INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-5, Issue-1, Jan-Mar-2015 Coden: IJPAJX-USA, Copyrights@2015 ISSN-2231-4490

Received: 16th Oct-2014 *Revised: 17th Nov-2014* *Accepted: 18th Nov-2014*

Research article

APPLICATION OF WATER QUALITY INDEX (WQI) AS A POSSIBLE INDICATOR FOR AGRICULTURE PURPOSE AND ASSESSING THE ABILITY OF SELF PURIFICATION PROCESS BY QALYASAN STREAM IN SULAIMANI CITY/IRAQI KURDISTAN REGION (IKR)

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ABSTRACT: An attempt has been made to use the calculated Water Quality Index (WQI) values for irrigation suitability and livestock drinking purposes (water quality for agriculture) and also to use it as a possible indicator for assessing the self-purification process with distances downstream in the dry season period for the water body of Qalyasan stream in Sulaimani city. Since, pollution load in Qalyasan stream increases continuously due to effluent discharge by means of many small and large scale industries, agricultural, domestic waste etc. WQI was calculated on the basis of Weighted Arithmetic Index by analyzing 8 to 9 physico-chemical parameters; the calculation of WQI was conducted twice, with and without the input of dissolved oxygen parameter, in case of including DO input, 2 mg L^{-1} DO was assigned as a standard limit. To determine WQI degree for agriculture and the self-purification capacity of the stream, water samples were collected four times from 1st July to 18th August, 2013 at 3 different sites of 6 km stretch. The results showed that the values of the investigated physico-chemical properties at these sites were mostly in permissible limits of WHO and FAO guidelines. Furthermore, the mean values of WQI were in a decreasing trend from S1 to S2 and then from S2 to S3 (S1> S2> S3). This condition proofed that Qalyasan stream had the potential capacity or ability for natural self purification and clean up the water pollutant through the natural process and also indicated that the water quality of Qalyasan stream was still suitable for irrigation and livestock drinking with regarding the investigated physico-chemical parameters and along the investigated stretch. Although no remarkable differences were noted between WQI values for the case of included and non-included DO input parameter, the multiple comparisons tests by standard deviation (SD) revealed that DO is an important input parameter for calculating WQI.

Keywords: Water Quality, Water Quality Index (WQI), Weighted Arithmetic Index, Relative (unit) Weight (Wi), Dissolved oxygen, Qalyasan Stream, Self-Purification, standard limits.

INTRODUCTION

Water quality is the condition of the water body or water resource in relation to its designated uses [1]. Water quality is of influential and significant importance because of its role to human health, aquatic life, ecological integrity and sustainable economic growth. Indeed, without good quality, water sustainable development and environmentally sound management of water resources will be meaningless [2]. As an example, on a global scale, water borne disease is estimated to be responsible for about 3 million deaths and also to cause sick a billion people [3]. Rapid population growths, land development along river basin, urbanization and industrialization have subjected rivers and streams to increase stress, giving rise to water pollution and environmental deterioration [4]. 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 [5]. In developing countries the surface water pollution issue has been enlisted as one of the most serious problems. Most of the rivers in the urban areas of the developing world are the end point of effluents discharged from the industries [6], our region IKR or Iraq as whole is an example of the developing countries which suffers from the case.

Freshwater ecosystems constitute one of the most important resources for human civilization. Thereby, self-purification capacity constitutes one of the key ecosystem services provided by those systems which is particularly relevant in polluted water bodies serving multiple societal uses [7].
Currently, multiple stressors acting on freshwater ecosystems, therefore, freshwater ecosystems are stated to be in 'worse condition than those of forests, grasslands or coastal systems [8]. Also, the Global Biodiversity Outlook 3 concluded that 'rivers and their floodplains, lakes and wetlands have undergone more dramatic changes than any other type of ecosystem' [9]. In general, five major threats which impacting freshwater ecosystems have been identified [10]. These comprise 'overexploitation', 'water pollution', 'flow modification', 'habitat degradation' and 'species invasion' that not only affect ecosystem integrity but also interact with each other. Thus, water management will continue to rely on the self-purification capacity in order to enable multiple uses of surface water bodies [11]. Within the self-purification process, chemical and biological processes play important roles in maintaining and improving water quality by removing organic matter [12]. Hence, [13] described self-purification as the sum of all physical, chemical, and biological processes by which the quantity of pollution in a stream is decreased. [14] have indicated that self purification potential and water quality changes in rivers are due to physical transport processes and biological, chemical, biochemical and physical conversion processes. These processes are linked to nearly all criteria of water quality such as dissolved oxygen, nitrate, ammonium and organic load. Therefore, knowledge about the self-purification capacity of streams and rivers is necessary to assess ecosystem integrity and health. Under these conditions, self-purification is a process for the preservation of the ecological balance.
In this study, the water quality index (WQI) was applied to show the impact of wastewater discharge or domestic sewage input on overall water quality deteriorations and also to achieve the pre-planned goals of this study. Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. However, WQI depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision makers [15]. As reported also by [16], water quality index is one of the most effective tools to monitor the surface as well as ground water pollution and can be used efficiently in the implementation of water quality upgrading programs. WQI provides the single number that expresses overall quality based on the different parameters. WQI summarizes large amount of water quality data into simple terms i.e. excellent, good, bad etc. that is easily understandable and usable by public [17]. A water quality index basically consists of a simpler expression of more or less complex parameters, which serve as water quality measurements. A number, a range, a verbal description, a symbol or a color could be used to represent the index [18]. WQI is a dimensionless number and is widely used by many scientists around the world. It has been mentioned that WQI formula has been modified over 55 difference type of use [19]. The use of WQI could be of particular interest for developing countries, because they provide cost-effective water quality assessment as well as the possibility of evaluating trends [5].
WQI indices has been applied for predicating ground and surface water condition and quality for different purpose in many cities of Iraq, including Sulaimani city, [20] and [21]; Erbil city, [22] and [23]; Tikkrit and Samarra cites, [24] and Basrah city, [25].
In view of the above, the purposes of this study were to: 1) Evaluate the suitability of Qalyasan's water body for irrigation and for livestock drinking purposes (water quality for agriculture) through calculating WQI, since the majority of the polluted water in this stream is used directly for agricultural activities and livestock purpose without any pretreatment. 2) Use the scores of WQI indices as indicator for assessing self purification process in Qalyasan stream. 3) Determine the effect of included and non-included dissolved oxygen parameter input on the results of the calculated WQI. For the case of included, 2 mg L^{-1} DO was assigned as a standard limit.

MATERIAL AND METHODS

1-Description of the Sample Sites

Qalyasan Stream lies in the southwest to south of Sulaimani city. Geographically, it is positioned between latitudes (35° 35' 01" to 35° 28' 44" N), and between longitudes (45° 21' 39" - 45° 26' 17" E) in Sulaimani city/Iraq, and elevated 656-787 m above sea level. The length of the stream is about 10 km till to the downstream point of the stream with Tanjaro river connection and flows southward through many agricultural fields and used as a source for irrigation and livestock drinking purposes (for agriculture purpose), it is also used 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 Qalyasan stream increased year after year because of discharging many pollutants directly into the stream from the expanding human habitats (domestic) and vibrant industrial, institutional, and socio-economic activities sources.

In order to carry out the proposed objectives of this study, three sites were chosen for sample collection along the stretch of the stream at the study area (Figure 1). Site one (S1) was selected after 50 meters from the first main outlet or effluent discharge into Qalyasan stream (Sarchinar outlet) with a GPS coordinates and elevation of (35° 35' 05" N and - 45° 22' 37" E -751m). Site three (S3) was selected before the next effluent or outlet of Kawstaha-Jahm and Awal villages by about 50m with GPS coordinates and elevation of (35° 31' 04" N and - 45° 22' 19" E – 711m). But site two (S2) was located in between site 1 and site 2 and under the Qalyasan Bridge directly, which has the GPS coordinates and elevation of (35° 33' 57" N and - 45° 22' 29" E - 730m). The overall distance between the sample site S1 to sample site S3 was about (6) km.

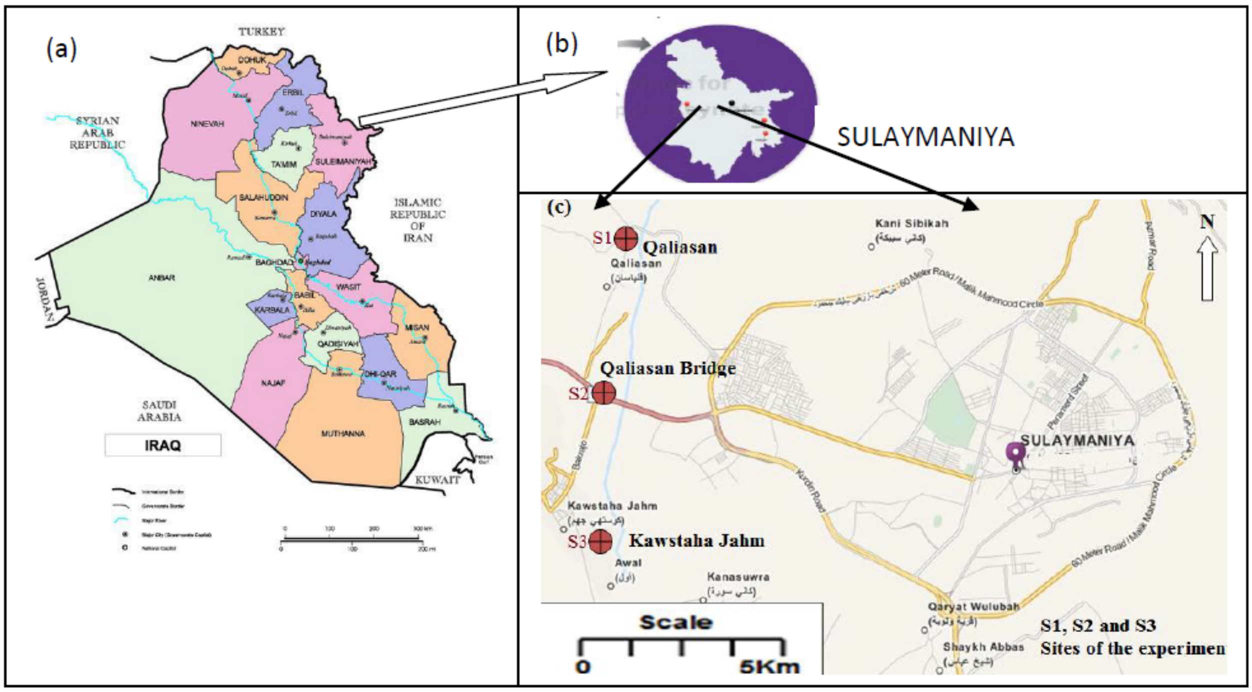

Figure (1): A map of the study area showing Iraq, Sulaimani city and also the different sampling sites along Qalyasan Stream.

2- Sampling and Analytical methods.

Water samples from the selected sites of Qalyasan stream in the downstream direction were taken during the dry season four times, namely (1^{st} July, 15^{th} July, 30^{th} and 16^{th} August, 2013).

The Samples were collected in sterilized bottles using the standard procedure for grab (or) catch samples in accordance with standard methods of [26]. The samples were analyzed as per standard methods for the Physico-chemical parameters namely; pH (Hydrogen ion concentration), EC (Electrical conductivity), (DO) (Dissolved oxygen), turbidity, TDS (Total dissolved solids). The samples were further analyzed for the heavy metals of Cr (chromium), Ni (nickel), Cu (copper) and Mn (manganese). The overall water samples were analyzed in duplicate for each parameters and the mean values have been recorded. 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. Then the samples were preserved till the other two parameters and heavy metals analyzed in laboratory.

Regarding determination of the investigated heavy metals in the representative water samples of Qalyasan stream, samples were collected at the designated sites by lowering precleaned 500 ml plastic bottles into the bottom of the water body, 30cm deep, and allowed to over flow before withdrawing. Then a 100 ml of the sampled water was evaporated and digested as described by [26]. Once the digest became clear, was diluted with deionized water, filtered through an ashless Whatman 41 filter and diluted to 100 ml with excess deionized water, then stored in polyethylene bottles at 4 ^{o}C for the heavy metals analysis of; Cr, Ni, Cu, and Mn by inductively coupled plasma-optical emission spectroscopy ICP-OES instrument (model PerkinElmer, precisely Optima 2100/USA).

3- Calculating of Water Quality Index (WQI)

In current study, calculation of water quality index was based on 8 to 9 important physico-chemical parameters. WQI was calculated by using the recommended standards of irrigation or agriculture water quality by [27] and Canadian Water Quality Guidelines, [28]. To determine the WQI, the Weighted Arithmetic Index method or model was used [29]. In this model, different water quality components were multiplied by a weighting factor and are then aggregated using simple arithmetic mean. For carrying out the calculation of WQI in this study, first, the quality rating scale (Qi) for each parameter was calculated by using the following equation:

$$Qi = [Ci / Si] \times 100$$

But, the quality rating (Qi) for pH or DO was calculated on the basis of the following equation:

$$Qi = [Ci - Vi / Si - Vi] \times 100$$

Where,

Qi =Quality rating of (i)th parameter for a total of (n) water quality parameters.

Ci = Represent values of the water quality parameter obtained from the laboratory analysis.

Si = Represents values of the water quality parameter obtained from recommended. standard of WHO or CCME or proposed by us for DO parameter.

Vi = the ideal values, which is for example considered as 7 for pH.

Then second, the Relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following relation;

$$Wi = 1/ Si$$

Where,

Wi = Relative (unit) weight for nth parameter.

Si = Recommended standard values for nth parameter (as described in Quality rating calculation equation).

I = Proportionality constant.

Thus, 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:

$$WQI = \sum QiWi / \sum Wi$$

Where,

Qi = Quality rating

Wi = Relative weight

The calculated values of WQI in this study were compared with the prescribed standards by [30] to show the water quality condition for agriculture purpose.

Because no standard level for DO in calculation of WQI for irrigation or livestock drinking purpose has been established or found in past WQI reviews. Therefore, in this study the calculation of WQI was carried out twice for each sampling sites and also for each schedule time of sample collection, firstly, without including dissolved oxygen DO parameter input in the calculated structure. Secondly, dissolved oxygen parameter was included in the calculation and 2 mg L^{-1} was assigned as standard limit for DO according to [31], who reported that a minimum of about 2.0 mg L^{-1} dissolved oxygen is required to maintain higher life forms.

[32] reported that adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg L^{-1}, many forms of aquatic life are put under stress. The lower the concentration is, the greater the stress. Oxygen levels that remain below 1mg L^{-1} for several hours can result in large fish kills.

On the other hand, [33] have reported that the present dissolved oxygen (DO) concentration in water reflects atmospheric dissolution, as well as autotrophic and heterotrophic processes that respectively, produce and consume oxygen. DO is the factor that determines whether biological changes are brought by aerobic or anaerobic organisms. Thus, dissolved oxygen measurement is vital for maintaining aerobic treatment processes intended to purify domestic and industrial wastewaters.
Finally, multiple comparisons tests by standard deviation (SD) analysis was carried out in this study to show the significant of DO parameter input in WQI calculations.

RESULTS AND DISCUSSION

As it can be seen in Table (1), pH values (7.29 to 8.06) of the entire sites and time sampling schedule were in the range of highest desirable limit (7.06 -8.5) of WHO for drinking water (Gupta, 2004) [34], the values showed no definite trend among the sites and sampling schedules time. In general, the pH values were slightly alkaline and that is due to the presence of bicarbonates (HCO_3). The variation in pH values of the stream can be due to the exposure of the stream water to atmosphere, biological activities and temperature changes [35] and [36]. It was observed that the pollutant water directly influenced the pH of surface water [37].
For electrical conductivity the results varied between 666 to 1208 µS cm^{-1}, both of the lowest and the highest values were found at S3, the highest limit was in the peak of the dry season (18th August) when the stream's discharge is at its lowest level or volume. August and September are usually the months of lowest flow for most streams and rivers in IKR. The lowest limit was recorded in 1st July, and that was due to self purification process by dilution, because at that time still the stream flow or discharge was high. However, site 2 had the lower conductivity as compared to S1 and S3 within the entire four time schedule of taking samples and that was due the ability of the stream for natural purification. Regarding the suitability of the Qalyasan stream's water quality for irrigation purpose, [34], reported that for conductivities up to 700 µS cm^{-1}, the water is considered as class I (excellent to good). But, if the conductivities fall between 700 to 2000 µS cm^{-1}, then the quality will take class II (good to injuries). Therefore, all the measured values except that for S3 in 1st July fall in class II rating. On the other hand, according to the water quality guide for livestock and poultry uses by FAO, the stream's water quality has excellent rating, since the determined conductivities were less than 1500 µS cm^{-1} [38].

Table 1: Physico-chemical parameter values for all sampling sites during 1st July 2013 to18th August 2013.

Parameter	1st July			15th July			30th July			18th August		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
pH	7.58	7.72	8.06	7.55	7.59	7.77	7.34	7.29	7.37	7.82	7.79	7.91
EC (µS/cm)	1004	784	666	793	770	1017	826	748	1046	1007	756	1208
Turbidity (NTU)	256.0	55.3	74.0	201.0	59.9	69.1	129.0	153.0	177.0	419.0	46.6	102.0
DO (mg/L)	0.21	0.43	0.45	0.21	0.14	0.15	0.12	0.59	0.18	0.09	0.15	0.10
TDS (mg/L)	921	741	636	720	707	930	750	659	915	881	647	1048
Cr (mg/L)	0.038	0.050	0.053	0.016	0.041	0.014	0.008	0.012	0.068	0.042	0.026	0.020
Ni (mg/L)	0.026	0.023	0.020	0.005	0.014	0.001	0.030	0.030	0.030	0.134	0.084	0.057
Cu (mg/L)	0.009	0.009	0.001	0.004	0.001	0.001	0.005	0.005	0.005	0.013	0.009	0.004
Mn (mg/L)	0.090	0.070	0.060	0.068	0.083	0.104	0.122	0.076	0.052	0.150	0.129	0.073

Turbidity is a measure of cloudiness in water. The higher the turbidity, the cloudier the water appears. In current study, the turbidity values had a wide range and fluctuated between 55.3 to 419.0 NTU, the water was found to be more turbid at site 1 and at all times of sample collection due to the approach of the site from the main outlet of Sarchinar waste discharge into Qalyasan stream, while the minimum values were recorded at site 2 at all times for sampling because of the ongoing self purification process. However at site 3 the turbidity once more has increased and that might be due to the algal growth and phytoplankton's organic matter, because the bottom of the Qalyasan stream is composed meanly of stones, rock, and gravel which increase opportunity of more settlement area in the stream and consequently this bottom substrate is densely populated with a thick biofilm of bacteria and algae [13]. This result was consistent with the findings of [13] at the Olbe in the “Magdeburger Börde” region of Germany. Other reason for being S3 much cloudier may be due to closing the site from the next outlet of Kawstaha-Jahm and Awal villages.

Dissolved oxygen (DO) is essential to all forms of aquatic life including the organisms that break down man-made pollutants. The amount of dissolved Oxygen (DO) in water is one of the most commonly used indicators of a river health. DO concentrations are influenced by many factors including water temperature, the rate of photosynthesis, the degree of light penetration (turbidity and water depth), the degree of water turbulence or wave action, and the amount of oxygen used by respiration and decay of organic matter (Water Action Volunteers,2006) [39]. In the present investigation DO levels was very low and ranged from 0.09 to - 0.59 mg L^{-1}, all the values were lower than 4 mg L^{-1} which is not suitable for aquatic life [40] , and this may be due to the microbial decomposition of organic component of domestic sewage and industrial water in the stream water. As reported by [41], dissolved oxygen is generally reduced in the water due to respiration of biota, decomposition of organic matter, rise in temperature, oxygen demanding wastes and inorganic reductant such as hydrogen sulphide, ammonia, nitrites, ferrous iron, etc. There is no doubt that only water bodies with sufficient dissolved oxygen can fulfill their ecological functions properly. Generally, all the lower limits of DO among the four sampling schedule times were found at S1 and that was due to closing the site from Sarchinar effluent discharge into the stream. The observed results of DO were much lower as compared with those found by [42] ,[43]; [17] and Sharma et al., 2013[40]) for a polluted streams or river in other countries.

Total Dissolved Solids (TDS) is a measure of solid substances dissolved in water. TDS includes salts, some organic materials, and a wide range of other things from nutrients to toxic materials [33]. For the study period, the TDS values of current study ranged from 636 to 1048 mg L^{-1}. Likewise of EC parameter and for the same mentioned reasons, the maximum value of TDS was also found at S3 on 18^{th} .In this respect and according to Gupta (2004) [34], the suitability of all the examined water except that of S2 on 1^{st} July and 30^{th} July were good to injurious for irrigation purposes (fall in class II which has the range of 700 to 2000 mg L^{-1}), while for S2 and for the mentioned times was excellent to good (fall in class I which has a TDS up to 700 mg L^{-1}). The observed results for pH, EC, Turbidity, DO and TDS were in close arrangement with the studies of [44] and [21] for the same stream.

Toxic levels of **heavy metals** in the environment have been reported worldwide over the last few decades, and their increasing concentrations are of the utmost concern because of the adverse effects on human life and ecosystems [45]. [46] has also reported that heavy metals are of great concern primarily due to their known toxicity to aquatic life and human health at trace levels.

The concentration of the heavy metals Cr, Ni, Cu, and Mn in the examined water samples of this study were presented in (Table 1), and ranged between 0.008 to 0.068 for Cr, 0.005 to 0.134 for Ni, 0.001 to 0.013 for Cu and 0.06 to 0.150 mg L^{-1} for Mn. The ranges were relatively wide for concentrations of all the investigated heavy metals, the maximum levels were lower than those suggested by [34] as compared to the standard limits for irrigation purpose (the suggested limits are; 5.0, 0.5, 0.2 and 2.0 mg L^{-1} for the metals Cr, Ni, Cu, and Mn respectively. Moreover, the maximum levels were lower for Cr and Cu as compared to those recommended by FAO standard for livestock drinking purpose, while for Mn was exceeded the recommended limit (recommended limits by FAO are; 1.0, 0.5 and 0.05 mg L^{-1} for the metals Cr, Cu, and Mn respectively [38]. Furthermore, the maximum limits of Ni, Cu and Mn were recorded at S3 on18^{th} August and that might be due to reduce of discharge volume for the stream; consequently, this resulted in an increase for the concentration of the metals at that time.

Finally, it was obvious that the results of the examined physico-chemical parameters showed a distinct variation either within the sites along the stream or among date and time of sample collection, these variations can be attributed mainly to the natural self purification of the streams. Factors such as nature and volume of the pollutants, the weather and the general characteristics of the surroundings are influencing the environmental of self purification processes. Nowadays, enhancing the self-purification of streams has become an important task of wastewater management.

Regarding WQI, Table (2, 3 and 4) presented an example calculation of WQI for the sample site 2 (S2) in June/ 2013.The calculation has been conducted twice, one without DO input parameter and the other with it. In case of including DO, 2 mg L^{-1} was proposed from us as standard value for DO. Likewise, the calculations were carried out for the other sites and also for the entire date and time of sample collection.

Based on the strength of pollution in Qalyasan stream, the score of WQI were rated as it is presented in Table 5 for irrigation and livestock drinking purpose, and 300 score was taken as a maximum permissible limit [30].

WQI values of the present study from different sampling sites, different sample collection times and for the included and non included DO parameter are depicted in (Table 6, Figure 2 and Figure 3). The overall computed average values of WQI ranged from 18.4 to 30.1, in accordance with these values of WQI output, the water quality of Qalyasan stream categorized as having excellent grade for irrigation and the water was also safe for livestock drinking. This consideration of rating was valid only with regards of the investigated water quality parameters and for the studied stretch of 6 km of the stream.

According to the recorded values of WQI at the studied sampling sites, there was a decreasing trend in WQI values with distance downstream; this indicated that a decrease in pollution load in the stream along the designated stretch was occurred by the natural self purification. This result was in correspondence with [2], who reported that running water is capable of purifying itself with distances through a process known as self purification. This process is the ability of rivers or streams to purify itself of sewage or other wastes naturally. It is well known that the purifying action of river-water polluted with sewage is very considerable, as a few miles below the outfall or point of pollution a river may show little or no sign of pollution at all [47]. According to [48], self-purification is a process which may allow the preservation of the ecological balance in a stream despite the presence of municipal sewage discharges upstream. This self purification results from mineralization of organic substances, nitrification-denitrification, sedimentation, and assimilation, as well as from dilution and mixing processes. Also, the process and rate of self purification are influenced by temperature, nature of organic pollutants, size and the hydraulic characteristics including algal content of the receiving stream [49].

Although all the calculated values of WQI for the studied parameters in this investigation were less than 65, which represent the first credit rating scales and has excellent quality, but all the highest values of WQI during the length of our designated study times were recorded at S1.This findings of maximum values at S1 was due to its approach from the direct effluent discharges of the main Sarchinar outlet in the stream and sill there was insufficient time, distance and the required conditions for occurring the natural self purification processes.

Table 2: An example calculation of WQI for the sample site (S1) on 1st June/ 2013 without Including (no input) of DO parameter.

Parameters	Unit	Actual measured values(Ci)	Standard Value (Si)	Relative Weight (Wi)	Quality Rating (Qi)	Weighted values (QiWi)
pH		7.58	6 - 8.5**	0.117647059	89.17647059	10.4913487
EC (μS/cm)	μS cm^{-1}	1004	700-2000** 1350 (mean)	0.000740741	74.37037057	0.05508911
Turbidity	NTU	256	10**	0.1	2560	256
DO (mg/L)	mg L^{-1}	-	-	-	-	-
TDS	mg L^{-1}	921	500-1500** 1000 (mean)	0.001	92.1	0.0921
Cr	mg L^{-1}	0.038	0. 2*	5	19	95
Ni	mg L^{-1}	0.026	0.2*	5	13	65
Cu	mg L^{-1}	0.009	0.2*	5	4.5	22.5
Mn	mg L^{-1}	0.09	0.2*	5	45	225
∑				20.2193878		674.138538
WQI =∑Wi Qi / ∑Wi = 674.138538/ 20.2193878 =33.3411						
Sources: * [27]. **[28].						

The lowest values of WQI were mostly found at S3 due the present of sufficient distance and condition for natural self purification processes. Therefore, in our view with this finding and by strengthens with further comprehensive study concerning other physico-chemical properties and polluted water recourse, it can be recommended that the resulting values of WQI can be used as an indicator for assessing the natural self purification process in Qalyasan stream. However, this recommendation might not be feasible or appropriate in all conditions because self purification of natural water systems is a complex process that often involves physical, chemical, and biological processes working simultaneously [31].

Additionally, as such this study concerns self purification issue, it must be noted that purification processes that occur naturally in rivers, lakes, oceans, and other water-receiving bodies, such as aeration, sedimentation, flocculation, and denitrification, are the same processes used in the design of wastewater treatment units [50]. Furthermore, it must also be cleared that when sufficient dilution water is available in the receiving water body, where the wastewater is discharged, then the physico-chemical properties level in the receiving stream may not reach to critical level.

Table 3: An example calculation of WQI for the sample site (S1) on 1st June/ 2013 by including DO parameter and assigning 2 mg L^{-1} as a standard limit for WQI calculation.

Parameters	Unit	Actual measured values(Ci)	Standard Value (Si)	Relative Weight (Wi)	Quality Rating (Qi)	Weighted values (QiWi)
pH		7.58	6 - 8.5**	0.117647059	89.17647059	10.491358
EC (µS/cm)	µS/cm	1004	700-2000** 1350 (mean)	0.000740741	74.37037037	0.0550891
Turbidity	NTU	256	10**	0.1	2560	256
DO (mg/L)	mg/L	0.21	2***	0.5	10.5	5.25
TDS	mg/L	921	500-1500** 1000 (mean)	0.001	92.1	0.0921
Cr	mg/L	0.038	0. 2*	5	19	95
Ni	mg/L	0.026	0.2*	5	13	65
Cu	mg/L	0.009	0.2*	5	4.5	22.5
Mn	mg/L	0.09	0.2*	5	45	225
∑				20.7193878		679.38854
WQI =∑Wi Qi / ∑Wi = 679.3885/ 20.7193878 = 32.789						
Sources: * [27]. ** [28]. *** Proposed by the researchers of current study.						

Table 4: Grads of Water Quality Index (WQI) and status of water Rating [30]

Water Quality Index levels	**Rating**
<50	Excellent
50-100	Good
100-200	Poor
200-300	Very poor (bad)
>300	Unsuitable (unfit)

According to Table (5) the mean values of WQI ranged from 23.16 to 36.44 for the case of non-included DO and from 22.87 to 35.76 for the case of including DO and when 2mg L^{-1} DO was assigned as a standard limit. In general, the values were a little bit higher in case of non-including DO than those of including and were in a decreasing trend from S1 to S2 and then from S2 to S3 (S1> S2> S3) due to the natural self purification effect.

Table 5: WQI values from different sampling sites, different sample collection times and for the included or non included DO parameter.

Time of sampling	WQI values					
	DO is not included in calculating of WQI			DO is included and 2 mg L^{-1} was assigned as standard limit)		
	S1	S2	S3	S1	S2	S3
1st July/2013	33.34	22.06	20.78	32.79	22.05	20.83
15st July/2013	21.96	20.67	18.79	21.69	20.34	18.52
1st August/2013	27.29	23.28	28.43	26.78	23.43	27.96
18st August/2013	63.18	33.88	24.64	61.76	33.24	24.16
Mean	36.44	24.97	23.16	35.76	24.77	22.87
DO stand for dissolved oxygen parameter						

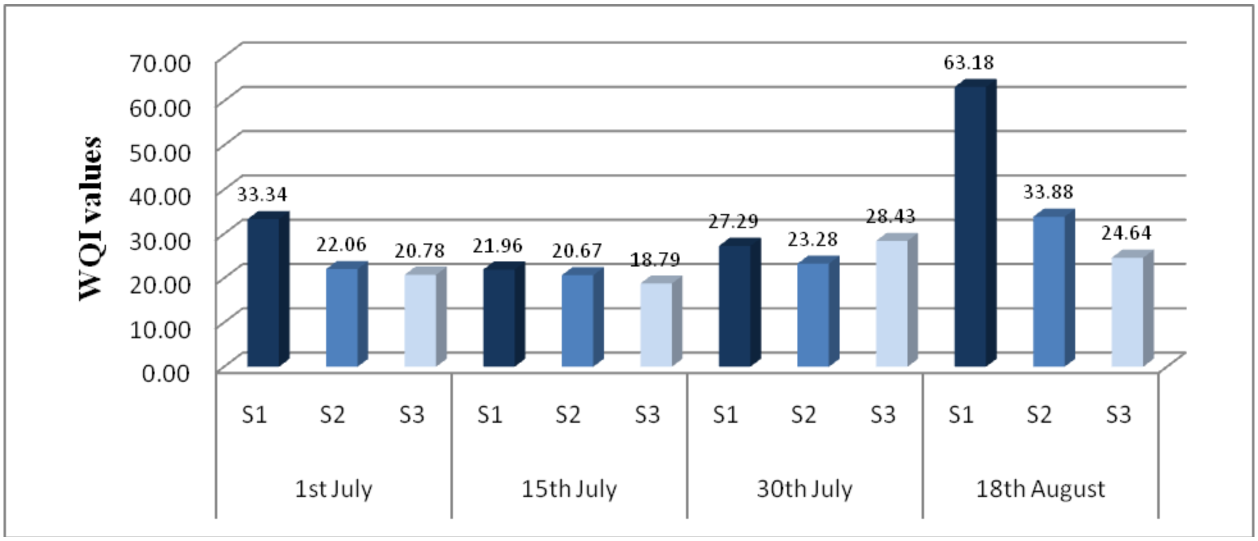

Figure 3: WQI values for all sampling sites during 1st July 2013 to18th August 2013 without Including DO parameter in the calculation.

Despite the amount of dissolved Oxygen (DO) in aquatic water is one of the most commonly used indicators of a river health, Table 5 revealed that the input of DO parameter in calculation of WQI caused no remarkable difference between the recorded values and also between the rating quality for the included and non- included cases of DO at the studied sites. The calculated values of WQI in both case of including and non-including dissolved oxygen were accordingly less than 65 and had the rating grad of excellent during the length of our designated study times. On the other hand, Table (6) showed that the multiple comparisons tests by standard deviation (SD) were highly significant for the difference between actual values of including and non- including DO. Therefore, dissolved oxygen (DO) can be considered as an important input parameter for calculating WQI.

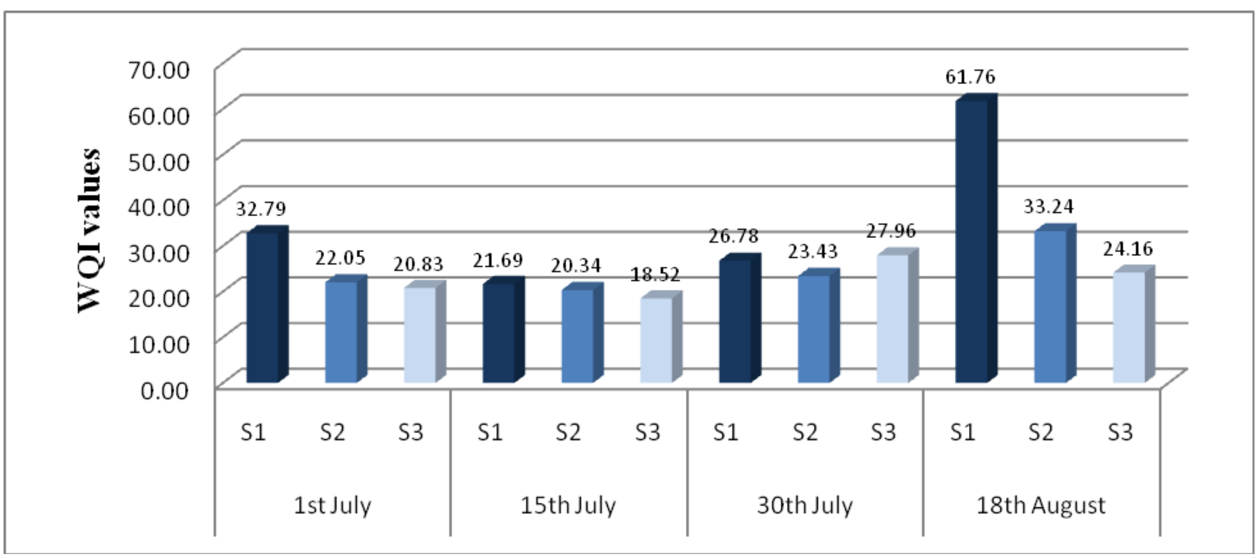

Figure 4: WQI values for all sampling sites during 1st July 2013 to18th August 2013, DO Parameter was included in the calculation and 2mg L^{-1} assigned as standard limit).

Table 6: multiple comparisons tests (± SD) between the calculated values of WQI for the case of including (with) and non-including (without) DO in the calculation.

No.	WQI values		± SD	Actual differences between without DO and with DO
	Without DO	With DO ($2\ mg\ L^{-1}$) assigned		
1	33.34	32.79	0.38976	0.55
2	21.96	21.69	0.195592	0.28
3	27.29	26.78	0.363284	0.51
4	63.18	61.76	1.001314	1.42
5	22.06	22.05	0.009609	0.01
6	20.67	20.34	0.233334	0.33
7	23.28	23.43	0.106146	-0.15
8	33.88	33.24	0.450108	0.64
9	20.78	20.83	0.029268	-0.04
10	18.79	18.52	0.19272	0.27
11	28.43	27.96	0.331562	0.47
12	24.64	24.16	0.335062	0.47

CONCLUSION

On the basis of the examined parameters in this investigation, it was concluded that the water quality of Qalyasan stream along the studied stretch (2km) was fit for irrigation and livestock drinking purposes.WQI might be used as indicator for assessing the ability of the stream for self purification and that has been observed within the selected sits with distance downstream for the studied parameters. Hence, we conclude that self purification for the discharged waste in the stream was observed as the waste went down the stream. Although the input of DO parameter in calculation of WQI caused no recognizable change in the scores, the multiple comparisons tests by standard deviation (SD) were highly significant for the difference between actual values of including and non-including DO. This means that DO is an important input parameter for calculating WQI. Furthermore, discharging of domestic and industrial wastewater and also other anthropogenic activities were the main sources for contaminating Qalyasan stream. Therefore, the results suggested that there is a need for cost-effective wastewater treatment system before discharging the waste water in the stream. Also, there should be regular monitoring for water quality of the stream in order to detect changes in physiochemical parameters of the stream water at different sites.

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