg/L (S1), which was reduced to 43.42 ± 4.73 mg/L (S2), but increased to 242.375 ± 112.14 mg/L (S3). No universal standard is known, Salinity increased from 4.105% to 5.150% and then decreased to 37.939%. The regulation does not specify any limits, Total Dissolved Solids (TDS) levels were higher than 500 mg/L at all sites, rising from 3526.3 mg/L ± 633.4 (S1) to 4538.35 mg/L ± 626.93 (S2) and 36171.2 mg/L ± 5881 (S3). This means the water is very polluted, and the conductivity of electricity (EC) increased from 1116.841 µS/cm ± 2722.11 (S1) to 9.767 µS/cm ± 1.2 (S2), but increased to 13456.4 µS/cm ± 32828.3 (S3), which is far greater than the 500 µS/cm limit. The results show that the water quality at S3 is very bad, with high TDS, EC, turbidity, and salinity. On the other hand, S2 (RCCPP) is the better, probably because it has been treated. Urgent measures are necessary for the management of wastewater, the control of salinity, and the regulation of industrial production, all of which are intended to ensure water sustainability.

3.2 Chemical Properties

The descriptive statistical analysis of Chemical parameters for three sites over the study period (Table 6).

Table 6: Descriptive Statistics results Chemical properties of inlet, RCCPP and outlet during the study period (mean, standard deviation, minimum and maximum, Stander Iraqi water value) and all parameters in mg. L^{-1}.

Chemical Properties	S1		S2		S3		(Law25, 1967)
	Mean ±SD	Mini-Maxi	Mean ±SD	Mini-Maxi	Mean ±SD	Mini-Maxi	
pH	7.805 ±0.898	6.577-8.833	7.884 ±0.366	7.640-8.620	7.819±0.93	6.927-8.937	**6.5-8.5**
Ca	262.111 ±180.999	94-591.667	454.333± 105.843	380 – 667	2624.611 ±1822.558	346.333-5852	**-**
Mg	243 ±175	1.028 - 460	789.333 ±346.160	476- 768	3634.433 ±2396.031	3.430-7215.833	**-**

Na	517.039 ±319.359	149.667-1107.133	700.217 ±320.086	501-1348.6	2323.233 ±2043.136	1105.667-6471.933	**-**
Cl	1146.143 ±615.95	1029.5-1265.3	1672.767 ±235.187	1456-1970.3	10684.714 ±5592.401	10437-17213	**200**
SO_4	357.868 ±229.443	86.251-750.38	291.542 ±94.221	124.635-356	975.522 ±301.426	686.9 - 1335.055	**200**
Nutrients							
$NO3^-$	0.75 ±0.68	0.044 - 1.646	0.176 ±0.211	0 - 0.489	2.111 ±1.843	0.205 - 5.142	**1**
$PO4^{-3}$	0.265 ±0.452	0.081 - 1.187	0.064 ±0.005	0.059 - 0.069	0.293 ±0.369	0.143 - 1.047	**0.4**
Organic and Inorganic Pollution							
DO	6.256 ±2.149	3.533 - 9.533	7.917 ±0.631	6.7 – 8.5	2.511 ±1.180	0.5 - 4	**5**
BOD_5	6.256 ±2.149	3.533 -16	4.883 ±1.42	3.5 – 7.4	7.417 ±5.371	2.833 - 17.5	**< 5**
COD	1590.122 ±1187.76	435.2 - 3394	2210.583 ±792.637	1745 – 3800	2804.344 ±1388.680	1160.533-4573.667	**< 100**
Hazardous Inorganic Compounds							
Fe	2.847 ±2.672	0.003 - 6.214	1.257 ±0.993	0.034 - 2.154	1.46 ±1.772	0.390 - 4.782	**0.3**
Pb	0.886 ±1.096	0.017-2.989	0.428 ±0.460	0.039 - 1.290	1.134 ±1.263	0.025-3.473	**0.05**
Cr	1.234 ±1.937	0 - 5.130	0.470 ±0.446	0.144-1.278	1.208 ±0.735	0.013-1.987	**0.05**
Zn	0.153 ±0.088	0 - 0.257	0.055 ±0.102	0 - 0.262	0.190 ±0.156	0 - 0.414	**0.5**
Ni	0.560 ±1.135	0 - 2.872	0.295 ±0.439	0.013 - 1.179	0.783 ±0.390	0.014 - 1.040	**0.1**

The chemical properties of water samples are described in this section presented by water's pH was between 6.5-8.5, with values of 7.805 (S1), 7.884 (S2), and 7.819 (S3), concentration of calcium (Ca) increased from 262.111 ± 180.999 mg/L (S1) to 454.333 ± 105.843 mg/L (S2), and it peaked at 2624.611 ± 1822.558 mg/L (S3). Magnesium (Mg) followed the same pattern, increasing from 243 ± 175 mg/L (S1) to 789.333 ± 346.160 mg/L (S2) and 3634.433 ± 2396.031 mg/L (S3), Sodium (Na) increased in a progressive manner from 517.039 ± 319.359 mg/L (S1) to 700.217 ± 320.086 mg/L (S2) and 2323.233 ± 2043.136 mg/L (S3). Chloride (Cl) increased dramatically from 1416.95 ± 16.65 to 1672.767 mg/L (S2) and 10684.714 mg/L (S3), exceeding the 200 mg/L threshold by far. Also, the concentration of sulfate (SO_4^{2-}) surpassed the 200 mg/L threshold, with 357.868 ± 229.443 mg/L (S1), 291.542 ± 94.221 mg/L (S2), and 975.522 ± 301.426 mg/L (S3), Nitrate (NO_3^-) remained within the 1 mg/L range at 0.75 ± 0.68 mg/L (S1) and 0.176 ± 0.211 mg/L (S2), but it exceeded the limit at 2.111 ± 1.843 mg/L (S3). Phosphate (PO_4^{3-}) concentrations were consistently around 0.4 mg/L at all sites. Dissolved oxygen (DO) was 6.256 ± 2.149 mg/L (S1), increased to 7.917 ± 0.631 mg/L (S2), but decreased to 2.511 ± 1.180 mg/L (S3), which is below the 5 mg/L requirement. The chemical oxygen demand (COD) exceeded the 5 mg/L threshold at 7.417 ± 5.371 mg/L (S3). The chemical oxygen demand (COD) was significantly higher than 100 mg/L, with a measurement of 1590.122 ± 1187.76 mg/L (S1), 2210.583 mg/L (S2), and 2804.344 mg/L (S3), this indicates that the water was heavily polluted by organic substances. Among the hazardous inorganic compounds, iron (Fe) exceeded the 0.3 mg/L threshold at all locations, with the highest concentration at 2.847 ± 2.672 mg/L (S1). Lead (Pb) exceeded the 0.05 mg/L threshold in all locations, with a maximum of 1.134 ± 1.263 mg/L (S3). Chromium (Cr) surpassed the 0.05 mg/L limit at 1.234 ± 1.937 mg/L (S1) and 1.208 ± 0.735 mg/L (S3). Zinc (Zn) maintained its current level of 0.5 mg/L, with a recorded value of 0.190 ± 0.156 mg/L (S3). Nickel (Ni) exceeded the 0.1 mg/L mark at all locations, with a maximum of 0.783 ± 0.390 mg/L (S3). The findings indicate severe pollution at S3, with a high concentration of chloride, sulfate, heavy metals, and oxygen, this necessitates enhanced pollution control and water treatment in order to mitigate the environmental risks.

3.3 Bacterial measurement

Total Coliform Bacteria (TCB) serve as a bioindicators indicator of water contamination, originating from both natural sources and fecal matter from humans and animal.

Figure 3 and Table (7), illustrate spatial and temporal variations in total coliform levels, variability in coliform counts is evident across sites, with, S2 maintaining stable and lower levels (130 MPN/100 ml), while S1 and S3 exhibiting the highest (4500 MPN/100 ml), likely influenced by environmental and anthropogenic factors.

Table 7: Total Coliform count (MPN/100 ml) during the study period at three sites (mean, standard deviation, minimum and maximum)

Wet season		Dry season		(Malaysia, 2000)
Mean ±SD	**Mini-Maxi**	**Mean ±SD**	**Mini-Maxi**	
587.88±878.38	15.67-2400	16.63±4.698	10-23	5000

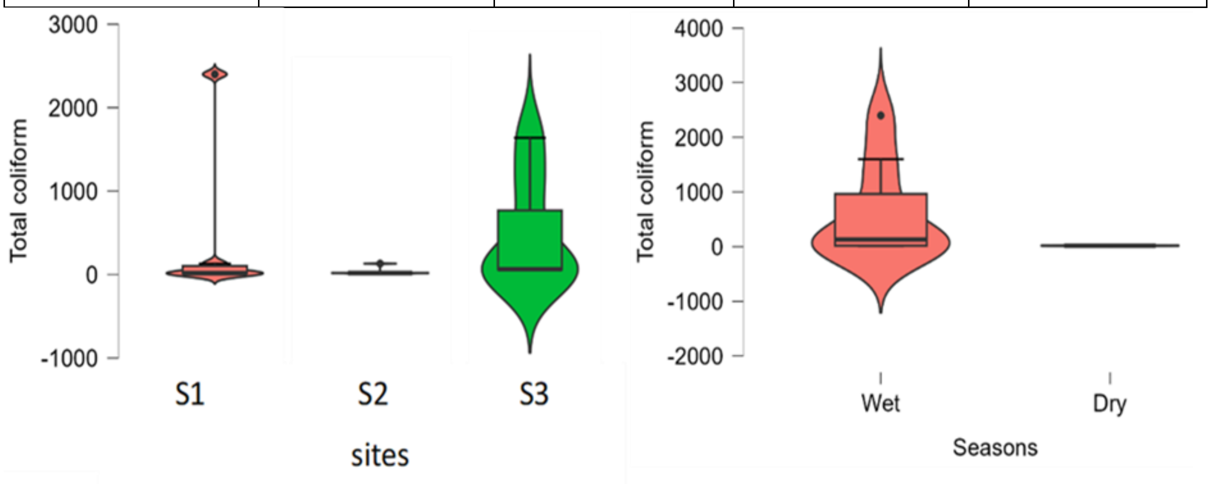

Figure 3: Spatial and Temporal of Total Coliform count (MPN/100 ml).

3.4 Correlation matrix (heat map) of Physical and chemical properties

The connections between water quality parameters, with red indicating positive associations and blue indicating negative associations. pH exhibits weak correlations with most parameters, suggesting minimal influence on overall water quality. Temperature (air and water) has a moderate association with dissolved oxygen (DO), this is because of its effect on the solubility of oxygen. Turbidity (Turb.) is positively associated with the total suspended solids (TSS) because of the increased amount of particulate matter. Similarly, the total dissolved solids (TDS) and electrical conductivity (EC) have a strong association, this indicates that ions dissolved in the water have a role in conductivity.

Salinity, chloride (Cl^-), and sodium (Na^+) are intrinsically linked due to their participation in the water's salinity. Other salts, including calcium (Ca^{2+}) and magnesium (Mg^{2+}), are also associated with this mineral, this is likely due to their common source of origin. Sulfate (SO_4^{2-}) and nitrate (NO_3^-) have a moderate to strong association with metals, this is indicative of pollution from agricultural or industrial sources. Phosphate (PO_4^{3-}) exhibits a variety of weak associations, except for a few specific biological markers. DO is negatively associated with temperature, chemical oxygen demand (COD), and biochemical oxygen demand (BOD_5), this indicates that oxygen is depleted due to organic pollution. BOD_5 and COD are intrinsically linked, this confirms their status as a measure of organic pollution. Total coliform bacteria are associated with multiple variables, this association is physicochemical in nature. The study identifies the main sources of water pollution in Basrah Governorate, highlighting the interactions between physical, chemical, and biological characteristics and agree with [25], include: Activities in the oil sector, including extraction, transportation, and storage, result in spills that release Ni, Pb, Zn and Fe into water, while the discharge of refinery wastes increases heavy metal concentrations, Inadequate wastewater treatment results in the release such as Pb from domestic and industrial sources, exacerbated by leaks from deteriorating infrastructure such as lead pipes, and Runoff from the oil-polluted Persian Gulf carries heavy metals into the Shatt al-Arab.

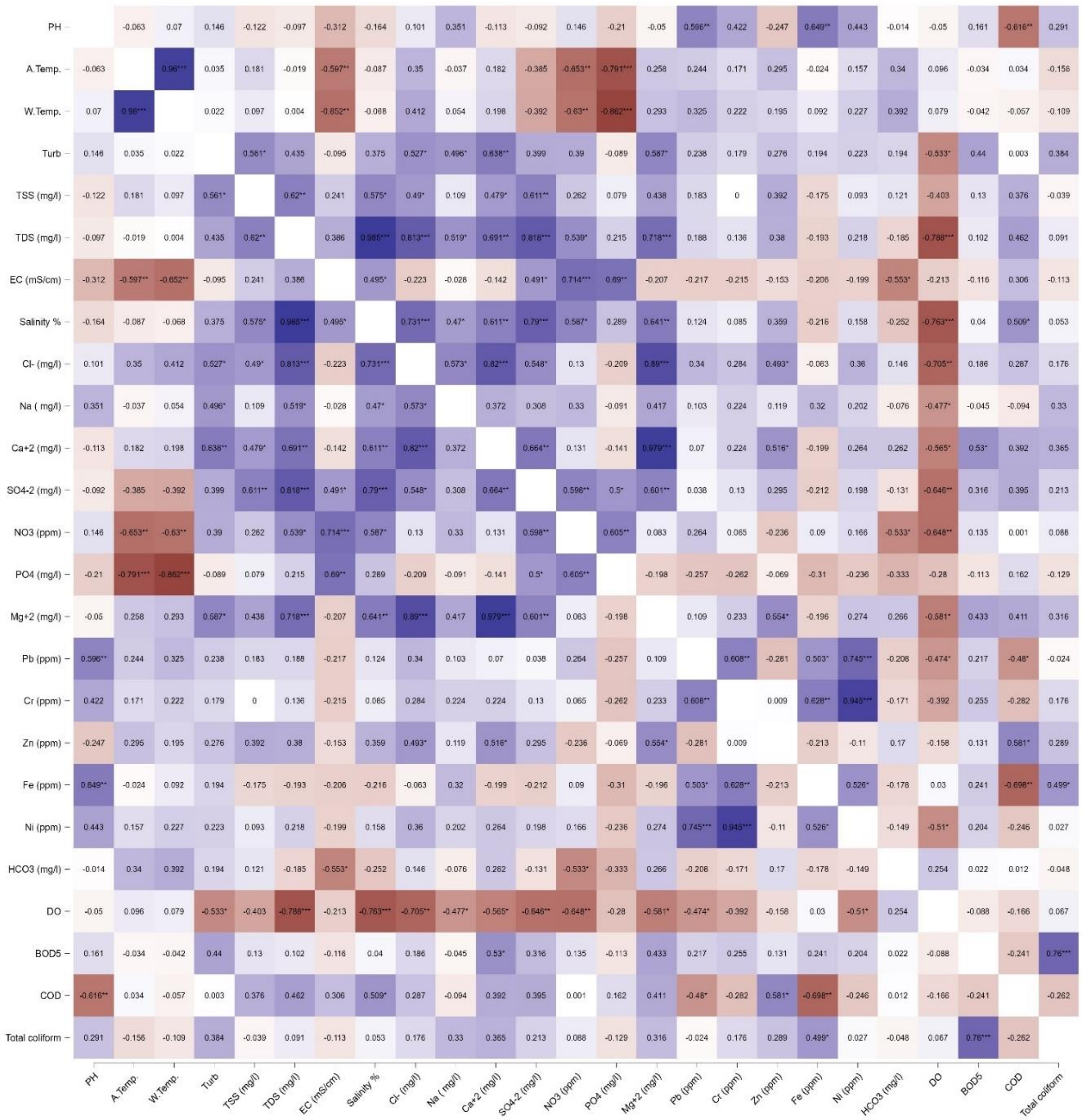

Figure 3: Pearson's Partial Correlations Between Chemical Factors during the study period. Positive relationship= blue box/ Negative relationship= red box Strong correlation=dark blue or red / weak correlation=lighter blue or red

3.5 Iraqi Water Quality Index (Iraq WQI)

Water quality monitoring consolidates different criteria into a single index (e.g., excellent, good, poor) for uniform reporting [27]. This index, first implemented in Iraq to assess the Tigris River [14] and the Euphrates River, evaluates freshwater use, aquatic life preservation, irrigation, and drinking water quality [14]. Twenty-one factors were investigated in this study, 14 of which were removed due to low relevance to Iraqi rivers. The second site, representing RCCPP, was evaluated for its impact on the water quality of Basrah (Shatt al-Arab and Shatt al-Basrah) in terms of aquatic life and agriculture. The IWQI did an excellent assessment of the quality of the water in Basrah by using pollution and risk indicators and avoiding connecting it to the Environmental Risk Index (ERI). These practices kept overall assessments from being altered by high levels of parameters. The results lowest values of IWQI and ERI recorded 31.5 and 40.19 respectively, at S2 (RCCPP 's effluent), which observed moderate environmental risk (highlighting the power plant's filtering efficacy in reducing deterioration), while both S1 and S3 recorded very high values of IWQI and ERI, ranging from (820 to 1116) and from (130 to 144.28) respectively. The index demonstrated very poor water (high risk) in Basrah, despite this RCCPP discharge the lowest risk due to its efficiency filtration. And which agreed with other previous investigation used new IQWI, like [28].which evaluated the Al-Dalmaj Marsh Drainage Canal at southern part of Iraq, determining that the Water Quality Index (WQI) varied from very bad to unsuitable for fresh water and irrigation use, while higher than water quality when conducted at Tigers and Euphrates as presented by [29]., the water quality of the Tigers River in Baghdad at the sites under study ranged from poor to very poor for fresh water, [12].demonstrated that the water quality of the Euphrates River at the sites under study between the governorates of Karbala and Babylon ranged from poor to very poor for fresh water, but that the water was suitable for aquatic organisms to live in and for agriculture. All of the above studies showed that sewage, industrial facilities, and densely populated areas have a detrimental effect on water quality.

Table 8: Spatiotemporal variations of IWQI for Fresh water (Natural).

Seasons	Wet season			Dry season		
Sites	S1	S2	S3	S1	S2	S3
WQI	698.79	363.95	1222.56	290.08	213.18	1316.63
ERI	103.40	56.77	206.09	41.86	31.53	225.80

Table 9: Spatiotemporal variations of IWQI for Agriculture use.

Seasons	Wet season			Dry season		
Sites	S1	S2	S3	S1	S2	S3
WQI	2294.71	2535.25	1033.63	714.62	353.15	2846.99
ERI	297.68	324.70	129.62	84.59	40.19	371.79

4. Conclusions

In this study the Rumaila Combined Cycle Power Plant (RCCPP) had the greatest success in terms of water quality, as a result of its effective physical and chemical treatments and the integration of advanced Siemens steam turbines that decrease corrosion. This contrasts sharply with the region's deplorable water quality, which is primarily caused by oil spills, sewage, salt, and the Arabian Gulf's influx of water. Additionally, the Tigris-Euphrates water level has been dropping due to the construction of upstream dams. These findings demonstrate the immediate necessity of increased pollution control, water management strategies that are sustainable, and more stringent regulations that are needed to mitigate environmental damage and preserve local water resources.

References

[1] R.K. Mishra, Freshwater availability and its global challenge, Br. J. Multidiscip. Adv. Stud. 4(2023) 1-78, https://doi.org/10.37745/bjmas.2022.0208.

[2] N. Akhtar, M.I. Syakir Ishak, S.A. Bhawani, K. Umar, Various natural and anthropogenic factors responsible for water quality degradation: A review, Water 13(2021) 2660, https://doi.org/10.3390/w13192660.

[3] A. Rahman, O. Farrok, M.M. Haque, Environmental impact of renewable energy source-based electrical power plants: Solar, wind, hydroelectric, biomass, geothermal, tidal, ocean, and osmotic, Renew. Sustain. Energy Rev. 161(2022) 112279, https://doi.org/10.1016/j.rser.2022.112279.

[4] N. Vig, K. Ravindra, S. Mor, Heavy metal pollution assessment of groundwater and associated health risks around a coal thermal power plant, Punjab, India, Int. J. Environ. Sci. Technol. 20(2023) 6259-6274, http://dx.doi.org/10.1007/s13762-022-04284-8.

[5] M.S. Al-Enazi, I.I. Lazim, H. Hilo Ali, Ability of Cyperus papyrus in the bioaccumulation of some heavy elements in the Shatt Al-Basrah canal, Iraq, Caspian J. Environ. Sci. 20(2022) 603–609, https://doi.org/10.22124/cjes.2022.5704.

[6] A.A. Hassan, A.S. Dawood, N.J. AL-Mansori, Assessment of water quality of Shatt Al-Basrah canal using a water pollution index, Int. J. Eng. Technol. 8(2019) 325-331.

[7] M.H. Al-Jaberi, M.A. Al-Dabbas, Evaluation of Iraqi coasts using littoral and marine bivalve shells, Iraqi Geol. J., 36(2016) 16-33. https://doi.org/10.46717/igj.39-49.2.2Ms-2016-12-25.

[8] A. Shokri, M.S. Fard, Principles, operational challenges, and perspectives in boiler feedwater treatment process, Environ. Adv. 13(2023) 100389, https://doi.org/10.1016/j.envadv.2023.100389.

[9] S. Giri, Water quality perspectives in the Twenty-First Century: Status of water quality in major river basins, contemporary strategies, and impediments: A review, Environ. Pollut. 271(2021) 116332, https://doi.org/10.1016/j.envpol.2020.116332.

[10] K.C. Goh, T.A. Kurniawan, H.H. Goh, D. Zhang, M. Jiang, W. Dai, C. Meidiana, Harvesting valuable elements from solar panels as alternative construction materials: A new approach of waste valorization and recycling in circular economy for building climate resilience, Sustain. Mater. Technol., 30(2024) e01030, https://doi.org/10.1016/j.susmat.2024.e01030.

[11] G. Zhao, H. Qi, S. Li, X. Yang, D. Shi, Effects of tensile load hold time on the fatigue and corrosion-fatigue behavior of turbine blade materials, Int. J. Fatigue, 152 (2021) 106448, https://doi.org/10.1016/j.ijfatigue.2021.106448.

[12] B.M. Khlaif, J.S. Al-Hassany, Water quality assessment using a novel Iraqi water quality index for Euphrates River between Karbala and Babylon provinces as a case study, Baghdad Sci. J., 22(2025) 15, https://doi.org/10.21123/bsj.2024.10179.

[13] Z.Z. Aljanabi, A.H.M.J. Al-Obaidy, F.M. Hassan, A novel water quality index for Iraqi Surface Water, Baghdad Sci. J., 20(2023) 2395-2395, https://doi.org/10.21123/bsj.2023.9348.

[14] M.S. Nasser, J.S. Al-Hassany, M.H. Al-Jiboori, Assessment of air pollution dispersion during the wet season: A case study of Rumaila Combined Cycle Power Plant, Basrah, Iraq, J. Agrometeorol., 26(2024) 411-418, https://doi.org/10.54386/jam.v26i4.2756.

[15] M. Bennauer, E.G. Egener, R. Schlehuber, H. Werthes, G. Zimmer, Automation and control of electric power generation and distribution systems: Steam turbines, Control Syst. Robot. Autom. – Vol. Industrial Applications of Control Systems-I (2009).

[16] A. A Al-Muhyi, F.Y.K. Aleedani, Impacts of global climate change on temperature and precipitation in Basra City, Iraq, Bas. J. Sci. 40(2022) 215-230. https://basjsci.net/index.php/bsj/article/view/155.

[17] B. H. AL-OBAIDI, S. K. ALI, and D. T. JASSIM, Influence of river water quality on the efficiency of water treatment using artificial neural networks, J. Eng. Sci. Technol. 15(2020) 2610-2623.

[18] S. Tyagi, B. Sharma, P. Singh, R. Dobhal, Water quality assessment in terms of water quality index, Am. J. Water Resour. 1(2013) 34-38. https://doi.org/10.12691/ajwr-1-3-3.

[19] Law 25/1967, Rivers Maintaining System and General Water from Pollution No. 25, Iraqi Official Gazette, Ministry of Health, Government of Iraq (1967) 1-3,

[20] CCME, Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table, Environment Canada, Winnipeg (2007).

[21] CCME, Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses, Environment Canada (2005).

[22] R.S. Ayers, D.W. Westcot, Water quality for agriculture, FAO Irrig. Drain. Pap. 29(1985) 174, Food and Agriculture Organization of the United Nations, Rome.

[23] Malaysia Raw Water Standard, National Standard for Drinking Water Quality, Ministry of Health of Malaysia (2000). Available at: https://www.beehive.govt.nz/release/national-standard-organics.

[24] S. Moran, An applied guide to water and effluent treatment plant design, Butterworth-Heinemann (2018).

[25] EPA, Environmental Protection Agency, Parameters of Water Quality: Interpretation and Standards, Environmental Protection Agency, Ireland (2001), https://doi.org/10.4315/0022-2747-35.12.715.

[26] S.A. Shnaishel, H.A. Kadhim, B.A.A.A. Aziz, Evaluation of environmental pollution by heavy metals in the waters of Al-Ezz River, north of Basra, Mesopotamian J. Mar. Sci. 38(2023) 85-94, https://doi.org/10.58629/mjms.v38i2.

[27] S.A. Shnaishel, H.A. Kadhim, B.A.A.A. Aziz, Evaluation of environmental pollution by heavy metals in the waters of Al-Ezz River, north of Basra, Mesopotamian J. Mar. Sci. 38(2023) 85-94, https://doi.org/10.58629/mjms.v38i2.

[28] Z. Z. Al-Janabi, A. A. Maktoof, R. R. Al-Ani, A. H. M. J. Al-Obaidy, Monitoring of Main Outfall Drain and Southern Marsh in Iraq by Arithmetic Water Quality Index, Iraqi J. Sci. 66(2025) 52-65, https://doi.org/10.24996/ijs.2025.66.1.5.

[29] Z.Z. Aljanabi, A.H.M.J. Al-Obaidy, F.M. Hassan, A novel water quality index for Iraqi Surface Water, Baghdad Sci. J., 20(2023) 50, https://doi.org/10.30684/etj.37.2C.6.

تقييم جودة المياه في محطة توليد الطاقة بالدورة المركبة بالرميلة: التأثيرات والتحديات واستراتيجيات الإدارة

مريم صلاح ناصر [1]*، جنان شاوي الحساني [1]، منعم حكيم الجبوري [2]

1: قسم الأحياء، كلية العلوم للبنات، جامعة بغداد.

2: قسم علوم الجو كلية العلوم الجامعة المستنصرية

المستخلص

يحلل هذا البحث جودة المياه في محطة الرميلة للطاقة ذات الدورة المركبة من خلال دراسة الخصائص الفيزيائية والكيميائية في ثلاثة مواقع مختلفة: الأول هو قناة أبو عبد الله، وهي نقطة الدخول، وكان مخرج محطة الطاقة الثاني وقائيًا، واستُخدمت قناة شط البصرة الثالثة كنقطة خروج، وتم استخدام مؤشر جودة المياه العراقي (IWQI) توضح أفضل النتائج جودة المياه في محطة الرميلة للطاقة ذات الدورة المركبة، بينما يظهر التدهور الشديد في جودة المياه في قناة شط البصرة، مع مستويات TDS و EC والكلوريد التي تزيد بشكل كبير عن الحدود المسموح بها، وهذا يدل على ارتفاع الملوحة والتلوث، كما أن استنفاد الأكسجين المذاب (DO) و الطلب البايولوجي للاوكسجين المرتفع (BOD_5)والطلب الكيميائي للأكسجين (COD) يدل على التلوث العضوي، في حين أن المعادن الثقيلة Fe و Pb و Ni و Cr قد تجاوزت عتبات السلامة الخاصة بها، وهذا يدل على التلوث الصناعي. تجاوزت البكتيريا القولونية في شط العرب الحدّ المعياري، مما يدل على خطر التلوث الميكروبي (مصادر الصرف الصحي). اعتبر دليل جودة المياه العراقي جميع المواقع غير صالحة للاستخدام البشري، إلا أن جودة مياه محطة الطاقة كانت الأفضل، مما يدل على فعالية وحدات المعالجة والتوربينات في محطة الطاقة في منع التآكل (معدات سيمنز).