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Environmental Impact of Al-Dalmaj Marsh Discharge Canal on the Main Outfall Drain River in the Eastern part of Al-Qadisiya City and Predicting the IQ-WQI with Sensitivity Analysis Using BLR

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ABSTRACT

Monitoring water quality changes in any body of water is crucial as it directly relates to climate change. Evaluating the quality and quantity of fresh water for various uses is essential to maintaining safe water sources now and in the future. This study examined the water quality of the Main Outfall Drain River (MOD) in the eastern part of Al-Qadisiya Governorate at three sites over four seasons in 2023, using the Iraqi Water Quality Index (IQ-WQI). In most cases, the concentrations of dissolved oxygen (DO), biochemical oxygen demand (BOD5), and total dissolved solids (TDS) exceeded allowable limits for freshwater and aquatic life protection. The major contributing parameters to the river's low water quality were TDS, BOD5, turbidity, and DO. The use of the MOD for discharging agricultural effluents led to increased levels of TDS, BOD5, and turbidity. Temporal variation indicated that the summer season had the highest values compared to other seasons due to increased evaporation and low water discharge. Spatial variation showed the IQ-WQI of the sites in descending order from very poor water to unsuitable, with Site 3 having double the TDS concentrations compared to other sites. This increase may be attributed to the impact of the Al-Dalmag Marsh discharge canal, which comes into contact with the MOD at this site. Sensitivity analysis using backward linear regression was applied to predict the IQ-WQI and determine the most influential parameters on the IQ-WQI score. The test was conducted for two sets of water parameters (from the IQ-WQI calculation) and included 7 parameters for each freshwater and aquatic life use, obtaining different models.

INTRODUCTION

Water is among the numerous, plentiful natural resources that all living things, including humans, animals, plants, and other species, rely on. The increasing population, rising economic activity, and urbanization increase water demand. The environment around human life is in danger due to declining water levels, deteriorating water quality, and excessive surface water usage, considered the most significant water resource (Ingrao et al. 2023). Changes in the global water cycle, resulting from environmentally damaging and water-intensive human activities and climate change, significantly impact many nations' natural ecosystems and human health. Therefore, It is no longer appropriate to think of water as a renewable natural resource, given the patterns of water usage today (Wang & Liu 2023). The study of Ingrao et al. (2023) mentioned the following key issues that pertain to freshwater consumption with critical environmental and socioeconomic repercussions: (i) the resource depletion, that is due to extraction surpassing regeneration over the long-term, with the risk that the resource may be unavailable for future generations; and - (ii) the rivalry for freshwater that arises when the availability of the resource is reduced for some users over a short time, leading to issues with the resource's appropriate distribution among a variety of users.

Surface water quality can be improved and preserved by utilizing various management strategies. One strategy to reduce pollution at its source is to use fewer chemicals and other contaminants. For example, on a national scale, the authorities can obligate industrial companies to implement green infrastructure practices like green roofs and rain gardens; for individual practices, homeowners can reduce the use of chemicals around their houses, like pesticides, fertilizer, etc., to reduce stormwater runoff. Still, the best solution to water pollution is to treat pollutants before they enter the surface water, which could be using sediment basins or artificial wetland treatment, among other techniques, to improve the water quality (Verma et al. 2020, Abed et al. 2021). Also, to avoid pollution disasters, it can use source management protocols, such as covering storage areas and reducing industrial effluent (Cheng et al. 2022).

In general, assessing water quality with a huge number of parameters is difficult to interpret, and the influence of these parameters on overall water quality is difficult to understand clearly. The process of estimating water quality is difficult, so a good judgment of the quality cannot be made depending on testing water parameters individually and for multiple samples (Syeed et al. 2023). Therefore, water quality analysis was subjected to several scientific techniques, like statistical evaluations and water quality indices WQI (Syeed et al. 2023). Chidiac et al. (2023) reviewed different indices applied worldwide with their mathematical combinations. They concluded there is no universal index that can be used by national agencies, users, or researchers, so the choice of the right index for any study will depend on the purpose of the water use and objectives; their study also illustrated the link between WQI and statistical analysis such as Pearson correlation and Principal component analysis to determine the interaction between the studied parameters.

WQI can be defended as a mathematical tool that can combine multiple values (water parameters) in an easy way to generate a single value or number that reflects the water quality status, and this method can be applied to different aquatic systems (lentic or lotic). Many local and international studies used several types of water quality indices like weighted index, Canadian water quality (CCME), etc. (Nong et al. 2020, Majeed & Nashaat 2022, Nguyen et al. 2022, Abed et al. 2023, Mohammed et al. 2022).

Backward Linear Regression (BLR) has been widely used in the past few years to handle a variety of environmental engineering issues, such as river water quality prediction modeling (Talukdar et al. 2023, Goodarzi et al. 2023). BLR models can be a very helpful tool to illustrate the change in water quality through time and sites and can reveal the most important parameters that affect water quality. It is an important resource, especially for developing forecast models using small sample sizes. Some researchers may find it tough to select a set of regressors for a model meeting all the necessary assumptions when using this method and when there are many alternative regressors. So, to test all possible permutations of regressors automatically using a brute-force method, the authors created an open-source Python software. Based on the user-specified assumptions (e.g., statistical significance of the estimates, multicollinearity, error normalcy, and homoscedasticity), the output shows the top linear regression models. Additional features of the script include the ability to choose linear regressions with user-specified regression coefficients (et al. 2023). In areas related to water research, artificial intelligence technology is a powerful and potentially multifunctional technique (Kouadri et al. 2021). The linear regression model is one of the first methods of statistical modeling.

However, in this study, sensitivity analysis based on Backward Linear Regression (BLR) was done to determine which water quality parameters influence the score of WQIs by observing an output variable's response concerning input variables' variations. Usually, the test is done by removing each parameter from the calculation of WQI and comparing the final results. The models can be evaluated using the correlation of coefficient (R2), Sum Squares Error (SSE), and Root Means Square Error (RMSE) (Cheng et al. 2022). This research aims to evaluate the effect of the Dalmaj Marsh discharge canal on the Main Outfall Drain River. As well as it also aims to introduce the most important indices of water quality used at present to assess the quality of surface water for overall and aquatic life protection purposes, which is based on weight anthemic mean that provides the current and proper weight for each parameter according to its significant impact on the aquatic system, the model used is built for Iraqi water assessment using Delphi method to communicate with local and global experts in water quality indices for a consultation about the best and most important parameter that can use in building the index according to the nature of the Iraqi aquatic system and established weight to each parameter, the index called Iraqi Water Quality Index (Al-Janabi et al. 2023), also in this study a sensitivity analysis was conducted to predict the IQ-WQI and determine the most influential parameters on the IQ-WQI score for both uses.

MATERIALS AND METHODS

Study Area and Sampling

Main Outfall Drain is a river constructed and began to operate in 1992 with a 565 km length and is used to dump effluents from agricultural and industrial sources in the middle and southern lands of Iraq (Shahadha & Salih 2021). The study area was located on the Main Outfall Drain River section in the Eastern Al-Qadisiya Government. The samples were collected seasonally from winter to autumn 2023. Three sites were chosen; the first site was selected downstream of the supplying canal of Al-Dalmag marsh with water (Fig.1). The first one is located within Afak City, eastern Al-Qadisiya Government, on the mainstream of the Main Outfall Drain about 2 km downstream to a branching canal that supplies Al-Dalmag marsh with water (recharge canal) at 32.175715," N latitude and 45.335072" E longitude (32°17’57.15’’ N) (45°33’50.72’’ E). The second site is located at 32°06’10.76" N, 45°49’77.21" E, about 19 km downstream of the first site. The third site is situated near the bridge of the main street going to the Maysan Government in Al Bedair city (31°86’50.8" N and 45°63’84.3" E), about 24 km from the second site. This site is situated about 2 km downstream of the meeting of the discharge canal of Al-Dalmag Marsh with the Main Outfall Drain.

Table 1: The rates of water discharges of the main outfall drain river.

Sites	Winter	Spring	Summer	Autumn
Site1	4 $m^3.s^{-1}$	1 $m^3.s^{-1}$	0.6 $m^3.s^{-1}$	0.58 $m^3.s^{-1}$
Site2	3.13 $m^3.s^{-1}$	0.9 $m^3.s^{-1}$	0.53 $m^3.s^{-1}$	0.51 $m^3.s^{-1}$
Site3	1 $m^3.s^{-1}$	0.3 $m^3.s^{-1}$	0.51 $m^3.s^{-1}$	0.4 $m^3.s^{-1}$

Water discharge rates ranged from 1 $m^3.s^{-1}$ in site 3 to 4 $m^3.s^{-1}$ in site 1 in winter. On the other hand, in the Spring season, it ranged from 0.3 $m^3.s^{-1}$ in site 3 to 1 $m^3.s^{-1}$ in site 1. Site 3 was 0.51 $m^3.s^{-1}$, and site 1 was 0.6 $m^3.s^{-1}$ in summer to 1 $m^3.s^{-1}$ in site 1. Whereas it ranged from 0.4 $m^3.s^{-1}$ in site 3 to 0.58 $m^3.s^{-1}$ in site 1, as shown in Table 1 (The data obtained from Ministry of Water Resources and personal communication).

The samples were collected in a clean polyethylene bottle. Eight parameters were chosen to calculate the water quality index. Field measurements, including pH, water temperature (WT), and turbidity, were taken using a portable device. Experimental Measurements included biochemical oxygen demand (BOD_5), dissolved oxygen (DO), phosphate (PO_4), nitrate (NO_3), and total dissolved solids (TDS); all the mentioned parameters were determined according to APHA (APHA 2017) (Table 2).

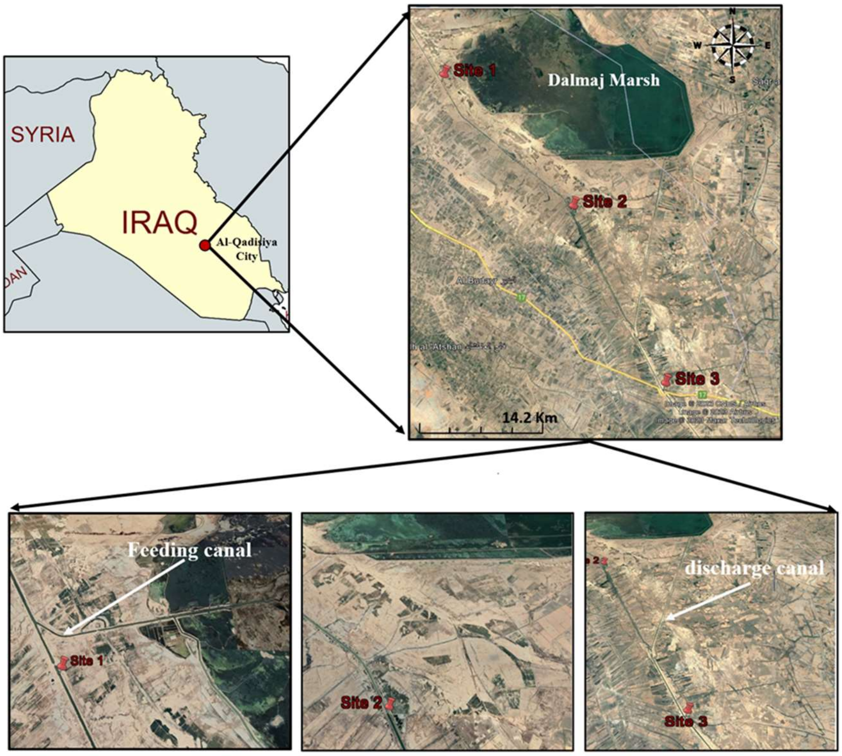

Fig. 1: Map showing the study area.

Table 2: Field and laboratory measurements (APHA 2017).

Parameters	Methods (APHA)	Instruments	Origin
pH	4500-H+ B	EC/Temperature/pH portable meter H19811	WTW, Germany
WT [Cº]	WT 2550B		
Turbidity (NTU)	2130 B, Nephelometric method	Turbidity meter	Lovibond, Germany
BOD_5 [$mg.L^{-1}$]	5210 B, 5-Day BOD Test	Incubator/ JRAD	Memmert, Germany
DO [$mg.L^{-}$]	4500-OC-Azide modification	Titration	-
PO_4 [$mg.L^{-1}$]	4500-P C, Ascorbic Acid method	Spectrophotometer UV-1200	China
NO_3 [$mg.L^{-1}$]	4500-NO3-F, Colorimetric method	Multiparameter photometer/HI 83200	Romania
TDS [$mg.L^{-1}$]	2540-C, Total dissolved solids dried at 180ºC	Oven	Memmert, Germany

IQ-WQI Calculation

The IQ-WQI was calculated according to (Al-Janabi et al. 2023), which was done in four steps: step one, each parameter has assigned weights; step two, calculation of quality rating (Qi) for each parameter based on the concentration (observed value) of the ith parameter (Ci) divided by standard value of the nth parameter (Si) as shown in eq. 1 and 2; step 3, determination of sub-indices (SIi) by multiplying the final weight (Wi) of each parameter by its quality rating (eq. 2); step four, aggregation of each sub-indices to get the final index score using the additive (arithmetic) method (eq. 4). The Water quality rating is shown in Table 3.

$$Qi = \frac{C_i - C_{ideal}}{s_i - C_{ideal}} \times 100$$

(for DO and pH; Cideal for DO= 14.6; Cideal for pH=7) …(1)

$$Qi = \frac{C_i}{s_i} \times 100 \quad \text{(for other parameters)} \qquad \ldots(1)$$

$$SI_i = final\ wight \times Q_i \qquad \ldots(2)$$

$$IraqiWQI{=}\sum SI_i\ /Wi \qquad \ldots(3)$$

Statistical Comparison

The sensitivity study for IQ-WQI for both purposes, which is based on Backward Linear Regression (BLR) to ascertain which water quality parameter most affects the score of IQ-WQI, was carried out using Jeffreys Amazing Statistics Program (JASP) for statistical analysis based on the R programming language.

RESULTS AND DISCUSSION

Physicochemical Parameters

The physicochemical parameters (DO, BOD_5, pH, PO_4, NO_3, water temperature TDS, and Turbidity) were measured to derive IQ- WQI. The ranges of parameters measured at three sites of the Main Outfall Drain are given in Table (4). No remarkable seasonal variation (Winter to autumn) was observed in the values of (pH, PO_4, NO_3, and water temperature that varied from (7.22-7.50) for pH, (0.05-0.1 $mg.L^{-1}$) for PO_4, (5.6- 11.7 $mg.L^{-1}$) for NO_3 in all sites, the values were well within the acceptable range of Iraqi standards for fresh water and for aquatic life protection.

The turbidity level varies from 31.82 to 39.47 $mg.L^{-1}$, and the mean concentrations were within the range for fresh water. At the same time, the turbidity values exceeded the recommended values for standard guidelines of aquatic life protection (5 NTU) (CMME 2001) in all sites.

In the majority of the cases, the DO, BOD_5, and TDS concentrations were higher than the allowable limit for Iraqi standards of fresh water and aquatic life protection, as well as turbidity for aquatic life protection. The ranges of these parameters were from (4.9- 5.6 $mg.L^{-1}$) for DO, (9.4 - 11.6 $mg.L^{-1}$) for BOD_5, (8008.2- 20636.8 $mg.L^{-1}$) for TDS, (31.8-39.4 NTU) for turbidity in all sites.

In the Assessment of Main Outfall Drain (MOD) using IQ-WQI, all study sites were ecologically unsuitable for freshwater and aquatic life protection with values > 100, except one value in site1 was 99.1 (very poor water quality) in winter because it falls within the range (70- 100) (Table 5).

The major contributing parameters to the river's very low water quality status were generally TDS, BOD5, turbidity, and DO (Table 4). It was used to discharge the agricultural effluents along about 565 km, thus leading to rising TDS, BOD5, and turbidity levels, as stated by Khuhawar et al. (2023), who studied the MOD River (Khuhawar et al. 2023). As well as the correlation of the high TDS concentrations with decreased levels of other parameters such as DO, as stated by Xu et al. (2019), who studied the Dan River basin

Table 3: Rating of the Water quality as per weight arithmetic water quality index method (Al-Janabi et al. 2023).

WQI Value	0-25	26-50	51-75	76-100	> 100
Rating of Water Quality	Excellent water quality	Good water quality	Poor water quality	Very Poor water quality	Unsuitable
	Blue	Green	Yellow	Orange	Red

Table 4: The results of physical-chemical parameters for the study sites.

Parameter	Observed mean Values			(Sn) for freshwater	(Wn) for freshwater	(Sn) For aquatic life protection	(Wn) for aquatic life protection
	St.1	St.2	St.3				
pH	7.225	7.25	7.5	7.50	0.0901	7.75	0.0901
WT[C°]	30.5	32.5	34.5	-	-	15	0.0926
Turbidity NTU	32.5	31.825	39.47	50.00	0.1150	5	0.1165
BOD_5 $mg.L^{-1}$	11.625	11.05	9.425	5.0	0.0901	-	-
DO $mg.L^{-1}$	5.2	4.91	5.65	5.00	0.4210	7.25	0.3986
PO_4 $mg.L^{-1}$	0.1552	0.0737	0.059	0.40	0.0947	0.1	0.0982
NO_3 $mg.L^{-1}$	7.089	5.685	11.70	15.00	0.096	15	0.0992
TDS $mg.L^{-1}$	8008.25	9841.125	20636.87	500.00	0.0931	500	0.1048
					ΣWn=0.1		ΣWn= 1.0

in China (Xu et al. 2019), where in nature, the relationship between DO and salts is opposite, an increase in salts will not allow atmospheric oxygen to dissolve in water.

IQ-WQI

Fig. (2) shows the temporal variation in IQ-WQI for Freshwater use and aquatic protection. The higher values of IQ-WQI were in the summer compared with other seasons. Meanwhile, the lower values were in winter in all sites. The reason may have been related to the higher levels of TDS and BOD_5 during the Summer season in all sites that coincided with low water discharges of the river, and vice versa in winter, as stated by Al-Zaidy (2021) who studied the same area for Main Outfall Drain in Al-Qadisiya Governorate.

Fig. 3 shows the spatial variation in IQ-WQI for Freshwater use and aquatic life protection. The higher values of IQ-WQI were in site 3 (lower quality). In contrast, the lower water quality index values were in site 1(higher quality). It was observed that Site 3 had double concentrations of TDS compared with S1 and S2, which may be due to being it was affected by water from the discharge canal of Al-Dalmag Marsh that met with the Main Outfall Drain in a site called the Waterfall Site about 2 km before Site 3, the fluxes of Al-Dalmag Marsh water contained higher content of TDS. The higher levels of TDS in Al-Dalmag Marsh water may related to the increasing evaporation rate and the low lentic water level of the marsh (Casamitjana et al. 2019) or may be due to the discharge of groundwater into the Main Outfall Drain River from the adjoining salt marsh (Al-Dalmag marsh) (Guimond & Tamborski 2021). In general, most of the sites during the winter season have low WQI values in comparison to other seasons, which can be related to increasing water discharges that can reduce the deterioration of water quality through the diluting of pollutants in water (Fan et al. 2022, Al-Janabi et al. 2024). As seen in Table 5, the only index value (99.11 bad water) at site 1 during winter was different from the rest of the values, and if it is compared with the discharge value in the same season (Table 1), will find the discharge value (4 $m^3.sec^{-1}$) is higher than the rest of the seasons. This study's finding is close to that of Hussein et al. (2019) in their research on assessing the water quality of the Al-diwanaiah River, where they declared that the water severely threatens aquatic life but can be used for irrigation purposes only.

Sensitivity Analysis

The sensitivity analysis studies the response of the output results of the test to input parameter variation (Álvarez et al. 2018). To determine the parameter that most influences the water quality of the Al-Dalmaj and MOD, the study selected Backward Linear Regression (BLR) for freshwater and aquatic life protection index score. To evaluate the BLR model performance, the coefficient of determination (R2), Root Mean Square Error (RMSE), and Sum Square error (SSE) were used, where the use of these three criteria remarkably affected the fitness and residual measurement of the model in the prediction of WQI. The sensitivity test was done by eliminating one parameter from the calculation of IQ-WQI each time and comparing the outcome with the

Table 5: The results of IQ-WQI for freshwater use and aquatic life protection.

IQ-WQI value for Freshwater use				
	Winter	Spring	Summer	Autumn
	99.11	121.54	210.51	144.05
	117.20	112.88	264.21	208.42
	145.22	212.90	438.67	325.98
IQ-WQI value for the protection of aquatic life				
	Winter	Spring	Summer	Autumn
Site1	140.65	253.32	280.97	215.90
Site2	187.96	228.39	316.24	275.33
Site3	263.05	374.6	513.53	440.52

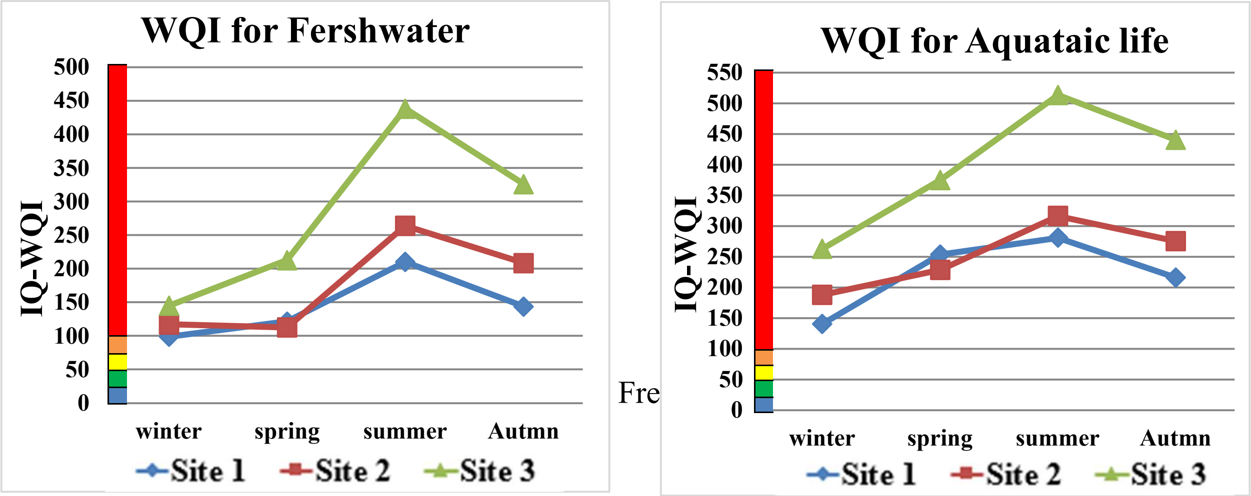

Fig. 2: Temporal variation in IQ-WQI for both Freshwater use and protection of aquatic life.

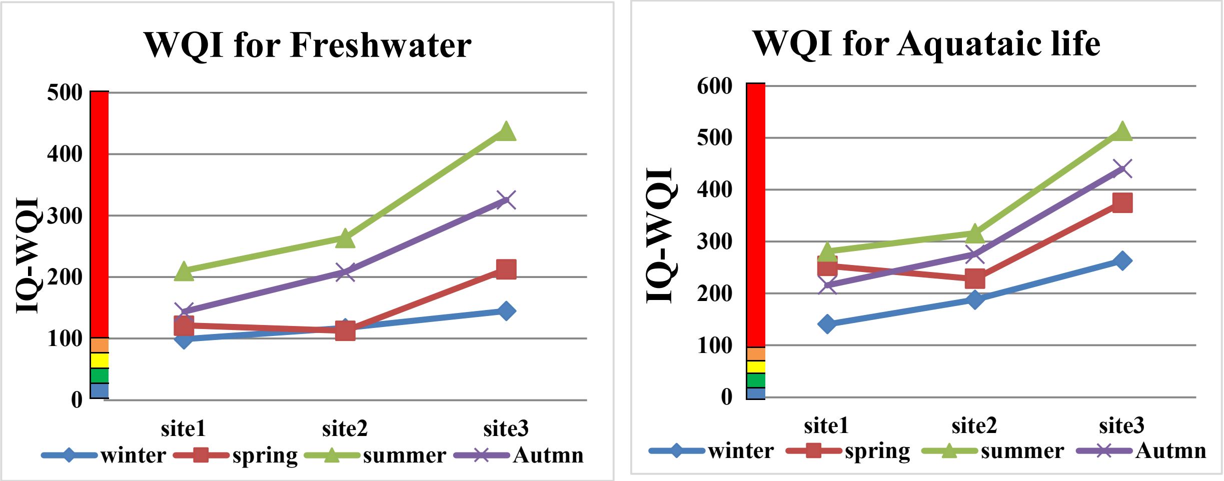

Fig. 3: Spatial variation in IQ-WQI for both freshwater use and protection of aquatic life.

original or reference results of IQ-WQI (reference IQ-WQI includes all parameters called IQ-WQI-Ref.). When the model has low R2 and high RMSE and SSE, it indicates an influencing parameter in calculating WQI; in contrast, if the model has High R2 and low RMSE and SSE, it indicates non-influencing parameters in the calculation. All data sets of this study (112 values) were subject to standardization before being used in the test to ensure a fair representation of all parameters in the IQ-WQI values.

The data set from the case study was chosen to describe this index's effectiveness and determine the most important parameters that must be present to calculate the index. 7 parameters from WQI calculation (DO, BOD$_5$, pH, PO$_4$, NO$_3$, TDS, Turbidity) were all selected as input and IQ-WQI as the output for BLR-IQ-WQI models.

BLR's first model, which represents the input parameters, called IQ-WQI-Ref, serves as a reference for the BLR model and includes all parameters used in calculating the index. Then, the assessing processes for the significance of the input parameters (IQ-WQI-Ref) were done by eliminating one parameter from the IQ-WQI-Ref (including seven parameters) for both uses (freshwater and aquatic life protection). Table 6 shows the performance of the BLR model that was evaluated using R2, RMSE, and SSE. The results of sensitivity analysis illustrated that the water quality index predicted by the BLR model brings reliable output, and the best-predicated model that contains the most effluence parameters on water quality for freshwater use is model number 4 and model 3 for aquatic life use, as shown in Table 5 where RMSE =11.347 and = 14.704, respectively.

Table 6: Sensitivity analysis for IQ-WQI model prediction (BLR-IQWQI) for freshwater use and aquatic life protection uses.

Model	Freshwater Use				Aquatic Life Protection Use			
	R	R²	Adjusted R²	RMSE	R	R²	Adjusted R²	RMSE
1	0.999	0.999	0.996	13.329	0.999	0.999	0.997	16.423
2	0.999	0.999	0.997	12.168	0.999	0.999	0.998	14.993
3	0.999	0.998	0.997	11.905	0.999	0.999	0.998	14.704
4	0.999	0.998	0.997	11.347	0.999	0.998	0.997	15.687

Table 7: Equations of sensitivity analysis for IQ-WQI prediction (BLR-IQ-WQI) for freshwater use.

Model Equation	Model Equation
BLR-IQ-WQI-Ref-model 1	0.049 * DO + 0.220 * pH + 0.024 *BOD_5 + - 0.046 * PO_4 + - 0.00342 * NO_3 +0.855 * TDS + -0.133 *Turbidity
BLR-IQ-WQI-model 2	0.049 * DO + 0.220 * pH + 0.024 *BOD_5 + - 0.046 * PO_4 + 0.855 * TDS + -0.133 *Turbidity
BLR-IQ-WQI- model 3	0.220 * pH + 0.024 *BOD_5 + - 0.024 * PO_4 + 0.864 * TDS + -0.101 *Turbidity
BLR-IQ-WQI- model 4	0.208 * pH + 0.020 *BOD_5 + 0.878 * TDS + -0.091 *Turbidity

Table 8: Equations of sensitivity analysis for IQ-WQI prediction (BLR-IQWQI) for the protection of aquatic life.

Model Equation	Model Equation
BLR-IQ-WQI-Ref-model 1	-0.080 * DO + 0.059* pH + -0.00994 *WT + -0.059 * PO_4 + - 0.094* NO_3 +0.0998* TDS + -0.068 *Turbidity
BLR-IQ-WQI-model 2	-0.080 * DO + 0.059 * pH + - 0.059 * PO_4 + -0.093 * NO_3 + 0.996 * TDS + -0.068 *Turbidity
BLR-IQ-WQI- model 3	-0.099 * DO + 0.053 * pH + 0.855 * + -0.125 * NO_3 + 1.055 * TDS + -0.101*Turbidity
BLR-IQ-WQI- model 4	-0.147 * DO + 0.049 * pH + 0.946 * TDS + -0.134*Turbidity

Equations of sensitivity analysis for IQ-WQI prediction (BLR-IQ-WQI) for both uses are given in Tables 7 and 8.

The most significant and influential parameters on IQ-WQI for freshwater uses are pH, BOD, TDS, and Turbidity. Al Yousif & Chabuk (2023) reviewed several studies that indicated the importance of these parameters in the evaluation of water quality for surface water using different types of indices and pointed out that developing countries have recently increased their efforts to focus evaluate the water quality of rivers because it's the primary source of water for different uses (Al Yousif & Chabuk 2023). Nowadays, water resource management and water resource protection are often used interchangeably in practice, and water resource protection focuses on measures put in place, such as the control and prevention of water pollution. Furthermore, water resources management emphasizes enabling institutional roles, regulating and policy the environment, and management instruments as prerequisites to deploying water resources to support economic and social development while ensuring resource sustainability (Makanda et al. 2022).

For aquatic life protection, the most important parameters that influence IQ-WQI are DO, pH, PO_4, NO_3, TDS, and Turbidity, where this model contains the most parameters that encourage and support the growth of aquatic life, which can called the limited factors (DO, PO_4, NO_3) for algae which consider the base of the food chain (Indraswari & Adharini 2022, Bourgougnon et al. 2021).

CONCLUSIONS

The WQI approach used in the study to evaluate sites' water quality was helpful. Turbidity levels were within the range for fresh water. Meanwhile, the turbidity values exceeded the recommended values for standard guidelines of aquatic life protection (5 NTU) in all sites.

In most cases, the DO, BOD_5, and TDS concentrations were higher than the allowable limit for Iraqi freshwater standards and aquatic life protection standards. The major contributing parameters to the river's very low water quality status were generally TDS, BOD_5, turbidity, and DO. Since it was used to discharge the agricultural effluents along about 565 km, this led to rising TDS, BOD_5, and turbidity levels. The temporal variation in IQ-WQI for Freshwater use and aquatic life protection showed that the higher values were in the summer compared with other seasons. The reason may be related to the higher levels of TDS and BOD_5 in the Summer season in all sites that coincided with low water discharges of the river, and vice versa in winter. The spatial variation showed that IQ-WQI was in descending order by very poor water, which was unsuitable. Site 3 has double concentrations of TDS compared with other sites may be due to it being affected by the water of the discharge canal for Al-Dalmag Marsh that meets with the Main Outfall Drain in a site called the Waterfall Site about 2km before Site 3; thus, it was exposed to fluxes of Al-Dalmag Marsh water with higher content of TDS. Using sensitivity analysis can show the most important parameters that can affect the water quality Characteristics, as well as using Backward Linear Regression (BLR) based on artificial intelligence techniques to predict the values of WQI, which can facilitate the calculations of indices accurately.

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