Assessment of the Water Quality of the Mollusca Community in the Janabi River-Hay City of Wasit Province by Using Canadian Water Quality Index

Intisar F. Abed
Department of Biology, College of Education for Pure Science/ Ibn Al-Haitham, University of Baghdad.

Muhanned R. Nashaat
Agricultural Research Directorate, Ministry of Science and Technology, Baghdad, Iraq, muhanned_nashaat@yahoo.com

Nada N. A. Mirza
Directorate of 3rd Karkh/Ministry of Education, Baghdad, Iraq.

Abstract

The Canadian Environment Council Water Quality Index (CCME-WQ) of the Janabi River water at Hay City in Wasit Province has been assessed and analysis for over all, drinking water and aquatic life and the impact of the river environment on presence and mollusca community. The samples were collected monthly during 2020, Most of the variables exceeded the Iraqi and global permission limits. It was clear that this index values was marginal category for over all purposes which ranged from 45-48 at all sites, while this index values was poor-marginal categories which ranged from 37-50 for all season, On the other hand the water quality index values for drinking purposes was poor category which were recorded from 40 -42 for all sites, also it was poor category which was ranging from 31-44 for all season. The values of this index for aquatic life was in the poor-marginal category which ranging from 38-61 for all sites and in the marginal- fair categories which ranging from 61-67 for all season. Nine species of mollusca was identified belonging to seven families. Two species of Melanopsidae and Cyrenidae and one species for Thiaridae, Physidae, Neritidae, Dressseinidae and Unionnoidae. It was concluded that the water of the Janabi River was highly polluted and undrinkable water characterized, as well as, it’s a clearly appeared impact of the river water quality on the mollusca densities.

Keywords: *Canadian Water Quality, Janabi River, Iraq, Mollusca.*

INTRODUCTION

Physical and chemical factors have a significant effect on the distribution of benthic organisms and appearance a differences on it density (Prince et al., 2022). The Canadian Water Quality Guide is also an efficient model used to assess water quality by summarizing water quality data into interpretable mathematical information (CCME, 2007), comparing water quality variables with standard permitted limits and specifications.

Tigris River has several branches. Gharaf River is one of the largest branch (230 Km) and the main source of water for agricultural purposes and the general requirements of the cities that pass through it (2,151,019 acres). This river receives most of the sewage from these cities in addition to industrial, agricultural and local wastewater (AL-Zamili, 2007). Janabi River is a branch of Gharaf River and is 13,300 Km long, 19 meters wide and 230 cm deep, irrigates an 200,000 acres of agricultural areas (Personal Communication).

Mollusca is one of the most important invertebrate groups after the Arthropoda. They are slow-moving organisms that are heterogeneous in shape and size, some with or without shells, and are common in many fresh environments and are relatively easy to combine and categorize (Jamil, 2001; McComb et al., 2005)

Therewith several local studies are dealing with mollusca as a group within benthic invertebrates, such as : Kassim et al. (1997); Al-Lami et al. (1998) ; Nashaat et al. (2000); Al-Lami et al. (2002ab); Radhi et al. (2004); Al-Lami et al. (2006); Abdullah et al.(2006); Radi et al.(2006); Nashaat et al.(2006); Nashaat (2010); Rhadi et al.(2017); Mirza et al.(2019). While this study considered as the first of its kind due to it included the study of the moullsca assemblage on one of the main branches of the Gharaf River called Janabi River at Hay City, in Wasit Province, southern Iraq. Which we can include it's the main objectives by assessments the changes of the Canadian Environment Council Water Quality Index (CCME-WQ) of this river and analysis for over all, drinking water and aquatic life purposes and the impact of the river environment on presence and mollusca densities.

Materials and Methods

Sampling site

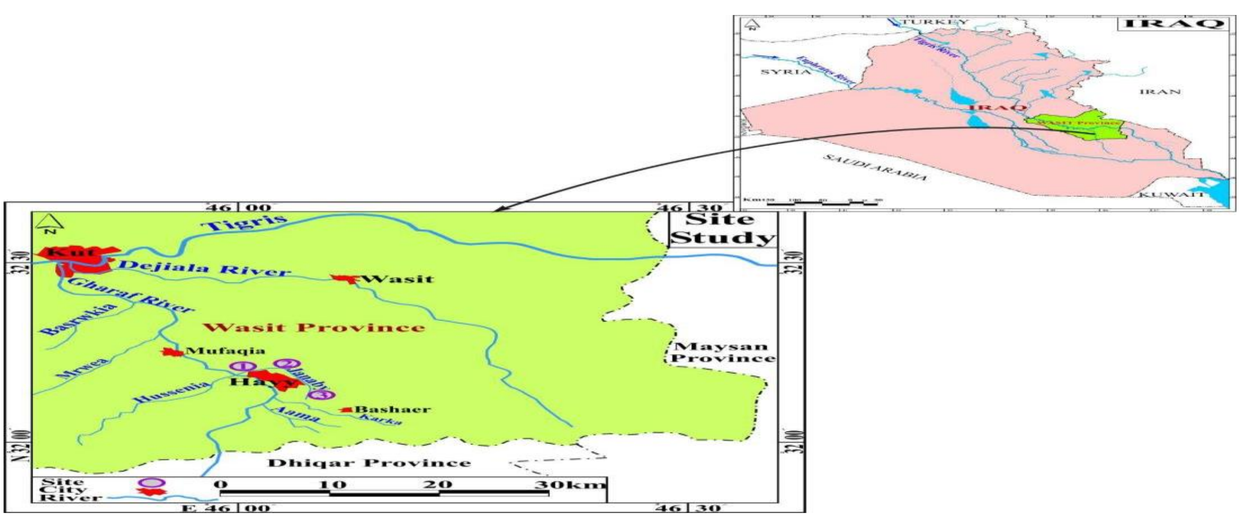
Janabi River, which passes through Al-Hay district of Wasit Province, has been studied and divided into three sites (Fig. 1):

Site 1: Located at 32.1873 E and 46.0262 N. This site with well running water because there are no barriers to its passage and with a large Typha domengnsis plant on the right side of the river while its lowest on the left side

Site 2: This site is about 5 Km away from site 1 which located at 32,1825 E and 46.0555 N, which characterized by the presence of civil residential area and large quantities of green algae and Nile flower, that made the water flow very slow compared with first site. Sewage pipes was presence .

Site 3: It is located at about 4 Km downstream site 2, at 32.1564 E and 46.0961 N, it is far from civil residential areas and the presence of Phragmites australis and Typha domengnsis.

Figure 1: Map of Janabi River with locations of the studies sites on Wasit Province.



Collecting and Analyzing Samples

Samples were collected monthly from January to December 2020. Thirteen importance physical and chemical factors were analyzed according to the methods described by: Brands and Tripke, (1982); EPA (2021); Sepllman (2015); Baird et al.(2017). These Thirteen parameters are: water temperature, turbidity, electrical conduction, pH, biological. oxygen demand, dissolved oxygen, total hardness, sulphate, bicarbonates, nitrates, phosphates, total dissolved solids and total suspended solids.

Four replicates Ekman Dredge mollusca samples were also collected monthly from the surface of the margin or rocks river and placed in plastic containers with some river water, then sieves was used in order to obtain mollusca from the river clay by washed several times with water river and the shells are cleaned using a small brush to remove any related clay or algae or any other impurities and then saved in 70% ethanol (Forsyth, 1999) in plastic containers or tubes according to sample sizes. Samples were diagnosed by using dissecting microscope according to taxonomic keys such as:- Stern (1990) , Throp and Rogers (2011), Rogers and Thorp (2019) and GBIF (2021). The results were expressed in an individual /m2.

Calculating the Value of the Water Quality Guide

The CCME WQI was developed to use as a tool for simplifying and definition the water quality data. Three measures were selected to calculate the CWQI (CCME, 2007).

F_1 (Scope)

$$F_1 = \left[\frac{\text{Number of Failed Variables}}{\text{Total Number of Variables}} \frac{\text{Number of Failed Variables}}{\text{Total Number of Variables}} \right] \times 100$$

F_2 (Frequency)

$$F_2 = \left[\frac{\text{Number of Failed Testes}}{\text{Total Numbers of Testes}} \frac{\text{Number of Failed Testes}}{\text{Total Numbers of Testes}} \right] \times 100$$

F3 (Amplitude)

When the test value must not exceed the objective:

$$\textit{Excursion} = \left[\frac{\text{failef test value}}{\text{Objective}} \left[\frac{\text{failef test value}}{\text{Objective}} \right] - 1$$

When the test value must not fall below the objective:

$$\textit{Excursion} = \left[\frac{\text{Objective}}{\text{failef test value}} \left[\frac{\text{Objective}}{\text{failef test value}} \right] - 1$$

$$nse = \frac{\sum_{i=1}^{n} excursion}{\text{number of tests}} \frac{\sum_{i=1}^{n} excursion}{\text{number of tests}}$$

$$F_3 = \left[\frac{nse}{0.01\,nse + 0.01} \frac{nse}{0.01\,nse + 0.01} \right]$$

$$CWQI = 100 - \left[\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732} \frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732} \right]$$

The final equation produces a value from 0 to 100 and gives a numerical value to the state of water quality. Note a zero (0) value indicates a very poor water quality, whereas a value close to 100 indicates excellent water quality .

The water quality is ranked in the following 5 categories:

Table 1: The five water quality ranks .

Rank	CCME WQI values
Excellent	95- 100
Good	80- 94
Fair	60- 79
Marginal	45- 59
Poor	0- 44

Results and Discussion

The values of the over all water quality index varied between sites, ranging from 45-48 which were classified as a marginal categories, the highest value was recorded at site 2, while the lowest value was recorded at site 3 (Table 2), that may be due to the increase electrical conductivity values, total fecal colon bacteria with depletion of dissolved oxygen (Bordalo et al., 2006), or may be due to the pollution because they were located near residential areas and receive directly large quantities of pollutants such as domestics sewage, agricultural and industrial waste. The values of the over all water quality index among seasons ranged from 37-50 which were classified as poor on winter, summer, autumn and marginal on spring, the highest value were recorded on spring and the lowest value were recorded on winter, that may be due to the increased value of this guide relatively during spring due to the relative improvement in the some parameter by decline in values such as turbidity, electrical connectivity, total hardness and the biological oxygen demand, resulting from rainfall dilution during winter with high water level as well as a gradual rise in the dissolved oxygen values and water temperatures (Moyle, 2010). The low values of the guide during the winter may be due to the soil drifting to the river by rain soil washing, which helps to increase of salts and dissolved minerals amount in water or to reduce in water levels (Al-Haidari, 2003).

The Water Quality Index for drinking purpose were recorded values ranging from 40-42 which were classified as a poor categories for all sites, the highest value was recorded at site 2, while the lowest value was recorded at site 3 (Table 2).

Table 2: Annual variation of water quality index of each site (2020).

Site 1			
Data Summary	Overall	Drinking	Aquatic
CWQI	46	41	62
Categorization	Marginal	Poor	Marginal
F1 (Scope)	33	33	50
F2 (Frequency)	31	33	42
F3 (Amplitude)	82	90	13
Site 2			
Data Summary	Overall	Drinking	Aquatic
CWQI	48	42	61
Categorization	Marginal	Poor	Marginal
F1 (Scope)	33	33	50
F2 (Frequency)	31	33	42
F3 (Amplitude)	79	88	19

Site 3			
Data Summary	Overall	Drinking	Aquatic
CWQI	45	40	67
Categorization	Marginal	Poor	Fair
F1 (Scope)	33	33	50
F2 (Frequency)	25	33	25
F3 (Amplitude)	86	92	7

The recording unsuitable river water for drinking may be due to the human activities resulting from rapid industrial and urban development (Sarwar et al., 2010) or to exceed some permission limits (Al-Mashhadani, 2012), also, this in agreement with what Salim et al. (Salim et al., 2009) mentioned that increased pollutants made the river water bad and unsuitable for drinking.

The values of the Water Quality Index for drinking water among season ranged from 31-44, during summer and spring, respectively. Also it has being classified as poor for all seasons (Table 3), which may be due to the effect of civil and agricultural waste that transported directly into river without treatment (Abdul-Razak et al., 2010). As for the low values of this index may be due to parameter values were far from its standard permission limits for drinking water, or may be due to lower water levels and increased evaporation rates during the summer due to high temperatures, which has led to an increase in the values of all variables from their standard permission limits except dissolved oxygen and pH values that remained within the standard permission limits of drinking water. While in Spring has seemed a clear week improved as a result of recorded higher dissolved oxygen values due to gradually lower temperatures as well as relative polluted dilution due to rainfall and increased discharge rates.

The values of the Water Quality Index for aquatic life ranged from 61-67, and were classified as marginal category in sites 1, 2 while it classified as fair category in site 3 (Table 2).

Site 3 was recorded a highest value of 67, while 61 at site 2 was recorded the lowest value, may be due to its far from pollution sources (Al-Heety et al., 2011), where all sites were recorded values ranging from a marginal-fair estimate during study period, may be due to the high level of pollution such as : industrial, health and sewage that flows into the river (Al-Janabi et al., 2012)

The values of the Water Quality Index for aquatic life among season were ranged from 38 to 61, which were during summer and winter, respectively, also it was classified as poor during the summer and marginal during winter, spring and autumn (Table 3).

Winter			
Data Summary	Overall	Drinking	Aquatic
CWQI	37	39	61
Categorization	Poor	Poor	Marginal
F1 (Scope)	50	33	50
F2 (Frequency)	31	33	40

F3 (Amplitude)	91	95	20

Table 3: Seasonal variation of water quality index in Janabi River sites (2020).

Spring			
Data Summary	Overall	Drinking	Aquatic
CWQI	50	44	60
Categorization	Marginal	Poor	Marginal
F1 (Scope)	33	33	50
F2 (Frequency)	32	33	47
F3 (Amplitude)	74	85	5
Summer			
Data Summary	Overall	Drinking	Aquatic
CWQI	40	31	38
Categorization	Poor	Poor	Poor
F1 (Scope)	50	67	100
F2 (Frequency)	29	36	37
F3 (Amplitude)	87	93	6
Autumn			
Data Summary	Overall	Drinking	Aquatic
CWQI	40	43	57
Categorization	Poor	Poor	Marginal
F1 (Scope)	33	33	50
F2 (Frequency)	33	33	50
F3 (Amplitude)	93	87	25

The deterioration in water quality index during summer may be due to the fact that most of the water quality variables studied exceeded Iraqi standard permission limits, as well as Canadian Environment Council standard permission limits for aquatic live (CCME, 2007), the total dissolved solid was exceeding the global standard permission limits values of 500 mg/L for aquatic life, which may be due to the presence of polluted organic matter, other effluent's and suspended solids or may be due to the effect of temperatures on metabolism, respiration and enzymatic reactions of aquatic organisms (Al-Saadi, 2006). As well as in the oxygen and other gases solubility and the level of dissolved salts in the water by accelerating chemical reactions in the water medium (Smith, 2004). Also, it affects the toxicity of some chemical compounds in aquatic ecosystem as well as it affects in the sensitivity of aquatic organisms to toxic substances (Odjadjare and Okoh, 2010).

The high values of the water quality index during winter may be due to the fact that temperatures were within the suitable range of aquatic organisms living which was 15-50°C and the pH values within the permission limits which was 5.5-8.5 and the values of dissolved oxygen within the permission limits and did not reach critical living levels of less than 4 mg/L (Alam et al., 2007), therefore it seemed clear effect of water quality on the mollusca community density, which recorded a clear increase during winter, spring and autumn, respectively, and a decrease during summer, with values ranging from 38-61 so, it was classified as poor and marginal categories (Table 3, Figure 2). This may be due to the availability of suitable temperatures and the abundance of aquatic plants, which are a source of food and habitat of these organisms, as well as increased of microorganisms activity due to moderate temperatures, which increases decomposition and nutrient availability, or may be due to the stability and suitability of environmental conditions for their growth and stability as the temperature is suitable of their eggs hatching, and may be due to the fact that the composition of the mollusca community is influenced by several factors, including bottom texture, abundance of algae, temperatures and water current (Martel et al., 2011).

As for spatial variation, the density of the mollusca recorded values ranging from 61-67 which classified as in the marginal and fair categories, the lowest values were recorded in site 2 and the highest values were recorded in site 3, which may be due to the fact that site 2 was located near residential areas with agricultural land, which may cause the river water to be under the influence of human and agricultural pollutants. While its height value were recorded in site 3 may be due to the presence of aquatic plants that slow down the water current so, these environmental conditions was provide suitable environment for the mollusca growth with increasing benthic stability and nutrient abundance (Ramadan et al., 2002).

The decrease in the values of this index may be due to the exceeding some variables the Iraqi permission limits and the Canadian Standards of Aquatic Life (CCME, 2007).

Turbidity exceeded the permission limit of 5NTU, which was ranging from 2.73-128 NTU (Table 1), may be due to increased organic matter resulting from plant decay or may be due to lack of vegetation leading to sedimentation of suspended substances and thus high turbidity values in the water column (Mustafa, 2002). While the biological oxygen demand was recorded high concentrations ranging from 2-8 mg/L, the lowest values were recorded at sites 2 and 3, while the highest values were recorded at site 1, which may be due to the presence of organic pollutants from sewage, industrial and agricultural near the river (Sarhan, 2002). Also, the high values of total hardness were recorded which was ranging from 320-540 mgCaCO3/L, that mean water was very hardness. Nitrates recorded values below the permission limits of 0.757-1.897 mg/L. Total dissolved solids recorded high values of from 410-610 mg/L and the permission values of aquatic life of 500 mg/L (Table 4), may be due to the discharge of rich various salts materials such as household, industrial and agricultural waste from Hay District (Boyd, 2000).

Table 4: Annual simple analysis of water quality parameters at the study sites on Janabi River(2020).

Parameter	Site 1			Site 2			Site 3		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
W.T	13	30.5	22.325	13	30.9	22.7	13.6	30.4	22.75
Tur. (NTU)	2.73	80	30.494	4.3	128	34.0792	5	95	36.71
EC (µs/cm)	606	1125	890.333	860	1120	974.33	950	1277	977.888

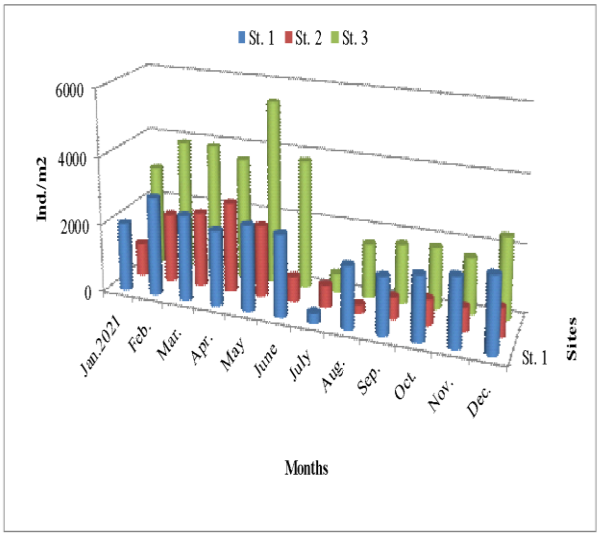
pH	7	8.2	7.516	7	8.4	7.616	7.2	8.4	7.641
DO)mg/L)	5.1	11.8	7.883	5.1	10.7	7.908	5.5	11.7	8.716
BOD5)mg/L)	2.2	8	6.950	2	7.3	4.008	2	6.9	4.391
TH)mg/L)	320	468	399.667	328	540	395.333	320	510	392.333
SO^{-2})mg/L)	50	125	85.8333	50	130	94.166	50	150	91.25
TDS)mg/L)	430	580	482	410	610	480	420	580	480
NO_3^{-1})mg/L)	0.79	1.759	1.399	0.881	1.897	1.398	0.757	1.802	1.226
PO_4^{-3})mg/L)	0.019	0.083	0.04183	0.016	0.072	0.03933	0.015	0.082	0.0365
Mollusca	300	4383.95	1532.06	250	2637.24	1426.63	550	5442.44	1883.44

During the study, nine species were identified from Gastropoda and Bivalvia groups, with two species of Melanopsidae family and one species for Thiaridae, Physidae and Neritidae families, which belong to the Gastropoda group. Two specis of Cyrenidae family and one species for Dresseinidae and Unionnoidae are identified for the Bivalvia group (Table 5).

Table 5: List of mullosca species recorded during the study period (2020).

Class	**Family**	**Genus**	**Species**	**Sites**
Gastropoda	Melanopsidae	*Melanopsis*	*Praemorsa* Linnaeus,1758	1,2,3
		Melanopsis	*nodosa*	1,3
	Thiaridae	*Melanoides*	*Tuberculata* (O.F.Müller,1774)	1,3
	Physidae	*Physa*	*acuta* Draparnaud,1805	1,2,3
	Neritidae	*Theodoxus*	*Jordani* (G.B. Sowerby I,1836)	1,3
Bivalvia	Cyrenidae	*Corbicula*	*fluminalis* (O.F.Muller,1774)	1,2,3
		Corbicula	*Fluminea* (O.F.Müler,1774)	1,2
	Dresseinidae	*Dreissena*	*Polymorpha* (Pallas,1771)	1,3
	Unionnoida	*Unio*	*Tigridis* Bourguignat,1852	1,2,3

Figure 2: Seasional variation of Mollusca density during the period of study (2020).



It was concluded that the water of the Janabi River was highly polluted and undrinkable water characterized, as well as, it's a clearly appeared impact of the river water quality on the mollusca densities.

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