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# Trend Analyzing of Chemical Water Quality Parameters (Case Study: Rudan River, Bernetin Station—Code 27013)

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**Abstract:** River water quality evaluation is one of the first and perhaps most important steps in river water quality management, because it makes the analyst's vision clear about trends and how pollution changes relative to time, place, and circumstances. The purpose of this research is to evaluate the water quality and the process of changes in the water quality parameters of this river by graphic methods such as Wilcox, Schuler and Piper diagrams. These charts were used to monitor water quality and evaluate the data obtained from Berthaen Station from 1976 to 2007. In this study, Piper introduced water qualitative type of chlorine and water façade from saddle type. Based on the Schuler diagram, all water samples of the river Rudan are in a moderate and acceptable category for drinking and there is no barrier to drinking. The Wilcox chart also shows that most of the specimens are highly salty and suitable for farming (C3S1, C3S2) and in some water are poor, highly unsuitable water areas ($C_4S_2$). The results of water quality parameters analysis using non-parametric Mann-Kendall test showed that the parameters of acidity, carbonate, soluble salts, total cations, sodium, magnesium and chloride adsorption percentages, and other parameters were not trendy at the surface The confidence is 95%. The upward trend in water soluble solute changes indicates a decrease in water quality and an increase in soluble salts of this river.

**Key words:** Water quality, Wilcox, Schuler, Piper, Mann-Kendall test.

## Introduction

These days, water is considered as one of the factors for the improvement and economic growth of societies. Therefore, optimal water resources management, especially freshwater, is considered as one of the countries' most important programmes. Due to the diversity of geological formations, geological structures and hydrogeological factors in different regions, surface water quality has different variations. Recognizing and evaluating the quality of water resources in its management and optimal use is very important (Ouyang et al., 2006).Therefore, surface water is an important part of renewable water ecosystems, where improper management of exploitation leads to a change in the quality of these resources and the direct or indirect degradation of other resources (Zahtabian et al., 2010).

Cities and industrial and agricultural centres are also close to the rivers to benefit from water resources. They contain suspended matter and organic and mineral solution (Masamba et al., 2008). Pollution caused by the discharge of various urban, industrial and agricultural wastewater, leachate, waste disposal sites and surface runoffs leads to its spread and limitation of water resources (Shokuhi et al., 2012). Surface water controlling and monitoring for various uses is necessary and essential to provide suitable quality water available to consumers.

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Water quality in marine ecosystems is studied by chemical, biological and physical parameters (Khadem and Kaluarachi, 2006). One of the very simple methods which is different from mathematical and statistical methods complexity that can capture the qualitative state of water and serve as a powerful tool for decision-making is the use of water quality indicators (Yosef Zadeh et al., 2013).The quality of surface water in different regions due to diversity of geological formations, geological structures and hydrogeological factors has different variations. Recognizing and evaluating the quality of water resources in its management and optimal use is very important. Investigating seasonal variations in surface water quality is an important aspect in assessing the temporary changes in river pollution due to natural and non-point sources (Ouyang et al., 2006). Also, because of the decreasing precipitation and dryness in the country, preservation of water resources and investigation of their pollution and, in general, the quality management of aquifers for various environmental, economic and other purposes is necessary.

Important parameters for assessing the quality of water are the presence of nutrients in it. Nitrogen and phosphorus are the main nutrients and the main cause of the occurrence of utrification phenomena in aquatic areas (Mousavi, 2010). On the other hand, agricultural land-use in the catchment can significantly modify surface and groundwater chemistry (Johnson et al., 1997) and recent studies conclude that over-usage of fertilizer and pesticide application can lead to deterioration of surface water quality (Amarathunnga et al., 2010; Azmy et al., 2010). Therefore, exploitation of natural water resources requires the recognition of quantity and especially its quality. The water sources are the final recipients of contamination from various human activities.

Water qualitative characteristics are the components that have become fully felt in the planning of water resources management as well as in assessing the health of the water catchment area and making managerial changes in it (Khadem and Kaluarachi, 2006). Many studies have been carried out in Iran and abroad related to the subject. Shokuhi et al. (2012) examined the water quality of the Ayudoghmoush River by measuring the quality parameters and the Wilcox index. Their results showed that livestock extinctions were considered as non-point pollutants of factors affecting river water quality. Also, Sadeghi et al. (2015) determined the status of water quality in the Zarrin Gol River of Golestan Province, using the Water Quality Index (NSF WQI) and Iran's Surface Water Quality Index ($IRWQI_{sc}$). The results of the study, based on both indicators, showed that the index for all stations was between 54 and 61; based on the NSF index WQI average (50-70) and based on the IRWQI index in the two moderate (45-55) and relatively good (55.1-70).

In another article, Pour Eshgh et al. (2013), the qualitative research on the water of the Khurkhoush Heroichea River was studied based on the NSFWQI and Wilcox quality indexes. The results showed that the NSFWQI qualitative index on the best condition was related to the first station with the number 74 in February 2008, which indicates the good quality of water at this station. The lowest index for the third station with the qualitative index was 53 in August 2008, indicating the average water quality at the station.

Buchani et al. (2014) reviewed the underground waters of the Sahara Plain for agricultural and industrial applications. For this purpose, ten years of qualitative information (2003 to 2013) on the groundwater of this plain was used. The results showed that the average LSI index in the aquifer of the plain is 4.8. In this regard, the groundwater of this region has a moderate potential for sedimentation. Also, the average RSI index was 4.6 which, based on this groundwater index, has a low potential for self-reliance. The average value of EC is 6978 µS/cm which puts the underground waters of the Desert Gardens in poor condition for irrigation and the amount of pH in the aquifer is in the alkali area.

In external sources, Samantray et al. (2009) examined the quality of the Mahanadi and Athrabanki rivers in India using the NSFWQI index; the results of the study showed that water quality was reduced based on the index used due to human and industrial activities. Sanchez et al. (2007) examined the quality of water and the deficiency of dissolved oxygen along the Guadarma River and the Manozaran River. The results of this study showed that the water quality index at the beginning of the Guadarra River had a numerical value of 70 (good quality) and at the end of 64 (average quality).

In addition, Gebrehiwot et al. (2014) also used the WQI method to study the groundwater quality of the Hantebet aquifer in northern Ethiopia for exploring drinking water. In this study, the quality of water in the region was evaluated by using 10 parameters: Cl, $Mg_2$, Na, TDS, pH, $HCO_3$, $NO_3^-$, $SO_4^{2-}$, $Ca_2$ and K. Based on the results, WQI variations for groundwater samples ranged between 54.14% and 86.24%, and all underground water samples were well placed and suitable for drinking purposes. Therefore, due to the importance of water quality in terms of drinking, agriculture and industry, the quality of surface water is at risk for sake of various uses. On the other hand, the study area is one of the arid areas of the country, that is why the importance of monitoring the quality of water in the area is multiplied. Therefore, in this research, we have tried to use the graphic methods to evaluate the chemical quality of the water in the study area and to introduce its chemical type and faces.

## The Study Area

The Persian Gulf and Oman Sea watershed are located between 25° and 10° to 36° 45° north latitude and 46° to 62° and 50° east longitude. This watershed includes vast parts of the west, southwest, and south of the country. The total area of the Persian Gulf and Oman Sea watershed is 377,668 square kilometres, and in some sources more than 395,800 square kilometres are mentioned. The vast majority of the Persian Gulf and Oman Sea watershed, about 280,250 $km^2$ in mountainous areas, and more than 1155560 $km^2$, are mountainous. The territory of this watershed includes the western and southwest areas of the Zagros Mountains, as well as altitudes south of Fars province and Bashaghord and southern Balochestan Mountains which include the provinces of West Azarbaijan, Kurdistan, Hamedan, Kermanshah, Lorestan, Ilam, Khuzestan, Chaharmahal and Bakhtiari, Kohkiluyeh and Boyerahmad, Bushehr, Fars, Hormozgan and Sistan and Baluchestan and small parts of Kerman.

## Materials and Methods

In order to advance the research objectives, the information related to the indicators used in the paper was prepared, as well as the tests of normality of the data were examined by the box diagram and the outliers data were discarded from the water quality measurement process. Information about the research is from 1976 to 2007. After normalizing the data and determining the outliers data, the static data were also analyzed. A series of Auto correlation (ACF) function is used to detect static or non-stationary. Auto-correlation function is a method for expressing time dependence in the structure of a time series. Since the correlation coefficient ($r$) is a function of the delays ($k$), it refers to its self-correlation function and it is indicated by (ACF) (Mosavi Nodosha et al., 2011). Also, one of the most important methods for examining the trend of data is the non-parametric Mann-Kendall test (Sheikh et al., 2009). Using non-parametric Mann-Kendall test is not sensitive to data normalization. The Kendall test was first developed by Mann (1945) and then by Kendall (1975) and recommended by the World Meteorological Organization (Mosaedi and Kohstani, 2010).

The procedures for implementing the test using the Mann-Kendall method are as follows:

1. The data are arranged in sequence, and the time sequence of the data is considered $n$.
2. The data is ranked, for which purpose the $T$ statistic (rank $i$'s rating is above our rating) is used.

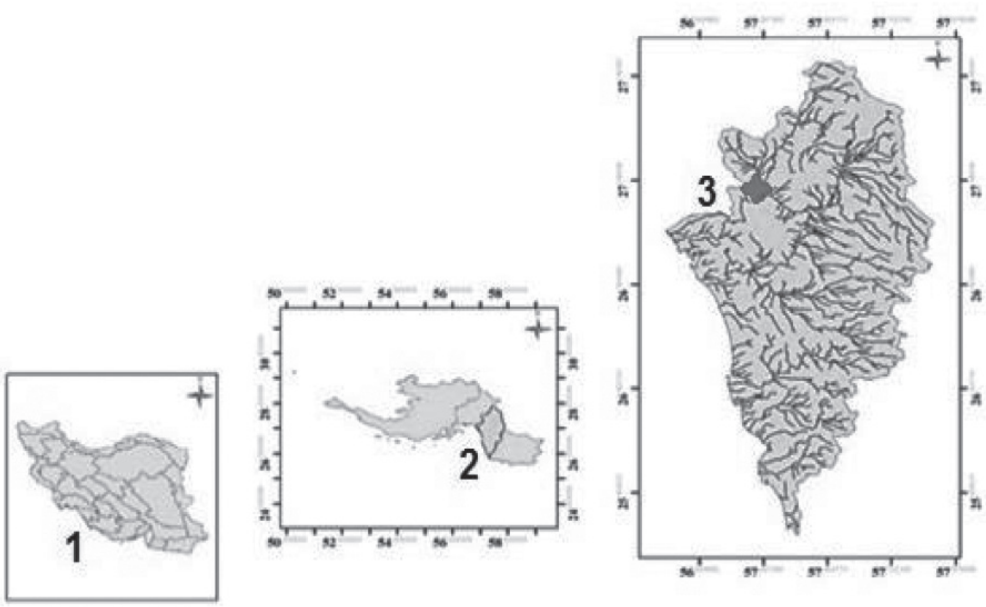


**Figure 1: Geographical location and station of the study area.**

3. The mathematical expectation of $E_i$, the variance $V_i$, and the Mann-Kendall index $U_i$ can be calculated using the numerical relations as below.

$$E_i = \frac{n_i(n_i-1)}{4} \quad (1)$$

$$V_i = \frac{n_i(n_i-1)(2n_i+5)}{72} \quad (2)$$

$$U_i = \frac{(\Sigma t_i - E_i)}{\sqrt{V_i}} \quad (3)$$

$n_i$ is the time sequence of the data.

The piper diagram is based on the location of some of the major cations and anions, such as Na, K, Mg, Ca, $SO_4$, Cl, $CO_3$ and $HCO_3$, to determine the type and facies of water (Sedaghat, 1993; Fetter, 1988; Gasemi et al., 2009; Piper, 1944).

**Assessing the Quality of Water in Terms of Drinking**

In order to investigate the ability of drinking, a semi-logarithmic diagram of Schuler was used. Physicochemical properties can also be used to classify different waters for human drink by measuring anions, cations, TH and T.D.S. using the Schuler diagram. The remaining dry matter (T.D.S.) is calculated from the following equation. Here the TDS or the dry residue is in mg/L, which can be calculated by determining these parameters and connecting their corresponding points on these axes.

$$TDS = 0/64 \times EC$$

**Temporary Bottlenecks, Total and Water Quality Assessment Based on Total Hardness**

One of the indicators of drinking water quality is its hardness, which is based on calcium carbonate. The highest water hardness is related to calcium and magnesium ions and the total hardness is obtained in milligrams per litre as following:

Ca and Mg are considered in milligrams per litre.

$$TH = 2.497\ Ca + 4.115\ Mg$$

$$TH = Ca \times \frac{CaCO_3 \text{ Equivalent weight}}{\text{Ca Equivalent weight}} + Mg \times \frac{CaCO_3 \text{ Equivalent weight}}{\text{Mg Equivalent weight}}$$

*Evaluation of Water Quality in terms of Irrigation Water Quality*

The most important qualitative criteria in water classification are agriculture, salinity (electrical conductivity) and the amount of sodium in it. In the Wilcox graph, the horizontal axis is devoted to water salinity and the vertical axis relative to sodium absorption (SAR).The coordinates of each water sample are located in the region, which, in terms of salinity C, is taken in terms of sodium S. The sodium absorption ratio of SAR was obtained from the opposite relation, in which sodium, calcium and magnesium are expressed in MilliEquivalent per litre. The output from the Wilcox charts in the various groups listed below is classified as follows:

- Very good waters where the EC is less than 250 micromos per cm and is in the $C_1S_1$ class.
- Good waters that belong to one of the classes $C_2S_1$, $C_2S_2$, $C_1S_2$.
- Medium quality water is suitable for one of the classes $C_3S_3$, $C_1S_3$, $C_2S_3$, $C_3S_1$, $C_3S_2$ and is suitable only for irrigation of coarse texture and good drainage.
- Inappropriate water in the $C_1S_4$, $C_2$ $S_4$, $C_3S_4$, $C_4S_4$, $C_4S_4$, $C_4S_1$, and $C_4S_3$ classes is becoming less appropriate as the index grows.

*Remaining Sodium*

The concentration of anions is in milliseconds of valentine per litre. The amount of excess sodium carbonate (RSC) is one of the most dangerous salts for the soil and plant, which creates a toxic state and the product is severely reduced. In general, the sodium carbonate in the water remaining for irrigation should not exceed 2.5 *Milli*Equivalents per litre. And waters with a residual sodium carbonate content of 1.25 mA/L are suitable for irrigation and should be handled for waters with an RSC value of 1.25 to 2.5 and land and crop conditions should also be considered (Mahdavi, 2007).

## Findings and Discussion

In this study, for the purpose of checking the quality of data, firstly, the outlier data related to the survey station were determined (Figure 2).

As shown in Figure 2 for the box diagram, in the information about the Berentin Station, out of a total of 24 data, only one data is equivalent to 4.3% of the outliers data.

**Pearson Correlation**

This coefficient calculates the correlation between two distances or relative variables, and the value is between 1+ and 1. If the value is positive, it means that the changes of the two variables occur simultaneously. That

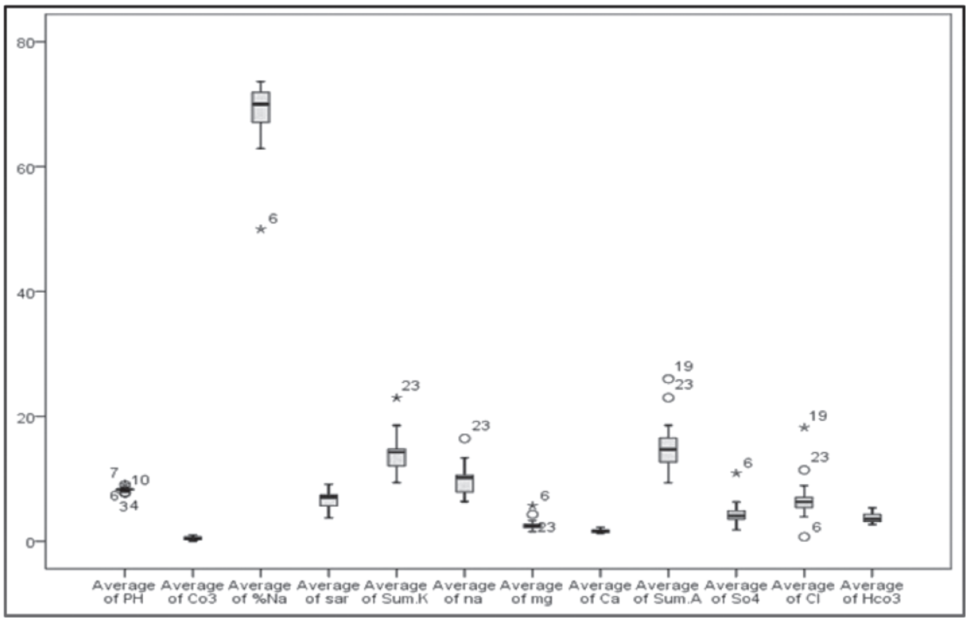


**Figure 2: Data box diagram.**

is, with increase in each variable, the other variable also increases, and vice versa; if the value of *r* is negative, the two variables act in the direction of the image.

**Non-parametric Test of Mann-Kendall for Rudan Station Berentin**

At this stage, the Mann-Kendall test was used to determine the quality parameters of the station.

According to the results of Table 2, the parameters of acidity, carbonate, total soluble salts, sodium adsorption, total cations, sodium, magnesium and chlorine have a rising upward trend (which indicates a decrease in water quality) over time and the rest of the parameters are not trendy.

**Assessment of Irrigation Water Quality Rudan-Berentin Stations**

The Wilcox classification method and the use of its diagram are the most practical method for classifying water in terms of agriculture in hydrological studies based on two parameters of electrical conductivity and sodium adsorption ratio.The points of intersection of these two parameters on the Wilcox chart represent the class of the water sample (the results are shown in Figure 3 and Table 3.

As it can be seen from the descriptive Table 3 and the Wilcox chart (Figure 3), the results of the chemical water quality analysis of this station are salty but suitable for agricultural activities. Also, the accumulation and

**Table 1: Pearson Correlation Coefficient for comparison of two-to-two parameters, Station Code 27013**

| | *pH* | *$CO_3$* | *TDS* | *%Na* | *SAR* | *Na* | *Mg* | *Ca* | *$SO_4$* | *Cl* | *$HCO_3$* | *EC* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | .658** | .102 | -.491* | -.263 | -.056 | .590** | -.317 | .369 | -.052 | -.071 | .110 |
| $CO_3$ | .658** | 1 | .264 | -.230 | -.023 | .132 | .498* | -.425* | .126 | .314 | -.272 | .124 |
| TDS | .102 | .264 | 1 | .429* | .792** | .939** | .557** | .239 | .296 | .560** | .668** | .917** |
| %Na | -.491* | -.230 | .429* | 1 | .867** | .629** | -.446* | .164 | -.503* | .605** | .236 | .301 |
| SAR | -.263 | -.023 | .792** | .867** | 1 | .926** | .013 | .289 | -.157 | .696** | .493* | .687** |
| Na | -.056 | .132 | .939** | .629** | .926** | 1 | .338 | .387 | .103 | .657** | .614** | .868** |
| Mg | .590** | .498* | .557** | -.446* | .013 | .338 | 1 | -.106 | .806** | .019 | .368 | .617** |
| Ca | -.317 | -.425* | .239 | .164 | .289 | .387 | -.106 | 1 | -.094 | .146 | .434* | .314 |
| $SO_4$ | .369 | .126 | .296 | -.503* | -.157 | .103 | .806** | -.094 | 1 | -.222 | .300 | .529** |
| Cl | -.052 | .314 | .560** | .605** | .696** | .657** | .019 | .146 | -.222 | 1 | .164 | .445* |
| $HCO_3$ | -.071 | -.272 | .668** | .236 | .493* | .614** | .368 | .434* | .300 | .164 | 1 | .725** |
| EC | .110 | .124 | .917** | .301 | .687** | .868** | .617** | .314 | .529** | .445* | .725** | 1 |

**Table 2: Mann-Kendall parameters Berentin Station**

| *Time series* | *First year* | *Last Year* | *n* | *Test Z* | *Signific.* |
|---|---|---|---|---|---|
| pH | 1976 | 2007 | 23 | 2.034 | * |
| $CO_3$ | 1976 | 2007 | 22 | 2.683 | ** |
| TDS | 1976 | 2007 | 23 | 2.113 | * |
| %Na | 1976 | 2007 | 23 | 0.951 | |
| SAR | 1976 | 2007 | 23 | 2.43 | * |
| Sum.K | 1976 | 2007 | 23 | 2.43 | * |
| Na | 1976 | 2007 | 23 | 2.54 | * |
| Mg | 1976 | 2007 | 23 | 2.22 | * |
| Ca | 1976 | 2007 | 23 | 0.00 | |
| Sum.A | 1976 | 2007 | 23 | 1.21 | |
| $SO_4$ | 1976 | 2007 | 23 | -1.21 | |
| Cl | 1976 | 2007 | 23 | 2.59 | ** |
| $HCO_3$ | 1976 | 2007 | 23 | -0.79 | |
| EC | 1976 | 2007 | 23 | 0.95 | |

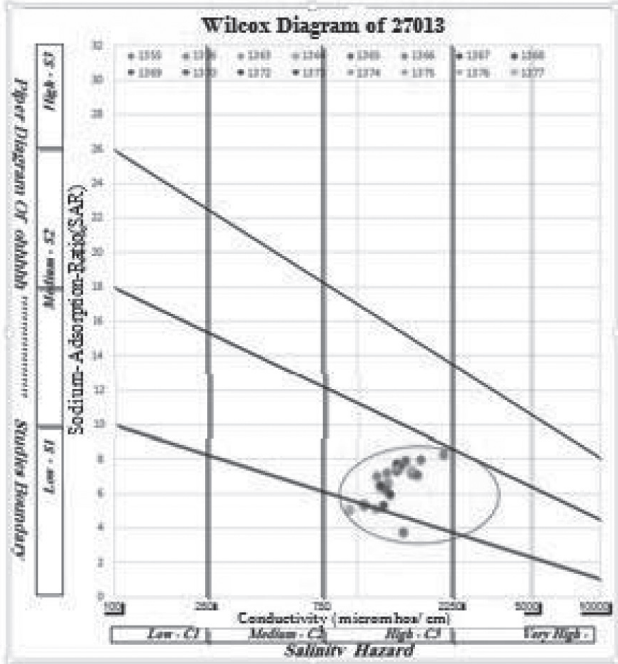


**Figure 3. Wilcox Charts Assessment of the quality of farming data of the Berentin Station.**

**Table 3: Agricultural data quality assessment is based on the Wilcox charts for Berentin Station data**

| *Row* | *Sample place* | *Symbol* | *SAR* | *EC* | *Water class* | *Water quality for agriculture* |
|---|---|---|---|---|---|---|
| 1 | 1976 | W1 | 5.37 | 1090.5 | C3-S1 | Salty_usable |
| 2 | 1977 | W2 | 7.03 | 1225 | C3-S2 | Salty_usable |
| 3 | 1984 | W3 | 7.19 | 1698.57 | C3-S2 | Salty_usable |
| 4 | 1984 | W4 | 7.32 | 1700 | C3-S2 | Salty_usable |
| 5 | 1986 | W5 | 7.08 | 1800 | C3-S2 | Salty_usable |
| 6 | 1987 | W6 | 3.74 | 1575 | C3-S1 | Salty_usable |
| 7 | 1988 | W7 | 5.3 | 1305 | C3-S2 | Salty_usable |
| 8 | 1989 | W8 | 7.71 | 1481.9 | C3-S2 | Salty_usable |
| 9 | 1990 | W9 | 7.37 | 1481.75 | $C_3$-S2 | Salty_usable |
| 10 | 1991 | W10 | 6.21 | 1332 | C3-S2 | Salty_usable |
| 11 | 1993 | W11 | 5.91 | 1381.75 | C3-S2 | Salty_usable |
| 12 | 1994 | W12 | 6.41 | 1255.4 | C3-S2 | Salty_usable |
| 13 | 1995 | W13 | 5.42 | 1081.17 | C3-S2 | Salty_usable |
| 14 | 1996 | W14 | 6.59 | 1360 | C3-S2 | Salty_usable |
| 15 | 1997 | W15 | 5.18 | 1211.67 | C3-S2 | Salty_usable |
| 16 | 1998 | W16 | 5.11 | 937.857 | C3-S1 | Salty_usable |
| 17 | 1999 | W17 | 7.18 | 1339.29 | C3-S2 | Salty_usable |
| 18 | 2000 | W18 | 7.37 | 1480.71 | C3-S2 | Salty_usable |
| 19 | 2001 | W19 | 7.66 | 1530.83 | C3-S2 | Salty_usable |
| 20 | 2004 | W20 | 7.89 | 1601.3 | C3-S2 | Salty_usable |
| 21 | 2005 | W21 | 7.95 | 1858.2 | C3-S2 | Too salty_Useless |
| 22 | 2006 | W22 | 8.3 | 2299.67 | C4-S2 | Too salty_Useless |
| 23 | 2007 | W23 | 9.13 | 2230.85 | C4-S2 | Too salty_Useless |

concentration of samples on the Wilcox chart shows that the data are in the $C_3S_1$ category (slightly salty) that are of moderate quality.

### Evaluation of Drinking Water Quality: Rudan-Berentin Station

The semi-logarithmic diagram of Schuler is used to display the main ions in terms of MilliEquivalents per litre, and to illustrate the chemical disparity of the samples in a graph. In this study, Schuler diagram is used to evaluate the water quality of drinking water.

Based on the Schuler diagram (Figure 4), the samples for this station are all medium to acceptable and are suitable for drinking.

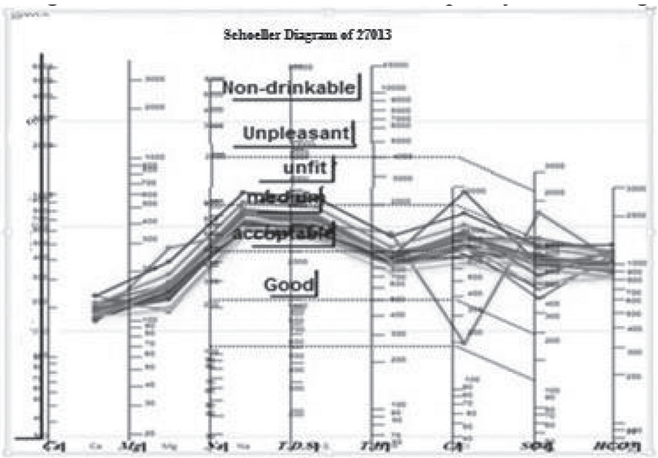


**Figure 4: Schuler Chart quality characteristics drinking Rudan-Berentin Station.**

### Assessing the Quality of Water for Use in the Industry, Rudan Berentin Station

The most important parameter for determining the quality for industrial use is corrosion and sedimentation; therefore, in this section, the waters were evaluated for corrosion and sedimentation in case of industrial application.

As can be seen from Table 4 of the water quality results of the Rudan-Berentin station, the use of water in the industry causes sedimentation in the devices.

**Table 4: Water quality assessment for industrial use at the Berentin Station**

| *Row* | *Sample place* | *Symbol* | *Alkalinity in CaO* | *Ca (mg/l)* | *Factor C* | *pHs* | *pH* | *pHs-pH* | *Waterquality for industrial use* |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1976 | W1 | 169.625 | 44.5 | 11.3 | 7.4 | 7.9 | -0.5 | Sedimentation |
| 2 | 1977 | W2 | 213.9 | 28 | 11.3 | 7.5 | 8.3 | -0.8 | Sedimentation |
| 3 | 1984 | W3 | 236.9 | 32.571 | 11.31 | 7.4 | 7.757 | -0.3571 | Sedimentation |
| 4 | 1984 | W4 | 239.711 | 32 | 11.31 | 7.4 | 7.75 | -0.35 | Sedimentation |
| 5 | 1986 | W5 | 247.677 | 38.286 | 11.31 | 7.3 | 8.369 | -1.0686 | Sedimentation |
| 6 | 1987 | W6 | 16.1 | 26 | 11.31 | 7.7 | 9.1 | -1.4 | Sedimentation |
| 7 | 1988 | W7 | 169.28 | 32 | 11.3 | 7.6 | 9.02 | -1.42 | Sedimentation |
| 8 | 1989 | W8 | 242.42 | 32.4 | 11.3 | 7.4 | 8.137 | -0.737 | Sedimentation |
| 9 | 1990 | W9 | 239.775 | 35 | 11.31 | 7.4 | 8.145 | -0.745 | Sedimentation |
| 10 | 1991 | W10 | 204.47 | 38 | 11.3 | 7.4 | 7.8 | -0.4 | Sedimentation |
| 11 | 1993 | W11 | 185.725 | 27.225 | 11.3 | 7.6 | 8.371 | -0.7713 | Sedimentation |
| 12 | 1994 | W12 | 196.236 | 31.16 | 11.3 | 7.5 | 8.268 | -0.768 | Sedimentation |
| 13 | 1995 | W13 | 165.868 | 37.667 | 11.3 | 7.5 | 8.222 | -0.722 | Sedimentation |
| 14 | 1996 | W14 | 212.98 | 28.6 | 11.31 | 7.5 | 8.333 | -0.8333 | Sedimentation |
| 15 | 1997 | W15 | 176.678 | 29.667 | 11.3 | 7.6 | 8.503 | -0.9033 | Sedimentation |
| 16 | 1998 | W16 | 145.656 | 29.057 | 11.3 | 7.7 | 8.203 | -0.5029 | Sedimentation |
| 17 | 1999 | W17 | 241.5 | 32 | 11.31 | 7.4 | 8.271 | -0.8714 | Sedimentation |
| 18 | 2000 | W18 | 244.359 | 28.571 | 11.31 | 7.5 | 8.341 | -0.8414 | Sedimentation |
| 19 | 2001 | W19 | 254.917 | 28.6 | 11.31 | 7.4 | 8.502 | -1.1017 | Sedimentation |
| 20 | 2004 | W20 | 260.13 | 31.8 | 11.31 | 7.4 | 8.3 | -0.9 | Sedimentation |
| 21 | 2005 | W21 | 267.697 | 32.82 | 11.31 | 7.4 | 8.318 | -0.918 | Sedimentation |
| 22 | 2006 | W22 | 307.349 | 37.42 | 11.31 | 7.2 | 8.646 | -1.446 | Sedimentation |
| 23 | 2007 | W23 | 306.317 | 38 | 11,45 | 7,6 | 8.428 | -1,18 | Sedimentation |

**Table 5: Water Quality estimator based on the severity of the entire Rhodean area at the Berentin Station**

| *Sample place* | *Symbol* | *Total hardness* | *Temporary difficulty* | *Permanent difficulty* | *Water quality based on total hardness* |
|---|---|---|---|---|---|
| 1976 | w1 | 187.66 | 187.66 | 0 | Hard |
| 1977 | w2 | 173.61 | 173.61 | 0 | Hard |
| 1984 | w3 | 203.37 | 203.37 | 0 | Hard |
| 1984 | w4 | 201.16 | 201.16 | 0 | Hard |
| 1986 | w5 | 229.63 | 229.63 | 0 | Hard |
| 1987 | w6 | 346.39 | 346.39 | 0 | Quite hard |
| 1988 | w7 | 191.01 | 191.01 | 0 | Hard |
| 1989 | w8 | 185.59 | 185.59 | 0 | Hard |
| 1990 | w9 | 198.5 | 198.5 | 0 | Hard |
| 1991 | w10 | 203.52 | 203.52 | 0 | Hard |
| 1993 | w11 | 184.83 | 184.83 | 0 | Hard |
| 1994 | w12 | 175.88 | 175.88 | 0 | Hard |
| 1995 | w13 | 175.61 | 175.61 | 0 | Hard |
| 1996 | w14 | 195.85 | 195.85 | 0 | Hard |
| 1997 | w15 | 218.1 | 218.1 | 0 | Hard |
| 1998 | w16 | 152.41 | 152.41 | 0 | Hard |
| 1999 | w17 | 211.82 | 211.82 | 0 | Hard |
| 2000 | w18 | 205.94 | 205.94 | 0 | Hard |
| 2001 | w19 | 207.7 | 207.7 | 0 | Hard |
| 2004 | w20 | 203.84 | 208,13 | 0 | Hard |
| 2005 | W21 | 212.76 | 212.76 | 0 | Hard |
| 2006 | W22 | 257.18 | 257.18 | 0 | Hard |
| 2007 | W23 | 322.29 | 322.29 | 0 | Quite hard |

**Determination of Hydrothermal Bridges and Faces in Rudan-Berentin Station**

Piper's diagram is one of the common ways to determine the type of water. Judging on the qualitative water type by the Piper diagram according to the focus area, the waters are divided into three—magnesia, calcium and sodium faces based on the anions and into three—bicarbonate, sulfate and chlorine types based on cations.

As shown in Piper diagram (Figure 5), the water type of this station is of chlorine type and its facade is Sadik, and finally, the type and facade of the type is sodium chloride.

**Assessment of Water Quality Based on the Severity of the Rudan-Berentin Station**

Based on the results of the classification of the waters of this station, as per their total hardness, water is classified into hard and very hard categories (indicating the presence of calcium and magnesium in this area).

**Water Quality Assessment Based on RSC, Rudan-Berentin Station**

As Table 6 shows, water quality is based on the RSC for many years in the appropriate category.

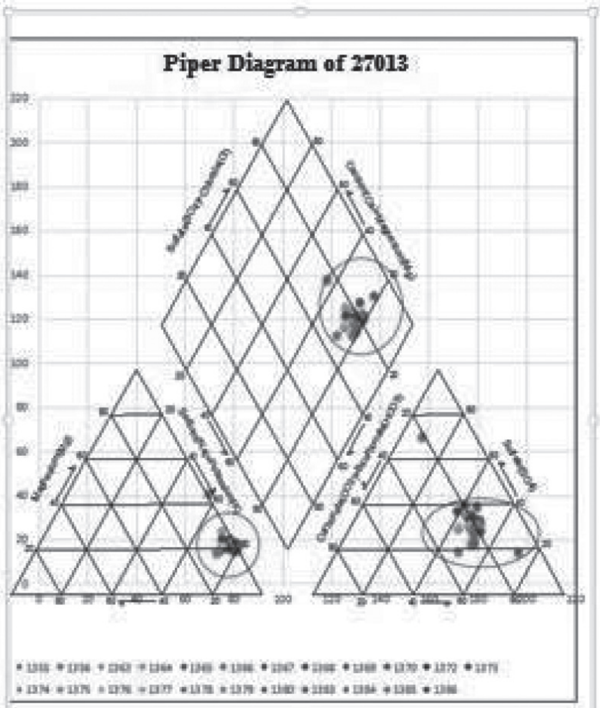


**Figure 5: Piper diagram for determination of hydrochemical faces in Rudan-Berentin station.**

**Table 6: Water quality assessment based on RSC-Rudan-Berentin Station**

| *Sampling year* | *SAR* | *Na%* | *Quality based on Na%* | *RSC* | *Quality based on RSC* |
|---|---|---|---|---|---|
| 1976 | 5.37 | 66.14 | suspicious | 1.15 | Suitable |
| 1977 | 7.03 | 72.66 | suspicious | 0.6 | Suitable |
| 1984 | 7.19 | 71.53 | suspicious | 0.51 | Suitable |
| 1984 | 7.32 | 71.99 | suspicious | 0.71 | Suitable |
| 1986 | 7.08 | 69.94 | suspicious | 0.24 | Suitable |
| 1987 | 3.74 | 50 | acceptable | -2.2 | Suitable |
| 1988 | 5.3 | 65.66 | suspicious | 0.23 | Suitable |
| 1989 | 7.71 | 73.81 | suspicious | 0.03 | Suitable |
| 1990 | 7.37 | 72.27 | suspicious | -0.4 | Suitable |
| 1991 | 6.21 | 68.44 | suspicious | -1.1 | Suitable |
| 1993 | 5.91 | 68.42 | suspicious | 0.17 | Suitable |
| 1994 | 6.41 | 70.65 | suspicious | -0.24 | Suitable |
| 1995 | 5.42 | 67.11 | suspicious | -0.48 | Suitable |
| 1996 | 6.59 | 70.1 | suspicious | 0.18 | Suitable |
| 1997 | 5.18 | 63.58 | suspicious | -0.88 | Suitable |
| 1998 | 5.11 | 67.35 | suspicious | 0.39 | Suitable |
| 1999 | 7.18 | 71.08 | suspicious | 0 | Suitable |
| 2000 | 7.37 | 71.89 | suspicious | -0.2 | Suitable |
| 2001 | 7.66 | 72.57 | suspicious | -0.11 | Suitable |
| 2004 | 7.89 | 73.35 | suspicious | -0,28! | Suitable |
| 2005 | 7.95 | 73.07 | suspicious | 0.54 | Suitable |
| 2006 | 8.3 | 72.04 | suspicious | -0.43 | Suitable |
| 2007 | 9.13 | 71.69 | suspicious | -0.36 | Suitable |

## Conclusion

Awareness of the quality and quantity of water resources is one of the most important requirements in planning and developing water resources and protecting and controlling them. Obviously, monitoring is required to be aware of the quality of water supplies and the production of information. Having comprehensive, accurate and reliable information with appropriate time intervals can be an important factor in decision making and policy making.The study of the chemical quality of the Rudan-Berentin station shows that at first, for the normalization of the data, using the chart and table for the box diagram, it was determined that the station information from a total of 24 data contained only one set of data, equivalent to 4.3% of data is outliers. Also, the parameters of acidity, carbonate, total soluble salts, sodium adsorption ratio, total cations, sodium, magnesium and chlorine are increasing over time, and the rest of the parameters are not trendy.

In the field of water quality assessment, for irrigation, as it has been shown in the descriptive table and the Wilcox chart, this saline station is suitable for agricultural activities and the concentration of samples in the chart is in the $C_3S_1$ category, which is of moderate quality. In the drinking water quality assessment section, according to the Schuler chart, it is shown that for this region all samples are in the medium to acceptable range and are suitable for drinking. In water quality assessment and evaluation for industrial use, the river water for industrial use causes sedimentation in plants. In addition, to determine the water type and hydrophilic faces of the region obtained from the Piper diagram, the water type is chlorine-type and its facade is sadik, and finally, the type and facade of the chlorine-sadik species. Also, the water of the study area is classified into two categories, hard, and quite hard according to the total severity. With water quality assessment based on RSC, it was shown that water quality is in good condition.

## References


Amarathunga, A.A.D., Weerasekara, K.A.W.S., Shirantha, R.R.A.R., Sureshkumar, N. and S.A.M. Azmy (2010). Nutrient Loading in Nanu Oya, Dabagasthalawa Oya and Agra Oya in Mahaweli Upper Catchment of Sri Lanka. International Symposium on "New Horizons in Humanities and Science Towards Sustainable Development", 26th to 28th August 2010, Sabaragamuwa University of Sri Lanka.

Azmy, S.A.M., Amarathunga, A.A.D., Shirantha, R.R.A.R. and K.A.W.S. Weerasekara (2010). Study of nutrient variation and physico-chemical characteristics including bio-indicators of the dik oya basin in Mahaweli upper catchment in Sri Lanka. Proceeding Part ii, 15th International symposium on forestry and environment, University of Sri Jayawardenapura, Sri Lanka.

Buchani, M.H., SH, T., S, SH., and A. E, F (2014). Groundwater Quality Assessment of Sahraye Bagh for use in agriculture and industry. *Journal of Ecohydrology*, Second course, **4:** 345-356.

Fetter, C.W. (1988). Applied Hydrogeology, 2nd ed. Macmillan Publishing Company, New York.

Gebrehiwot, A.B., Tadesse, N. and E. Jigar (2014). Application of Water Quality Index to Assess Suitablity of Groundwater Quality for Drinking Purposes in Hantebet watershed, Tigray, Northern Ethiopia. *Journal of Food and Agriculture Science*, **1(1):** 22-30.

Gasemi, E., Zareabyane, H., Shahsavar, A. and B. Yagobiyekikle (2009). Evaluation of quality and quantity of groundwater of Hamadan plain. *J. Plants and Ecol.*, 19.

Johnson, L.B., Richard, C., Host, G.E. and J.W. Arthur (1997). Landscape influences on water chemistry in Midwestern stream ecosystems. *Freshwater Biology*, **37:** 193-208.

Khadem, I.M. and J.J. Kaluarachi (2006). Water quality modeling under hydrologic variability and parameter uncertainty using erosion-scaled export coefficients. *J. Hydrol*.

Kendall, M.G. (1975). Rank Correlation Methods. Griffin, London, UK.

Mann, H.B. (1945). Nonparametric tests against trend. *Econometrica*, **13:** 245-259.

Masamba, W.R.L. and D. Mazvimavi (2008). Impact on water quality of landuses along Thamalakane-Boteti River: An outlet of the Okavango Delta.

Mousavi, G. (2010). Water Engineering. Hafiz Published. **2(1):** 78.

Mahdavi, M. (2004). Applied Hydrology. Volume two. Publishers of Tehran University.

Mousavi Nodoshan, S.S., Bani Habib, M.A. and V.R. Bandari (2011). Prediction of daily flow into the Dez Dam reservoir Using time series models. Eleventh National Irrigation Seminar and Reduction of Evaporation.

Mosaedi, A. and N. Kohstany (2009). Analysis of Flow Changes in Golestan Province Rivers Using parametric and nonparametric methods. Proceedings of the Fourth Regional Conference on Climate Change, Tehran.

Ouyang, Y., Nkedi-Kizza, P., Wu, Q.T., Shinde, D. and C.H. Huang (2006). Assessment of seasonal variations.

Piper, A.M. (1944). A graphic procedure in the geochemical interpretation of water analysis. *Trans. Am. Geophys. Union*, **25:** 914-923.

Poureshgh, Y., Parastar, S., Poureshgh, B., Rezaei, M., Doorgahi, A. and M. Vosugi (2013). Water Quality Assessment of Herouchai Khalkhal River for qualitative indicators WILCOX and NSFWQI. *Health Journal*, **4(3):** 273-283.

Sedaghat, M. (1993). Earth and water resource (grandwater). Payamnor University Press.

Sheikh, A. and B.Y. Moshekhyan (2009). Investigation of the trend of precipitation regime in Gorganroud watershed. *Journal of Science and Engineering Watershed of Iran*, **3(8):** 10.

Shokoohi, R., Hoseinzadeh, E., Alipour, M. and S. Hoseinzadeh (2012). Evaluation Aydughmush River quality parameters changes and Wilcox index calculation. *Rasayan Journal of Chemistry*, **4(3):** 673-680.

Samantray, P., Mishra, B.K., Panda, C.R. and S.P. Rout (2009). Assessment of water quality index in Mahanadi and Atharabanki Rivers and Taldanda Canal in Paradip Area, India. *Journal of Human Ecology*, **26(3):** 153-161.

Sánchez, E., Colmenarejo, M., Vicente, J., Rubio, A., García, M., Travieso, L. and R. Borja (2007). Use of the water indicators of watersheds pollution. *Journal of Ecological Indicators*, **7(2):** 315-328.

Yosefzadeh, E.A., Khoram Abadi, Gh.A., Godiny, H., Hosseinzadeh, A. and M. Safari (2013). Khorramabad River Water Quality Index (NSFWQI) and its zoning with GIS. *Journal of Scientific-Research Lorestan University of Medical Sciences*, **15(5):** Lorestan.

Zahtabians, Gh.R., Janfaza, E.A., Mohammadasgary, H. and M.J. Nematollahy (2010). Modeling the spatial distribution of some chemical properties of groundwater (Case study: Garmsar Watershed). *Scientific and Research Journal of Research on Range and Desert of Iran*, **17(1):** 61-73.