International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 02, 2021

# Cluster analysis for classification water quality of Shatt Al-Arab river

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***Abstract: Cluster analyses technique has been used to assess for the classification of water quality of Shatt Al-Arab river for drinking purposes. Three stations ahead of water treatment plants have been chosen, St.1, upper stram of Shatt Al-Arab River close to the main water treatment plant and it is effected by discharging of untreated waste from little small scale industries. St.2, Salhia which is about 4 km downstream st.1 close to Al-Bradhiah water treatment plant and it is effected heavily by cattle bathing and discharge of laundering cloths. St.3, Abu Al-Khaseeb about 7 km downstream st.1, close to Mhellah water treatment plant. All stations are effected heavily by waste water from Basrah City. Cluster analysis grouped the 11th physico-chemical parameters of the three selected sampling stations within Shatt Al-Arab river and during the period of study into three clusters at (Dlink/Dmax) x 100 < 80 :1st DO and Trans. , 2nd pH, and 3rd all the rest of the studied water parameters. And Results suggested three sources of water quality which cause an overall water quality of Shatt Al-Arab River.***

***KeyWards: Shatt Al-Arab river, water quality, cluster analysis, physico-chemical parameters, multivariate.***

## 1. INTRODUCTION

Anthropogenic activities as well as natural processes and climatic changes are main factors for rapid change in the quality of surface water (Akbar et al., 2013).

Water quality of Shatt Al-Arab river is effected by waste water discharge from Basrah city represented by certain vital pollutants, and climatic factors represented by dust fall which carries heavy metals, salts, and petroleum hydrocarbons (CCME, 2001).

Water quality classifications facing a certain problems in which cluster analysis is the data analysis tool to solve such problems as well as determination of pollution sources ( Ozbay et al., 2009), or even effected by pollutants transport through upstream rivers, Tigris, Euphrates as well as tributaries of Shatt Al-Arab river itself from landfills and marshlands ( Al-Imarah et al., 2017).

Water quality is the main concern if the major interest is for drinking purposes ( Higler, 1988). A multivariate statistical techniques s (uch as cluster analysis was used to assess the spatial variation in the river water quality for Terrenganu river basin of Malaysia (Ibraheim et al., 2015).

Quality of source water upstream Cairo drinking water
Treatment plant along Nile river was studied by applying the multivariate statistical techniques ( Hamed, 2019).

Cluster analysis has been used to classify wells water within and around Mosul City/Iraq by adopting ground water quality (Shihab and Hashim, 2006). Certain types of classification for water quality to match good or better ecological conditions was established by Australian authorities (Olden et al., 2002).

For assessing water quality, water and sediment samples were studied for more than 30 stations along Tigris river, Shatt Al-Arab river and North West Arabian Gulf in which Multivariate Statistical Techniques,Cluster Analysis and Principle Component Analysis were applied for evaluation and interpretation of huge water and sediment parameter sets, PCA resulted in four factors explaining more than 76.055% of the total variance in water quality data set, while For sediments, four factors were accounted 83.790% for explaining the behavior of the studied parameters (Al-Imarah et al., 2014).

The purpose of this study is to assess the water quality classification by cluster analysis to meet the requirements for high quality to be used for human consumption.

## 2. MATERIALS AND METHODS

### Study area

Shatt Al- Arab River formed from the convergence of the Tigris and Euphrates rivers, which finally discharges into the Northern part of the Arabian Gulf. Shatt Al Arab river discharged with approximately 50 $m^3.s^{-1}$ capacities. This discharge is changed depending on the season and the discharge from the source (Hamdan, 2016).

For the assessment of water quality requirements to be used in water treatment plants for human supply, three sites along Shatt Al-Arab river, Figure 1, were selected: 1) st.1 close to the main water treatment plant supply's Middle, Northern and Western sectors of Basrah Province, 2) st.2 close to Al-Bradhieh water treatment plant, and 3) st.3 close to Mehellah water treatment plant in Abu Al-Khaseeb town which supply's the Southern sector of Basrah Province

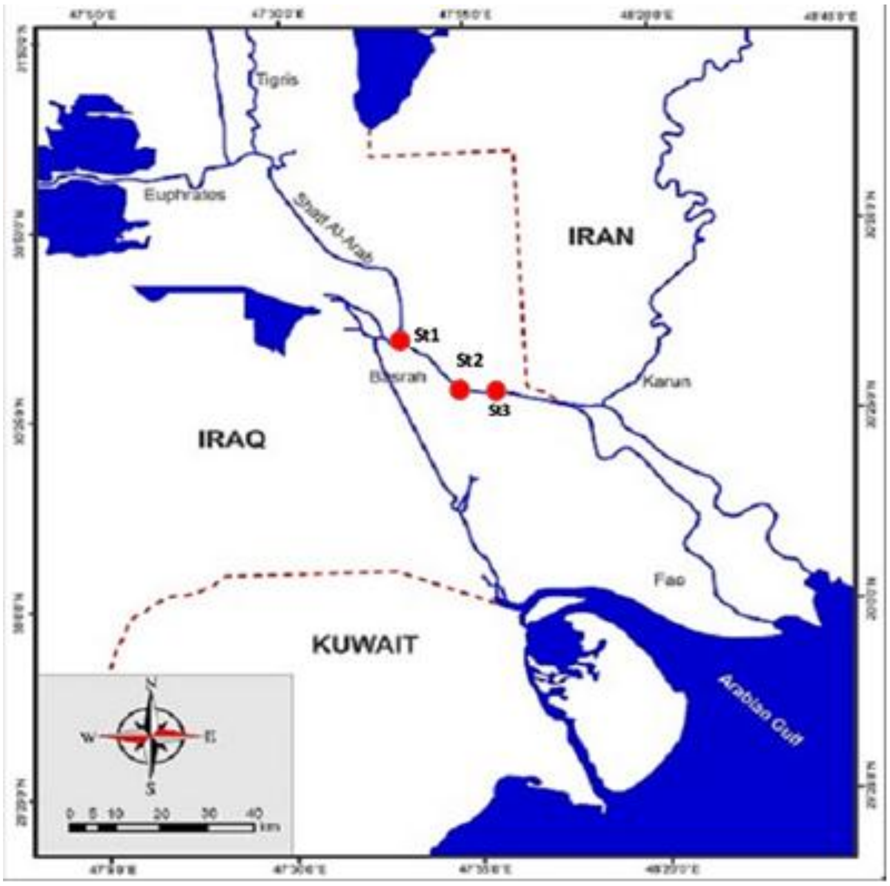


Figure 1. Map of Southern part of Iraq showing Shatt Al-Arab river and sites for sampling stations 1-3.

During the period of this study the waters of Shatt Al-Arab river were at law tide with natural flow( Ryberg, 2006).

**Water analysis**

Water quality parameters for surface water of Shatt Al-Arab river used within this study were: Water temperature ºC, Salinity, Sal‰, pH, Transparency, cm, Dissolved Oxygen, DO, mg/l, Biological oxygen demand, $BOD_5$, mg/l, Total Dissolved Solid, TDS, mg/l, Nitrate, $NO_3$, mg/l, Nitrite, $NO_2$, mg/l, Total Phosphate, $PO_4$, mg/l, Total Alkalinity, $T_{alk}$, mg/l.

Surface water samples were monthly collected, in cleaned plastic containers, from each site during December 2015 to November 2016. Field water quality parameters, included water temperature, salinity, hydrogen ion, dissolved oxygen, and TDS, were measured with YSI multimeter which has been calibrated prior to use. In the lab parameters ($NO_3$, $NO_2$, $PO_4$ and $T_{alk}$) were analyzed following standard analytical techniques (APHA, 2005).

Table (1): Water quality parameters, units and analytical methods used for surface water of Shatt Al-Arab River

| **Parameters** | **Abbreviations** | **Units** | **Analytical methods** |
|---|---|---|---|
| Water temperature | wt | $C^o$ | Thermometer |
| Salinity | Sal | ppt | Electrometric |
| pH | pH | - | Electrometric |
| Transparency | Trans | cm | Secchi disk |
| Dissolved Oxygen | DO | mg/l | Winkler method |
| Biochemical Oxygen Demand | $BOD_5$ | mg/l | Winkler method |
| Total Dissolved Solid | TDS | mg/l | Electrometric |
| Nitrate nitrogen | $NO_3$ | mg/l | Colorimetric |
| Nitrite nitrogen | $NO_2$ | mg/l | Colorimetric |
| Total Phosphate | $PO_4$ | mg/l | Colorimetric |
| Total Alkalinity | Talk | mg/l | Titration |

**Statistical analysis**

Principal Component Analysis (PCA) was carried out on the data of the mean values of each of the studied water physico-chemical parameters as listed in Table 2. In order to objectively define the groups of stations, hierarchical cluster analysis (HCA) was used.

## 3. RESULTS AND DISCUSSION

The data for the studied parameters for the three stations during the period of study were set in tables from which statistical summary was extracted and listed in table 2.

Table (2). Statistical summary of studied physico-chemical parameters.

| | **Wt** | **Sal** | **pH** | **Tran** | **DO** | **BOD** | **TDS** | **NO3** | **NO2** | **PO4** | **Talk** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **N** | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| **Min** | 11.7 | 1.12 | 6.99 | 30 | 6.5 | 1.6 | 1800 | 6 | 0.01 | 0.11 | 121 |
| **Max** | 35.2 | 6.23 | 8.4 | 80 | 11.2 | 6.58 | 7129 | 46.3 | 1.61 | 1.26 | 230 |
| **Sum** | 825.5 | 90.41 | 281.83 | 1851 | 288.16 | 146.53 | 102263 | 621.36 | 11.447 | 18.664 | 5798.7 |
| **Mean** | 22.931 | 2.511 | 7.829 | 51.417 | 8.004 | 4.070 | 2840.639 | 17.260 | 0.318 | 0.518 | 161.075 |
| **Std. error** | 1.317 | 0.210 | 0.063 | 2.036 | 0.214 | 0.235 | 208.268 | 1.964 | 0.059 | 0.058 | 4.355 |
| **Varia** | 62.4 | 1.5 | 0.14 | 149.2 | 1.65 | 1.98 | 1561519. | 138.8 | 0.12 | 0.12 | 682.9 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **nce** | 88 | 93 | 1 | 79 | 6 | 4 | 000 | 13 | 4 | 3 | 03 |
| **Stand. dev** | 7.90 5 | 1.2 62 | 0.37 5 | 12.21 8 | 1.28 7 | 1.40 9 | 1249.608 | 11.78 2 | 0.35 2 | 0.35 0 | 26.13 2 |
| **Media n** | 23.7 5 | 2.0 2 | 7.9 | 50 | 7.85 | 3.88 5 | 2356.5 | 12.75 5 | 0.19 | 0.44 | 159.6 5 |

Cluster analysis is an aggregation of multivariate methods whose primary principle is to grouping objects based on their characteristics; consequently, all objects in same cluster are similar. Each object is similar to the others in the cluster with consider to a certain point. Accordingly, cluster analysis was used to find the similarity assemblage between sampling sites. Samples collected monthly during the study period at station no. 1 were divided into five significant clusters as shown in dendrogram, Fig. 2, it produced 5 statistically significant clusters at (Dlink/Dmax) x 100 < 80. Cluster 1 DO, cluster 2 (Trans), cluster 3 (Talk), cluster 4 (pH) and cluster 5 (PO4, NO2, NO3, TDS, Sal, BOD5 and Wt).

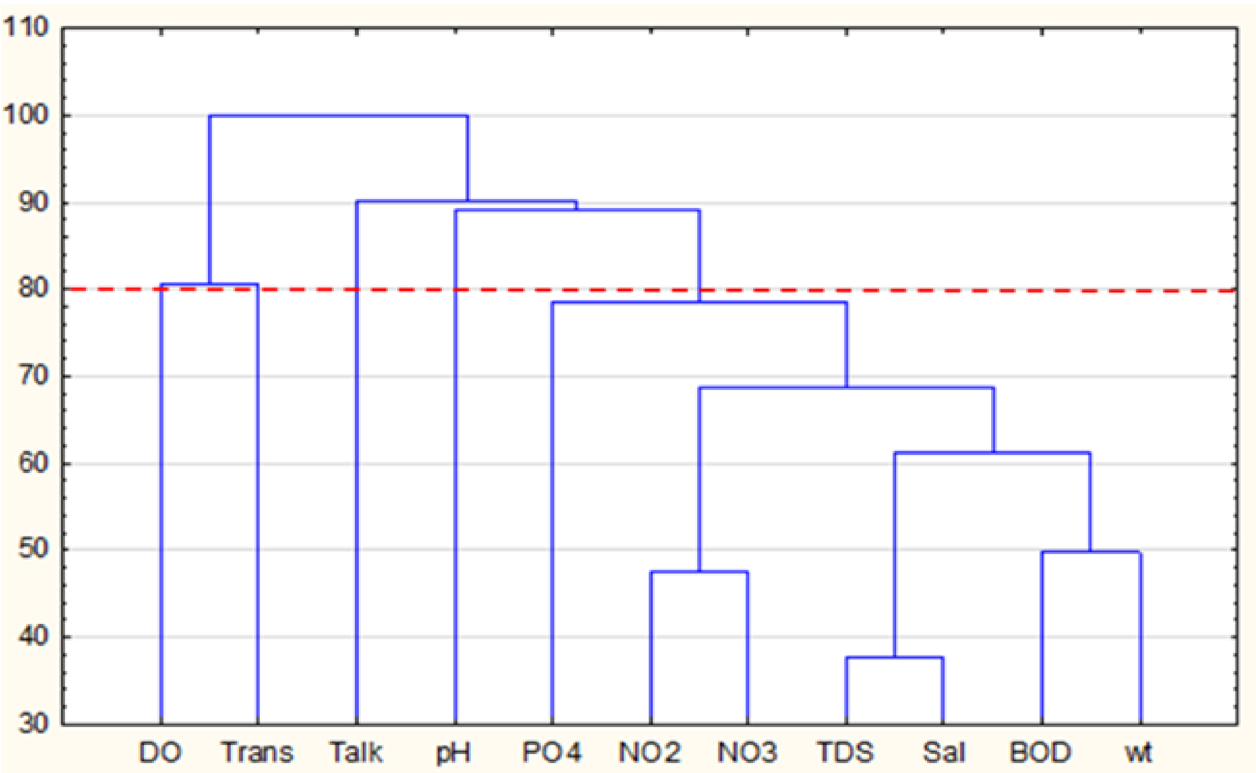


Fig. 2. Clustering of sampling sites according to surface water quality characteristics of station No. 1.

The samples of station no.2 were divided into three basic groups as shown in dendrogram Fig.3. Cluster 1 ($PO_4$), cluster 2 (DO and pH) , and cluster 3 (Trans, $NO_3$, $BOD_5$ ,$T_{alk}$, TDS, Sal, $NO_2$ and $W_t$).

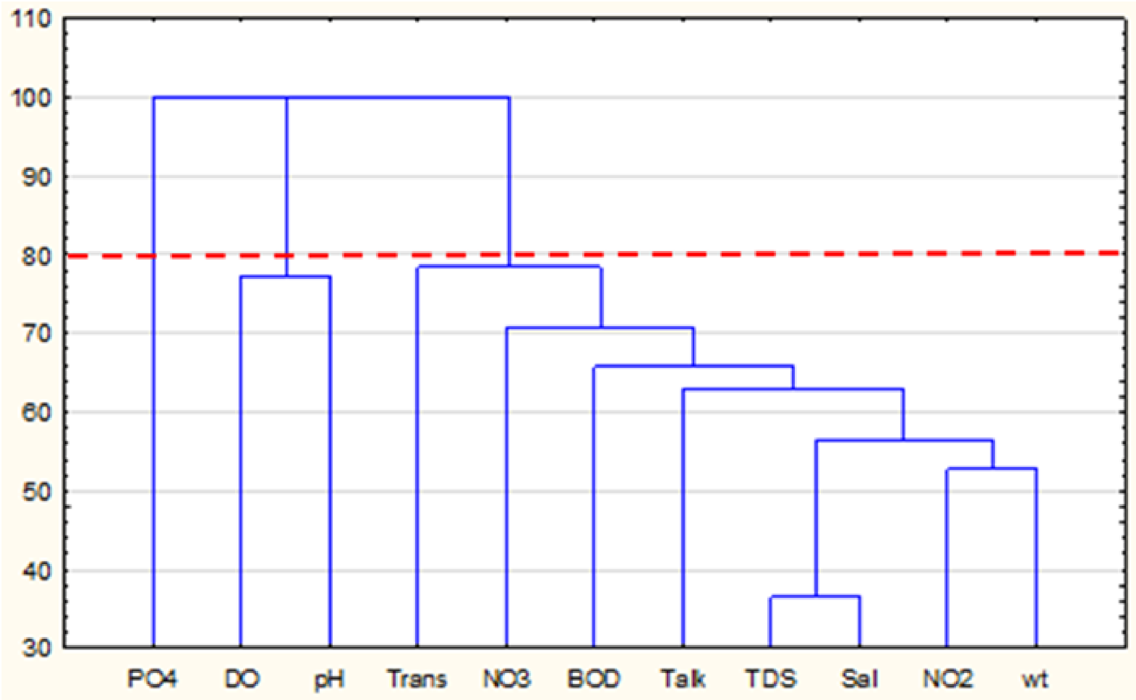


Fig. 3. Clustering of sampling sites according to surface water quality characteristics of station no.2.

Finally, the samples of station no.3 shows three significant clusters as shown in dendrogram Fig.4, at level >80 which included, cluster 1 (DO and Trans), cluster 2 ($T_{alk}$ and $BOD_5$) and cluster 3 ($NO_2$, $NO_3$, $PO_4$,TDS, Sal, pH and $W_t$).

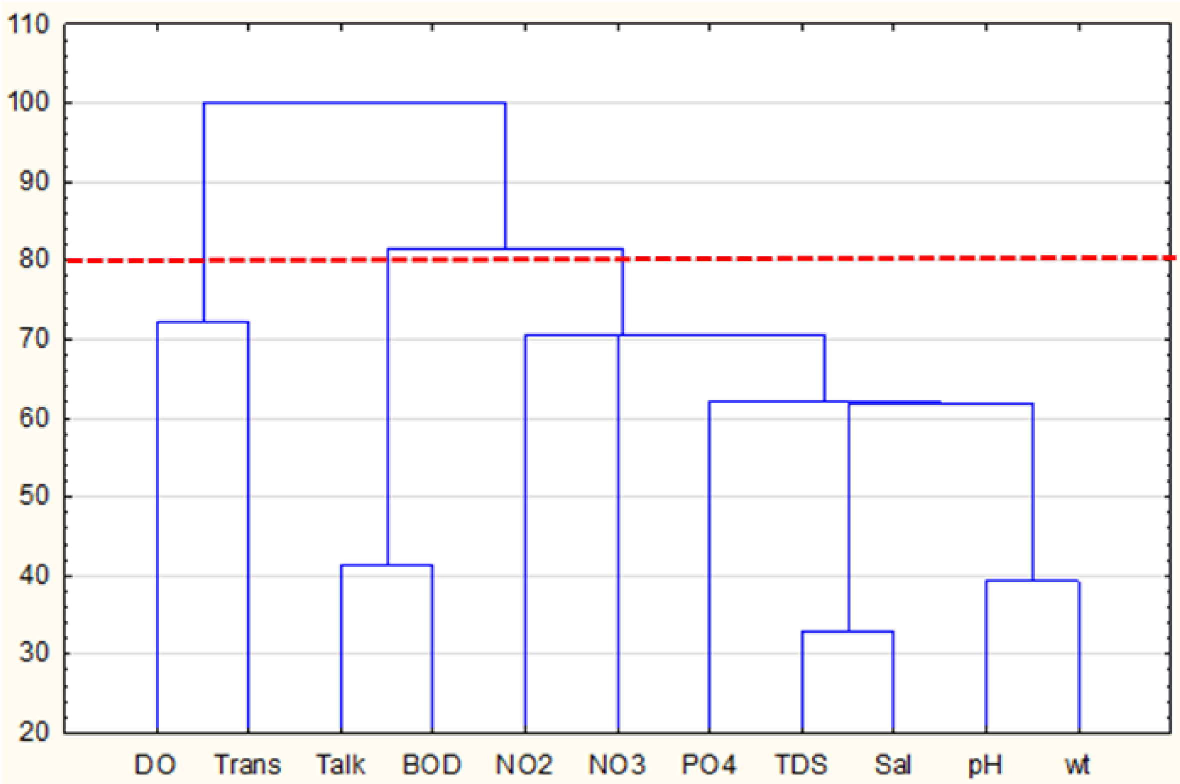


Fig. 4. Clustering of sampling sites according to surface water quality characteristics of station no. 3.

For all sampling sites and periods of study, water quality was evaluated using Spatial CA which classified the three sampling sites as shown in dendrogram Fig.5, depending on the whole studied physico-chemical parameters.

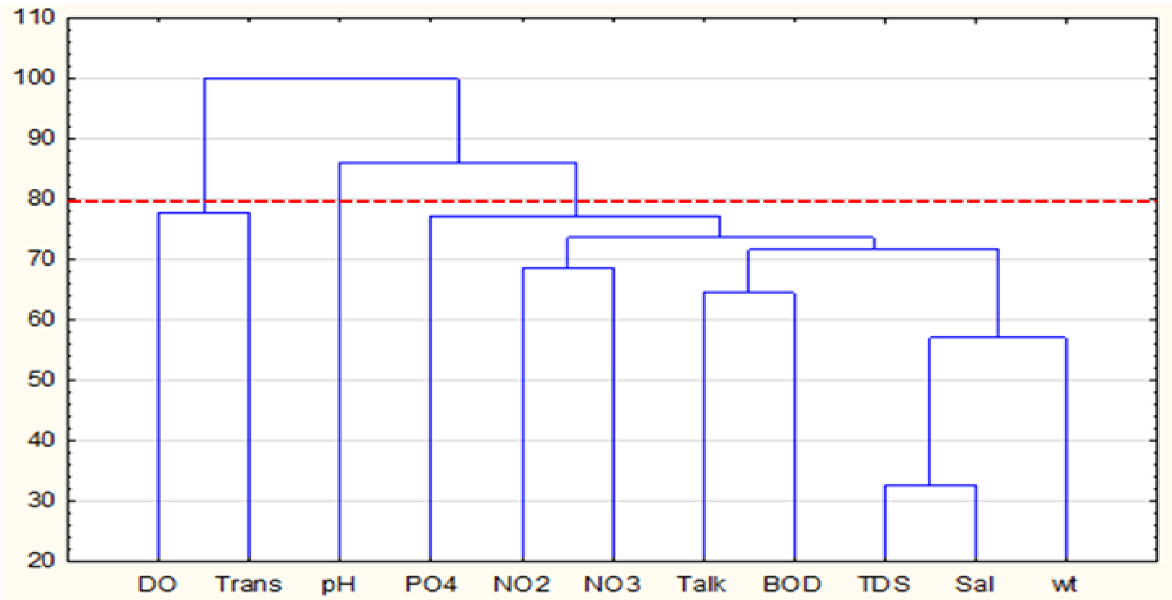


Fig. 5. Clustering of sampling sites according to surface water quality characteristics of stations 1,2 and 3.

Figure 5 shows all the physico-chemical parameters for the sampling sites which categorized based on graphical investigation into three clusters (A , B and C) at (Dlink/Dmax) × 100 < 80. Cluster A consisted of DO and Trans. Cluster B consisted of pH , whereas group C was exemplified by all rest water parameters. Therefore, figure 5 , suggested three sources of water quality which contributed to its impact on the overall water quality of the river.

## 4. CONCLUSION

Cluster analysis grouped the 11$^{th}$ physico-chemical parameters of the three selected sampling stations within Shatt Al-Arab river and during the period of study into three clusters at (Dlink/Dmax) x 100 < 80:1$^{st}$ DO and Trans. , 2$^{nd}$ pH, and 3$^{rd}$ all the rest water parameters. And Results suggested three sources of water quality which cause an overall water quality of Shatt Al-Arab River.

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