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A Comparative Study on the Water Quality of Two Nilotic Canals in the Delta of Egypt

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Abstract

The River Nile branches into irrigation canals, which extends for many kilometers (40 km to 85 km), where each represents a semi-independent ecosystem. Of those, Bahr Shebeen and Alkhadraweya Canals are present in the Minufiya Governorate, and extend through out other governorates in the Delta of Egypt. Water Quality data included the following parameters: total hardness, total dissolved solids, electrical conductivity, dissolved oxygen, pH, Cl, Mg, Ca, Zn, Mn, PO 4, Fe, NO_3, and Cu. These parameters were examined and discussed, for significant relationships for each Canal. The favorability of each ecosystem for fish is examined, on the basis of fish growth condition. Subsequently, Water Quality Index was discussed for those Canals, and a WQI is suggested.

Keywords: Water quality Index; Nilotic canals; *Oreochromis niloticus*

Introduction

Bahr Shebeen Canal (BSC) is an irrigation canal with a depth of 3-5 meters and about 30 m wide, and extends about 80 kms through three different governorates in the Delta of Egypt. Kharaweya Canal (KHC), with a similar depth, but 10 m wide, is rather shorter but extends throughout two governorates (Figure 1). Although both are considered canals belonging to the River Nile system, but KHC receives drainage from the surrounding villages, fields, and industrial wastes from the city of Quesna. Each channel is considered a semi-independent ecosystem. Studying the water quality and fish condition is important to define the state of favorability for life in aquatic environment.

The growth of fish is responsive to various environmental factors, such as physico-chemical factors and fishing [1]. According to Rounsfell and Everhart [2], the length-weight relationship and condition coefficient of fish are used to detect changes in feeding, seasonal variation, or geographical differences. The measure for those changes is the slope of the weight-length relationship, or variation in the fish condition coefficient.

The need for a single value to define the health of an ecosystem is important for non-scientist community, who perform decisions concerning aquatic habitats [3,4]. Such value is thought of as a non-dimensional index which can be read on a scale (From 1 to 100) to define status of the environment under study. Thus, Water Quality index "WQI", is based on various chemical, physical, and biological parameters such as micro-organisms in the habitat. The WQI is accepted worldwide, USEPA, UNEP and other organizations as well as managers in agriculture or health as a means of expressing the status of aquatic environments [5-7]. However, different indexes based on different methods of calculations were used in previous works, such as CWQI, Baseline WQI, or weighted WQI [3].

Method

Water samples were collected monthly, November 2014 to October 2015, from BSC and KHC, and brought to the laboratory, at Faculty of Science, for analyses. Chemical parameters are measured by The HACH DR 5000 UV-Vis Laboratory Spectrophotometer. The pH values of the collected field samples are determined by the use of bench- top pH/ Ion Meter (Model 6500, China). The oxygen content of the water samples was measured by SB70D DO Bench top meter (S/NDO 0800, USA), and expressed as mg/L. The total hardness of water (calcium and magnesium) in water samples was determined according to APHA [8]. Electrical conductivity was measured at 25°C, as standard temperature, by using CON 6000 Bench Electrical Conductivity Meter (model No. EPA-30 IDAN-9, Eutech Instruments, Singapore), and expressed as µmhos/cm. Total dissolved solids of the collected water samples were expressed as mg/L.

The length-weight relationship and condition coefficient "K" are calculated according to Le Cren [9]:

$W = aL^b$, and $K = W / L^3 \times 100$.

Where W is in grams and L in cm.

Gonado-Somatic Index (GSI) is calculated as follows:

$(gonad\ weight\ /\ weight\ of\ fish)\ X\ 100$.

The Stomach Somatic Index (SSI) is predicted by:

$(stomach\ weight\ /\ weight\ of\ fish)\ X\ 100$.

Regression analyses are carried out according to Neter and Wasserman [10], and MS Office 2013.

Results

A 313 fish samples from BSC and 319 fish samples from KHC were used for the length-weight relationships. The following mathematical equations are predicted as follows:

BSC:

$$Log\ W(g) = -1.70906 + 2.99931\ log\ L(cm)$$

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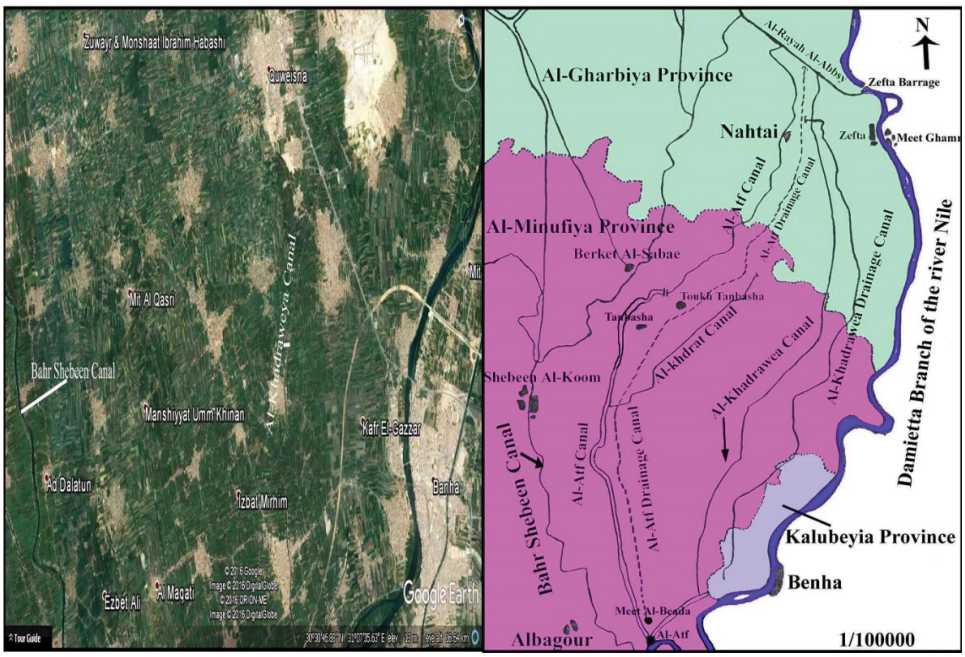

Figure 1: Bahr Shebeen Canal and Khadraweya Canal (Google Earth).

Or: $W(g) = 0.01954\, L(cm)^{2.99931}$

$r^2 = 0.983$,

And KHC:

$Log\ W(g) = -1.22841 + 2.55857\ log\ L(cm)$

Or: $W(g) = 0.059100\, L(cm)^{2.55857}$

$r^2 = 0.9053$,

The condition coefficient and length relationships, for BSC and KHC values, are shown in Figures 2 and 3. Correlation coefficient for either relationship is: 0.55 in BSC, while it is 0.9084 for KHC. Generally, K decreased with the increase of length.

When the monthly variation of the condition coefficient for both canals is considered, some irregularities found to appear as shown in Figures 4 and 5. The fish of BSC were indicated to have better K during April, July, and November. In Khadraweya, the K value peaked in January, March, June, and September-November period. Concomitantly, the SSI and GSI for BSC (Figure 6) and for KHC (Figure 7) showed changes which can be related to multiple spawning nature of *O. niloticus*, and variation in physicochemical parameters. The difference in variation of those parameters can be related to such activity. However, more effects are interfering with this biological process.

Water quality data

These are presented in Tables 1 and 2, for BSC and KHC respectively. On examining these data, with the exception of March TDS value in KHC, which almost doubled the Water Quality Standard (WQS: 500 mg/l), the measured values for the parameters under study were within the safe limit. It is worth to mention, that the increase in TDS in March is accompanied by a rise in all other parameters. However, some of the studied values are sometimes close to the WQS. More or less findings were noticed for the correlation of various parameters to the variation to TDS monthly change.

This result was conspicuous in KHC, where various factories might discharge their waste materials in this canal. This was even emphasized by significant correlations between those parameters values as shown in Table 3. The significant association of the sum of physical or chemical parameters with TDS in either canal is noticed, as shown in Figures 8-11. Those findings lead to propose TDS as a measure of WQI. Thus, a multiple regression relationship is presented for each canal as follows:

BSC:

$TDS = 89.53 + 0.404\ SII - 0.077 SI$

$r^2 = 0.844$

And KHC:

$TDS = 103.785 + 0.5725\ SII - 0.7231\ SI$

$r^2 = 0.995$

Where TDS is mg/l and SI equals the sum of DO, pH, and EC, while SII equals the sum of all observed chemical parameters.

Consequently, the TDS for a given ecosystem can be calculated, by a researcher taking into account the average values of physical and chemical parameters, and examine if it exceeds the WQS. Subsequently, the status for the environment in question will be identified.

It is well established by many authors [1,9] that the slope of the length-weight relationship is an indicator of the variation in fish condition and health. In addition, it may vary with species, sex, or geographical areas. Slope of the length –weight relationship for KHC is less than that of BSC. This indicates that the health of fish is better in BSC than that of KHC. This can be quantified by dividing the two slope values as follows:

KHC/BSC: 2.5586/ 2.9993 = 0.853. This result indicates a deficiency

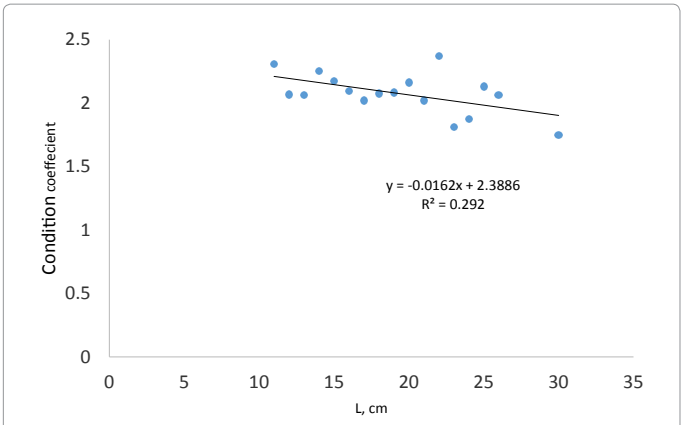

Figure 2: Condition coefficient variation with length of *O. niloticus* in BSC.

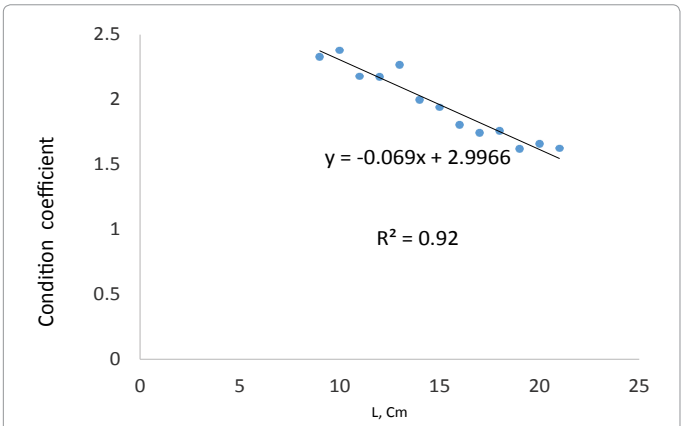

Figure 3: Condition coefficient variation with length of *O. niloticus* in KHC.

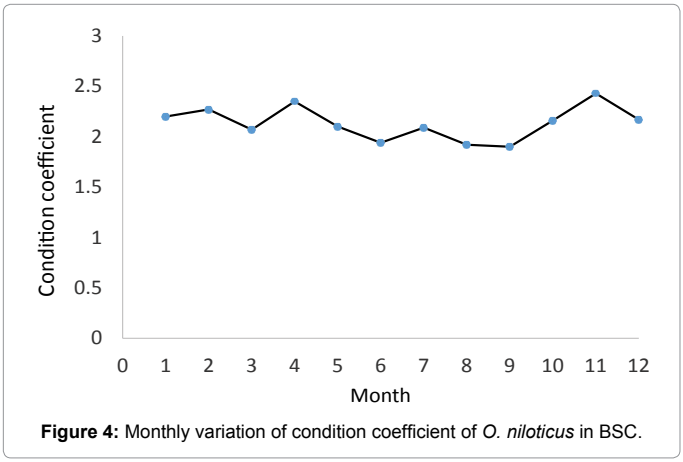

Figure 4: Monthly variation of condition coefficient of *O. niloticus* in BSC.

of 14.7 % in health of *O. niloticus* in KHC than in BSC. In concomitance, if the average monthly K for the two canals, a comparable result is predicted: 0.868. In other words, the difference in water quality between the two canals ranges between 13.2 to 14.7%.

Discussion

As the fish grow in size, it means getting older, and the period of rapid growth or health deteriorate. Thus, decline of K with length of fish, though follow that tendency, but it is conspicuous in KHC than in BSC. KHC has more sources of pollution which in turn means deterioration in the fish health. The conspicuous rise in TDS exceeding the maximum permissible limit, sure had its effect on the fish health in that canal. Such observation was indicated earlier by Knight [11], Ricker [1], Nwadiro and Okorie [12], and Khallaf [13], Khallaf et al. [14]. This is exemplified by the slope of the length-weight relationship, where it is lower for the fish in KHC (2.5587) than that in BSC (2.9993). When the average monthly values of K are taken into account, it gave 1.85 and 2.13 respectively for the two canals. Those finds indicate that KHC is less favorable to the fish health by 13 to 15%.

The change in values of GSI and SSI (Figures 6 and 7) did not give a conspicuous trend in either canal. However, the variation in GSI is a simple measure for spawning. BSC values appear more or less at

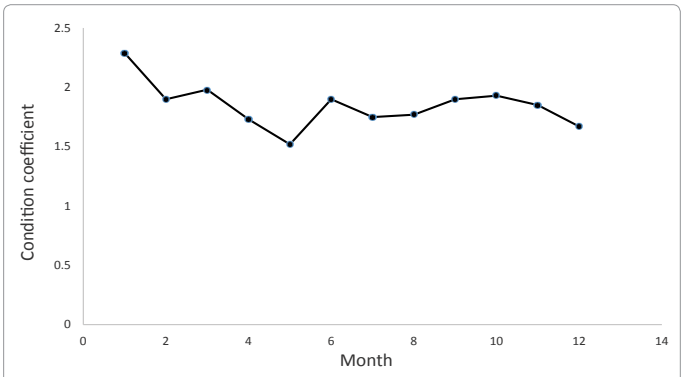

Figure 5: Monthly variation of condition coefficient of *O. niloticus* in KHC.

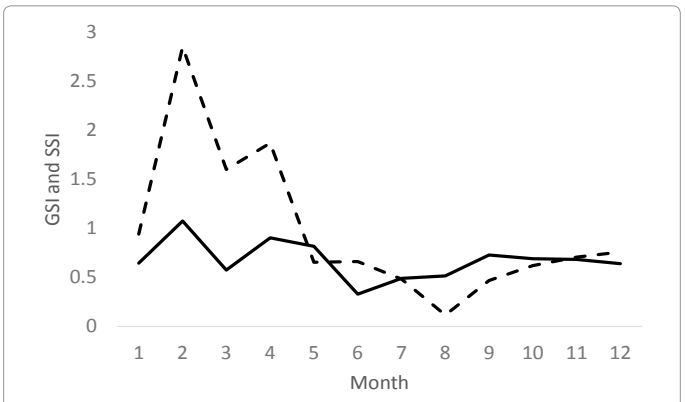

Figure 6: Monthly variation of GSI (Solid line) and SSI (Dashed line) of *O. niloticus* in BSC.

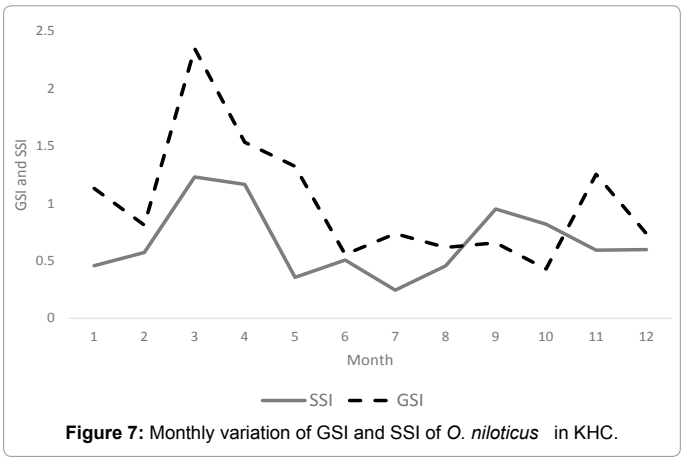

Figure 7: Monthly variation of GSI and SSI of *O. niloticus* in KHC.

Month	T.H	TDS	E.C	D.O	pH	Cl^-	Mg	Ca	Zn	Mn	PO_4	Fe	NO_3	Cu
Nov	200	300	504	6.21	7.41	39.2	21.87	44	_	0.3	49.2	0.13	2.4	0.02
Dec	225	278.4	495	7.92	8.17	49	25.5	48	0.14	0.1	0.8	0.05	2.9	0.03
Jan	180	249	415	7.67	7.84	29.4	18.2	42	0.1	0.01	0.75	0.07	2.4	0.03
Feb	175	228.6	381	6.99	8.03	24.5	17.01	42	0.17	0.006	0.82	0.04	2.6	0.06
Mar	160	246	410	10.36	8.29	29.4	14.58	40	0.013	0.009	5.95	0.11	3.6	0.07
Apr	150	245	408	6.12	8.37	24.5	11.15	40	0.13	0.012	65.58	0.07	3.4	0.05
May	175	220	365	6.2	7.33	25.6	26.4	39	0.16	0.011	6.2	0.06	3.1	0.02
June	160	199.5	332	5.71	7.9	44	19.4	32	0.13	0.009	1.2	0.46	2.3	0.02
July	170	178.8	298	5.92	8.49	24.5	19.4	36	0.13	0.003	1.95	0.05	2.3	0.02
Aug	160	182.4	298	4.02	7.97	24.5	20.6	30	0.09	0.002	0.75	0.05	1.4	Trace
Sep	170	190.8	318	6.52	7.93	24.5	19.4	36	0.12	0.002	0.94	0.05	2.5	0.01
Oct	158	218	357	5.32	8.23	24.5	17.2	34	0.09	0.009	Trace	0.05	1.4	0.01

Table 1: Water quality data of BSC.

Date	T.H	T.D.S	E.C	D.O	pH	Cl^-	Mg	Ca	Zn	Mn	PO_4	Fe	NO_3	Cu
Nov	180	259.8	433	7.19	7.83	29.4	19.4	40	_	0.2	18.45	0.29	1.8	0.05
Dec	195	240.7	376	6.87	7.64	46.5	20.65	44	0.08	Trace	Trace	0.09	Trace	0.01
Jan	320	444.6	741	5.52	7.56	68.6	34.02	72	0.16	0.3	20.8	0.28	3.4	0.15
Feb	240	310.5	514	7.99	7.67	29.4	27.95	50	0.13	0.009	1.83	0.26	2.1	0.06
Mar	500	970.8	1613	11.44	8.36	186.2	63.2	96	0.15	0.032	8.84	0.2	3.4	0.1
Apr	255	400	664	8.1	7.98	32	22.2	41.1	0.12	0.013	5.3	0.12	2.9	0.01
May	195	300	509	7.99	7.51	35.2	30.2	41	0.14	0.003	1.4	0.08	2.4	0.04
Jun	180	284.2	408	4.06	7.8	24.5	24.3	32	0.11	0.007	27.7	0.15	1.5	0.01
Jul	175	178.2	297	4.71	8.52	22	23	32	0.12	0.002	1.8	0.09	3.2	0.06
Aug	150	178.8	304	4.24	7.8	22	19.4	28	0.1	0.003	3.11	0.15	2.1	Trace
Sep	150	234	390	3.93	7.34	29.4	17	32	0.09	0.007	2	0.12	1.2	0.03
Oct	160	220	365	4.95	7.06	24.5	19.4	32	0.1	0.004	Trace	0.08	1.7	0.05

Table 2: Water quality data in KHC.

Relationship	Coefficient of Determination
TDS vs. TH	0.951
TDS vs. EC	0.996
EC vs. Ca	0.862
EC vs. Mg	0.907
Mg vs. Ca	0.849
Mg vs. Cl	0.902
TDS vs. SI	0.990
TDS vs. SII	0.980

Table 3: Significant correlations of various parameters in KHC.

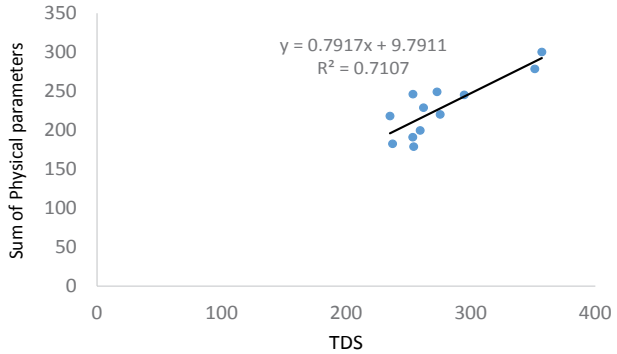

Figure 8: Relationship between TDS and sum of physical parameters in BSC.

months earlier than those of KHC, which might be attributed to the effect of pollution, which cause delay in sexual maturity. As indicated by Khallaf et al. [14], GSI of *O. niloticus* correlated significantly with heavy metals and pesticides. *O. niloticus* is known to be a multiple spawner [14-17], but this variation in timing between the two canals might be explained by the prevalent conditions in each specific canals. As the fish are not healthy as they should be, they need longer time for the gonads to mature. This was shown earlier by Bakhoum and Faltas [18], and Khallaf et al. [14].

Conclusion

In conclusion, the need for a single measure to represent the quality status of a specific aquatic environment was dealt with a number of previous works, but no specific index is used universally [19]. The WQI's proposed are sometimes tedious and has vulnerability [3].

In this study, another index, using TDS, is proposed, as a useful

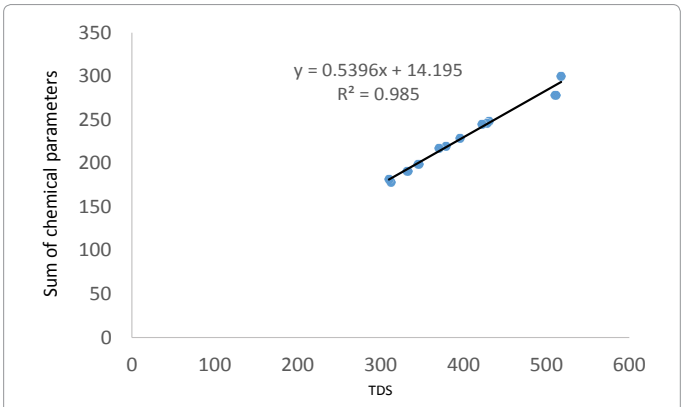

Figure 9: Relationship between TDS and sum of chemical parameters in BSC.

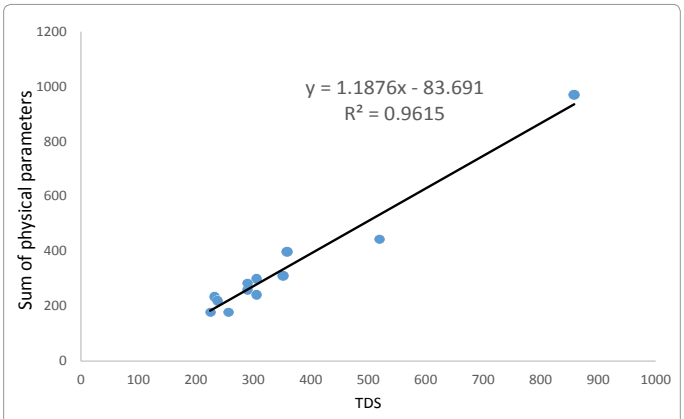

Figure 10: Relationship between TDS and sum of physical parameters in KHC.

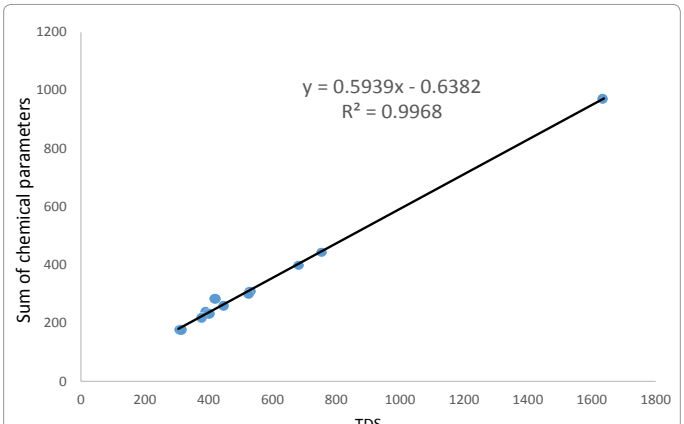

Figure 11: Relationship between TDS and sum of chemical parameters in KHC.

representation for describing the status of the environment. In accordance, Welcomme [20] emphasized that TDS reflect the extent of industrial and domestic discharge. The significant correlations found for the association of TDS and either sum of physical or chemical factors for the fish in BSC and KHC (Figures 8-11) perform a solid basis for such index. Thus, this indicated the efficiency of the TDS to represent the water quality in such canals. The subsequent prediction of a multiple regression for TDS and SI and SII, and the significant correlation for each equation, indicate the usefulness of this proposal as a WQI, and as a representative for the physicochemical prevalent parameters. When the predicted value of TDS is compared with the WQS, it performs a simple way to indicate the status of a specific aquatic habitat.

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