

# Analysis of Water Quality Parameters in Erbil City

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## *Introduction :*

Erbil city was chosen for this study. Time series analysis was applied to the Physicochemical, Chemical and Bacteriological characteristics in all sources of water in Erbil City.



Erbil  
City

Sources of water in Erbil City

The analyzed time series is (18) years data during the period (2004-2021) of monthly several data taken.

The water quality parameters selected are pH, Electrical Conductivity, Turbidity, Total Dissolved Solid, Total Hardness as  $\text{CaCO}_3$ , Total Alkalinity as  $\text{CaCO}_3$ , Nitrate, Chloride, Sulphate, Sodium, Potassium, Calcium, Magnesium, Total Coliform and Escherichia Coliform. The data compared with the Iraqi standards.



Parameter		Unit
pH		
Electrical Conductivity	EC	μmhos/cm
Turbidity		NTU
Total Dissolved Solid	TDS	mg/L
Total Hardness as CaCO <sub>3</sub>	TH	mg/L
Total Alkalinity as CaCO <sub>3</sub>		mg/L
Nitrate	NO <sub>3</sub> <sup>-1</sup>	mg/L
Chloride	Cl <sup>-1</sup>	mg/L
Sulphate	SO <sub>4</sub> <sup>-2</sup>	mg/L
Sodium	Na <sup>+1</sup>	mg/L
Potassium	K <sup>+1</sup>	mg/L
Calcium	Ca <sup>+2</sup>	mg/L
Magnesium	Mg <sup>+2</sup>	mg/L
Total Coliform		CFU/100 mL
Escherichia Coliform	E. Coli	CFU/100 mL

## List of water quality parameters

Parameter		Permissive Limits	
pH		6.5	8.5
Electrical Conductivity	EC	1980	2020
Turbidity		5	25
Total Dissolved Solid	TDS	500	1000
Total Hardness as CaCO <sub>3</sub>	TH	100	500
Total Alkalinity as CaCO <sub>3</sub>		125	200
Nitrate	NO <sub>3</sub> <sup>-1</sup>	44.55	45.45
Chloride	Cl <sup>-1</sup>	200	250
Sulphate	SO <sub>4</sub> <sup>-2</sup>	200	400
Sodium	Na <sup>+1</sup>	198	202
Potassium	K <sup>+1</sup>	247.5	252.5
Calcium	Ca <sup>+2</sup>	75	200
Magnesium	Mg <sup>+2</sup>	50	150
Total Coliform		0	0
Escherichia Coliform	E. Coli	0	0

Specification of drinking water according Iraqi standards

## *Objective of the Present Study :*

The analysis can be achieved by obtaining a:

- ❖ Missing Values Statistics Analysis.
- ❖ Comparison Analysis between data and specification of the drinking water according Iraqi standards.
- ❖ Descriptive Statistics Analysis.

## *Missing Values Statistics Analysis:*

The most effective mathematical method is Regression Analysis of several data before and after missing value and calculating the most suitable regression function then finds the relationship with data by Correlation Factor.

The most suitable regression methods to fill the missing values of time series were:

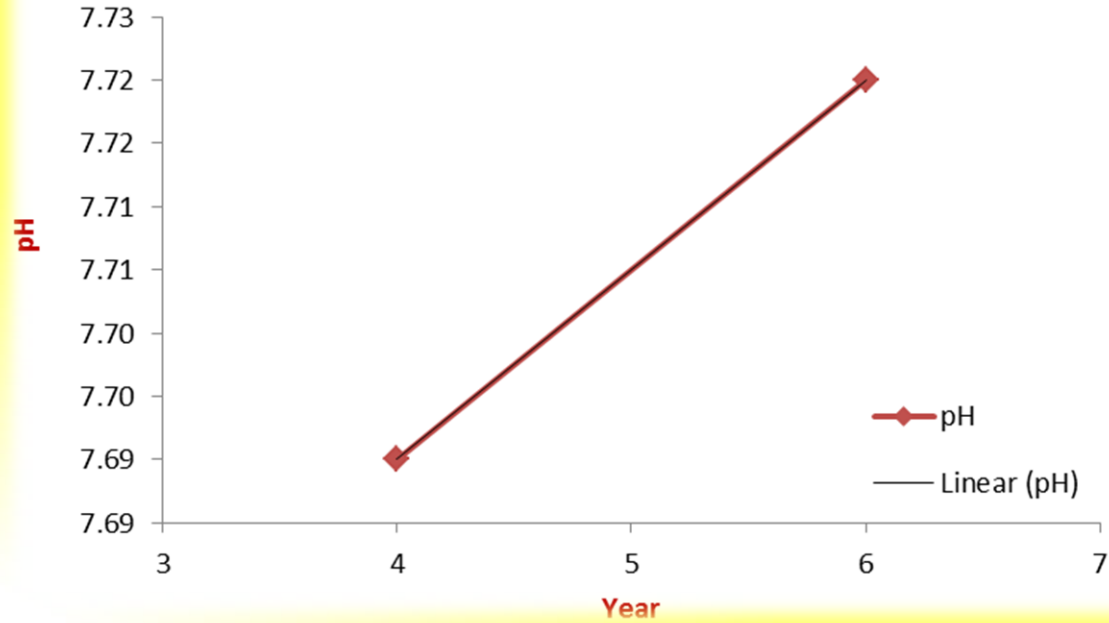
- ❖ Linear Regression
- ❖ Polynomial Regression 2nd degree
- ❖ Polynomial Regression 3rd degree



## February

$$y = 0.015x + 7.63$$

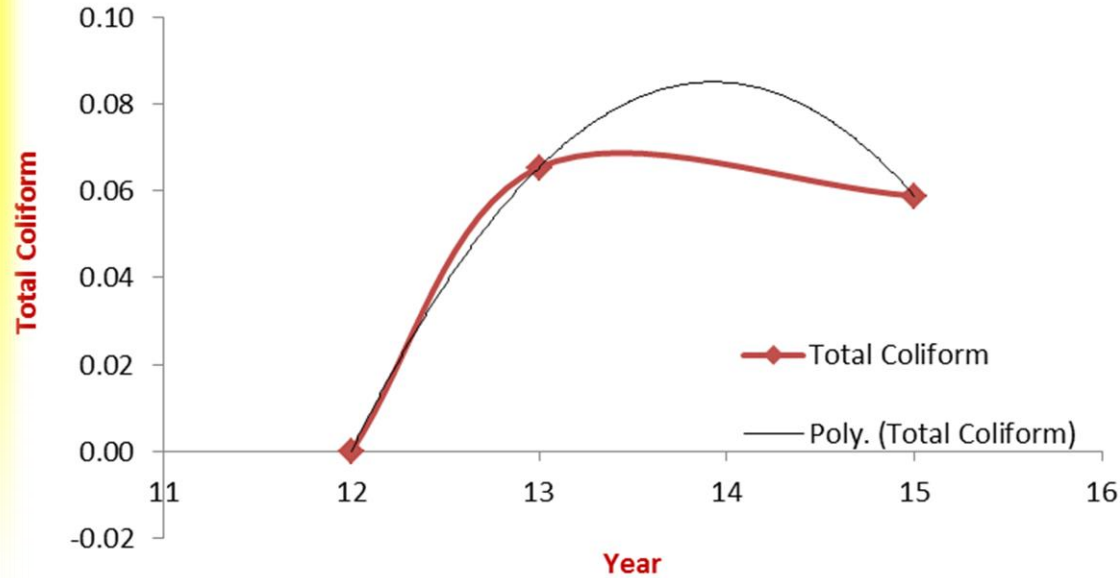
$$R^2 = 1$$



Linear Regression

## March

$$y = -0.0229x^2 + 0.6365x - 4.3482$$
$$R^2 = 1$$

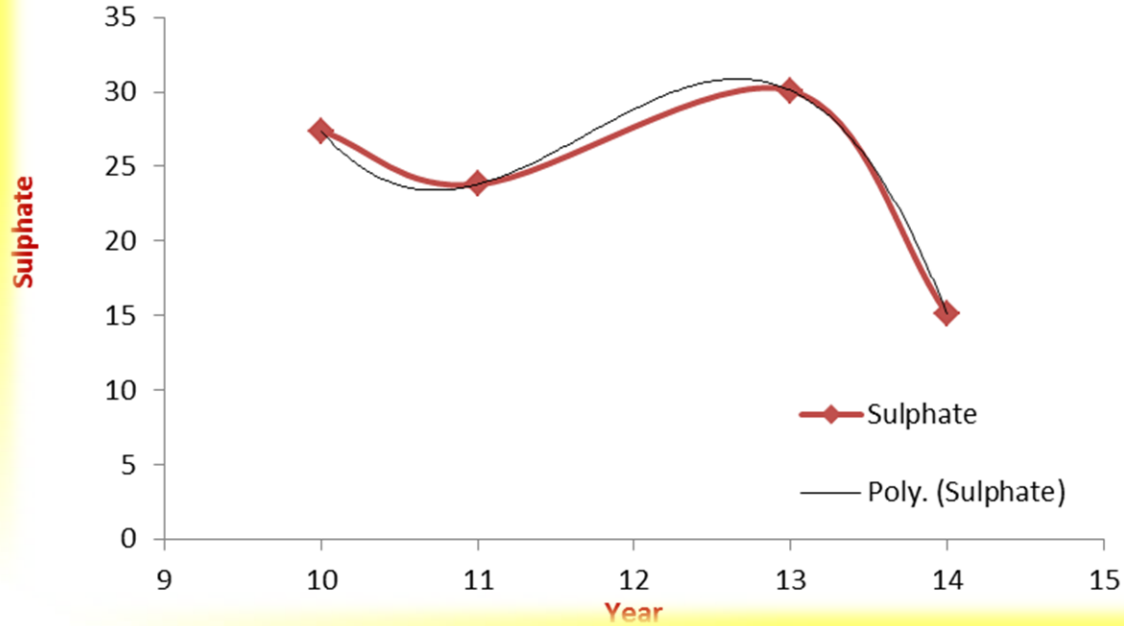


Polynomial Regression 2nd degree

**July**

$$y = -2.0727x^3 + 72.718x^2 - 844.6x + 3274.3$$

$R^2 = 1$



**Polynomial Regression 3rd degree**

## *Comparison Analysis between data and specification of the drinking water according Iraqi standards:*

The monthly average data after filling the missing values have to be compared with the specification of drinking water according Iraqi standards to calculate the percentage of suitability of each water quality parameter with the standards.

<i>Physicochemical Parameters</i>					
<b>pH</b>	<b>Electrical Conductivity</b>	<b>Turbidity</b>	<b>Total Dissolved Solid</b>	<b>Total Hardness as CaCO<sub>3</sub></b>	<b>Total Alkalinity as CaCO<sub>3</sub></b>
	<b>EC</b>		<b>TDS</b>	<b>TH</b>	
	<b>µmhos/cm</b>	<b>NTU</b>	<b>mg/L</b>	<b>mg/L</b>	<b>mg/L</b>
<b>97.22%</b>	<b>0.00%</b>	<b>7.41%</b>	<b>5.56%</b>	<b>98.61%</b>	<b>33.80%</b>

**Percentages of Physicochemical Parameters with standards**



Chemical Parameters						
Nitrate	Chloride	Sulphate	Sodium	Potassium	Calcium	Magnesium
$\text{NO}_3^{-1}$	$\text{Cl}^{-1}$	$\text{SO}_4^{-2}$	$\text{Na}^{+1}$	$\text{K}^{+1}$	$\text{Ca}^{+2}$	$\text{Mg}^{+2}$
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.00%	0.00%	0.00%	0.00%	0.00%	14.81%	1.85%

Percentages of Chemical Parameters with standards

<b>Bacteriological Parameters</b>	
<b>Total Coliform</b>	<b>Escherichia Coliform</b>
	<b>E. Coli</b>
<b>CFU/100 mL</b>	<b>CFU/100 mL</b>
<b>33.80%</b>	<b>56.48%</b>

**Percentages of Bacteriological Parameters with standards**

## *Descriptive Statistics Analysis:*

The primary goal of descriptive statistics is to provide a clear and concise summary of the data, enabling researchers or analysts to gain insights and understand patterns, trends, and distributions within the dataset. This summary typically includes measures such as central tendency (e.g., count, sum, mean, median), dispersion (e.g., range, maximum, minimum, variance, standard deviation, standard error), and shape of the distribution (e.g., skewness, kurtosis).

<i>Physicochemical Parameters</i>						
	pH	Electrical Conductivity	Turbidity	Total Dissolved Solid	Total Hardness as CaCO <sub>3</sub>	Total Alkalinity as CaCO <sub>3</sub>
		EC		TDS	TH	
		µmhos/cm	NTU	mg/L	mg/L	mg/L
Mean	7.377	520.055	2.093	285.164	262.296	206.481
Standard Error	0.067	17.722	0.307	17.172	7.701	2.915
Median	7.428	491.584	1.783	251.408	251.438	205.682
Standard Deviation	0.285	75.186	1.302	72.857	32.674	12.366
Sample Variance	0.081	5653.001	1.695	5308.087	1067.583	152.928
Kurtosis	4.072	4.625	2.825	2.923	-0.800	-0.493
Skewness	-1.858	2.112	1.565	1.972	0.311	0.029
Range	1.142	313.158	5.150	243.015	109.688	47.052
Minimum	6.518	433.000	0.691	234.503	211.071	182.302
Maximum	7.660	746.158	5.841	477.518	320.759	229.354
Sum	132.787	9360.988	37.675	5132.944	4721.328	3716.654
Count	18.000	18.000	18.000	18.000	18.000	18.000

Descriptive statistics of yearly average of Physicochemical Parameters

Chemical Parameters							
	Nitrate	Chloride	Sulphate	Sodium	Potassium	Calcium	Magnesium
	$\text{NO}_3^{-1}$	$\text{Cl}^{-1}$	$\text{SO}_4^{-2}$	$\text{Na}^{+1}$	$\text{K}^{+1}$	$\text{Ca}^{+2}$	$\text{Mg}^{+2}$
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	26.125	22.033	49.874	18.924	1.366	58.449	27.351
Standard Error	0.854	1.623	6.693	1.510	0.105	3.557	1.504
Median	24.896	23.562	35.775	16.844	1.290	59.740	27.451
Standard Deviation	3.621	6.886	28.395	6.408	0.446	15.093	6.381
Sample Variance	13.114	47.412	806.297	41.063	0.199	227.801	40.719
Kurtosis	-0.469	0.277	-0.319	-1.012	0.411	0.129	-0.404
Skewness	0.776	-0.069	1.102	0.508	1.025	-0.670	-0.001
Range	11.480	27.336	86.433	20.088	1.596	51.159	23.266
Minimum	21.894	9.579	24.509	10.001	0.788	29.191	14.940
Maximum	33.374	36.916	110.942	30.089	2.384	80.350	38.206
Sum	470.246	396.589	897.735	340.633	24.582	1052.086	492.320
Count	18.000	18.000	18.000	18.000	18.000	18.000	18.000

Descriptive statistics of yearly average of Chemical Parameters



<b>Bacteriological Parameters</b>		
	<b>Total Coliform</b>	<b>Escherichia Coliform</b>
		<b>E. Coli</b>
	<b>CFU/100 mL</b>	<b>CFU/100 mL</b>
<b>Mean</b>	<b>0.489</b>	<b>0.083</b>
<b>Standard Error</b>	<b>0.176</b>	<b>0.035</b>
<b>Median</b>	<b>0.112</b>	<b>0.012</b>
<b>Standard Deviation</b>	<b>0.745</b>	<b>0.149</b>
<b>Sample Variance</b>	<b>0.556</b>	<b>0.022</b>
<b>Kurtosis</b>	<b>0.791</b>	<b>4.372</b>
<b>Skewness</b>	<b>1.500</b>	<b>2.151</b>
<b>Range</b>	<b>2.149</b>	<b>0.538</b>
<b>Minimum</b>	<b>0.000</b>	<b>0.000</b>
<b>Maximum</b>	<b>2.149</b>	<b>0.538</b>
<b>Sum</b>	<b>8.805</b>	<b>1.499</b>
<b>Count</b>	<b>18.000</b>	<b>18.000</b>

**Descriptive statistics of yearly average of Bacteriological Parameters**

<i>Physicochemical Parameters</i>						
	pH	Electrical Conductivity	Turbidity	Total Dissolved Solid	Total Hardness as CaCO <sub>3</sub>	Total Alkalinity as CaCO <sub>3</sub>
		EC		TDS	TH	
		µmhos/cm	NTU	mg/L	mg/L	mg/L
<b>Count</b>	12.000	12.000	12.000	12.000	12.000	12.000
<b>Sum</b>	88.524	6240.658	25.116	3421.962	3147.552	2477.769
<b>Mean</b>	7.377	520.055	2.093	285.164	262.296	206.481
<b>Median</b>	7.477	525.100	1.950	285.532	259.450	206.726
<b>Range</b>	0.628	107.700	2.185	65.850	40.742	24.785
<b>Minimum</b>	6.942	448.407	1.372	242.513	249.434	194.656
<b>Maximum</b>	7.570	556.107	3.557	308.363	290.176	219.441
<b>Sample Variance</b>	0.048	999.025	0.416	359.594	139.691	49.701
<b>Standard Deviation</b>	0.219	31.607	0.645	18.963	11.819	7.050
<b>Standard Error</b>	0.063	9.124	0.186	5.474	3.412	2.035
<b>Kurtosis</b>	0.085	1.157	1.040	0.890	1.695	-0.247
<b>Skewness</b>	-1.329	-1.171	1.136	-0.924	1.336	0.053

**Descriptive statistics of periodic yearly average of Physicochemical Parameters**

Chemical Parameters							
	Nitrate	Chloride	Sulphate	Sodium	Potassium	Calcium	Magnesium
	$\text{NO}_3^{-1}$	$\text{Cl}^{-1}$	$\text{SO}_4^{-2}$	$\text{Na}^{+1}$	$\text{K}^{+1}$	$\text{Ca}^{+2}$	$\text{Mg}^{+2}$
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Count	12.000	12.000	12.000	12.000	12.000	12.000	12.000
Sum	313.497	264.393	598.490	227.089	16.388	701.391	328.214
Mean	26.125	22.033	49.874	18.924	1.366	58.449	27.351
Median	25.662	21.558	49.642	19.059	1.245	58.025	26.819
Range	7.921	10.099	17.049	2.615	1.126	8.674	7.034
Minimum	22.397	19.040	39.615	17.466	1.053	56.018	24.443
Maximum	30.319	29.139	56.665	20.081	2.179	64.692	31.477
Sample Variance	5.112	7.502	24.507	0.513	0.096	6.444	3.908
Standard Deviation	2.261	2.739	4.950	0.716	0.310	2.538	1.977
Standard Error	0.653	0.791	1.429	0.207	0.089	0.733	0.571
Kurtosis	-0.033	3.624	0.312	0.446	3.860	2.224	0.569
Skewness	0.523	1.696	-0.443	-0.572	1.794	1.358	0.919

Descriptive statistics of periodic yearly average of Chemical Parameters

<b>Bacteriological Parameters</b>		
	<b>Total Coliform</b>	<b>Escherichia Coliform</b>
		<b>E. Coli</b>
	<b>CFU/100 mL</b>	<b>CFU/100 mL</b>
<b>Count</b>	<b>12.000</b>	<b>12.000</b>
<b>Sum</b>	<b>5.870</b>	<b>0.999</b>
<b>Mean</b>	<b>0.489</b>	<b>0.083</b>
<b>Median</b>	<b>0.472</b>	<b>0.081</b>
<b>Range</b>	<b>0.496</b>	<b>0.156</b>
<b>Minimum</b>	<b>0.226</b>	<b>0.031</b>
<b>Maximum</b>	<b>0.722</b>	<b>0.188</b>
<b>Sample Variance</b>	<b>0.019</b>	<b>0.001</b>
<b>Standard Deviation</b>	<b>0.136</b>	<b>0.039</b>
<b>Standard Error</b>	<b>0.039</b>	<b>0.011</b>
<b>Kurtosis</b>	<b>0.459</b>	<b>4.966</b>
<b>Skewness</b>	<b>0.009</b>	<b>1.754</b>

**Descriptive statistics of periodic yearly average of  
Bacteriological Parameters**

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