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Evaluation of the Impact of Pollution on Aquatic Organisms in the El-Tebbin Industrial Area

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ABSTRACT

Biological tracking refers to the use of microorganisms' physical reactions to evaluate environmental changes. The relationship between algal, protozoan and related physical-chemical properties in the highly industrial Helwan and El-Tebbin area was the focus of this study. Four sites are included in the study region south of Helwan City: El-Shorafa (I, II), El-Hekr (Canals) and El-Tebbin drain. An excellent indication of the chemical quality of surface waters is the analysis of chemical parameters for water. The concerns of water chemistry and ecological condition are integrated into biological metrics, which are used as a guide for evaluating biological communities. Various environmental factors as well as the populations of algae and protozoa were addressed. Certain algae species and other factors were found to be correlated using statistical analysis and Palmer's index of pollution. The final findings showed that the El-Tebbin industrialized region is a somewhat organically polluted area due to the presence of major microalgae such as *Synedra, Chlorella, Cyclotella, Melosira* and *Pediastrum* that are thought of as bio-indicators. Furthermore, the presence of species of ciliated protozoa that are thought to be the most pollution-tolerant include *Vorticella, Tintinnidium, Strombidiom, Burselopsis* and *Arcella.* Utilizing living organisms to bio-monitor organic and inorganic contaminants has recently attracted increasing interest. This study suggests using the recorded bio-indicators in organic pollution management.

INTRODUCTION

The ecosystem has become contaminated with a wide range of natural and inorganic pollutants as a result of the rapid expansion of various industrial operations. Because of these contaminants, aquatic ecosystems have become less stable, which has raised questions about effective wastewater management reuse and detrimental repercussions on both the environment and human health **(Lim *et al.*, 2010; Varsha *et al.*, 2011; Maria & Inés, 2017)**. Water bodies may now be more contaminated with heavy metals (HMs) as a result of urbanisation, industrialisation and natural earth processes. Natural factors like wind and floods, as well as human-caused activities release HMs into the environment **(Gupta *et al.*, 2016)**.

As a result of consuming contaminated food and water, these HMs can build up in people. Heavy metals (HMs) are a significant global problem for surface and subsurface water contamination **(Kobielska *et al.*, 2018)**. Due to its toxicity to plants, animals and people's health, HMs poisoning of aquatic habitats is a serious issue. Several algae species have been identified as potential low-cost substitutes for pysico-chemical remediation approaches as well as promising candidates for the removal and/or detoxification of HMs **(Salama, *et al.*, 2019)**.

It has been widely used to remove toxic metals industrial and domestic treated wastewater due to organisms' direct binding for metals and their capacity to concentrate such pollutants by a number of mechanisms **(Zafar *et al.*, 2007; Ansari & Malik, 2007)**. **Rehman *et al.* (2008)** found that, due of their small size, living organisms have a high surface area per unit volume, which gives organisms a huge contact area for reacting with metals in water. Utilization of aquatic creatures for bioremediation has grown recently, and these organisms play a crucial bio-sorption function in regulating biotic stress (heavy metals) and hazardous chemicals (organic pollutants) in aquatic ecosystems **(Ahamed & Malik, 2011)**. As a result of tolerance mechanisms, some species of algae exhibit a high potential for absorbing and accumulating heavy metals, and many algae produce phytochelatins and metallothioneins that can bind to heavy metals and transport them into vacuoles **(Anbalagan & Sivakami, 2018)**. Additionally, some algae species contribute significantly to the water system's ability to purify itself, reflect aquatic environmental conditions and assess the effects of toxins associated with organic wastes **(Kshirsagar, 2013)**. An essential component of the pond ecology, fresh water algae (FA) serves as the base of the food chain. They give fish and other lake species food and energy and have the capacity to absorb nutrients and heavy metals.

Protozoa are sensitive to little amounts of human-made toxins; certain species can endure harsh conditions, while others can respond swiftly to environmental changes. As a result, they frequently develop into a special biotic instrument for comprehending the ecological state of an aquatic area. Protozoans are known to be natural bio-sorbents that can withstand high metal ion concentrations. Traditional heavy metal remediation procedures for contaminated soils and streams are costly and only useful in small regions **(Ayansina & Babalola, 2017)**. Efforts have been made to look for new eco-friendly cost effective technologies that include the use of biological bio-sorbents, microorganisms, biomass, and live plants that have various mechanisms of metal sequestration **(Srivastava *et al.*, 2015l; Mosa *et al.*, 2016)**. In addition, protozoans play main role in metabolizing of toxic metal ions such as cupper, mercury, lead, zinc, cadmium and other toxic compounds in industrial effluents **(Majid, 2010; Akpor *et al.*, 2014)**.

The aim of the present study was to investigate the capability fresh water algae and free living protozoa in adapting and tolerating organic and heavy metals water pollution in industrial area.

MATERIALS AND METHODS

Description of study area

The industrial and sanitary wastewaters disturb environmental balance of waterways that affect shallow and deep groundwater. The investigated area (Helwan) is reprehensive of industrial areas with great residential in Egypt. It is located in the extreme south of Cairo governorate between latitudes 31° 15´ and 31° 23´ N and longitudes 29° 44´ and 29° 52´ 30″E at the East of the River Fig. (1). The industrial area is restricted to 40 kilometer southern Cairo and the industries are concentrated in southern Helwan more than in the north of these industries (90 companies and workshops approximately) produce about 300 tons /day wastes including organic biodegradable materials and trace metals. The study chose four areas in the El-Tebbin area in south Helwan city: El-Tebbin drain, El-Hekr canal, and two sites of El-Shorafa canal (start and end) (IV). The drainage effluent from these canals, which are flanked by several industrial factories like the Iron and Steel Company Factory on the right side of the Nile, is a mixture of agricultural and industrial wastes. Sampling was done to examine the state of the aquatic environment at the researched sites for chemical, physicochemical and organismal populations. The preservation and sampling were done in accordance with industry standards for waste and water analysis **(APHA, 2012)**.

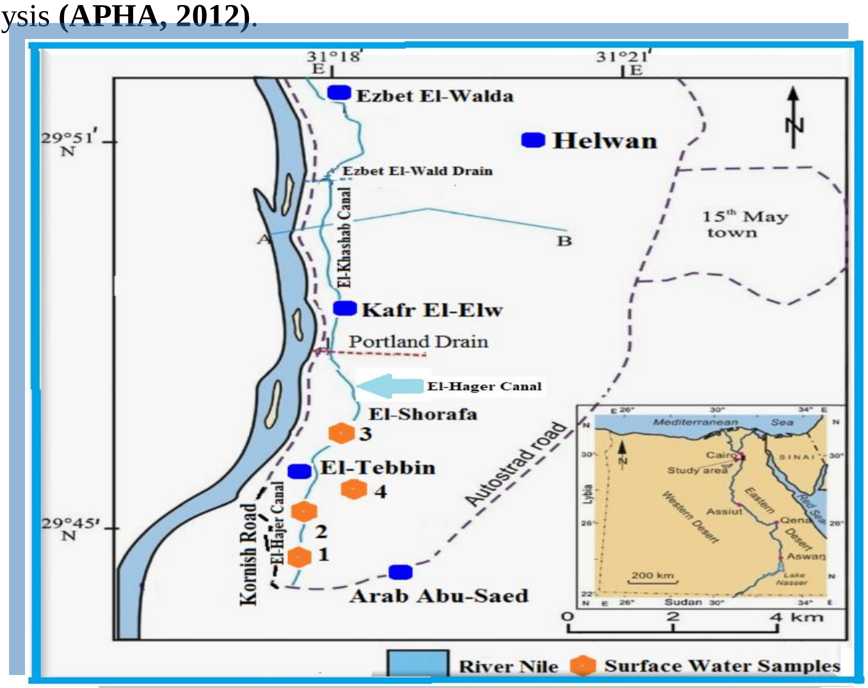

Fig. 1. Location of Study along Helwan Area Environmental Sampling Program

To verify data accuracy, field parameters including pH, electric conductivity (EC-ms), and total dissolved solids (TDS-mg/l) were measured on-site using a multi-probe system, model Hydra Lab-Surveyor. The results were then double-checked in the lab using the following bench-top equipment. Water samples were collected from each site in a variety of containers in accordance with the parameters that needed to be assessed for physical and chemical analysis. For the purpose of analyzing trace elements, one sample bottle of polyethylene was acidified with 2 ml of nitric acid. Algae samples were collected in a clean container and filtered through a 20-mm net mesh that was treated with Lugol's solution for bio-indicators **(APHA, 2012)**. The protozoa were sampled by collecting one liter of water in plastic container for each point, preserved in 4 % neutralized formalin solution, and their volumes were adjusted to 50ml in the laboratory by settling and removing the supernatant **(Amer, 2007**). Algae and protozoa identification were carried out by Sedgwick Rafter counting method **(APHA, 2005)** using the American optical Leica DM 750 binocular research microscope, fitted with Cat Com Digital Image camera that was used to take microphotograph of each specimen, and algae density was expressed on organism/liter. The algae were identified by following different monographs **(Edmondson, 1959; Verlecar & Desai, 2004; Bellinger & Sigee, 2010)**. The protozoa were identified in the studies of **Needham and Needham (1962)**, **Dhanapathi (1976)** and **Kumar *et al.* (2011)**. For chlorophyll analysis, samples were filtered again with Whatman GF/C membranes to measure chlorophyll using spectrophotometer DR-3600 - after acetone extraction **(Golterman *et al.*, 1978)**.

Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) with Ultra Sonic Nebulizer (USN) type Perkin Elmer Optima 3000 was used to examine trace elements (Al, Ba, Cu, Fe, Pb, Mn, Sr, and Zn) for laboratory examination. Before analysis, the materials were filtered using a membrane filtration system with a 0.45 um pore size. In addition, repeated measurements of the standard solution's multi-element 1000 mg/l concentration were used to confirm the analysis's accuracy and precision (Merck, Darmstadt German). For the estimations of overall suspended solids (TSS) and alkalinity (carbonate and bi-carbonate), respectively, gravimetric and titration methods have been used. Whole micronutrients (nitrogen and phosphorus) were tested that use the per-sulphate decomposition procedure at 120°C to gauge their susceptibility to organic analyses.

Palmer index

Palmer (**1969**) developed a method to determine the level of organic pollution by tudying the algae present in a sample of water. A pollution index factor of 1 through 5 has been assigned to each of the 20 types of algae depending on their relative tolerance to organic pollution. Algal pollution index was established for use in rating water samples for high or low organic pollution as shown in Table (1).

Table 1. Palmer's Index

Score	Pollution class
0-10	Lack of Organic Pollution
10-15	Moderate Organic Pollution
15-19	Probable Organic Pollution
≥20	High Organic pollution

RESULTS AND DISCUSSION

Aquatic communities may suffer from organic and heavy metal pollution in the environment. In order to safeguard human health and other global ecosystems, it is necessary to protect water against pollution and contamination **(Akbar and Darvish, 2014; Beni and Akbar, 2020)**. Heavy metals can be removed from wastewater using microalgal biosorption, which has proven to be an environmentally friendly alternative. Microalgae serve as a viable feedstock for heavy metal biosorption due to their rapid and strong growth in a variety of industrial waste and resistance to pollutants **(Ubando *et al.*, 2021)**. As a result of various contaminants, El-Tebbin and Helwan's water resources receive a significant amount of industrial effluent, which has now turned ecological contamination caused by several companies into a national environmental problem. Table (2) provides an overview of the average information from samples that were collected and analyzed from four sampling locations in the Helwan-El-Tebbin area on a monthly basis during the study period.

The absorption of heavy metals results from physic-chemical interactions of metal ions with cellular components of living species; this phenomenon revealed to be specifically caused by the cell wall structure of some algae. Because of their significant sorption capacity and their presence in large quantities in surface water, algae are one of the most interesting forms of biosorbents that are being researched and developed as new bio-sorbent materials **(Abbas *et al.*, 2014)**. By using absorption mechanisms and phytochelatins, which they produce in response to harmful heavy metal stress, microalgae can sequester heavy metal ions. Algal species differences in heavy metal removal effectiveness are evident. In reality, studies have demonstrated the effectiveness of metal removal by several species, with lead and copper being successfully removed by chlamydomonas and *chlorella vulgaris*, respectively **(Sen *et al.*, 2013)**.

Table 2. Average values of measured parameters (mg/l)

No.	**Parameter**	**El- Shorafa Canal (I)**	**El- Shorafa Canal (II)**	**EL Haker Canal (III)**	**El-Tebbin Drain (IV)**	**Egyptian Law 92/2013**
1	**pH**	7.24 ± 0.055	7.20± 0.021	7.73± 0.02	7.40± 0.010	6.5-8.5
2	**HCO_3**	244± 1.155	278.2± 0.252	197.6± 2.55	212.3± 0.451	--
3	**EC**	0.929± 0.001	4.320 ± 0.01	0.440± 0.02	0.452± 0.002	--
4	**TDS**	594± 4.0	3024± 2.082	282± 5.0	289± 0.577	1000
5	**TSS**	7± 0.058	18 ± 0.058	4± 0.1	9± 0.20	--
6	**OP**	0.200± 0.006	0.329± 0.003	0.065± 0.001	0.057± 0.002	--
7	**TP**	0.0± 0.001	0.03± 0.001	0.083± 0.002	0.089± 0.001	--
8	**TN**	2.22± 0.02	2.88± 0.006	2.81± 0.015	4.97± 0.006	--
9	**COD**	15± 0.1	12± 0.058	14± 0.058	23± 0.058	<50
10	**Al**	0.034± 0.002	0.006± 0.001	0.113± 0.011	0.053± 0.003	--
11	**Ba**	0.051± 0.001	0.055± 0.004	0.096± 0.001	0.039± 0.001	--
12	**Cu**	0.026± 0.001	0.028± 0.001	0.015± 0.001	0.018± 0.001	<1
13	**Fe**	0.008± 0.001	0.008± 0.0	0.008± 0.008	0.008± 0.0	<3
14	**Pb**	0.003± 0.001	0.003± 0.0	0.003± 0.001	0.003± 0.0	<0.1
15	**Mn**	0.005± 0.001	0.005± 0.001	0.005± 0.0	0.005± 0.001	<2
16	**Sr**	0.883± 0.002	1.42 ± 0.01	0.347± 0.001	0.324± 0.002	--
17	**Zn**	0.001± 0.001	0.001± 0.001	0.001± 0.001	0.001± 0.001	<2
18	**Chl *a***	39.85± 0.006	96.44± 0.015	8.25± 0.045	13.86± 0.01	--

This research examined the correlation involving metals and algae dominant species. Al and Ba had a favorable connection (r = 0.9) with *Synedra* and *Pediastrum*. It was discovered that Cu and *Chlorella* (r = 0.834) and *Oscillatoria* (r=0.9) also had a favorable connection. Sr and *Chlorella* and *Cyclotella* showed a substantial correlation (r = 0.9). *Chlorella* spp. abundance (ranging from 40% to almost 55% of the entire Chlorophceae group) may be responsible for the significant decreasing level of heavy metals like Cu in El-Shorafa drains; this finding is consistent with that of **Sen *et al.* (2013)** (Table 3a).

Palmer's Algal Genus Index values can be effectively used to demarcate the areas of a water body which is susceptible to organic pollution **(Palmer, 1969)**. Based on Palmer's assessment, the study identified 35 genera of algae; the results showed that out of (35) genera, (20) pollution tolerant genera were found at all sampling stations of El-Tebbin industrial area (Table 4a). Pollution tolerant genera recorded in area of study belongs to four categories Chlorophyceae (Ch-6), Euglenophyceae (E-2), Bacillariophyceae (B-6) and Cyanophyceae (Cy-6) constituting the algal flora and their distribution, as shown in Table (4b). According to Palmer's Algal Pollution Index values between 0-10 indicate lack of organic pollution, 10-15 moderate pollution, 15-20 probable high organic pollution and 20 and above as confirmed high organic pollution. **Khare and Saxena (2013)** supported the high adsorption, bioaccumulation and clarification of the natural bio-sorption for organic pollution of the *Chlorella*, *Oscillatoria* and *Scenedesmus* genera. The obtained results explained organic pollution levels at El-Shorafa Canal (I, II), El-Hekr Canal (III) and El-Tebbin Drain (IV) (Table 4b).

El-Hekr Canal (III) and El-Tebbin Drain (IV) sites have probable organic pollution (Total scores = 15-19) according to the results, while El-Shorafa Canal (I, II) sites have proven significant organic pollution (Total scores >20). The high index value represents local human activity and industrial effluent issues (Fig. 3).

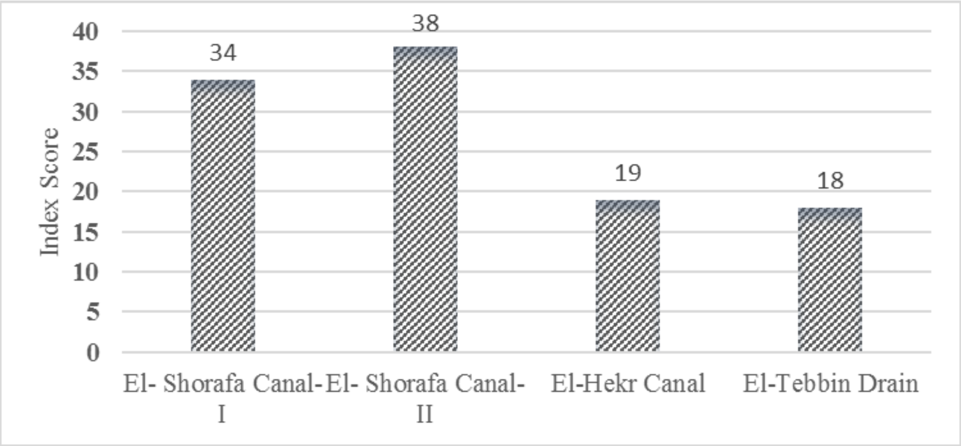

Fig. 3. Palmer's pollution index levels in investigated area

Table 3a. Correlation matrix between algal species and heavy metals

	Al	Ba	Cu	Fe	Pb	Mn	Sr	Zn	Chlorella	Synedra	Cyclotella	Melosira	Pediastrum	Oscillatoria	Scenedesmus
Al	1														
Ba	0.7620	1													
Cu	-0.9191	-0.504	1												
Fe	0.2036	0.242	0.098	1											
Pb	0.4234	-0.264	-0.654	0	1										
Mn	-0.4234	0.264	0.654	0	-1	1									
Sr	-0.8242	-0.261	0.933	-0.079	-0.861	0.861	1								
Zn	0.8105	0.874	-0.516	0.636	0.000	0.000	-0.438	1							
Chlorella	-0.8068	-0.274	0.834	-0.353	-0.828	0.828	0.960	-0.560	1						
Synedra	0.9151	0.957	-0.728	0.205	0.023	-0.023	-0.527	0.885	-0.517	1					
Cyclotella	-0.8053	-0.291	0.811	-0.408	-0.804	0.804	0.942	-0.593	0.998	-0.525	1				
Melosira	-0.6442	-0.118	0.640	-0.541	-0.813	0.813	0.851	-0.510	0.958	-0.340	0.967	1			
Pediastrum	0.9138	0.952	-0.744	0.147	0.026	-0.026	-0.531	0.856	-0.504	0.998	-0.509	-0.313	1		
Oscillatoria	-0.7516	-0.148	0.909	0.010	-0.908	0.908	0.991	-0.316	0.931	-0.428	0.907	0.823	-0.435	1	
Scenedesmus	-0.7319	-0.773	0.422	-0.771	-0.031	0.031	0.407	-0.981	0.574	-0.782	0.614	0.579	-0.744	0.286	1

Table 3b. Correlation matrix between algal species and physical parameters

	Chlorella	Synedra	Cyclotella	Melosira	Pediastrum	Oscillatoria	Scenedesmus	Chl a	COD	TN	TP	OP	TSS	TDS	EC	HCO3
Chlorella	1															
Synedra	-0.517	1														
Cyclotella	0.998	-0.525	1													
Melosira	0.958	-0.340	0.967	1												
Pediastrum	-0.504	0.998	-0.509	-0.313	1											
Oscillatoria	0.931	-0.428	0.907	0.823	-0.435	1										
Scenedesmus	0.574	-0.782	0.614	0.579	-0.744	0.286	1									
Chl a	0.995	-0.452	0.996	0.982	-0.434	0.905	0.571	1								
COD	0.990	-0.437	0.994	0.988	-0.417	0.888	0.583	0.999	1							
TN	-0.295	-0.232	-0.239	-0.176	-0.190	-0.606	0.584	-0.267	-0.240	1						
TP	-0.987	0.438	-0.981	-0.997	0.441	-0.999	-0.446	-0.993	-0.992	0.556	1					
OP	0.955	-0.524	0.936	0.843	-0.529	0.993	0.395	0.927	0.911	-0.513	-0.998	1				
TSS	0.941	-0.638	0.958	0.934	-0.610	0.761	0.811	0.943	0.948	0.045	-0.899	0.820	1			
TDS	0.989	-0.415	0.992	0.990	-0.396	0.891	0.564	0.999	1.000	-0.257	-0.995	0.911	0.939	1		
EC	0.990	-0.421	0.993	0.988	-0.402	0.896	0.561	0.999	1.000	-0.265	-0.995	0.916	0.939	1.000	1	
HCO3	0.950	-0.677	0.937	0.821	-0.678	0.952	0.536	0.914	0.898	-0.372	-0.965	0.981	0.868	0.893	0.898	1

Table 4a. Algal species and their distribution

No	Algal genera	Group	Total count	Sites			
				1	II	III	IV
1	*Synedra*	B	2538	+	+	+	+
2	*Chlorella*	Ch	838	+	+	+	+
3	*Cyclotella*	B	640	+	+	+	+
4	*Melosira*	B	522	+	+	+	+
5	*Pediastrum*	Ch	432	+	+	+	+
6	*Oscillatoria*	Cy	396	+	+	-	-
7	*Scenedesmus*	Ch	362	+	+	-	+
8	*Oocystis*	Ch	318	+	+	+	+
9	*Gomphosphaeria*	Cy	254	+	+	+	+
10	*Merismopedia*	Cy	234	+	+	+	+
11	*Microcystis*	Cy	206	-	+	+	+
12	*Euglena*	E	136	+	+	-	-
13	*Dictyosphaerium*	Ch	128	+	+	+	-
14	*Navicula*	B	128	-	+	-	+
15	*Micractinium*	Ch	96	+	+	-	-
16	*Selenastrum*	Ch	80	+	-	+	-
17	*Lagerheimia*	Ch	66	+	+	+	+
18	*Ankistrodesmus*	Ch	64	+	+	-	+
19	*Golenkinia*	Ch	50	+	+	-	+
20	*Phormidium*	Cy	50	+	+	-	+
21	*Coelastrum*	Ch	36	-	+	+	-
22	*Staurastrum*	Ch	36	+	+	-	-
23	*Microcystis*	Cy	36	-	+	+	+
24	*Sphaerocystis*	Ch	32	+	-	-	-
25	*Nitzschia*	B	32	-	-	+	-
26	*Phacus*	E	32	-	-	+	-
27	*Lyngbya*	Cy	30	-	-	+	+
28	*Spirulina*	Cy	30	-	-	+	+
29	*Kirchnerella*	Ch	28	-	-	-	+
30	*Chroococcus*	Cy	28	-	-	-	+
31	*Chlamydomonas*	Ch	20	-	+	-	-
32	*Errella*	Ch	20	-	+	-	-
33	*Ceratium*	D	16	-	-	+	-
34	*Anabaena*	Cy	16	-	-	+	-
35	*Cymbella*	B	14	-	-	-	+

According to the current study, algal genus pollution index station El-Shorafa (I & II) total scores were 34 and 38, respectively. As bio-indicators for the eutrophic condition of water chemistry, the results demonstrated a strong link between *Chlorella, Cyclotella, Melosira* and *Oscillatoria* and phosphorus. These findings are in line with those of **Kshirsagar and Gunale (2011)** and **Kshirsagar *et al.*, (2012)**. **Palmer (1969)** found the most tolerant of his sixty genera to contamination is the genus *Euglena*. *Euglena* and *Oscillatoria* are extremely pollution-tolerant taxa and, as a result, trustworthy markers of eutrophication, according to a research by **Patrick (1965)**. By looking to pollution of Palmer's index at El-Shorafa drains results showed that; this area had high organic pollution, while El-Hekr and El-Tebbin drain stations suggest moderate organic pollution. The key processes for heavy metal tolerance, storage or intake depend on a variety of variables, including the architecture of the algal species, the environment or the growing mediums **(Benchraka, 2014)**.

Table 4b. Tolerant pollution and index values in industrial area

Algal genera group	**Tolerant pollution & index weight value**			
	I	**II**	**III**	**IV**
Chlorophyceae (Ch-**6**)				
Chlorella	+(4)	+(4)	+(4)	+(4)
Pediastrum	+(4)	+(4)	-(0)	-(0)
Scenedesmus	+(3)	+(3)	-(0)	-(0)
Micractinium	+(2)	+(2)	-(0)	-(0)
Chlamydomonas	+(0)	+(1)	-(0)	-(0)
Ankistrodesmus	+(1)	+(1)	-(0)	+(1)
Euglenophyceae (E-**2**)				
Euglena	+(2)	+(2)	-(0)	-(0)
Phacus	-(0)	-(0)	+(1)	-(0)
Bacillariophyceae (B-**6**)				
Navicula	-(0)	+(2)	-(0)	-(0)
Synedra	+(5)	+(5)	+(5)	+(5)
Melosira	+(4)	+(4)	-(0)	-(0)
Cymbella	-(0)	-(0)	-(0)	+(1)
Cyclotella	+(4)	+(4)	+(4)	+(4)
Nitzschia	-(0)	-(0)	+(1)	+(1)
Cyanophyceae (Cy-**6)**				
Anabaena	-(0)	-(0)	+(1)	-(0)
Oscillatoria	+(4)	+(4)	-(0)	-(0)
Lyngbya	-(0)	-(0)	+(1)	+(1)
Microcystis	-(0)	+(1)	+(1)	+(1)
Phormidium	+(1)	+(1)	-(0)	-(0)
Spirulina	-(0)	-(0)	+(1)	+(1)
Total of Occurrence (+ & -)	**11**	**14**	**9**	**8**
Index weight value	**34**	**38**	**19**	**18**

Protozoans are sensitive indicators of water chemistry quality to specify the load of organic matter in surface waters and their putrefaction levels **(Sarma *et al.*, 2016)**. Protozoa group plays a vital role for pollution degree in aquatic environment. Protozoa may be attributed to the effect of swage dumping from Iron and steel factory, this indicates that it has the ability to tolerate high pollution and similar observation recorded by **Ibrahiem (2013)** in the Nile River. The checklist of protozoa recorded 45333 Org./l., this indicated that it has the ability to tolerate high pollution. The populations' variety of microorganisms seems to fluctuate depending upon heavy metals concentrations and other organic contaminates **(Ibrahiem, 2013)**. The most important ciliate communities that dominated the study area were that of *Vorticella, Tntinnidium, Strombidiom, Burselopsis* and *Arcella*, which are considered as the most pollution tolerant ciliated protozoan species. The average account of recorded species was *Tintinnidium, Vorticella, Strombidium, Burselopsis* and *Arcella* org./l. According to **Shakoori *et al.*** (**2004**) and **Rehman *et al.* (2008)**, ciliates are typically present in polluted waterways with harmful metal ion concentrations of less than 10 µg/ml, and *Vorticella* reduces Zn and Cr by 99% and 48%, respectively. These microorganisms actively help to improve the effluent quality. Protozoa have developed mechanisms to tolerate, resist or detoxicate heavy metals, as evidenced by their long-term survival in media with relatively high concentrations of heavy metal ions **(Haq *et al.*, 2000)**.

CONCLUSION

Aquatic communities may suffer from the effects of organic and heavy metal pollutants. Defending health of individuals and other habitats from around world by safeguarding water against contaminants and pollutants. The water quality of the El-Tebbin industrial region can be compared and categorised using the Palmer Algal Genus Index and changes in algal communities. According to these findings, the El-Tebbin industrial region is moderately organically polluted due to the presence of *Chlorella*, *Synedra, Cyclotella, Melosira, Pediastrum, Oscillatoria* and *Scenedesmus* species. On the other hand, the available protozoans, which are efficient bio-indicators and are present in practically all freshwater bodies of water, reproduce in enormous numbers and adapt to shifts in the environment. They make it much more affordable to determine the aquatic environment's condition. These tiny cousins are highly beneficial in preventing the spread of diseases as they can be closely monitored and used to better understand ecological processes. They can be utilized as tools for the bioremediation of aquatic contaminants since they are effective at absorbing heavy metals. Because ciliated species are available in the research area, it is clear why levels of heavy metals could be reduced by taking these taxa into account when monitoring pollutants in the future.

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