INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
VOLUME-2, ISSUE-4, OCT-DEC-2012 ISSN 2231-4490

Coden : IJPAES www.ijpaes.com

Received: 08th Sept-2012 ***Revised: 12th Sept-2012*** ***Accepted: 15th Sept-2012***

Research article

DETERMINATION OF WATER QUALITY INDEX (WQI) FOR QALYASAN STREAM IN SULAIMANI CITY/ KURDISTAN REGION OF IRAQ

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ABSTRACT: Qalyasan Stream in Sulaimani city is used as a source for irrigation and drinking water, and also as a sink for the untreated urban and industrial domestic's wastewater. Therefore, the good quality of the stream changed from protected to impacted and finally to degraded. Degradation of water quality in the Qalyasan stream increased year after year due to unprecedented increase in population and rapid rate of urbanization in Sulaimani city and consequently effluence of many pollutants into the stream from the sources of domestic, agricultural, and industrial wastes. The present study aimed to calculate water quality index (WQI) by the analysis of thirteen physicochemical parameters on the basis of Weighted Arithmetic Index in order to assess the suitability of water for drinking, irrigation purposes and other human uses. The parameters were measured periodically at 10 sampling sites during June 2007 to January 2008. The results obtained on WQI for the different sampling sites were found to fall under the class from good (50- 100) class at the sample sites of S1, S2, S3 and S4 to unsuitable or unfit (> 300) class at the sample sites of S5, S6, S7, S8, S9 and S10. This indicated heavy pollution at the sites of S5, S6, S7, S8, S9 and S10 which hints at a number of sewage outlets and industries around.
Keywords: Water Quality, Water Quality Index (WQI), Quality rating scale (Qi), Grads of water Quality Index, Weighted Arithmetic Index, Relative (unit) weight (Wi) , Qalyasan Stream.

INTRODUCTION

Water is a dynamic renewable natural resource. Its availability with good quality and adequate quantity is very important for human life and other purposes. In general, the quality of water is equally important as the quantity. Therefore, water quality is considered as an important factor to judge environment changes which are strongly associated with social and economic development [1]. In developing countries about 1.8 million people, mostly children, die every year as a result of water related diseases [2]. Nowadays, surface water quality became a critical issue in many countries; especially due to the concern that freshwater will be a scarce resource in the future, therefore, water quality monitoring program is necessary for the protection of freshwater resources [3]. Water quality is used to describe the condition of the water, including its chemical, physical and biological characteristics, usually with respect to its suitability for a particular purpose (i.e., drinking, swimming or fishing), [4, 5, and 6]. Water quality is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose [7]. It is most frequently used by reference to a set of standards against which compliance can be assessed. Monitoring programs of aquatic systems play a significant role in water quality control since it is necessary to know the contamination degree so as not to fail in the attempt to regulate its impact [8]. However, the quality is difficult to evaluate from a large number of samples, each containing concentrations for many parameters [8]. On the other hand, Water Quality Index (WQI) is a very useful and efficient method for assessing the suitability of water quality. It is also a very useful tool for communicating the information on overall quality of water [9 and 10] to the concerned citizens and policy makers.WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves [11]. Factors to be included in WQI model could vary depending upon the designated water uses and local preferences. Water quality indices (WQIs) have been developed to integrate water quality variables [12, 13, and 14]. A WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to managers and the public in a consistent manner [15].

The researcher [16] proposed the first WQI by weighting some water quality variables. Since then, the formulation and use of indices have been strongly advocated by agencies responsible for water supply and water pollution control. For example, US National Sanitation Foundation's Water Quality Index (NSF-WQI), Canadian Council of Ministers of the Environment's Water Quality Index (CCME-WQI), British Columbia Water Quality Index, Oregon Water Quality Index, and the Florida Stream Water Quality Index have been proposed for water quality assessment [17, 18 and 19]. Therefore, a continuous periodical monitoring of water quality is necessary so that appropriate steps may be taken for water resource management practices. The objectives of the current study were;

1- To examine and evaluate the water quality of Qalyasan Stream based on the Physiochemical characteristics and to identify the most serious pollutant parameters which caused alterations to ascertain the quality of stream water.
2- To identify the point sources of discharged pollutant in to the stream in order to aware and envisage the local authority toward careful management of water resources.
3- Recommendations for future work and provide guidelines for other water sources in the city, such as groundwater.

MATERIAL AND METHODS

Description of the Sample Sites:

Qalyasan Stream is geographically located between latitudes 35° 35□01□ N and 35° 28□ 44□ N and between longitudes 45° 21□ 39□ E and 45° 26□ 17□ E in Sulaimani city/Iraq and elevated 656-787 m above sea level. In order to determine the water quality index, ten sites were chosen for sample collection in the study area along the stretch of the stream (Figure 1). As it is described in Table (1), the samples sites of S1, S2 and S3 were near to the Sarchinar Cement Factory along the stream. The sample site S4 was from the Sarchinar spring which discharges its remainder of water into Qalyasan stream, but sample site S5 was under Qalyasan Bridge directly. While, the sample sites of S6, S7 and S8 were situated near to Kostai-Cham and Awal villages along the stretch of the stream where many point source of domestic (municipal) and industrials (Sulaimani oil refining foundations) wastewater discharged in the stream near Kostai-Cham and Awal villages. The sample site S9 was before the discharge of Kani-Ban upstream into Qalyasan stream (before linking Qalyasan stream with Kani-Ban stream). But the final sample site of number S10 was situated in a location after linking of the two major streams (Qalyasan and Kani-Ban) to form a Tanjero river which represents a small river. The overall distance between the sample sites S1 to sample site S10 was about 10 km and selecting this distance was due to the facts that most of the domestic and other hazardous waste outlets were located there, furthermore, there was an intensive human and agricultural activities within that distance stretch.

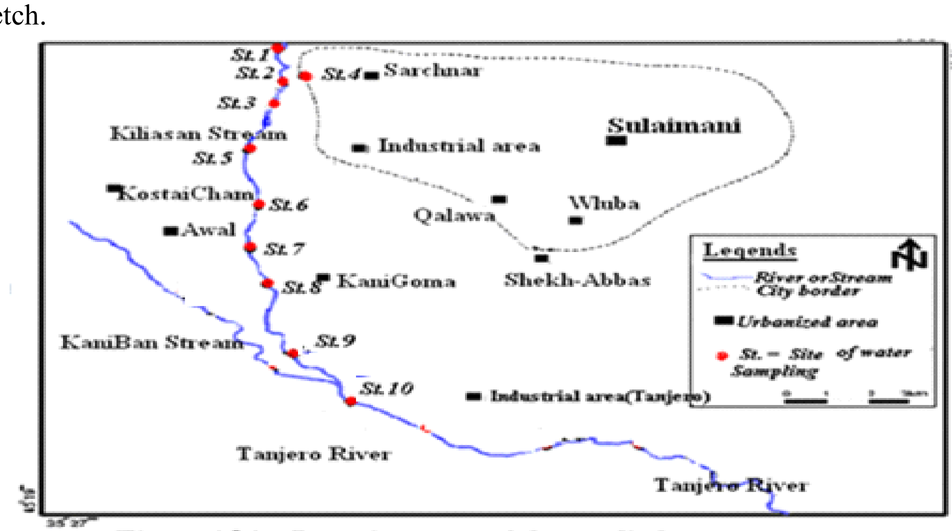

Figure (1): A map of the study area showing the different sampling sites of Qalyasan Stream.

Laboratory Analysis

In order to determine the water quality index, surface water samples were collected along Qalyasan stream from ten sampling sites during June 2007 to January 2008. The Samples were collected in sterilized bottles using the standard procedure for grab (or) catch samples in accordance with standard methods of [20]. The samples were analyzed as per standard methods for thirteen Physico-Chemical parameters namely; pH (Hydrogen ion concentration), EC (Electrical conductivity), (DO) (Dissolved oxygen), turbidity, TH (Total hardness), ions of Ca^{2+} (Calcium), Mg^{2+} (Magnesium), Na^{+} (sodium), K^{+} (potassium), Cl^{-} (chloride), SO_4^{2-} (sulfate), NO_3^{-} (nitrate) and PO_4^{3-} (phosphate). In situ measurement was adopted to determine unstable parameters including; pH, EC and DO by portable meters. The probe of each meter device was placed in the center of the stream in approximately half of its total depth. But the analysis of the parameters total hardness and ions of each calcium, magnesium, chloride, sulfate, and phosphate were carried out by volumetric analysis in accordance with standard methods of [20]. The analysis of sodium and potassium were conducted by flame-photometer as per standard methods given by [20]. While for nitrate ion analysis digital nitrate-meter was used.

Table (1): Description of water quality sampling sites.

Longitude	Latitude	Description	Sites No.
45°22'41.86"E	35°35'34.67" N	Near to the Sarchinar cement Factory	S1
45°22'40.36"E	35°35'29.49" N	Near to the Sarchinar cement Factory	S2
4^{5o}22'39.12"E	35°35'23.18" N	Near to the Sarchinar cement Factory	S3
45°22'34.11"E	35°35'18.31" N	At the Sarchinar spring	S4
45°22'35.01"E	35°34'44.31" N	Under Qalyasan bridge	S5
45°22'26.55"E	35°33'47.78" N	Near to Kostai-Cham and Awal villages	S6
45°22'24.76"E	35°32'57.47" N	Near to Kostai-Cham and Awal villages	S7
45°22'26.75"E	35°32'8.71" N	Near to Kostai-Cham and Awal villages	S8
45°24'45.99"E	35°28'59.12" N	Before linking of Qalyasan stream with Kani-Ban stream	S9
45°24'50.20"E	35°28'52.68" N	After linking of Qalyasan stream with Kani-Ban stream to form Qalyasan river	S10

Calculating of Water Quality Index (WQI)

Calculating of water quality index is to turn complex water quality data into information that is understandable and useable by the public. Therefore, water Quality Index (WQI) is a very useful and efficient method which can provide a simple indicator of water quality and it is based on some very important parameters.

In current study, Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Index method as described by [12]. In this model, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean.

For assessing the quality of water in this study, firstly, the quality rating scale (Qi) for each parameter was calculated by using the following equation;

- Qi = {[(Vactual – Videal) / (Vstandard – Videal)] * 100}

Where,

Qi = Quality rating of ith parameter for a total of n water quality parameters

Vactual = Actual value of the water quality parameter obtained from laboratory analysis

Videal = Ideal value of that water quality parameter can be obtained from the standard Tables.

Videal for pH = 7 and for other parameters it is equaling to zero, but for DO Videal = 14.6 mg/L

Vstandard = Recommended WHO standard of the water quality parameter.

Then, after calculating the quality rating scale (Qi), the Relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression;

- Wi = 1/ Si

Where,
- Wi = Relative (unit) weight for nth parameter
- Si= Standard permissible value for nth parameter
- I = Proportionality constant.

That means, the Relative (unit) weight (WI) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation:
- WQi = ∑QiWi/ ∑ Wi
- Where,
- Qi = Quality rating
- Wi = Relative weight

In general, WQI is defined for a specific and intended use of water. In this study the WQI was considered for human consumption or uses and the maximum permissible WQI for the drinking water was taken as 100 score.

RESULTS AND DISCUSSION

A-Physiochemical parameters

The values of thirteen physicochemical parameters of Qalyasan stream for calculation of Water Quality Index (WQI) and for the months of June, July, August, September, November /2007 and also January/2008 are presented in Tables (2, 3, 4, 5, 6 and 7) respectively. The WQI of the Qalyasan stream is established from important various physicochemical parameters namely; pH (Hydrogen ion concentration), EC (Electrical conductivity), (DO) (Dissolved oxygen), turbidity, TH (Total hardness), ions of Ca^{2+} (Calcium), Mg^{2+} (Magnesium), Na^+ (sodium), K^+ (potassium), Cl^- (chloride), SO_4^{2-} (sulfate), NO_3^- (nitrate) and PO_4^{3-} (phosphate) in different season (summer, autumn and winter). The calculation of WQI was month wise and in ten different sampling sites in order to assess the suitability of Qalyasan water body for different purpose.

In general, the results at sampling sites 5 to 10 indicated that the values of most parameters such as (EC, turbidity, TH, Ca^{2+}, Na^+, K^+, Cl^-, NO_3^- and PO_4^{3-}) were beyond the permissible limits and exceeding the permissible limits as prescribed by World Health Organization (WHO) standards for drinking water [21]. But for the other sampling sites the concentrations were within the desirable limit for drinking purpose except for few ions.

High concentration of some ions like NO_3^- and PO_4^{3-} may cause physiological damage or distress in human bin, for example, water containing more than 45mg/liter has been reported to cause methemoglobemia in infants. The high level of those ions may be attributed to the discharge of wastewater from domestic activities and hazardous waste of industrial and agricultural activities into Qalyasan stream.

Furthermore, the water samples of the site number S5, S6, S7, S8, S9 and S10 were found to be more turbid during the summer months. This can be caused by reducing water body, more waste discharge, more urban domestic activities, algal growth and etc. Hence, there is a continuous need for routine monitoring for the quality of Qalyasan stream water.

Table (2): Physiochemical parameter values for all sampling sites in June/ 2007.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.43	7.3	7.77	7.63	7.66	8.2	8.14	7.99	7.52	7.54
EC μS/cm	488	500	484	653	676	505	502	491	793	836
DO	5.56	5.65	5.38	5.72	3.89	5.75	4.95	4.67	4.62	5.09
Turbidity NTU)	3.94	5.77	7.54	2.15	145	9.57	7.48	21.82	123.6	54.9
TH mg/L	258.6	236.9	236.9	262.1	276.6	254.8	265.8	262.1	326.9	326.7
Ca^{2+} mg/L	79.9	82.8	79.9	87.1	85	92.2	83.5	84.2	98.6	107
Mg^{2+} mg/L	14.5	7.47	9.22	11	15.8	6.15	14.1	12.7	19.8	14.9
Na^{+} mg/L	3.15	2.58	3.45	3.33	35.5	25.2	27.4	36.2	25.7	38.1
K^{+} mg/L	0.55	1.2	1.5	0.25	5.22	3.5	3.7	2.7	8.8	9.3
Cl^{-} mg/L	13.7	9.26	10.22	49.11	41.69	31.8	34.33	36.72	66.87	110.3
SO_4^{2-} mg/L	112.3	89.28	91.21	70.08	129.6	103	122	103	166.1	133.4
NO_3^{-} μ/L	13.2	12.2	13.4	17.3	73	47.3	38.9	56.9	66.9	92.1
PO_4^{3-} mg/L	0.46	0.31	0.43	0.37	3.62	3.53	3.83	4.11	5.1	4.75

Table (3): Physiochemical parameter values for all sampling sites in July/ 2007.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.26	7.72	7.75	7.76	7.53	7.95	8.3	7.46	7.46	7.51
EC μS/cm	378	377	362	369	374	603	629	722	771	974
DO	5.3	5.44	5.73	5.5	4.8	4.52	5.17	4.72	4.64	4.87
Turbidity (NTU)	2.54	3.1	11.5	4.01	39.4	8.13	6.76	19.9	242	31.1
TH mg/L	236.9	244.3	276.7	262.4	312.4	330.5	319.6	323	341.4	326.6
Ca^{2+} mg/L	80.6	72	76.3	70.6	99.4	101	104	112	96.5	117
Mg^{2+} mg/L	8.78	15.8	21.1	21.1	15.8	19.3	14.9	10.5	24.6	8.78
Na^{+} mg/L	3.28	3.06	3.61	3.06	30.6	22.8	23.9	25	29.5	45
K^{+} mg/L	0.38	0.38	0.3	0.21	3.62	2.6	2.43	3.71	12.34	4.67
Cl^{-} mg/L	51.12	28.76	22.37	12.78	44.73	35.15	54.32	57.51	57.51	105.4
SO_4^{2-} mg/L	121.9	112.3	118.1	127.7	189	139	164	139	127.7	156.5
NO_3^{-} μ/L	15.7	13.9	12.5	15.5	68.3	60.2	55.1	65.4	78.6	85.2
PO_4^{3-} mg/L	0.34	0.4	0.58	0.4	3.31	3.28	3.25	3.96	2.97	3.07

Table (4): Physiochemical parameter values for all sampling sites in June/ 2007

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.46	7.77	7.64	7.76	7.38	7.84	8.19	7.6	7.77	7.65
EC μS/cm	511	431.1	503.2	487.1	936.2	946.2	944.9	957.3	1029	1012
DO	5.87	6.6	5.74	5.58	4.93	5.32	4.88	4.79	4.23	4.08
Turbidity (NTU)	8.6	20.4	6.41	3.36	129	10.4	8.28	34.7	71.4	131
TH mg/L	287.4	255	276.6	272.9	377	388.06	355.5	362.9	341.6	334.3
Ca^{2+} mg/L	86.4	77.8	85	86.4	120.96	111	112	102	86.4	86.4
Mg^{2+} mg/L	17.6	14.9	15.8	14.1	18.5	27.2	18.5	26.4	30.7	29
Na^{+} mg/L	1.76	1.25	0.73	0.48	26	26.5	28.6	31.2	39.9	37.9
K^{+} mg/L	0.26	0.16	0.26	0.28	1.77	2.8	1.25	3.32	7.96	7.45
Cl^{-} mg/L	15.98	19.17	12.78	31.95	57.51	51.12	63.9	76.68	76.68	86.97
SO_4^{2-} mg/L	174.3	130.1	150.7	164.8	206	221	192	215	202.7	109.6
NO_3^{-} μ/L	16.1	15.3	14.2	16.7	85	55	45.3	76.7	88.1	95.2
PO_4^{3-} mg/L	0.77	0.18	0.4	0.28	3.89	3.34	4.17	3.04	5.7	6.41

Table (5): Physiochemical parameter values for all sampling sites in September/ 2007.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.35	7.53	7.59	7.89	7.56	7.79	7.75	7.55	8.14	7.91
EC μS/cm	493	518	595	531	930	1116	1118	991	982	1000
DO	4.52	5.3	4.36	6.64	0.68	1.01	1.32	0.8	3.75	3.28
Turbidity (NTU)	1.15	2.33	1.15	1.59	21.1	6.43	6.98	22.9	167	95.3
TH mg/L	262.1	244.1	280.2	251.4	366.9	362.9	323.3	355.5	359	341.1
Ca^{2+} mg/L	86.4	80.6	86.4	77.8	82.1	102	99.4	112	120	109
Mg^{2+} mg/L	11.4	10.5	15.8	14.1	39.53	26.4	18.5	18.5	14.9	16.7
Na^{+} mg/L	3.27	3.38	3.95	4.52	41.8	53.2	52.1	51	61.2	61.2
K^{+} mg/L	0.06	0.12	0.18	0.23	2.43	3.22	3.67	3.55	6.7	5.35
Cl^{-} mg/L	9.59	19.17	15.98	9.59	41.54	63.9	60.71	57.51	79.88	73.49
SO_4^{2-} mg/L	145	131.5	171.8	165.3	201	227.52	183	210	206.4	193
NO_3^{-} μ/L	11.6	14.8	15.1	18.3	67.8	48.1	35.9	70.2	73.7	83.9
PO_4^{3-} mg/L	0.06	0.09	0.12	0.05	1.35	3.59	7.17	5.33	7.6	5.46

Table (6): Physiochemical parameter values for all sampling sites in November/ 2007.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.86	8.27	7.93	8.12	7.86	7.84	8.21	7.94	8.11	8.09
EC μS/cm	577	582	623	595	879	989	1102	1219	1715	1645
DO	4.39	5.68	4.38	5.45	3.1	0.64	4	2.62	1.92	2.35
Turbidity (NTU)	5.95	29.8	8.91	1.08	496	165	40.9	46.2	131	149
TH mg/L	272.8	262.2	276.4	265.6	283.8	280.2	312.6	323.4	312.6	298.2
Ca^{2+} mg/L	93.6	82.1	92.2	90.7	86.4	83.5	87.8	90.7	89.3	86.4
Mg^{2+} mg/L	9.66	14.1	11.4	9.66	16.7	17.6	22.8	23.7	22	20.2
Na^{+} mg/L	3.41	2.85	3.97	3.08	53.2	40.9	37.5	44.2	70.22	66.6
K^{+} mg/L	1.87	2.32	1.52	1.29	4.4	4.98	4.87	4.98	9.59	8.6
Cl^{-} mg/L	11.5	9.59	7.75	7.67	34.51	47.93	46.01	63.26	101.6	97.77
SO_4^{2-} mg/L	155.2	124.7	165.2	153.3	201	221	176	210	177.2	157
NO_3^{-} μ/L	17.1	16.4	14.3	17	71.2	44.1	43.7	82	99.2	100
PO_4^{3-} mg/L	0.18	0.18	0.15	0.09	2.36	4.63	6.41	7.02	10.18	10.21

Calculation of Water Quality Index (WQI Development)

Table (8) presents the result of WQI of the sample site S2 for June/ 2007 and it was 76.6. This result of 76.6 has been calculated as an example for the method of calculating WQI by applying the values of the basic elements of; actual measured values, Water quality standard values (Si), Relative (unit) weight (Wi), Quality rating (Qi) and the weighted values in the corresponded equations.

Table (7): Physiochemical parameter values for all sampling sites in January/ 2008.

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.38	7.75	7.66	8.03	8	7.93	8.06	8.13	7.94	7.8
EC μS/cm	422	427	537	374	1154	1164	1189	1472	1033	1179
DO	7.98	7.25	9.19	8.82	3.82	4.87	3.91	2.95	4.78	4.52
Turbidity (NTU)	7.72	6.55	36.7	1.2	139	141	180	142	97.1	92.6
TH mg/L	219.4	226.7	233.4	237	248	287.5	276.7	233.5	204.9	251.7
Ca^{2+} mg/L	50.4	48.96	73.4	74.9	67.7	80.6	80.6	72	50.4	64.8
Mg^{2+} mg/L	22.8	25.5	12.3	12.3	19.3	21.1	18.5	13.2	19.3	22
Na^{+} mg/L	3.71	3.25	4.59	3.48	29.5	32.1	35.6	37.6	34.5	38.1
K^{+} mg/L	0.65	1.25	1.26	0.24	4.32	3.95	4.44	4.56	8.67	8.78
Cl^{-} mg/L	11.5	17.25	32.59	11.5	40.26	44.09	42.17	67.09	53.68	63.26
SO_4^{2-} mg/L	122.4	130.1	144.9	133.4	187	212	186	212	156.8	187.1
NO_3^{-} μ/L	10.2	11.5	13.3	10.1	58.4	33.4	21.2	44.6	61.5	71.1
PO_4^{3-} mg/L	0.37	0.15	0.28	0.04	1.99	3.62	6.29	5.67	7.48	7.14

Table (8): An example calculation of WQI for the sample site 2 (S2) in June/ 2007.

Parameters	Actual measured values	WQ standard Value (Si)	Relative Weight (Wi)	Quality Rating (Qi)	Weighted values
pH	7.3	8.5	0.117647059	20	2.352941
EC μS/cm	500	250	0.004	200	0.8
DO	5.65	6	0.166666667	104.0698	17.34496
Turbidity (NTU)	5.77	5	0.2	115.4	23.08
TH mg/L	236.9	100	0.01	236.9	2.369
Ca^{2+} mg/L	82.8	100	0.01	82.8	0.828
Mg^{2+} mg/L	7.47	30	0.033333333	24.9	0.83
Na^{+} mg/L	2.58	200	0.005	1.29	0.00645
K^{+} mg/L	1.2	10	0.1	12	1.2
Cl^{-} mg/L	9.26	250	0.004	3.704	0.014816
SO_4^{2-} mg/L	89.28	250	0.004	35.712	0.142848
NO_3^{-} μ/L	12.2	50	0.02	24.4	0.488
PO_4^{3-} mg/L	0.31	0.4	2.5	77.5	193.75
			$\sum$Wi 3.174647059		$\sum$Wi.Qi 243.207

In this study, the computed grads of WQI values were categorized into five types for human consumption according to [22], as they were revealed in (Table 9).

WQI indicates the quality of water in terms of index number which represents overall quality of water for any intended use.The mean values of six months for the calculated water quality index were 86.7, 66.6, 89.0 and 52.6 for the sampling sites S1, S2, S3 and S4 respectively (Table 10).

Table 9: Grads Water Quality Index (WQI) and status of water quality [22].

Water Quality Index levels	Description
<50	Excellent
50-100	Good water
100-200	Poor water
200-300	Very poor (bad) water
>300	Unsuitable (unfit) for drinking

Those index values revealed that the status of the Qalyasan stream was suitable for human uses in sampling sites S1, S2, S3 and S4 according to WHO guideline standards[22], since they were all in the range good class (50-100) over all the six months of the study (Table 10 and Figure 2).

On the contrary, there was almost general progressive increase in WQI means values for the sampling sites S5, S6, S7, S8, S9 and S10 and the mean values were 758.6, 806.3, 1087.0, 1029.5, 1470.5 and 1346.1 respectively. Thus, a general progressive increase in WQI values along the Qalyasan downstream indicated as increase in pollution due to the discharge of various domestic and industries wastewater and also other anthropogenic hazardous waste along the stretch. Therefore, the quality of water at the sampling sites S5, S6, S7, S8, S9 and S10 was unsuitable or unfit (> 300) for the human uses during the six months of the study (Figure 2).

Table (10): WQI values and mean values for all sampling sites during the six months.

Months	WQI Values									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
June	104.3	76.61	103.95	84.702	908.25	718.73	775.76	848.59	1173.3	1018
July	78.36	92.13	138.3	93.542	712.76	668.51	661.08	816.07	904.47	655.69
August	171.3	70.03	96.105	69.011	939.68	683.13	843.98	654.74	1227.1	1441.6
September	22.27	29.6	35.135	21.098	307.29	729.88	1434.6	1092.8	1721.8	1209.6
November	53.97	84.45	51.917	29.896	1103.4	1134.6	1327.8	1455.4	2187.1	2214.9
January	89.81	46.71	108.62	17.34	580.45	902.88	1478.4	1309.4	1608.9	1536.7
Mean Values	86.67	66.59	89.01	52.59	758.63	806.28	1086.95	1029.49	1470.45	1346.06

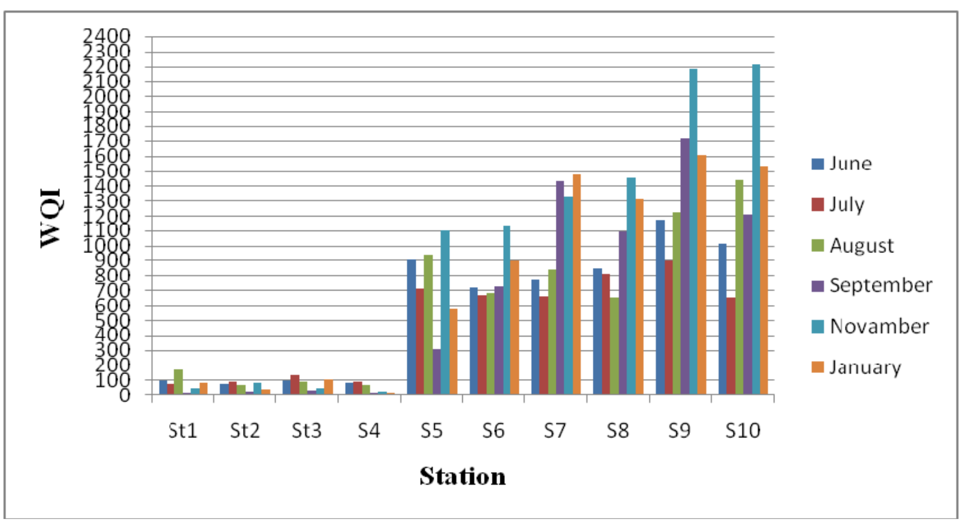

Figure (2): Water Quality Index (WQI) at the studied sampling sites of Qalyasan stream.

As indicated from the results of the present study, Qalyasan stream is seriously contaminated at the sampling site from S5 and till to S10 along the Qalyasan downstream, But still this stream is used as an important source for many purposes demand. Therefore, one of the important recommendation outputs of the present study is that the local authority in Sulaimani city should take this serious issue of water quality degradation in Qalyasan stream into account by reducing the effluence sources of the pollutant into the stream. Moreover, there should be a regular or constantly monitoring for the quality of the stream, because this could increase the risk of direct threats to human health and environment, because more pollution could increase the concentrations of unhealthy water pollutants for all organisms.

CONCLUSION

Water Quality index (WQI) of the present study for Qalyasan stream was calculated from important various physiochemical parameters in order to evaluate the suitability of water for various purposes. The calculated WQI provides an easy way of understanding the overall water quality and water management.

The water quality rating at more of the sampling sites clearly showed that the status of the water body in Qalyasan stream was degraded and unsuitable for the human uses during the period of study because it was not within the WHO standards and guidelines for drinking. It was also observed that the pollution load was relatively high during summer season when compared to the winter and rainy seasons. It has been concluded that discharging of domestic and industrial wastewater and also other anthropogenic activities were the main factors for contaminating Qalyasan stream. However, there is need for regular monitoring of water quality in order to detect changes in physiochemical parameters concentration and convey it to the public through WQI.

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