

Effect of Tharthar Canal Ecological Indices of Tigris River, North Baghdad City Iraq

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Abstract: This study investigated the effect Tharthar Canal on values of of Tigris River, North Baghdad City Iraq of the waters of the Tigris River; the measurements were conducted for 12 months, starting from January to December 2020, five sites were selected. Results showed that after the confluence of the Tharthar Canal with the Tigris River, a change happens in values of the Ecological Indices increased in the Tigris River after the junction with the Tharthar Canal. In contrast, the low values of Ecological Indices decreased in the Tigris River directly below the confluence area. Therefore, it concludes that the Tigris River Ecological Indices are affected by the Tharthar canal in the values of the river within the study area.

Keywords: Relative Abundance Index, Constancy Index, Species Richness Index, Shannon – Weiner Diversity Index, Species Uniformity Index, Jaccard Presence – Community Index, Tgris River, Tharthar Canal.

1. INTRODUCTION

Rivers have been the most important freshwater resources, along the banks of which ancient civilizations have flourished, and most developmental activities are still dependent upon them [1]. Rivers have multiple uses in every development sector, agriculture, industry, transportation, etc. A considerable quantity of waste from, domestic sewage, and agricultural activity find their way into rivers, resulting from large-scale deterioration of the water quality [2]. Tigris River is one of the Iraqi most crucial surface waters; Baghdad city uses water supplies for drinking and industrial. Therefore, when the Tigris River passes through Baghdad city, it receives discharges of many pollutants, which require continuous monitoring [3].

2. MATERIALS AND METHODS

Study area

Tharthar-Tigris Canal was construct in 1988. It diverted from the left side of the diviion regulator, located on the Tharthar-Euphrates Canal. It continues to the east for 65 Km until the confluence with Tigris River north of Baghdad City. Then, it directly discharges up to 600 m³/s to the Tigris River [4].

Five sites were selected, two on Tharthar Canal and three along Tigris River. The first of the Tigris River is about 2.4 km before the confluence Tharthar Canal with Tigris River at 33°29'04.5"N latitude and 44°18'06.3"E longitude. The second site was on Tharthar at 33°28'27.2"N, 44°07'49.6"E. Third site was on Tharthar Canal before the entrance to the main street (33°28'43.0" 44°14'06.9" E) before the confluence of the canal with Tigris. The

fourth site was on Tigris River, the joining point of Tharthar Canal with Tigris River, at 33°27'46.4"N and 44°18'10.3"E. Fifth site lies in Tigris River near Al-Muthana Bridge area at 33°25'43.0"N, 44°20'39.4"E below the joining point of Tharthar Canal with Tigris River.

Sample collection

Samples were collected monthly from January to December 2020. Water samples were in a well-stopped polyethylene bottle 1000 ml in a 4°C refrigerator. In addition, some properties were conducted on the site directly.

Theoretical concepts

Relative Abundance Index (Ra)

The Relative Abundance Index (Ra) was calculated using the formula of [5] as follows:

$$Ra = \frac{N}{N_s} \times 100$$

Were

N representing the total number of individuals of each taxon in the sample.

N_s representing the total number of individuals in the sample.

The results may be represented as a percentage, as follows:

> 70%: Dominant Species.

70% -40%: Abundant species.

10%-40%: Less abundant species.

< 10%: Rare species.

Constancy Index (S):

By the presence and frequency of each species calculated according to the formula mentioned by [6]:

$$S = \frac{n}{N} \times 100$$

Were

n representing the number of species samples.

N representing the total number of the samples

The results may be represented as a percentage, as follows:

> 50%: Constant species.

25% -50%: Accessory species.

1%-25%:

The Species Richness Index (D*)

This indicator was calculated monthly by using the formula mentioned by [7] as follows:

$$D^* = \frac{(S - 1)}{\log N}$$

Were

S representing the number of species.

N representing the total number of individuals.

Shannon – Weiner Diversity Index (H)

This indicator was calculated monthly for all groups of invertebrates by using the equation of Shannon and Weiner according in the [8] :

$$H = -\sum \frac{n_i}{N} \ln \frac{n_i}{N}$$

Were

n_i representing the number of individual species.

N representing the total number of individuals.

And the result is expressed as the unit bit/Ind.as a bit equal to one piece of information. Values less than 1 bit / Ind. are a little diversified while values more than 3bit/Ind. is most highly diversified [9].

The Species Uniformity Index

The index measured according to the formula contained in the [10]:

$$E = \frac{H}{\ln S}$$

Were

$\ln S$ natural logarithm representing values of H_{max}

H representing the Shannon –Weiner index value.

S representing the number of species in the Site.

Considered values are greater than 0.5 as equal or uniformity in appearance.

Jaccard Presence – Community

This indicator is calculated according to [11] as follows:

$$ISj = \frac{C}{A + B - C} \times 100$$

Were:

A representing the Number of species at Site A.

B representing the Number of species at Site B.

C representing the Number of species found in both Site A and B.

3. RESULTS

Relative Abundance Index (Ra)

The relative abundance index represents the number of individuals of one taxonomic unit compared to the total group of individuals [12], This guide gives information about the extent to which individuals contribute to the total number of organisms, and that the increase in the values of this index for species resistant to pollution gives Evidence for the lack of biodiversity in their locations [13].

During the study period, the Ra over the study period ranged between 42.6- 167 in all sites. The lowest Relative Abundance Index was 42.6 in sit-2 during winter, while the highest Relative Abundance Index was 167 in site-3 during Summer (Figure , Table 1).

The abundance and presence of plankton in general is affected by many physical and chemical factors of water, availability of food, and predation by other aquatic organisms. The abundance increases when there are high levels of dissolved oxygen, low water flow rate, and

dense vegetation cover [14], as well as the availability of adequate lighting for the growth of phytoplankton and consequently the zooplankton that depend on it as a suitable food for them [15].

The correlation of Relative Abundance Index between site-1, site-2, site-3, and site-4 were $r=0.5826, -0.7858, 0.6253$ and, 0.9169 respectively.

Non-significant differences in Relative Abundance Index were recorded between months during the study period in all locations.

Table 1. Seasonal values for Relative Abundance Index of Taxa through the study periods.

Sea-	Tigris site-1	Tharthar site-2	Tharthar site-3	Tharthar site-4	Canal Joined	Ti- site-	LSD
Au-	130	73	59		78	141	14.5
Win-	87	42.60	100		48	85	9.06
Sprin	121	100	63		154	113	15.7
Sum	91	79	167		63	60	19.1
LSD	12.37*	11.82 *	17.54 *		15.42 *	18.0	---

* ($P \leq 0.05$).

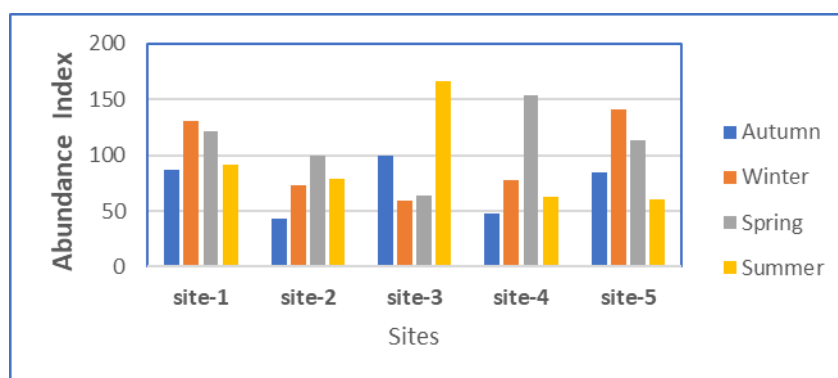


Figure 1. Seasonal values for Relative Abundance Index of Taxa through the study periods.

Constancy Index (S):

The stability index refers to the stability of taxonomic groups in their environments and the nature of their recurrence [16]. It also tends to express the sensitivity of species to environmental changes, which include species resistant or sensitive to pollution [17]. Some of them are widely visible and widespread because they tolerate a wide range of environmental conditions and the presence of more than one generation with their reproduction [18].

During the study period, Constancy Index over the study period ranged between 4.84-34.14 in all sites. The lowest Constancy Index was 4.84 in sit-1 during autumn, while the highest Constancy Index was 3.414 in site-4 during summer (Figure Error! **No text of specified style in document.2**, Table 2).

In general, stability is affected by many factors, including temperature, salinity, turbidity, lighting, and the presence or absence of predators. The most stable species are characterized by a wide range of tolerance to change in environmental conditions [19].

The correlation of Constancy Index site-1, site-2, site-3, and site-4 were $r=0.3527, 0.3527, 0.2476$ and, -0.3117 respectively. Non-significant differences in Constancy Index were recorded between months during the study period in all locations.

Table Error! No text of specified style in document.. Seasonal values for Constancy Index of Taxa through the study periods.

Sea- son	Tigris River	Tharthar Canal	Tharthar Canal	Tharthar Canal Joined Tigris River	Ti- gris Riv- er	LSD
	site-1	site-2	site-3	site-4	site-5	
Au- tumn	4.84	5.13	6.40	6.39	8.37	8.92 *
Win- ter	7.52	11.28	12.85	6.06	11.5 3	10.4 7 *
Sprin- g	17.98	12.34	15.59	12.33	7.23	13.8 7 *
Sum- mer	10.54	23.21	6.29	3.41	13.7 0	11.0 6 *
LSD	17.84 *	15.07 *	11.67 *	17.93 *	10.4 1 *	---

* ($P \leq 0.05$).

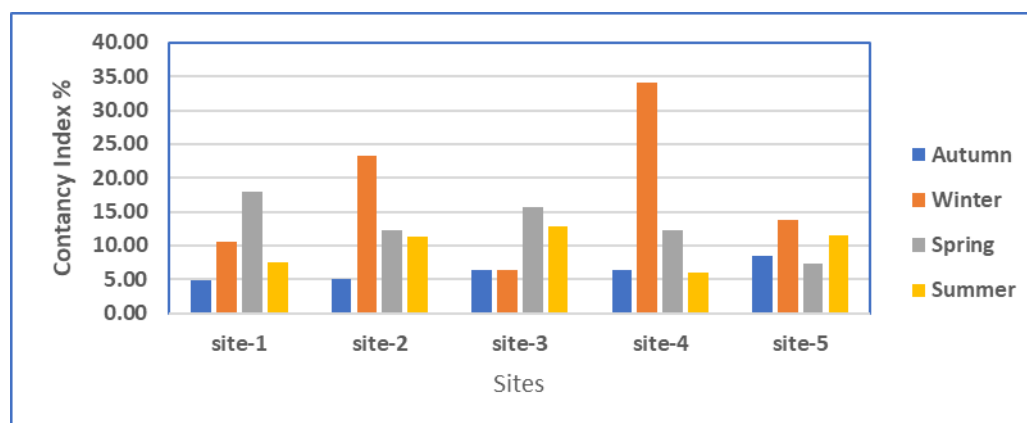


Figure Error! No text of specified style in document.2. Seasonal values for Constancy Index of Taxa through the study periods.

The Species Richness Index (D*)

During the study period, Species Richness Index ranged between 0.44-3.34 in all sites. The lowest value was 0.44 in site-5 during Autumn and the highest value was 3.44 in site-3 during Summer, (Figure Error! No text of specified style in document.31, Table 3.31).

The range of the index values ranges from (0 to infinity), that is, the higher the index value indicates the high diversity of algae [20], as indicated by [21], and [22]. In the natural conditions, the water quality is appropriate to increase diversity due to the wide range of suitable growth conditions to increase diversity, and when there are critical conditions such as lack of plant nutrients, this reduces the presence of many species and limits productivity.

The correlation of Species Richness Index site-1, site-2, site-3, and site-4 were $r = -0.7702$, -0.9796 , -0.6924 and, -0.2254 respectively.

Significant differences of Species Richness Index in site-3, and non-significant difference in sites 2, 4 and 5 were recorded between months during the study period.

Table **Error! No text of specified style in document..** Seasonal values for Richness Index of Taxa through the study periods.

Season	Tigris River	Tharthar Canal	Tharthar Canal	Tharthar Canal Joined Tigris River	Tigris River	
	Site-1	Site-2	Site-3	Site-4	Site-5	LS D
Autumn	2.818	2.395	2.875	2.306	0.44	0.763 *
Winter	3.245	2.185	2.005	2.177	0.5376	0.977 *
Spring	2.846	2.658	2.718	3.163	0.5056	0.804 *
Summer	2.351	2.616	3.34	3.083	0.5632	0.816 *
LSD	0.798 *	0.578 NS	0.892 *	0.712 *		---

* ($P \leq 0.05$).

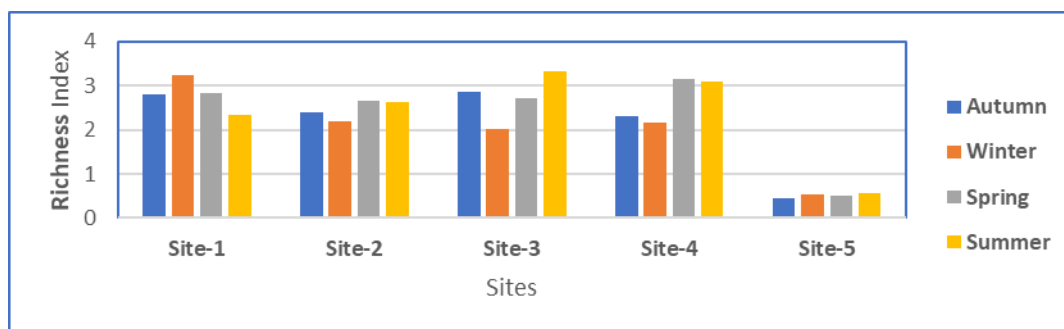


Figure **Error! No text of specified style in document..** Seasonal values for Richness Index of Taxa through the study periods

Shannon – Weiner Diversity Index (H)

The Diversity Index is one of the most important and most widely used guides, as it is considered an appropriate way to know the nature of biological communities, as it is possible to obtain important information about the prevalence or scarcity of species in a biological community and its reflection on the water quality in that community.

During the study period, Shannon–Weiner Diversity Index over the study period ranged between 0.435-3.342 in all sites, The lowest Shannon–Weiner Diversity Index was 0.435 in site-5 during summer, while the highest Shannon – Weiner Diversity Index (H) was 3.342 in site-3 during winter (Figure **Error! No text of specified style in document..**, (Table 4).

Where the highest values were recorded in the winter season, due to the rainy season and the washing away of nutrients from the neighboring soils, which leads to an increase in nutrients that lead to the diversity of algae [23], and the lowest values were recorded in the summer

due to the low water level and high temperatures, which negatively affect the growth of algae and diversity of algae [24].

This guide represents a measure of water quality and the extent of its pollution [25], so if the value is more than 1, the water is clean; but if the value is from 1-3, the water is moderately polluted; but if the value is less than 1, the water is highly polluted.

The correlation of Shannon–Weiner Diversity Index site-1, site-2, site-3, and site-4 were $r = -0.5142, 0.7521, -0.5630$ and, 0.1252 respectively.

Non-Significant differences in Shannon–Weiner Diversity Index were recorded between months during the study period in all locations.

Table **Error! No text of specified style in document..** Seasonal values for Shannon - Weiner Diversity Index of Taxa through the study periods.

Season	Tigris River	Tharthar Canal	Tharthar Canal	Tharthar Canal Joined Tigris River	Tigris River	
	site-1	site-2	site-3	site-4	site-5	LSD
Autumn	3.245	2.185	2.005	0.5376	2.177	1.07 *
Winter	2.351	2.616	3.342	0.5632	3.083	1.16 *
Spring	2.846	2.658	2.718	0.5056	3.163	0.866 *
Summer	2.818	2.395	2.875	2.306	0.435	0.844 *
LSD	0.705 *	0.591 NS	0.894 *	0.325 NS	0.785 *	---

* ($P < 0.05$).

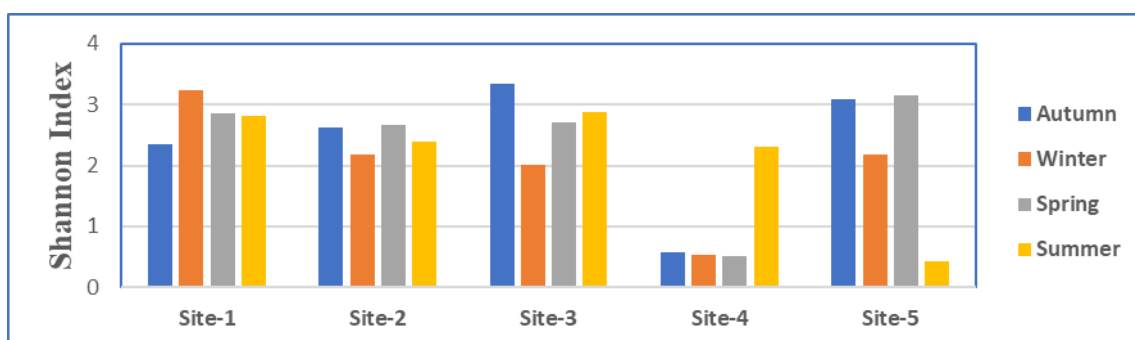


Figure **Error! No text of specified style in document..** Seasonal values for Shannon - Weiner Diversity Index of Taxa through the study periods.

The Species Uniformity Index

This evidence expressed the degree of equal number of individuals for each type in the sample, and the values of this indicator range between (0-1).

During the study period, Species Uniformity Index over the study period ranged between 0.184- 0.7794 in all sites. The lowest Species Uniformity Index was 0.183 in sit-5 during winter, while the highest Species Uniformity Index was 0.7794 in site-4 during Summer (Figure , Table 5).

Low values indicate the dominance of one or more species and have a strong impact on the ecosystem, while high values indicate the equal abundance of each species and thus have a limited impact on the ecosystem when adding or removing any type of one sample [26]. The correlation of Species Uniformity Index site-1, site-2, site-3, and site-4 were $r = -0.5142$, 0.7521 , -0.5630 and 0.1252 respectively. Non-Significant differences in Species Uniformity Index were recorded between months during the study period in all locations.

Table 5. Seasonal values for Uniformity Index of Taxa through the study periods.

Season	Tigris River	Tharthar Canal	Tharthar Canal	Tharthar Canal Joined Tigris River	Tigris River	
	site-1	site-2	site-3	site-4	site-5	LSD
Autumn	0.6937	0.4042	0.571	0.4901	0.5654	0.412 NS
Winter	0.5075	0.2741	0.3773	0.3135	0.184	0.398 NS
Spring	0.4785	0.6206	0.4736	0.5629	0.644	0.347 NS
Summer	0.3619	0.5947	0.4218	0.7794	0.486	0.455 NS
LSD	0.377 NS	0.409 NS	0.321 NS	0.487 NS	0.371 NS	0.326 NS

NS: Non-Significant.

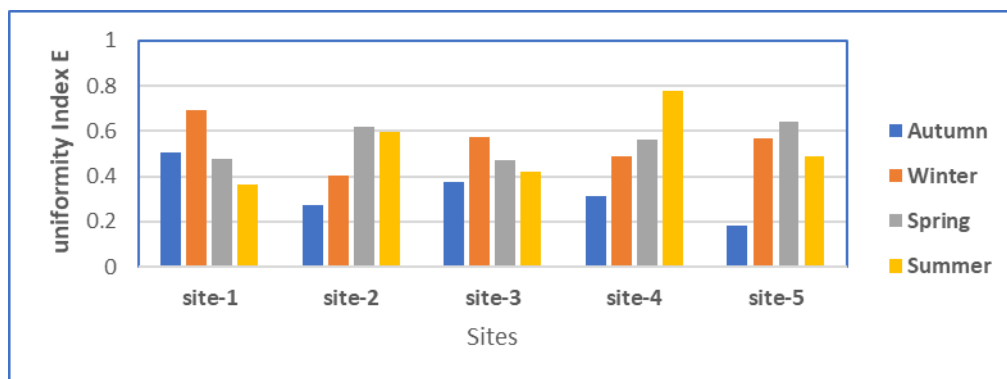


Figure 5. Seasonal values for Uniformity Index of Taxa through the study periods. Jaccard Presence – Community

During the study period, Jaccard Presence - Community Index over the study period ranged between 0.840764-0.9925 in all sites, The lowest Jaccard Presence – Community Index was 0.840764 in sit-3 during Summer, while the highest Jaccard Presence–Community Index was 0.9925 in site-1 during Winter (Figure Error! **No text of specified style in document.**, Table 6). The variation in the similarity values between the stations is due to the physical and chem-

ical characteristics, the properties of water, the presence of plants, and the suitability of these factors for the growth of plankton [27], as any change in the physical and chemical factors of water quality is reflected in the presence of species and their relationship with each other. Significant differences in Jaccard Presence – Community Index were recorded between months during the study period in all locations.

The correlation of Jaccard Presence–Community Index site-1, site-2, site-3, and site-4 were $r = -0.6079, 0.6992, 0.3095$ and -0.8572 respectively. Non-Significant differences in Jaccard Presence – Community Index were recorded between months during the study period in all locations.

Table **Error! No text of specified style in document..** Seasonal values for Jaccard Presence Index of Taxa through the study periods.

Sea- son	Tigris River	Tharthar Canal	Tharthar Canal	Tharthar Canal Tigris River	Ti- gris Riv er	LSD
	site-1	site-2	site-3	site-4	site- 5	
Au- tumn	0.98	0.95	0.94	0.92	0.97	0.18 NS
Win- ter	0.99	0.94	0.92	0.97	0.94	0.20 NS
Sprin g	0.96	0.981	0.97	0.97	0.95	0.17 NS
Sum mer	0.93	0.97	0.84	0.94	0.99	0.23 NS
LSD	0.26 NS	0.21 NS	0.20 NS	0.19 NS	0.18 NS	---

NS: Non-Significant.

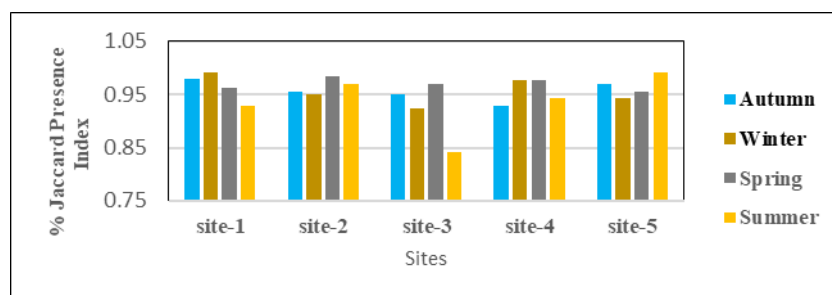


Figure **Error! No text of specified style in document..** Seasonal values for Jaccard Presence Index of Taxa through the study period.

4. CONCLUSIONS

1. The lowest value of Relative Abundance Index was in joining point of Tharthar canal and Tigris River, whereas the highest values was in Tharthar canal.
2. The lowest value of Constancy Index was in joining point of Tharthar canal and, whereas

the highest values was in Tigris River.

3. The lowest value of Species Richness Index was in Tigris River, whereas the highest values was in Tharthar canal.
4. The lowest value of Shannon – Weiner Diversity Index was in Tigris River, whereas the highest values was in Tharthar canal.
5. The lowest value of Species Uniformity Index was in Tigris River, whereas the highest values was in joining point of Tharthar canal and Tigris River.
6. The lowest value of Jaccard Presence – Community Index was in Tigris River, whereas the highest values was in Tharthar canal.

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