AL- Rafidain University College

PISSN: (1681-6870); EISSN: (2790-2293)

Journal of AL-Rafidain University College for Sciences

Available online at: https://www.jrucs.iq

JRUCS

Journal of AL-Rafidain University College for Sciences

A Modified MANOVA Model to Assess Water Quality

Dr. Huda Z. Naji

huda.naji@uobasrah.edu.iq

Department of Mathematics - College of Science - University of Basrah, Basrah, Iraq.

Article Information

Article History:
Received: December, 17, 2022
Accepted: March, 3, 2023
Available Online: December, 31, 2023

Keywords:
MANOVA model, Spatial and temporal characterizations, Water quality assessment.

Correspondence:
Dr. Huda Z. Naji
huda.naji@uobasrah.edu.iq

Abstract

The water quality of the Shatt Al-Arab River has worsened as a result of fast population expansion as well as industrial and agricultural activities. As a result, water purification services are a significant source of supply for the densely populated Basra area in Iraq. To analyze the geographical and temporal impacts of Basrah water quality, a two-way MANOVA analysis of the main components was performed using imbalance cell sizes and imbalance cell of covariance matrices. Factor A represents the spatial level, which has eight levels, while factor B represents the temporal level, which has two levels (dry and wet season). This study sampled water quality parameters (pH, Turbidity, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Calcium (Ca^{+2}), Magnesium (Mg^{+2}), Total Hardness (TH), Potassium (K^{+}), Sodium (Na^{+}), Sulphates (SO_4^{-2}), Chloride (Cl^{-}), and Alkalinity) from the influence of eight water treating sites for the years from (2017 - 2019). The statistical results of the suggested model demonstrate significant geographical differences across stations. A significant difference was observed between stations with no source of pollution (Al- Shaebah and Al-Abbas) and stations located near sewage discharge outfalls (Al- Bradhiah, Al- Jubailah, and Garmmat Ali) and stations primarily affected by salinity intrusion from the Arabian Gulf into the Shatt Al-Arab River (Al- Bradhiah, Al- Jubailah, and Garmmat Ali) (Al- Labanie, Mhejran, Maheilah).

https://doi.org/10.55562/jrucs.v54i1.614

1. Introduction

All humans and other organisms may continue to survive for ages on river water [1]. Water quality is a significant determinant of environmental change and is directly linked to social and economic growth [2 - 4]. Global attention is now being paid to surface water contamination. The principal factors of surface water quality decline include natural and human activities such as hydrological features, climate change, precipitation, agricultural operations, and wastewater discharges from industry [5 - 7]. In recent decades, as a consequence of these human activities, the water quality of several big rivers in a variety of nations has worsened significantly [9]. In the last several decades, a number of studies have been done to determine the type and origins of pollution in many rivers [10 - 12]. Various physical, chemical, and biological technologies, including coagulation and membrane filtration (micro and ultrafiltration), adsorption, advanced oxidation, photo catalysis, and others, have been used to address river surface water pollution [13 - 15]. The selection of the treating procedure is dependent on the kind and concentration of the discovered contaminants. However, in the management of water index quality, a cost of treatment may be as significant as achieving index quality objectives. Consequently, knowledge regarding the variability of river and surface water quality is necessary for the proper management of water resources [16, 17]. It is essential to do a spatial study of the water quality of a river in order to determine a black sites of pollution, when the contamination are centered, and so optimize the cost of water index. However, temporal variables, such as temperature and deposition, impact the river's water index and cause seasonal differences in its properties. Thus, the examination of samples from various locations (spatial studies) at different times of the year improves river and surface water treatment management.

Research into surface and groundwater quality has been more prominent in the last several decades, and it has been a growing subject of study over the previous century. Statistical analysis is a crucial method for studying correlations, trends, and other patterns between different categories of information. It's useful in a wide range of academic disciplines, from linguistics to sociology to environmental science, where statistical analysis has been essential in assessing water quality in a variety of places. Multivariate statistical analysis methods, as shown by a case study of the Fuji River Basin in Japan [18], are useful for analyzing and making sense of large datasets and judging water quality. The author carried out a discriminant analysis in order to lessen the dimensionality of the massive dataset and to narrow down the number of indicator factors that are to blame for the significant shifts in water quality. The data on the quality of the surface water in the Tahtali Basin in Turkey were also subjected to factor, principal component, and cluster analysis [19]. In order to understand a huge and complicated data matrix acquired during a monitoring program of surface waters in Northern Greece, Simeonov et al. [20] used several multivariate statistical methodologies. Cluster analysis (CA), principal component analysis, and multiple regression on principal components were used to process the dataset. In order to evaluate the database, Rahmat, at el. [21], used a multivariate statistical analysis technique. In this method, multiple linear regression (MLR) was used to predict the performance of the wastewater quality index and principal component analysis (PCA) was utilized to minimize the dimensionality of datasets acquired from the field wastewater treatment facility.

In light of the information presented above, the purpose of this research is to propose an imbalanced multivariate analysis of variance (MANOVA) two-way model with interactions so that an investigation can be conducted into the impact that spatial and temporal characterizations water quality in the Basra district.

The remaining parts of this work are structured as follows. In Section 2, we discussed the methods used in this investigation. Materials and methods for the experiment were described in Section 3. Part Four discusses the Evaluation of Water Pollution Using an Unbalanced Two-Way MANOVA; Part Five discusses the Analysis of the Results. Concluding remarks were offered in Section 6.

2. Materials and Methods

- ***Proposed Model Under Heteroscedastic and Unbalance Cell Size***

In this part, an unbalanced and heteroscedastic MANOVA two-way Interactional model was provided. The primary purpose of the model that has been proposed is to determine the influence that the interaction of the two primary elements A (spatial factor) and B (temporal factor) have on the water quality index. The structure and notation should be represented as follows:

$$Y_{ijk} = \mu + \vartheta_i + \psi_j + (\vartheta\psi)_{ij} + e_{ijk} \qquad (1)$$

Where, μ represent an overall mean, i is the experiment with different amounts of factor A (indexed by a) and j is the experiment with different amounts of factor B (indexed by b) while, the experimental unit level index (i,j) represents by k (indexed by n_{ij}). ϑ_i is i^{th} main effect of factor A, ψ_j represents j^{th} main effect of fact or B and $\vartheta\psi_{ij}$ is $(i, j)^{th}$ interaction effect between factor A and factor B.

To ensure that the parameterization is of full rank, we apply the following conditions:

$$\sum_{i=1}^{a} \vartheta_i = 0 \,;\, \sum_{j=1}^{b} \psi_j = 0 \,;\, \sum_{i=1}^{a} \sum_{j=1}^{b} (\vartheta\psi)_{ij} = 0$$

$$\sum_{i=1}^{a}(\vartheta\psi)_{ij} = 0\ ;\ j = 1,\dots,b-1 \quad , \quad \sum_{j=1}^{b}(\vartheta\psi)_{ij} = 0\ ;\ i = 1,\dots,a-1 \tag{2}$$

$$\sum_{i=1}^{a} Z_{ijk} = \sum_{j=1}^{b} Z_{ijk} = 0 \quad ; \quad e_{ijk} \sim N_P\ (0, \textstyle\sum_e)$$

- ***Model Estimation and Hypothesis Testing***

The estimator of effects of unbalanced MANOVA models is influenced by the fact that the set of factors of unequal lengths in weights A two-way MANCOVA with interaction, which is of interest in this study, belongs to a class of fixed effects models. In the proposed paradigm (2), these talents may be expressed as:

$$\hat{\vartheta}_\iota = \sum_{i=}^{a} n_{ij}(\bar{Y}^*_{i..} - \bar{Y}^*_{...})(\bar{Y}^*_{i..} - \bar{Y}^*_{...})' \tag{3}$$

$$\widehat{\psi_J} = \sum_{j=1}^{b} n_{ij}\left(\bar{Y}^*_{.j.} - \bar{Y}^*_{...}\right)\left(\bar{Y}^*_{.j.} - \bar{Y}^*_{...}\right)' \tag{4}$$

$$\widehat{(\vartheta\psi)}_{\iota J} = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n_{ij}} n_{ij}\ \left(\bar{Y}^*_{ij.} - \bar{Y}^*_{i..} - \bar{Y}^*_{.j.} + \bar{Y}^*_{...}\right)\left(\bar{Y}^*_{ij.} - \bar{Y}^*_{i..} - \bar{Y}^*_{.j.} + \bar{Y}^*_{...}\right)' \tag{5}$$

The following are the null hypotheses for an imbalanced proposed model of Type III (When a main factor (i.e., A and B) is analyzed after each other factors (lines with interactional) have been respected:

With respect to factor A (there being no primary impact):

$H_{01} = \vartheta_1 = \vartheta_2 = \cdots = \vartheta_a = 0$

With respect to factor B (there being no primary impact):

$H_{02} = \psi_1 = \psi_2 = \cdots = \psi_b = 0$

Without A effects:

$H_{03}^{(A|B)} = \vartheta_1 + \vartheta_1\psi_1 = \cdots = \vartheta_1 + \vartheta_1\psi_b = \vartheta_2 + \vartheta_1\psi_1 = \cdots = \vartheta_2 + \vartheta_2\psi_b = \cdots = \vartheta_a + \vartheta_a\psi_b = 0$

Without B effects:

$H_{04}^{(B|A)} = \psi_1 + \vartheta_1\psi_1 = \cdots = \psi_1 + \vartheta_a\psi_1 = \psi_2 + \vartheta_1\psi_2 = \cdots = \psi_2 + \vartheta_a\psi_2 = \cdots = \psi_b + \vartheta_a\psi_b = 0$

For no mutual influences of factors A and B :

$H_{05} = \vartheta_1\psi_1 = \vartheta_2\psi_1 = \cdots = \vartheta_a\psi_1 = \vartheta_1\psi_2 = \vartheta_2\psi_2 = \cdots = \vartheta_2\psi_b = \cdots = \vartheta_a\psi_b = 0$

Because the homogeneity requirement is broken in the cell covariance matrices, the standard statistical tests cannot be employed to assess the assumptions stated above [22]. The sum of squares for cross product (SSCP) matrices for the unbalanced proposed model are defined as follows [23]:

$$H_A = \frac{1}{a-1}\sum_{i=1}^{a}\sum_{j=1}^{b}(\bar{Y}_{i..} - \bar{Y}_{...})(\bar{Y}_{i..} - \bar{Y}_{...})' \tag{6}$$

$$H_B = \frac{1}{b-1}\sum_{i=1}^{a}\sum_{j=1}^{b}(\bar{Y}_{.j.} - \bar{Y}_{...})(\bar{Y}_{.j.} - \bar{Y}_{...})' \tag{7}$$

$$H_{AB} = \frac{1}{(a-1)(b-1)}\sum_{i=1}^{a}\sum_{j=1}^{b}(\bar{Y}_{ij.} - \bar{Y}_{i..} - \bar{Y}_{.j.} + \bar{Y}_{...})(\bar{Y}_{ij.} - \bar{Y}_{i..} - \bar{Y}_{.j.} + \bar{Y}_{...})' \tag{8}$$

$$H_{(A|B)} = \frac{1}{a\ (b-1)}\sum_{i=1}^{a}\sum_{j=1}^{b}(\bar{Y}_{ij.} - \bar{Y}_{...})(\bar{Y}_{ij.} - \bar{Y}_{...})' \tag{9}$$

$$H_{(B|A)} = \frac{1}{b\ (a-1)}\sum_{i=1}^{a}\sum_{j=1}^{b}(\bar{Y}_{.j.} - \bar{Y}_{...})(\bar{Y}_{.j.} - \bar{Y}_{...})' \tag{10}$$

The SSCP matrixes for the above hypotheses with respect to factor no primary impact of A, B and the interaction. In contrast to the normal statistical examinations, a modified examinations are dependent on strange variables: Σ, f_H and f_G. To get f_H and f_G for imbalanced proposed model based H and G, respectively by substituting the initial values of H and G with $\left(\Sigma \text{ by } I_p \text{ , } \Sigma_{ij}\ by\ \Sigma^{-1/2}\,\Sigma_{ij}\,\Sigma^{-1/2}\ and\ \ \Sigma_{\vartheta\psi}\ by\ \Sigma^{-1/2}\,\Sigma_{\vartheta\psi}\,\Sigma^{-1/2}\right)$, such that [16]:

$e_{ijk} \sim N_p\left(0, \frac{\Sigma^{-1/2}\,\Sigma_{ij}\,\Sigma^{-1/2}}{n_{ij}}\right)$ then obtain:

$$f_G = \frac{p\,(p+1)}{(ab)^{-2}\sum_{i,j}(n_{ij}-1)^{-1}\,(n_{ij})^{-2}\{\,tr\,\left(\left[\Sigma_{ij}\,\Sigma^{-1}\right]^2 + \,tr^2\left[\Sigma_{ij}\,\Sigma^{-1}\right]\right)\}} \tag{11}$$

$$f_H = \frac{p\,(p+1)}{\sum_{i,j}\sum_{\vartheta,\psi}\frac{c_{ij,\vartheta\psi}^2}{n_{ij}n_{\vartheta\psi}}\left\{\,tr\,\left(\left[\Sigma_{ij}\,\Sigma^{-1}\,\Sigma_{\vartheta\psi}\,\Sigma^{-1}\right]^2 + \,tr\,\left[\Sigma_{ij}\,\Sigma^{-1}\right]\right)tr\,\left[\Sigma_{\vartheta\psi}\,\Sigma^{-1}\right]\right)\}} \tag{12}$$

3. The Components and Procedures of the Experiment

- ***Location of the Study Area***

Basra is Iraq's third largest city and the most southern governorate, located 542 kilometers south of Baghdad, and has a population of 4,700,000 people in 2019. The Tigris and Euphrates rivers form the Shatt Al-Arab water stream, which flows into the Persian Gulf and has various small lakes and marshlands. Basra is very hot and arid. because of Basra's world-class summer heat. The Arab Gulf increases humidity and precipitation. Between October and May, Basra receives 152 mm of rain. Abu AlKhaseeb, Al Midaina, Al-Qurna, Al-Zubair, Basrah, Fao, and Shatt Al-Arab are the seven cities of Basra. [24] Capital. Previously, Iraqi governments were unable to manage and regulate water supplies, particularly in Basra, where four million people relied on the Shatt al-Arab river for safe drinking water for humans, animals, and plants. Since the 1980s, Iraq has failed to control upstream sources, treat pollutants and sewage, and maintain water streams, resulting in poor water purity. In 2018, over 100,000 individuals were hospitalized with water-related ailments including; rashes, stomach discomfort, vomiting, and diarrhea due to Basra water deterioration. Basra Health Directorate advised citizens to boil all water in August due to water pollution. Similar pollution disasters occurred in many other nations [25].

- ***Compilation of Data***

This research focused on eight of Basra's most important water treatment facilities: the Al-Bradhiah (S_1), Al-Jubailah (S_2), Garmmat Ali (S_3), Al-Shaebah (S_4), Al-Labanie (S_5), Al-Abbas (S_6), Mhejran (S_7), and Maheilah (S_8). These treatment facilities are located at strategic points around the Basra Governorate, allowing them to service the majority of the urban core of Basra.

Table 1: Quality parameter of drinking water

Parameters	Iraqi guideline standard
PH	8.5 – 6.5
Turbidity	5
EC	2000
TDS	1000
Ca^{+2}	50
Mg^{+2}	50
TH	500
K^{+}	12
SO_4^{-2}	250
Na^{+}	200
Cl^{-}	250
Alkalinity	120

***all values in mg/L except EC in μm/cm and Turbidity in NTU. PH has no unit.**

This information was gathered from the end of the dry season (2017) to the beginning of the rainy season (2019). In this study, twelve physicochemical parameters are chosen for analysis: pH, Turbidity, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Calcium (Ca^{+2}), Magnesium (Mg+2), Total Hardness (TH), Potassium (K^{+}), Sodium (Na^{+}), Sulphates (SO_4^{-2}), Chloride (Cl^{-}), and Alkalinity. Table 1 outlines the quality characteristics of drinking water [26].

4. Water Pollution Assessment Using Unbalanced Two-Way MANOVA

The proposed two-way MANOVA model was utilized to assess effect of spatial and temporal on Basrah water quality. Factor A represents the spatial level, which has 8 locations, while factor B represents the temporal level, which has two levels (dry and wet season). Univariate and multivariate quality tests for response variables in the MANOVA model conducted using SPSS programming version 26. The Shapiro-Wilk goodness-of-t test that utilized to determine univariate normality, while the Mardia-test that utilized to determine multivariate normality in a given sample. Furthermore, QQ-plots of the calculated MANOVA model are generated. The low p-values of the quality test statistics obtained show that both the univariate and multivariate normality of the data have been violated in both cases. In addition, the findings of Box's M test for samples are summarized below in Table 2, which uses a significance level of 5 %.

Table 2: Box's M test at 5%

Sample	x^2	*p- value*
	69.43	0.0004

5. Observation of the Results

The results of the tests for the Wilks' (WL), Hotelling-Lawley (HLT), and Pillai's trace (PT) for all water quality parameters, as produced in SAS for heteroscedastic covariance matrix and unbalance cell size are shown in Table 3. The SSCP matrices used in the tests are Type III partitioned. At a 5% level of significance, the two-way MANOVA model tests the spatial (factor A) and temporal (factor B) variations of the water quality parameters as well as the interaction effect between A and B.

- ***Spatial Data Analysis***

Table 3 displays the results of a two-way unbalanced MANOVA model of Spatial data. As a result of the consequences on human life, pH is an essential measure of water quality. The pH of the sites varies significantly as a consequence of being impacted by industrial and household wastewater from the city, with the lowest value being 7.02 in S_7 and the highest value being 8.24 in S_6. Turbidity is an indicator of water clarity; Iraqi regulations establish the value of Turbidity equal to 5 NTU. Turbidity two-way MANOVA shows a significant variation between locations. S_7 had the lowest value of 2.5 NTU while S_4 had the highest value of 48.1 NTU. Ca^{+2} is found naturally in water and may dissolve in rocks such as limestone, dolomite, gypsum, and fluorite. Because calcium exists in water as a Ca^{+2} ion, it is a determinant of water hardness. The findings revealed that the variance between S_4, and S_6 was not statistically significant, but it was different across all sites; nevertheless, there is no significant variation between S_1, S_2, S_3, and S_8, and no significant variation between S_5, S_1, and S_8.

When water travels through soil and rock, it dissolves and holds minuscule quantities of minerals in solution (Mg^{+2} as Ca^{+2}). The Mg^{+2} data demonstrate that there is no statistically significant difference between S_4 and S_6, however there is a statistically significant difference between S_7 and the remainder sites. The TH data reveal that the S_4 had the lowest concentration of 293 mg/l and the highest concentration of 1078 mg/l.

On the other hand, the lowest K^{+} concentration was 3 mg/l in S_4 and the highest concentration was 15 mg/l in S_7. Also, the concentrations of Na^{+}, Cl^{-}, TDS, EC, and Alkalinity in S_4 were the lowest (58 mg/l - 128 mg/l - 520 mg/l - 840 mg/l - 110 mg/l), respectively and the highest (1645 mg/l - 2450 mg/l - 6590 mg/l - 10035 mg/l - 204 mg/l) in S_7, respectively.

Table 3: Results of a two-way unbalanced MANOVA model of Spatial data

S / P	S_1			S_2			S_3			S_4			S_5			S_6			S_7			S_8		
	WL Sig.	**HLT Sig.**	**PT Sig.**	**WL Sig.**	**HLT Sig.**	**PT Sig.**	**WL Sig.**	**HLT Sig.**	**PT Sig.**	**WL Sig.**	**HLT Sig.**	**PT Sig.**	**WL Sig.**	**HLT Sig.**	**PT Sig.**	**WL Sig.**	**HLT Sig.**	**PT Sig.**	**WL Sig.**	**HLT Sig.**	**PT Sig.**	**WL Sig.**	**HLT Sig.**	**PT Sig.**
PH	0.000	0.021	0.703	0.005	0.138	0.486	0.023	0.500	0.500	0.006	0.735	0.518	0.016	0.579	0.005	0.038	0.486	0.923	0.000	0.500	0.566	0.005	0.025	0.138
Turbidity	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.000*	0.005	0.018	0.016	0.09	0.005	0.735	0.518	0.016	0.000	0.000	0.002	0.001	0.000	0.000
EC	0.002	0.001	0.000	0.000	0.002	0.001	0.000	0.000	0.735	0.518	0.016	0.579	0.005	0.038	0.486	0.923	0.000	0.500	0.566	0.005	0.025	0.138	0.923	0.000
TDS	0.000	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.005	0.138	0.486	0.005	0.138	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca^{+2}	0.211	0.002	0.2456	0.219	0.219	0.219	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.005	0.138	0.017	0.082	0.015	0.201	0.000	0.006	0.011	0.017	0.082
Mg^{+2}	0.030	0.020	0.022	0.058	0.030	0.000	0.002	0.001	0.000	0.000	0.002	0.001	0.000	0.000	0.002	0.001	0.000	0.000	0.002	0.001	0.191	0.015	0.937	0.227
TH	0.003	0.054	0.519	0.404	0.581	0.146	0.949	0.728	0.527	0.253	0.152	0.014	0.465	0.170	0.862	0.794	0.525	0.920	0.668	0.662	0.393	0.054	0.519	0.404
K^+	0.000	0.016	0.104	0.546	0.191	0.015	0.937	0.227	0.958	0.134	0.130	0.000	0.002	0.398	0.317	0.000	0.002	0.001	0.000	0.000	0.449	0.416	0.434	0.546
SO_4^{-2}	0.003	0.005	0.406	0.935	0.218	0.674	0.757	0.094	0.005	0.568	0.303	0.000	0.002	0.004	0.952	0.000	0.002	0.001	0.000	0.000	0.063	0.805	0.416	0.935
Na^+	0.012	0.002	0.030	0.020	0.022	0.058	0.699	0.640	0.000	0.648	0.817	0.000	0.002	0.080	0.269	0.000	0.002	0.001	0.000	0.000	0.662	0.792	0.830	0.520
Cl^-	0.025	0.163	0.103	0.008	0.588	0.206	0.683	0.004	0.004	0.952	0.000	0.324	0.121	0.703	0.562	0.000	0.002	0.001	0.000	0.000	0.925	0.963	0.193	0.758
Alkalinity	0.019	0.045	0.093	0.008	0.034	0.124	0.066	0.000	0.009	0.4003	0.847	0.119	0.858	0.071	0.000	0.002	0.001	0.000	0.000	0.002	0.001	0.000	0.000	0.002

- ***Temporal Data Analysis***

Temperature and pressure in particular have an impact on the physicochemical qualities of water. The samples were divided into two groups (dry and wet season) based on the month's average temperature and amount of precipitation in order to evaluate the seasonal evolution of physicochemical parameters. The outcomes demonstrated that during the rainy season, total dissolved oxygen levels increased at all sites owing to new water entering the Shatt Al-Arab via water runoff. The identical observation was made about TDS, electrical conductivity, and salinity at all eight locations at the same time period. This is due to the fact that runoff accelerates erosion and then transports several ions, including magnesium, sodium, potassium, carbonate, and chloride, to the riverbed, so increasing the turbidity of the water [27]. Figure 1 summarizes the water quality index of raw water generated from eight sites throughout the research period.

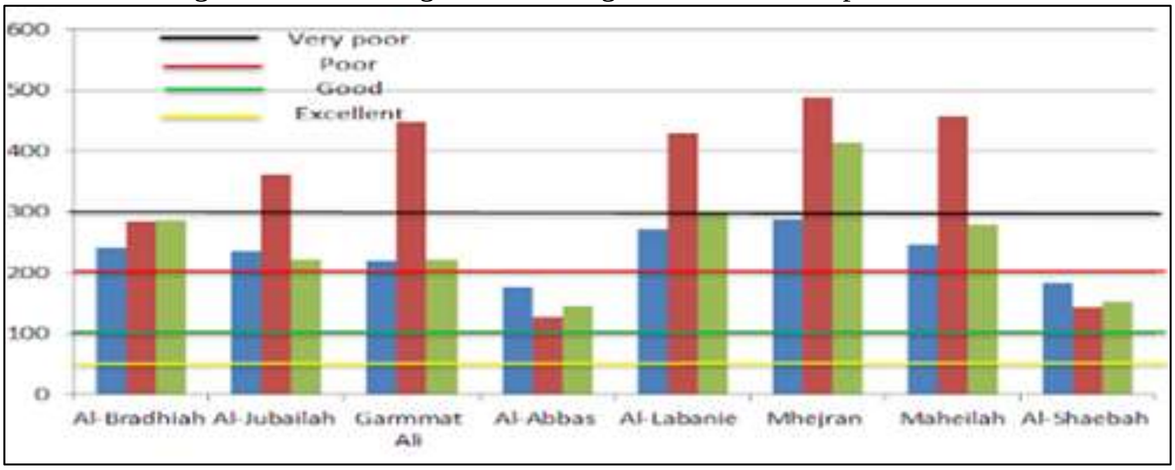

Figure 1: Water quality index of eight sites throughout the research period

6. CONCLUSION

This work provided the unbalanced MANOVA two-way model based on kind III summed squares of an influence are calculated that adjusted for all other effects for recommended two way MANOVA model, regardless of order. Data was collected from eight places along the Shatt Al-Arab River throughout the dry and rainy seasons. Different analytical techniques were used to determine the physicochemical parameters of the treated water. A two-way MANOVA analysis of the various factors was carried out under imbalance cell sizes and imbalance cell of covariance matrices. The statistical approaches were useful in analyzing the particular and seasonal changes in water quality. The statistical data demonstrate that there is a significant disparity in water quality across the eight locations. The statistical findings of the proposed model show large geographical variances between stations. Where the effect of sewage discharge and salinity intrusion from the Arabian Gulf was very clear, a significant difference was observed between stations with no source of pollution (Al- Shaebah and Al-Abbas) and stations located near sewage discharge outfalls (Al-Bradhiah, Al- Jubailah, and Garmmat Ali) and stations primarily affected by salinity intrusion from the Arabian Gulf into the Shatt Al-Arab River (Al- Labanie, Mhejran, Maheilah). Furthermore, it can be determined that the Mhejran plant differs significantly from all other stations owing to a very high quantity of ions in the source.

Climate conditions, particularly temperature and precipitation, have a significant impact on all metrics. During the rainy season, TDS, salinity, electrical conductivity, and the concentrations of all contaminants rise. Thus, during a dry season when the temperature is pleasant, bacterial activity raise. River water quality may be impacted by many factors, including local topography and seasonal human activities like tourism.

References

[1] A. McKee "Development of a Public Education Website: Building Bridges over Water" B. Sc. Project, Faculty of the Agricultural Education and Communication Department California Polytechnic State University, San Luis Obispo, 2014.

[2] R. M. Brown, N.I. McClelland, Deininger and R.G, Tozer, “A water quality index-do we dare”, Water and sewage works, Vol. 117, No. 10, 1970.

[3] M.A. House, “A Water Quality Index for Use in the Operational Management of River Water Quality in Europe” Wheeler, D., Richardson, M.L. and Bridges, J., Eds., Watershed 89: The Future for Water Quality in Europe, Pergamon, Oxford, p.p. 159-168, 1989.

[4] E. Srikanth, S. Kumar, E.B. Sudhakar, K.S.R. Krishna, and P.V. Rao, “De- termining Water Quality Index for the Evaluation of Water Quality of River Godavari”. International Journal of Engineering Research and Applications, Vol. 1, p.p. 174-182, 2014.

[5] S. Ravichandran, “Hydrological Influences on the Water Quality Trends in Tamiraparani Basin, South India”, Environmental Monitoring and Assessment, No. 87, p.p. 293-309, 2003.

[6] N. Gantidis, M. Pervolarakis, and K. Fytianos, “Assessment of the Quality Characteristics of Two Lakes (Koronia and Volvi) of N. Greece”, Environmental Monitoring and Assessment, No. 125, p.p. 175-181, 2007.

[7] M.B. Arain, T.G. Kazi, M.K. Jamali, N. Jalbani, H.I. Afridi, H.I. and A. Shah, A. “Total Dissolved and Bioavailable Elements in Water and Sediment Samples and Their Accumulation in Oreochromis mossambicus of Polluted Manchar Lake”. Chemosphere, No. 70, p.p. 1845-1856, 2008.

[8] T. Hamieh, “Modeling of Runoff as a Function of Temperature and Precipitation: Application to the Litani River in Lebanon”, Journal of Earth Science & Climatic Change, No. 10, 2019.

[9] O. Altansukh, G. Davaa, “Application of Index Analysis to Evaluate the Water Quality of the Tuul River in Mongolia”, Journal of Water Resource and Protection, No. 3, p.p.398-414 2017.

[10] H. Huang, and J. Lu, “Identification of River Water Pollution Characteristics Based on Projection Pursuit and Factor Analysis”, Environmental Earth Sciences, No. 72, p.p.3409-3417, 2014.

[11] Y. Zhang, F. Guo, W., Meng, and X.O. Wang, “Water Quality Assessment and Source Identification of Daliao River Basin Using Multivariate Statistical Methods”, Environmental Monitoring and Assessment, No. 105, 2008.

[12] A. Hayek,et al., “ Evaluation of the Physico-Chemical Properties of the Waters on the Litani River Station Quaraoun”, American Journal of Analytical Chemistry, No. 11, p.p. 90-103, 2008.

[13] K. Konieczny, D. Sakol, J. Płonka, M. Rajca, M. and Bodzek, M., “Coagulation-Ultrafiltration System for River Water Treatment”, Desalination, 240, p.p.151-159, 2009.

[14] C.Y.P. Ayekoe, D. Robert, and D.G. Lanciné, “Combination of Coagulation-Flocculation and Heterogeneous Photocatalysis for Improving the Removal of Humic Substances in Real Treated Water from Agbô River (Ivory-Coast)”, Catalysis Today, No. 281, p.p. 2-13, 2017.

[15] K.D. Balke, and Y. Zhu, “Natural Water Purification and Water Management by Artificial Groundwater Recharge“, Journal of Zhejiang University science, No. 9, p.p. 221-226, 2008.

[16] A. Barakat, M. El Baghdadi, J. Rais, B. Aghezzaf, and M. Slassi, “Assessment of Spatial and Seasonal Water Quality Variation of Oum Er Rbia River (Morocco) Using Multivariate Statistical Techniques” International Soil and Water Conservation Research, Vol. 4, p.p 284-292, 2019.

[17] Official Website of the Litani Rever Authority, “The Characteristics of the Litani River” References - Scientific Research Publishing. (n.d.), 2019.

[18] S. Shrestha, F. Kazama, "Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin, Japan" Environ. Model. Software, Vol. 22, No. 4. p.p. 22, 464–475, 2022.

[19] H. Boyacioglu, H. Boyacioglu, "Water pollution sources assessment by multivariate statistical methods in the Tahtali Basin, Turkey" Environ. Geol., 54, p.p. 275–282, 2008.

[20] V. Simeonov, J.A., Stratis, C. Samara, .G Zachariadis, D. Voutsa, A. Anthemidis, M. Sofoniou, and T. Kouimtzis, "Assessment of the surface water quality in Northern Greece", Water Research, No. 37, p.p. 4119–4124, 2003.

[21] Rahmat, Sofiah, et al., "Prediction of Wastewater Treatment Plant Performance Using Multivariate Statistical Analysis: A Case Study of a Regional Sewage Treatment Plant in Melaka, Malaysia" Water, No. 14, 2022.

[22] J.T. Zhang, B. Zhou, J. Guo, J., and T. Zhu, "Two-sample Behrens–Fisher problems for high-dimensional data: A normal reference approach.", Journal of Statistical Planning and Inference, No. 213, p.p. 142-161, 2021.

[23] J. Zhang, and S. Xiao, "A note on the modified two-way MANOVA tests", Statistics and Probability Letters, Vol. 82, 519–527, 2012.

[24] A.M. Al-Lami, Z.R. Abbas, Z. R., and G.A. Alshammary, "Study of water pollution problem in Basra city of Iraq: a case study", Plant Archives, Vol. 2, No. 1, p.p 2274-2276, 2020.

[25] M.M. Ramzan, Z. Malik, N. Iqbal, S. Arshad, Khan and M. Arshad, "Study of hematological indices in tannery workers exposed to chromium in sheikhupura (Pakistan)", Toxicol. Ind. Health, Vol. 27, No. 9, p.p 857-864, 2011.

[26] H. Issa, R. Alrwai, "Long-Term Drinking Water Quality Assessment Using Index and Multivariate Statistical Analysis for Three Water Treatment Plants of Erbil City, Iraq", UKH Journal of Science and Engineering, Vol. 2, No. 2, p.p 39-48, 2018.

[27] A.S. Hayek, A. Andaloussi, N. Tabaja, J. Toufaily, E. Garnie-Zarli, and Hamieh, "Multivariate Spatial and Temporal Analysis to Study the Variation of Physico-Chemical Parameters in Litani River, Lebanon" American Journal of Analytical Chemistry, Vol. 12, No. 11, p.p 373-391, 2021.

مجلة كلية الرافدين الجامعة للعلوم (2023)؛ العدد 54؛ 462 - 471

PISSN: (1681-6870); EISSN: (2790-2293)
مجلة كلية الرافدين الجامعة للعلوم
Available online at: https://www.jrucs.iq

JRUCS
Journal of AL-Rafidain University College for Sciences

AL- Rafidain University College

نموذج MANOVA المعدل لتقييم جودة المياه

د. هدى زكي ناجي
huda.naji@uobasrah.edu.iq
قسم الرياضيات - كلية العلوم - جامعة البصرة، البصرة، العراق

المستخلص

تدهورت جودة مياه نهر شط العرب نتيجة التوسع السكاني السريع والأنشطة الصناعية والزراعية. نتيجة لذلك، تعد خدمات تنقية المياه مصدرًا مهمًا لإمداد منطقة البصرة المكتظة بالسكان في العراق. لتحليل التأثيرات الجغرافية والزمنية لنوعية مياه البصرة، تم إجراء تحليل MANOVA ثنائي الاتجاه للمكونات الرئيسية باستخدام أحجام خلايا غير متوازنة وخلية عدم توازن لمصفوفات التغاير. يمثل العامل A المستوى المكاني، الذي يحتوي على ثمانية مستويات، بينما يمثل العامل B المستوى الزمني، والذي يحتوي على مستويين (موسم جاف وموسم رطب). أخذت هذه الدراسة عينات من معايير جودة المياه (الأس الهيدروجيني، العكارة، التوصيل الكهربائي (EC)، إجمالي المواد الصلبة الذائبة (TDS)، الكالسيوم (Ca^{+2})، المغنيسيوم (Mg^{+2})، الصلابة الكلية (TH) ، البوتاسيوم (K^{+}) ، الصوديوم (Na^{+}) ، الكبريتات (SO_4^{-2}) ، الكلوريد (Cl^{-}) ، والقلوية) من تأثير ثمانية مواقع لمعالجة المياه للأعوام من (2017 - 2019). تظهر النتائج الإحصائية للنموذج المقترح اختلافات جغرافية مهمة عبر المحطات. لوحظ فرق معنوي بين المحطات التي لا يوجد بها مصدر للتلوث (الشيبة والعباس) والمحطات الواقعة بالقرب من مصبات الصرف الصحي (البراضعية والجبيلة و كرمة علي) والمحطات التي تأثرت بشكل رئيسي من تسرب الملوحة من الخليج العربي في نهر شط العرب (البردية، الجبيلة، كرمات علي) (اللباني، مهيجران، محيلة).

معلومات البحث

تواريخ البحث:
تاريخ تقديم البحث: 2022/12/17
تاريخ قبول البحث: 2023/3/3
تاريخ رفع البحث على الموقع: 2023/12/31

الكلمات المفتاحية:
نموذج MANOVA، الخصائص المكانية والزمانية، تقييم جودة المياه.

للمراسلة:
د. هدى زكي ناجي
huda.naji@uobasrah.edu.iq

https://doi.org/10.55562/jrucs.v54i1.614