Center for Water Quality Research (CWQR)
Institute for Environmental Research (IER)
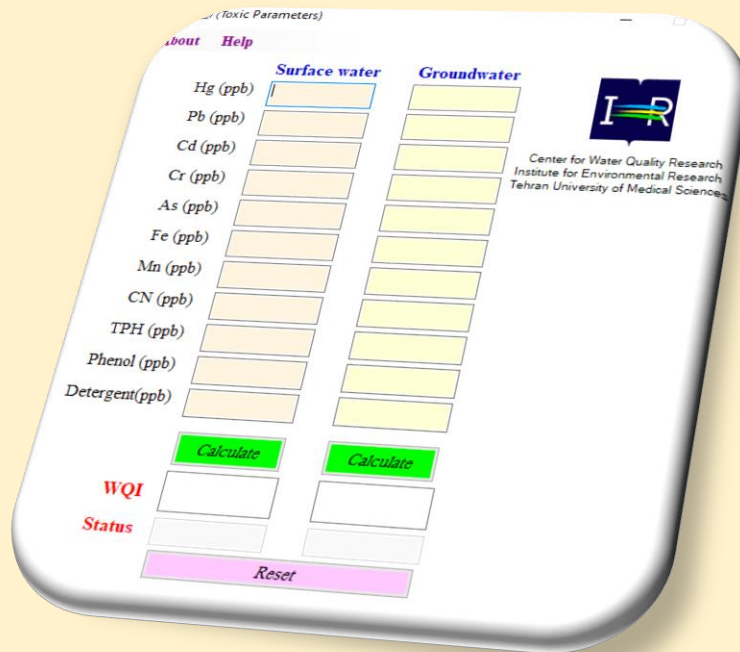*Tehran University of Medical Sciences*

Water Quality Index Calculator for Toxic Parameters in Water Resources

Version: 1.0.0

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2024

Introduction

One of the most significant health concerns in the world is the provision of safe and sufficient potable water with acceptable quality. Various indicators and laboratory tests are necessary to ensure water quality. Water Quality Index (WQI) is one of the techniques used to evaluate the quality of surface and groundwater. This index is a suitable and simple tool to determine the status of water quality, which is calculated by entering data related to water quality parameters in a mathematical formula and the obtained value shows the water quality. This index is classified with a relative scale that indicates the water quality from very bad to very good. In other words, high values indicate better quality and lower values indicate lower water quality. The characteristics of this index are summarizing water quality data as a value, simple and understandable for users, and determining the conditions of acceptance or rejection of a water source for drinking purposes. Since high concentrations of heavy metals such as arsenic, cadmium, lead and mercury pose a particular risk to human health, along with the conventional parameters of the quality of water resources, toxic parameters should also be investigated. Therefore, in this work, the calculation of the index of toxic parameters of the quality of water resources is considered.

Calculating WQI index for toxic parameters in surface water resources

The steps for calculating the index of toxic parameters of the quality of surface water resources are:

1) Selection of parameters based on Table 1

2) Determining the weight of each parameter using Table 1

3) Obtaining the index value for each parameter using rating curves

Table 1 Toxic parameters of surface water resources and their weights

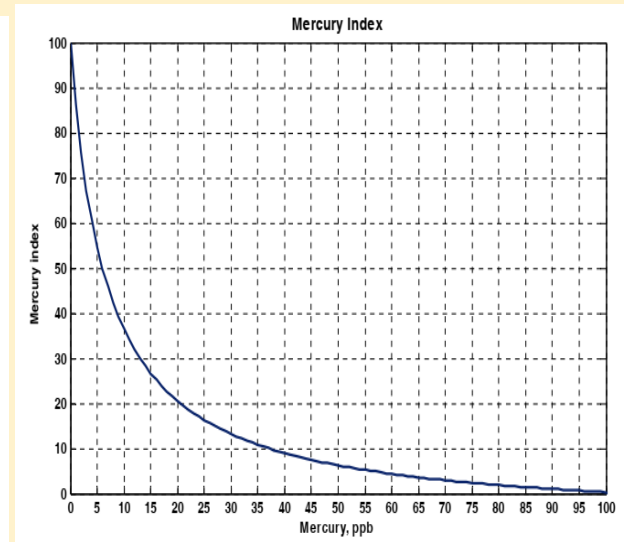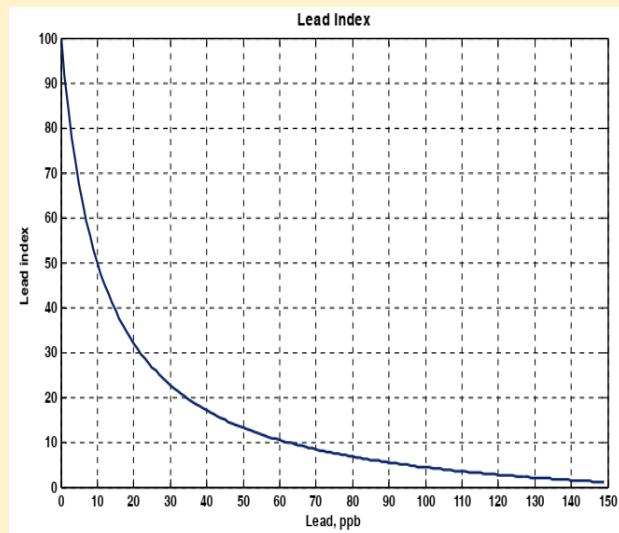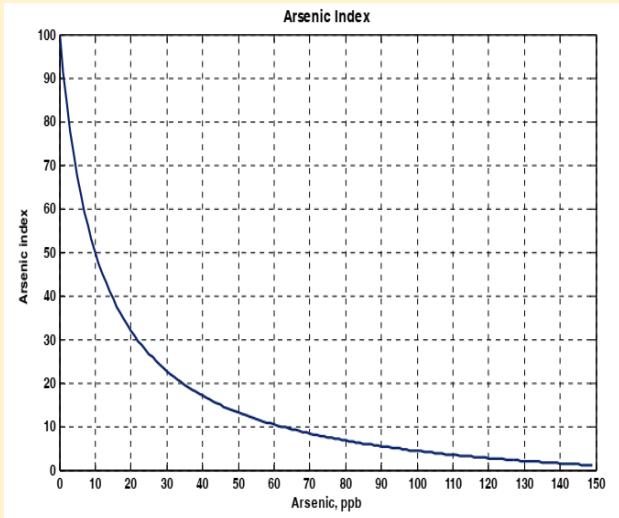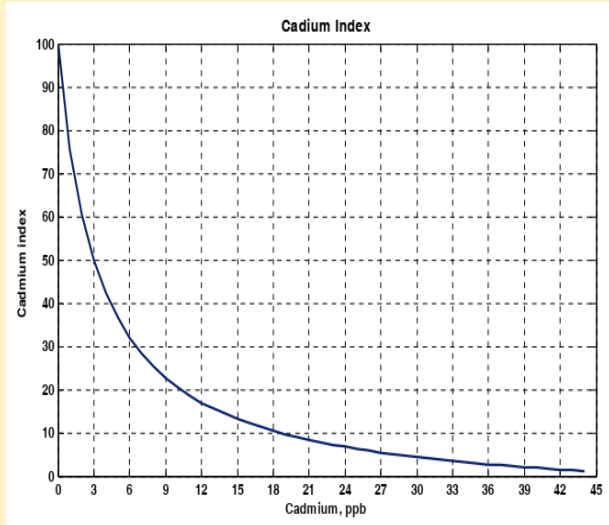|	Parameter	Weight	Description
1	Arsenic (As)	0.128	As ppb
2	Mercury (Hg)	0.117	As ppb
3	Total petroleum hydrocarbons (TPH)	0.108	As ppb
4	Detergent	0.100	As ppb
5	Lead (Pb)	0.092	As ppb
6	Cadmium (Cd)	0.092	As ppb
7	Phenol	0.091	As ppb
8	Chromium (Cr)	0.084	As ppb
9	Cyanide (CN)	0.070	As ppb
10	Iron (Fe)	0.063	As ppb
11	Manganese (Mn)	0.056	As ppb

Rating curves

Based on the equations that we obtained from the rating curves in next pages (Table 2), the WQI value for each parameter can be calculated.
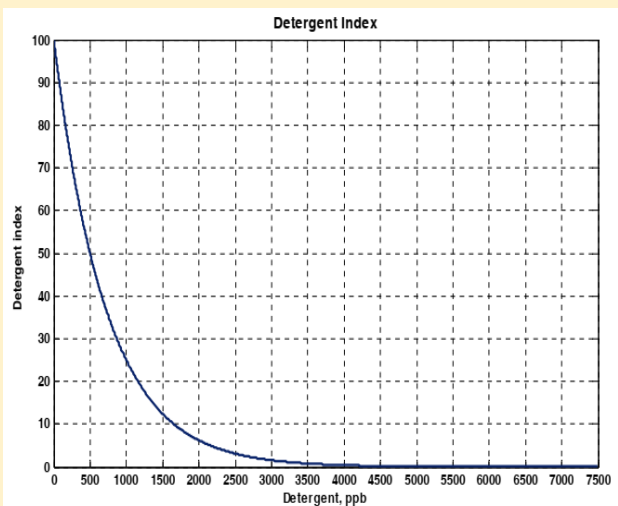
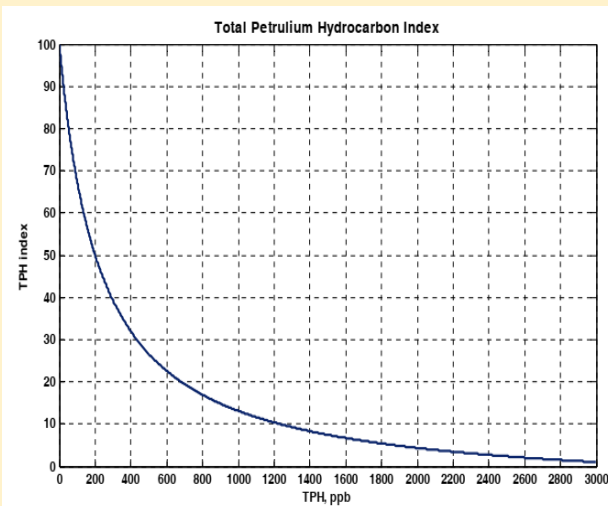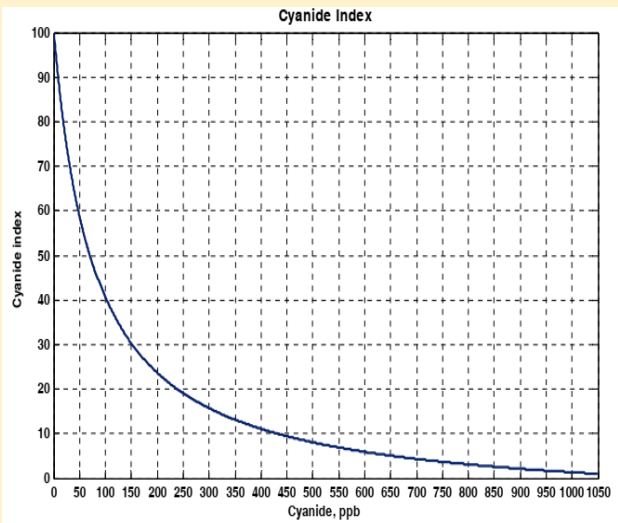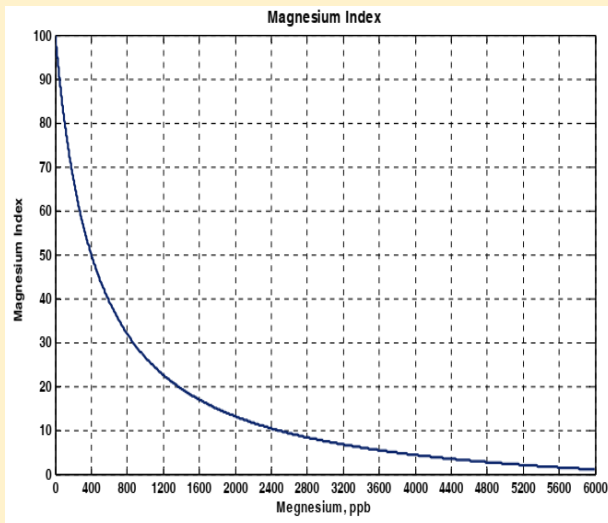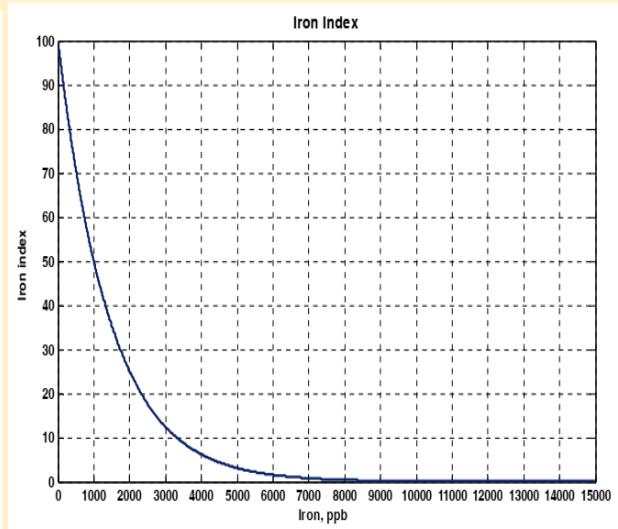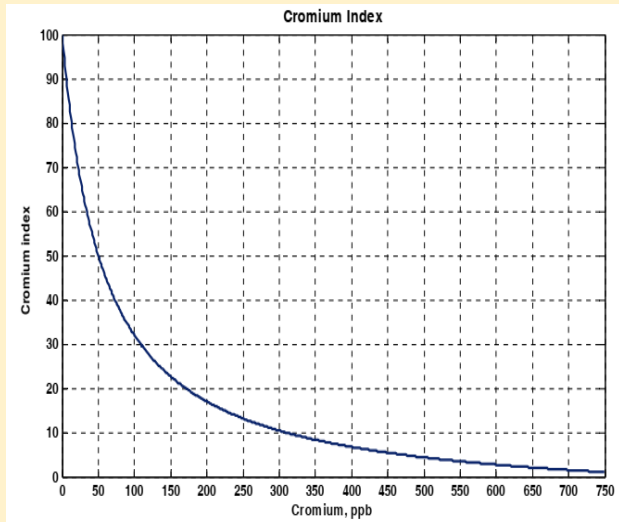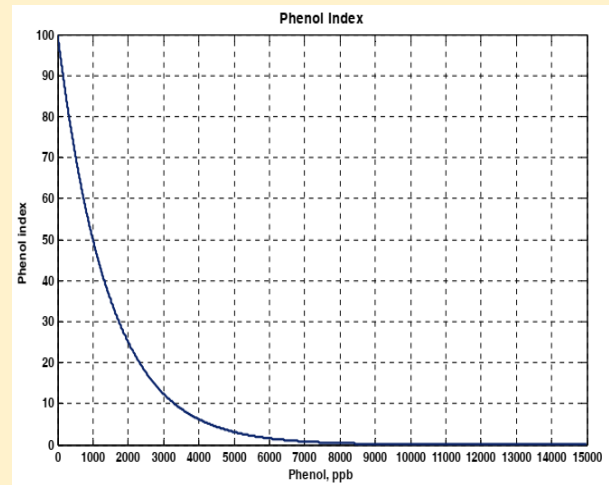**Table 2** WQI formula for water quality parameters

WQI_Hg = 100.3278971454447 * (2.71 ^ ((-0.049209008950069) * (Hg)))
WQI_Pb = 69.5500604885486 * (2.71 ^ ((-0.026778197503242) * (Pb)))
WQI_Cd = 65.4056532034431 * (2.71 ^ ((-0.091074553288794) * (Cd)))
WQI_Cr = 65.905962623975 * (2.71 ^ ((-0.005522030732569) * (Cr)))
WQI_As = 97.2444974977967 * (2.71 ^ ((-0.027421343460983) * (As)))
WQI_Fe = 100.2724093348286 * (2.71 ^ ((-0.000521826404749) * (Fe)))
WQI_Mn = 74.4549217974468 * (2.71 ^ ((-0.000675572651534) * (Mn)))
WQI_CN = 65.9825834746033 * (2.71 ^ ((-0.003942126052053) * (CN)))
WQI_TPH = 87.7802927090388 * (2.71 ^ ((-0.001318085662786) * (TPH)))
WQI_Phenol = 90.7671950201202 * (2.71 ^ ((-0.000444231648164) * (Phenol)))
WQI_Detergent = 99.9117537855903 * (2.71 ^ ((-0.000933798808211) * (Detergent)))

Rating curves

Cromium Index

Iron Index

Magnesium Index

Cyanide Index

Total Petrulium Hydrocarbon Index

Detergent Index

The WOI index can be calculated using the following equation:

$$WQI = [\prod_{i=1}^{n} I_i^{Wi}]^{\frac{1}{\gamma}}$$

$$\gamma = \sum_{i=1}^{n} W_i$$

W_i = the weight of the i-th parameter

n = number of parameters

I_i = the index value for the i-th parameter of the rating curve

The following table is used to determine the descriptive equivalent of the calculated index:

Index description	WQI
Very bad	< 15
Bad	15-29.9
Relatively bad	30-44.9
Medium	45-55
Relatively good	55.1-70
Good	70.1-85
Very good	> 85

Example:

In a monitoring station related to a river (surface water), the following parameters have been measured for water quality. Determine the value of the water quality index and its descriptive equivalent.

Hg = 0.3 ppb
As = 0.6 ppb
Fe = 30 ppb
Pb = 7 ppb
Mn = 150 ppb
CN = 52 ppb
Cd = 3 ppb
Cr = 50 ppb
TPH = 2800 ppb
Phenol = 200 ppb
Detergent = 100 ppb

Solution:

First, we determine the equivalent index of each parameter using rating curves and the weight of each parameter using Table 1:

Parameter	Weight	Index value
Hg	0. 117	99
As	0.128	96
Fe	0.063	99
Pb	0.092	58
Mn	0.056	67
CN	0.07	54
Cd	0.092	50
Cr	0.084	50
TPH	0.108	2
Phenol	0.09	83
Detergent	0.1	91

Total weight of parameters:

$$\gamma = \sum_{i=1}^{n} W_i$$

$\gamma = 0.117 + 0.128 + 0.063 + 0.092 + 0.056 + 0.07 + 0.092 + 0.084 + 0.108 + 0.09 + 0.1 = 1$

Calculation of WQI:

$$WQI_{GT} = [\prod_{i=1}^{n} I_i^{Wi}]^{\frac{1}{\gamma}}$$

WQI = [(99^0.117) * (96^0.128) * (99^0.063) * (58^0.092) * (67^0.056) *(54^0.07) * (50^0.092) * (50^0.084) * (2^0.108) * (83^0.09) * (91^0.1)] ^ 1/1 = 49.9

The guide table is used to determine the descriptive equivalent of the index. According to the numerical value of the index which is equal to 49.9, the water quality is equivalent to medium with yellow color.

Medium	45-55

* Using the application, almost the same result is obtained. Due to the inaccurate visual reading of the equivalent index of each parameter using the rating curves compared to the calculation of the equivalent index through the equation by the application, this insignificant difference is normal.

WQI (Toxic Parameters)

Application Information   **Help**

	Surface water	Groundwater
Hg (ppb)	0/3	
Pb (ppb)	7	
Cd (ppb)	3	
Cr (ppb)	50	
As (ppb)	0/6	
Fe (ppb)	30	
Mn (ppb)	150	
CN (ppb)	52	
TPH (ppb)	2800	
Phenol (ppb)	200	
Detergent(ppb)	100	

Calculate	Calculate

WQI 50/4688273820912

Status Medium

Reset

Calculating WQI index for toxic parameters in groundwater resources

The steps of calculating the index of toxic parameters of the quality of groundwater sources are:

1) Selection of parameters based on Table 3

2) Determining the weight of each parameter using Table 3

3) Obtaining the index value for each parameter using rating curves

Table 3 Toxic parameters of groundwater resources and their weights

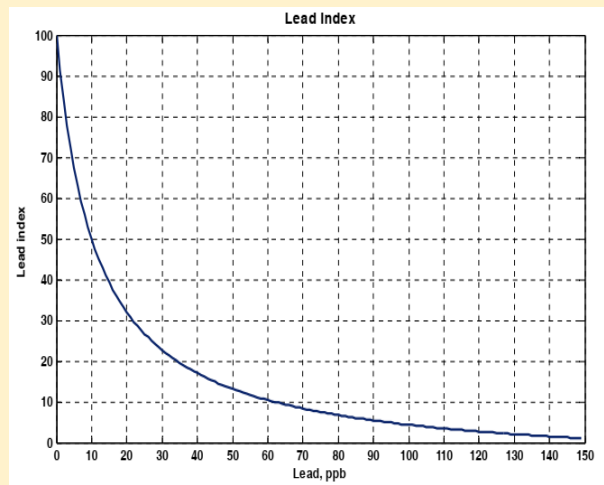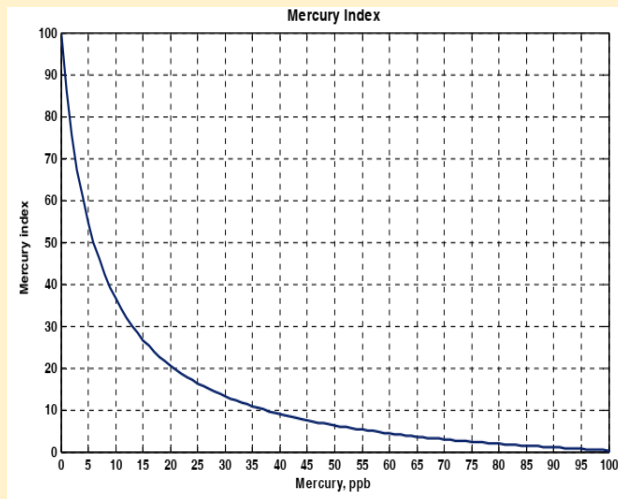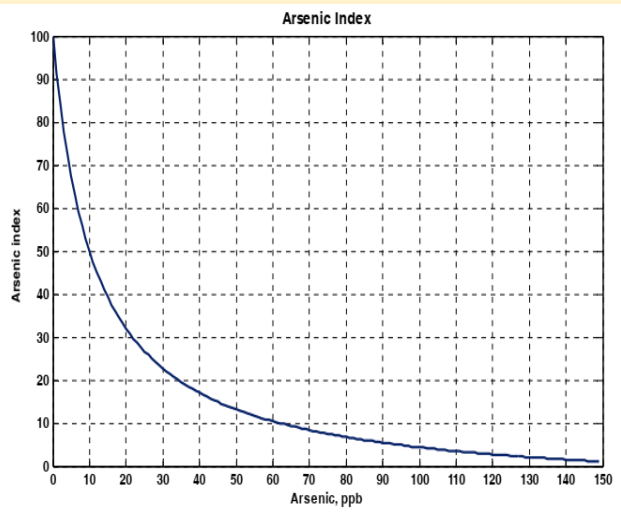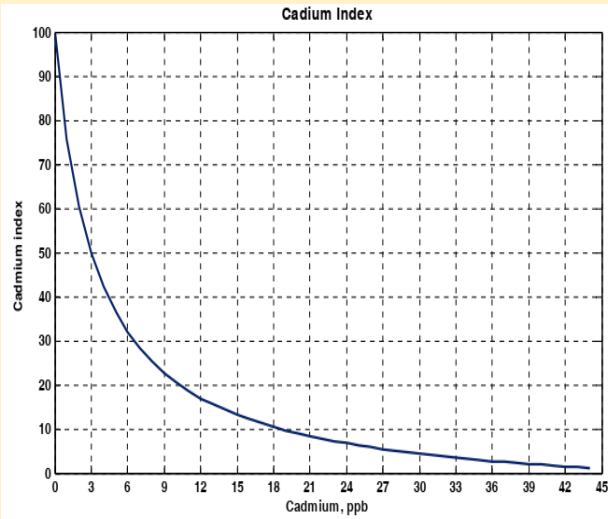|	Parameter	Weight	Description
1	Arsenic (As)	0.128	As ppb
2	Phenol	0.119	As ppb
3	Mercury (Hg)	0.113	As ppb
4	Detergent	0.107	As ppb
5	Total petroleum hydrocarbons (TPH)	0.097	As ppb
6	Cadmium (Cd)	0.086	As ppb
7	Lead (Pb)	0.079	As ppb
8	Chromium (Cr)	0.079	As ppb
9	Cyanide (CN)	0.072	As ppb
10	Iron (Fe)	0.066	As ppb
11	Manganese (Mn)	0.054	As ppb

Rating curves

Based on the equations that we obtained from the rating curves in next pages (Table 4), the WQI value for

each parameter can be calculated.

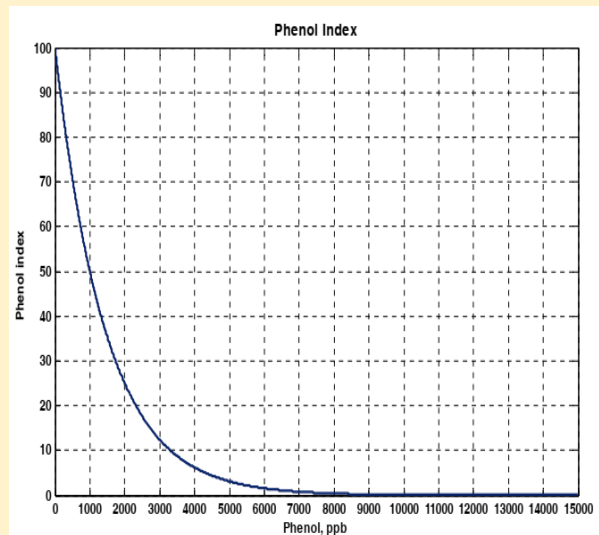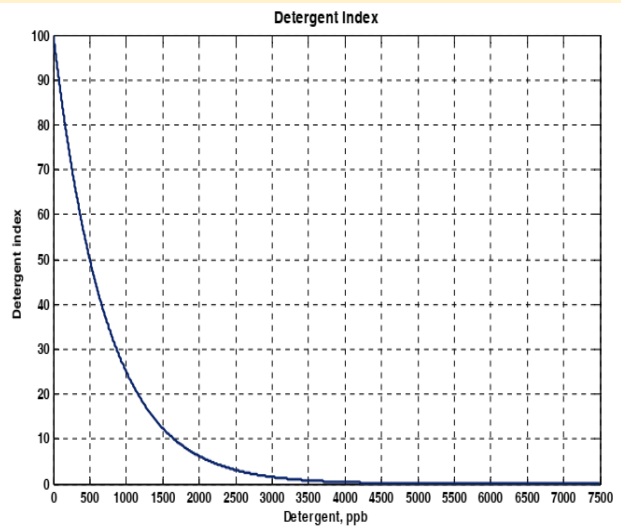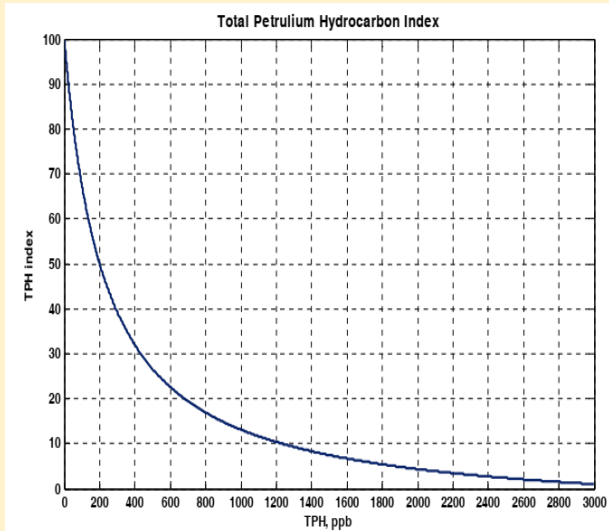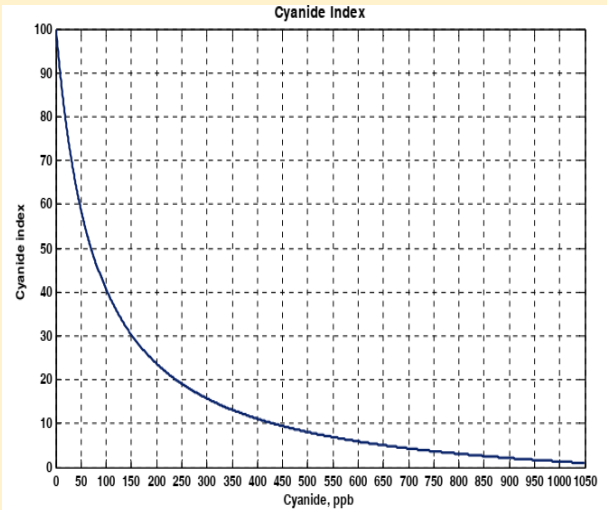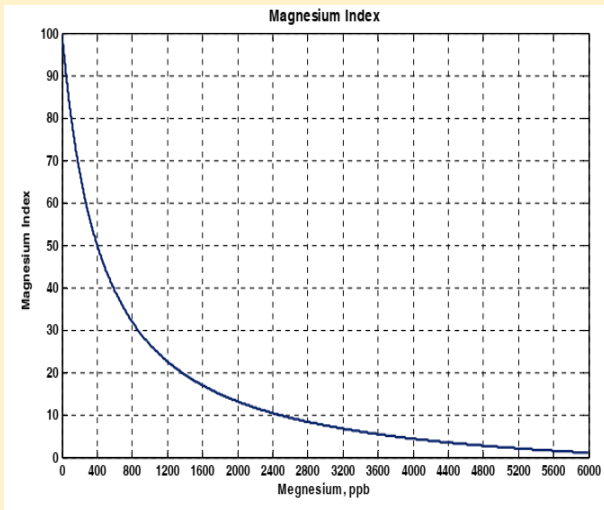**Table 4** WQI formula for water quality parameters

WQI_Hg = 99.3746067119634 * (2.71 ^ ((-0.047457892170821) * (Hg)))
WQI_Pb = 70.6272145067615 * (2.71 ^ ((-0.037128202170685) * (Pb)))
WQI_Cd = 101.15367065445641 * (2.71 ^ ((-0.084129301087307) * (Cd)))
WQI_Cr = 96.1893249213183 * (2.71 ^ ((-0.005135975233511) * (Cr)))
WQI_As = 99.578825785791 * (2.71 ^ ((-0.027839376216101) * (As)))
WQI_Fe = 102.286765661746 * (2.71 ^ ((-0.000719831999011) * (Fe)))
WQI_Mn = 77.4274305601084 * (2.71 ^ ((-0.000696380215326) * (Mn)))
WQI_CN = 100.60556215175861 * (2.71 ^ ((-0.004023050773938) * (CN)))
WQI_TPH = 88.8671174682016 * (2.71 ^ ((-0.001328374075797) * (TPH)))
WQI_Phenol = 99.7447746196143 * (2.71 ^ ((-0.000418599642396) * (Phenol)))
WQI_Detergent = 100.8293391052988 * (2.71 ^ ((-0.000980098966693) * (Detergent)))

Rating curves

Cadium Index

Arsenic Index

Mercury Index

Lead Index

Cromium Index

Iron Index

Magnesium Index

Cyanide Index

Total Petrulium Hydrocarbon Index

Detergent Index

Phenol Index

The WOI index can be calculated using the following equation:

$$WQI = [\prod_{i=1}^{n} I_i^{Wi}]^{\frac{1}{\gamma}}$$

$$\gamma = \sum_{i=1}^{n} W_i$$

W_i = the weight of the i-th parameter

n = number of parameters

I_i = the index value for the i-th parameter of the rating curve

The following table is used to determine the descriptive equivalent of the calculated index:

Index description	WQI
Very bad	< 15
Bad	15-29.9
Relatively bad	30-44.9
Medium	45-55
Relatively good	55.1-70
Good	70.1-85
Very good	> 85

Example:

In a groundwater monitoring station, the following parameters have been measured for water quality. Determine the value of the water quality index and its descriptive equivalent.

Hg = 0.5 ppb
As = 2 ppb
Fe = 20 ppb
Pb = 10 ppb
Mn = 200 ppb
CN = 3 ppb
Cd = 0.5 ppb
Cr = 10 ppb

TPH = 40 ppb
Phenol = 2 ppb
Detergent = 1 ppb

Solution:

First, we determine the equivalent index of each parameter using rating curves and the weight of each parameter using Table 3:

Parameter	Weight	Index value
Hg	0.113	97
As	0.128	94
Fe	0.066	100
Pb	0.079	49
Mn	0.054	67
CN	0.072	99
Cd	0.086	97
Cr	0.079	92
TPH	0.097	84
Phenol	0.119	99
Detergent	0.107	100

Total weight of parameters:

$$\gamma = \sum_{i=1}^{n} W_i$$

$\gamma = 0.113 + 0.128 + 0.066 + 0.079 + 0.054 + 0.072 + 0.086 + 0.079 + 0.097 + 0.119 + 0.107 = 1$

Calculation of WQI:

$$WQI = [\prod_{i=1}^{n} I_i^{W_i}]^{\frac{1}{\gamma}}$$

WQI = [(97^0.113) * (94^0.128) * (100^0.066) * (49^0.079) * (67^0.054) *(99^0.072) * (97^0.086) * (92^0.079) * (84^0.097) * (99^0.119) * (100^0.107)] ^ 1/1 = 88.9

The guide table is used to determine the descriptive equivalent of the index. According to the numerical value of the index which is equal to 88.9, the water quality is equivalent to very good with a dark blue color.

Very good	> 85

* Using the application, almost the same result is obtained. Due to the inaccurate visual reading of the equivalent index of each parameter using the rating curves compared to the calculation of the equivalent index through the equation by the application, this insignificant difference is normal.

WQI (Toxic Parameters)   —   □   ✕

Application Information   **Help**

	Surface water	**Groundwater**
Hg (ppb)		0/5
Pb (ppb)		10
Cd (ppb)		0/5
Cr (ppb)		10
As (ppb)		2
Fe (ppb)		20
Mn (ppb)		200
CN (ppb)		3
TPH (ppb)		40
Phenol (ppb)		2
Detergent(ppb)		1

Calculate   *Calculate*

WQI   89/14669166334 17

Status   Very good

Reset