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Assessing the Effects of Urbanization on Water Quality Metrics in Shat Al Garaf River: A Comparative Analysis of BOD5, COD and TOC

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Abstract: This study investigates the strength of the connection between (total organic carbon TOC and other measures of water quality, such as biological and chemical oxygen demand BOD5, COD), in the context of water quality in the Shat Al Garaf River, southern Iraq. Over two years, water samples were collected and tested to obtain BOD5, COD, and TOC data. The analysis shows a good correlation between TOC and BOD5 (r = 0.95) and TOC and COD (r = 0.93), facilitating the formulation of predictive equations for calculating BOD5 and COD concentrations derived from TOC measurements. Based on the findings, it seems that total organic carbon (TOC) has the potential to function as a trustworthy indicator for evaluating the water quality of the Shat Al Garaf River, which would allow for improved management and monitoring procedures. the need for more research was significant on the link between TOC and BOD5 to improve the knowledge of freshwater resources management in the field.

Keywords: Effects of Urbanization. Water Quality Metrics, Shat Al Garaf. TOC. BOD5. COD.

INTRODUCTION

Biological oxygen demand (BOD_5) and chemical oxygen demand (COD) are two of the most important measurements of water quality recognized internationally. Other critical measurements include modeling and monitoring of wastewater systems. It takes five days to determine BOD_5 concentration, while COD concentration can be obtained in just a few hours. It is important to note that the presence of large amounts of chloride may result in erroneous findings regarding organic contaminants, as BOD_5 is very sensitive to chemicals that hinder the formation of water samples [1, 2, 3].

On the other hand, COD is not affected by compounds and does not require extensive time for measurement. However, it is important to be aware that the sample vial generated from the COD test may contain hazardous chemical waste that exceeds standard limits [4].

Despite the widespread use of the COD test as a substitute for BOD_5 testing, it is clear that COD cannot effectively replicate the extent of industrial effluent contamination due to the influence of different types of oxidants, catalysts, and the acidity of the reaction solution. However, the severity of organic contamination may be accurately represented by employing total organic carbon (TOC) because of the advantages that this approach offers. Although there is a lack of information confirming the relationship regarding the benefits of using TOC tests as alternatives to BOD_5 or COD, it is evident that this method can provide fast and accurate data and could be reliable [5, 6, 7].

COD and BOD_5 are standard assays for wastewater and represent the most precise measurements of organic matter that can be oxidized by chemical or biological processes [8, 9]. These methods

are interrelated, and their concurrent use is strongly recommended. The readings derived from COD are often greater than those from BOD_5 and depend on the type of water being examined. The BOD_5/COD ratio should be less than or equal to 1.0, indicating the percentage of degradable organic matter present in wastewater [10, 11, 12].

In this research, the relationship between BOD_5, COD, and TOC was investigated. The coefficients (R^2) and the correlation coefficient (r) were calculated for the Shat Al Garaf River, located in southern Iraq. Data for this study were collected through monthly monitoring over two years, beginning in 2022.

MATERIAL AND METHOD

This study concentrated on the course of the Al Garaf River, specifically in the provinces of Al Kut and Dhi Qar, particularly in the cities of Al Hay, Al Fajer, and Al Qalaa, through which the Shat Al Garaf River flows. Samples were collected from designated stations in these three cities along the course of the Shat Al Garaf (see Fig. 1). This figure illustrates the whole course of Shat Al Garaf across the province. The pollution flow into this river originates from the settlements along its banks, mostly due to industrial effluent, human activities, sewage discharge, and the unregulated allocation of industrial zones, which have significantly degraded of the quality of water.

Fig .1 Map of the course of the Shat Al Garaf. Map data © Google. The scale displayed indicates that the horizontal distance represented is 300 meters, while the vertical distance is 1787 meters."

The scholar embraced the profundity The integrating sampling method accounts for concentration variations with stream depth by collecting samples throughout the river's vertical profile rather than solely from the surface. This method involves deploying a descending sampler near the stream bed and gradually elevating it until three-quarters of the sampler is filled.[13,14]

Due to the aggregation of pollutants into larger masses than their typical size, concentration varies across the river cross-section as a result of the altered dimensions, water discharge, and velocity. Consequently, the river was spilite into four segments, and representative samples were collected from one-quarter, one-half, and three-quarters of the river's width, as illustrated in Fig. No. 2.

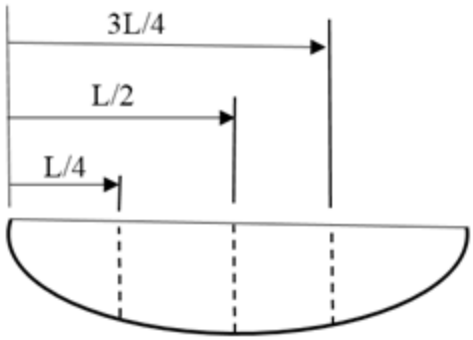

Fig 2 The site of sampling inside the river cross-section.

To ensure that the samples accurately reflect the impact of the communities on river water excellence, samples were taken regularly from three different locations over a duration of 24 months starting in 2022. These stations were situated at the river's crossing point at the end of the cities. Three samples were taken at each station, resulting in a total of 216 samples that were organized and analyzed to determine the rates of Total Organic Carbon (TOC), Biochemical Oxygen Demand over five days (BOD5), and Chemical Oxygen Demand (COD) at each station. The average values for river cross-action samples were calculated. in this study, the researcher has adopted the ASTM D7573 - 18ae1, ASTM D638-98, and ASTM D152-06to gain the TOC, BOD5 and COD. The tests were done at the Pollutant Laboratories at the Southern Technical University.

RESULTS AND DISCUSSION

The samples were classified according to their stations and tested to obtain information about the water BOD5, COD, and TOC levels. The average value for each section has been calculated, which leads to 72 BOD5, COD, and TOC values. The mean values for these 72 concentrations were 2.37 ppm, 5.19 ppm, and 2.69 ppm for BOD5, COD, and TOC. In respective, furthermore, the minimum concentration of BOD5 was 1.35 ppm at Al Fajer station. recorded in March. The minimum concentration of COD was 3.05 ppm recorded in March at Al-Fajer also. the minimum Toc concentration recorded also in March at the same station with a value of 1.91 ppm. The reason for these lower values could be due to Al Fajer's lower population proportion compared to the other two station cities. The maximum concentrations of BOD5, COD, and TOC were 3.81 ppm,7.92 ppm, and 4.31 recorded in August at Al Qalaa station.

This outcome is rational given the substantial population of Al Qalaa city relative to other station cities. The analysis of the samples from all three stations shows that the river in those cities could be categorized as unaffected by pollution attributable to the lack of industrial establishments at the area, the significant concentrations of (TOC), (BOD5), and (COD) for each site are displayed in Table 1.

TABLE 1. The s concentrations of (TOC), (BOD5), and (COD) at the three cities.

location	Concentration ppm	BOD_5 ppm	COD ppm	TOC ppm
Al Hay	Mean	2.44	5.40	3.08
	Max	3.86	7.93	4.40
	Min	1.41	3.34	1.99
Al Fajer	Mean	2.23	4.84	2.78
	Max	3.27	7.26	4.06
	Min	1.33	3.05	1.91
Al Qalaa	Mean	2.42	5.26	3.03
	Max	3.85	8.00	4.35
	Min	1.46	3.36	2.05

The results showed that values of BOD5 are consistently lower than those of COD and TOC. This can be attributed to BOD being an accurate measure of dissolved organic contaminants in aquatic systems, in contrast, TOC and COD include both biological materials that break down naturally and those that don't. pollutants in water. The BOD5 concentrations for the first quarter are the smallest measured for the year, likely due to the increased rainfall during these months, which introduces low-BOD water from snowmelt or precipitation, thereby influencing BOD levels.

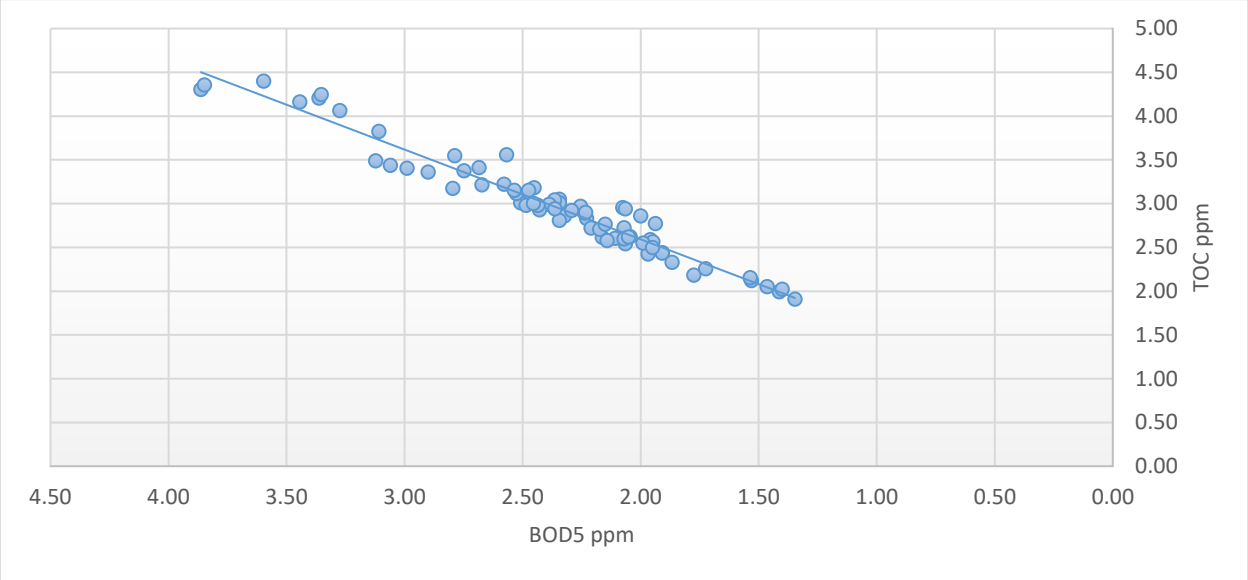

Fig 3 The TOC and BOD correlation in Shat Al Garaf.

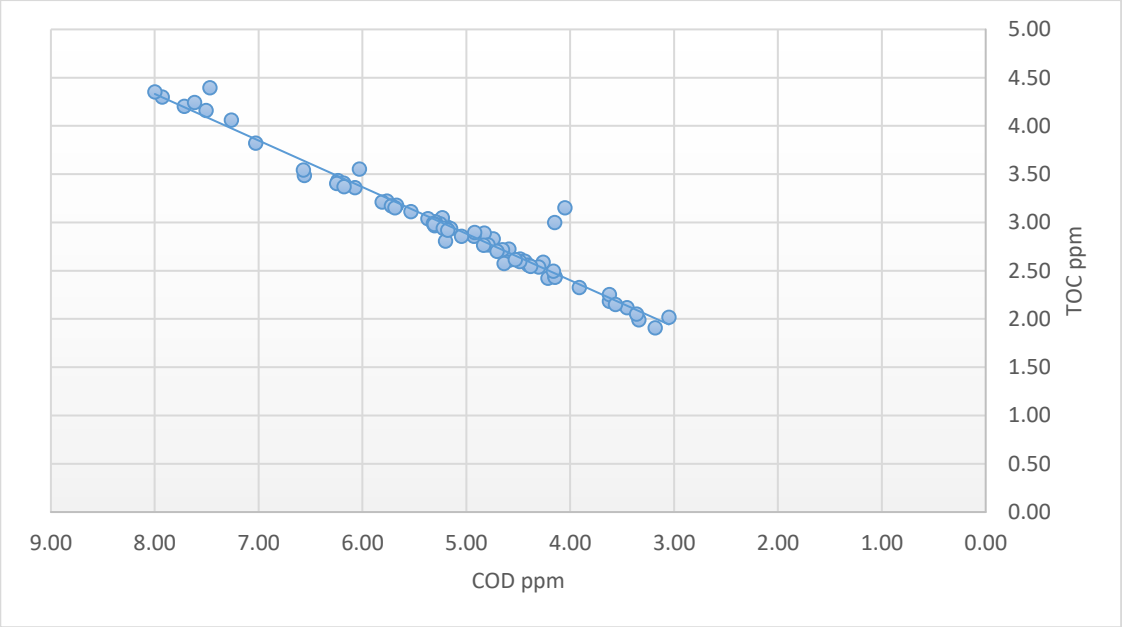

Fig 4 The TOC and COD correlation in Shat Al Garaf.

The association between TOC and COD or BOD5 was assessed by analyzing BOD, COD, and TOC data using the SPSS software. Table 2 presents the (r) coefficients and the (R^2) coefficients between total organic carbon (TOC) and biochemical oxygen demand (BOD_5), as well as chemical oxygen demand (COD) in the Shat Al Garaf river. There is a strong straight link between TOC and BOD indicated by the coefficient (r = 0.95) and the coefficient (R^2 = 0.92). The analysis demonstrates that BOD_5 can be predicted based on TOC values using the equation.

$$BOD_5 = 0.63 * TOC^{1.19}$$

Additionally, the coefficient of correlation (r) between COD and TOC is 0.93, with a determination coefficient ($R^2 = 0.90$); hence, COD may be approximated based on TOC value by the formula.

$$COD = 1.39 * TOC^{1.17}$$

The appropriateness of the proposed formulae was evaluated using two methods: graphical analysis and statistical assessment, using data from the Pollutant Laboratories for the Shat al Gharaf River in Al Refaae City.

The statistical assessment,

The two newly proposed formulae were statistically evaluated by contrasting the observed BOD5 and COD with the projected BOD5 and COD. Table 3 presents the results for the POE method for the new proposed formulas.

TABLE 2. POE results to the suggested formulas.

Eq.	POE method									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
BOD eq.	93%	95%	95%	96%	96%	96%	100%	100%	100%	100%
COD eq.	94%	95%	97%	97%	97%	99%	100%	100%	100%	100%

The graphical assessment

Graphically comparing the new formulas results with the obtained data demonstrated that the measured BOD5 concentration is close to the BOD formula's results. The graphical comparison shows that the anticipated formula results converge with the real tested values, as the observed COD is near the expected COD and the dots spread nicely about the diagonal line. Fig.5-6 compares the new formulations graphically. Even though (BOD5) is is an accepted method by nearly all ecological protection Agencies and the sole analytical technique for measuring water quality and wastewater facility compliance. The statistical analysis and graphical comparison show that total organic carbon (TOC) is a good indicator of water quality.

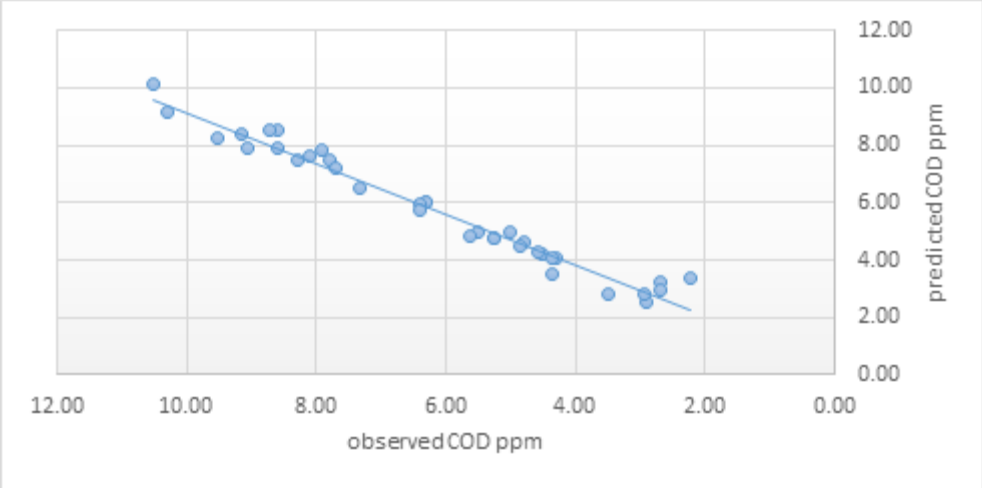

Fig 5. Graphically comparing actual and expected COD

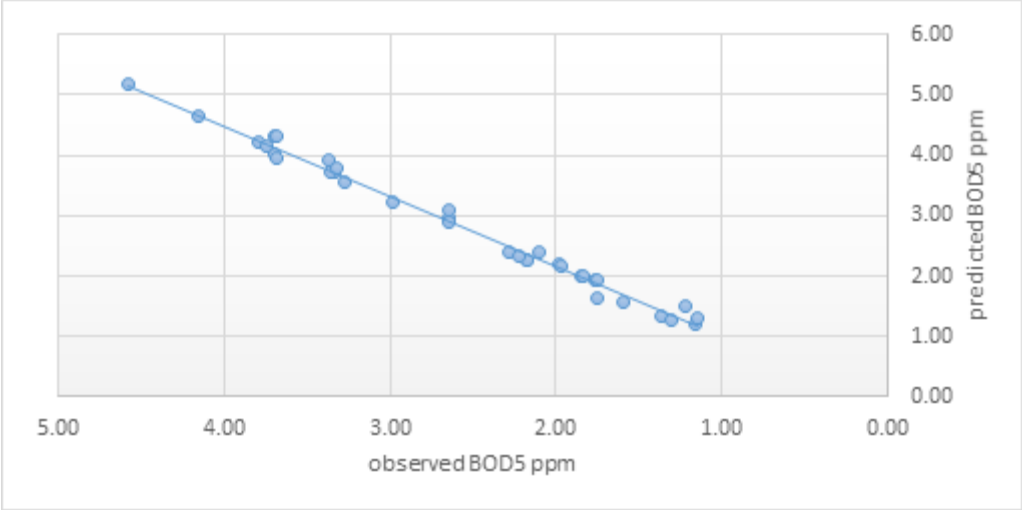

Fig 6. Graphically comparing actual and expected BOD5

CONCLUSION

Two formulae were provided in the assessment of water quality data from the Shat Al Garaf River that lasted for two years. These formulas were used to estimate BOD5 and COD concentrations based on TOC measurements. With values of r=0.95 for BOD5 and r=0.93 for COD in respect to TOC, a significantly high correlation coefficient was found to exist between the two variables. Our results suggest that the suggested formulae should be used in order to estimate BOD5 and COD based on TOC in the Shat Al Garaf River, which is located in southern Iraq. This is because these substantial connections have been found. The link between total organic carbon and biological oxygen demand (BOD) in other Iraqi rivers requires more research to be conducted.

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