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Pollution tolerant protozoa in polluted wetland

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HIGHLIGHTS

- Protozoan communities of polluted wetland were identified.
- Eight dominating protozoan species were proposed to be pollution tolerant species.
- These species can be used as indicator for polluted waters.
- The protozoa can participate in the energy transfer chain in polluted wetlands.

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ABSTRACT

This study for the first time confirmed that eight dominating protozoan species, *Cryptomonas erosa*, *Euglena axyuris*, *Euglena caudate*, *Euglena gasterosteus*, *Euglena acus*, *Vorticella campanula*, *Vorticella convallaria* and *Epistylis lacustris*, were the pollution tolerant species at chemical oxygen demand 54–104 mg/L. These species cannot be used as indicator for clean water quality as commonly believed. The protozoa can be actively participating in the energy transfer chain between nano-planktonic and higher plants in polluted wetlands.

1. Introduction

Wetlands are a cost-effective wastewater treatment technology that utilizes plants and microbes for removing organic, inorganic and heavy metal pollutants in the presence of oxygen (Wu et al., 2016; Liu et al., 2016). Different groups of microbes exist in wetlands as players for different purposes (Cao et al., 2017). Constructed wetlands are built to simulate the functions for natural wetlands, principally on the purpose to efficiently handle municipal or industrial effluents at an affordable cost (Zhang et al., 2017). The microbial communities in the wetlands determine their performances on wastewater treatment (Fan et al., 2016; Hu et al., 2016).

Daqing City is located in the west of Heilongjiang province, has the largest oil reserve in China and is home to the country's mega petroleum chemical factories. The Longfeng Wetland is in the eastern part of Daqing City, which has 5050.39 hm^2 area and average depth of 1.5 m, that receives about 5.5-million tons annually industrial and municipal effluents of the City. The denitrifying sulfide removal processes occurred in one of the main inflow, Liming River, has been investigated (Guo et al., 2014). Longfeng Wetland is a polluted water body for decades.

Aquatic protozoa are important energy transfer mediators from nano-planktonic to higher trophic levels in an ecosystem such as a wetland. As a grazer, protozoa are considered an adverse factor to reduce biomass productivity of microalgal open ponds (Erkelens et al., 2014; Peng et al., 2015, 2016). Protozoa presented in biohydrogen bioreactors were proposed to reduce the reactor performance (Wang et al., 2016). Since protozoa are sensitive to living environment and are rapidly responsive to environmental changes, they have been used as indicators for water quality and the health status of an aquatic ecosystem (Table 1). The biological treatment unit with lowest protozoa population was used as an indicator for poor pollutant removal in that unit (Shariati et al., 2011). The role of protozoa in polluted system, such as in a wetland is however commonly overlooked.

The studied water for the distribution and composition of protozoa species is generally of low chemical oxygen demand (COD) level. This study demonstrated for the first time that certain pollution tolerant protozoa species can stably exist in the polluted

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Table 1
Protozoa studies in aquatic ecosystems (2012–2016).

Author	Site	Environmental index	COD (mg/L)	Function
Xu et al. (2015)	A coastal area within a gradient of contamination of Yellow Sea	COD, WT, pH, salinity, DO, transparency, NO_3^--N, NO_2^--N, NH_4^+-N, SRP, SiO_3-Si	0.5–0.6	Multivariate dispersions of microbial eukaryote communities as indicator of water quality.
Xu and Xu (2016a)	Coastal waters of Yellow Sea	pH, salinity, DO, transparency, NO_3^--N, NO_2^--N, NH_4^+-N, reactive P	NA	Indicator of bioassessment in marine ecosystems
Zheng et al. (2016)	Coastal waters of Yellow Sea	NA	NA	Paired body-size distinctness measures as useful indicator for homogeneity of body-size spectrum
Xu and Xu (2016b)	Coastal waters of Yellow Sea	WT, pH, salinity, DO, transparency, NO_3^--N, NO_2^--N, NH_4^+-N, SRP	NA	Indicator of water quality status
Feng et al. (2015)	Jiaozhou Bay	NO_3^--N, NO_2^--N, NH_4^+-N, SRP, SRSi	NA	Tintinnids as indicator for discriminating water quality status
Jiang et al. (2014)	Jiaozhou Bay	WT, pH, salinity, DO, NO_3^--N, NO_2^--N, NH_4^+-N, SRP, Chla	NA	To assess the status of marine water quality using the taxonomic relatedness
Xu et al. (2014a)	Coastal waters of Yellow Sea, near Qingdao	COD, WT, pH, salinity, DO, NO_3^--N, NO_2^--N, NH_4^+-N, SRP	0.5–0.59	Biofilm-dwelling ciliate communities as indicator for discriminating water quality
Xu et al. (2014b)	Coastal waters of Yellow Sea	COD, WT, pH, salinity, DO, transpancy NO_3^--N, NO_2^--N, NH_4^+-N, SRP	0.5–0.59	The step-best-matching analysis to identify indicator species pool
Shi et al. (2012)	Hangzhou section of the Grand Canal, southern China	WT, pH, DO, BOD_5 COD, TP, TN	17.66–47.64	Protozoa as a robust indicator of water quality in fresh water river systems.

Table 2
Parameter ranges for samples at sites S1–S6 in Long-feng wetland from individual sampling site.

Site	WT (°C)	pH	SpCond (μS/cm)	DO (mg/L)	NH_4^+-N (mg/L)	TN (mg/L)	TP (mg/L)	COD (mg/L)
S1	19.38 ± 10.66	7.99 ± 0.17	1409 ± 410	4.16 ± 1.80	4.14 ± 1.75	9.70 ± 1.75	2.29 ± 0.78	88.41 ± 17.17
S2	16.25 ± 8.42	8.01 ± 0.16	1042 ± 119	5.11 ± 1.46	2.39 ± 1.03	4.26 ± 1.34	0.74 ± 0.40	80.18 ± 17.34
S3	17.75 ± 10.41	8.09 ± 0.08	993 ± 243	4.98 ± 1.63	2.56 ± 1.72	5.23 ± 1.69	1.69 ± 1.18	78.63 ± 14.29
S4	18.50 ± 10.11	7.94 ± 0.05	983 ± 324	5.21 ± 1.62	2.25 ± 0.87	3.74 ± 1.35	1.60 ± 1.37	70.92 ± 12.11
S5	17.88 ± 9.75	7.95 ± 0.15	836 ± 237	4.11 ± 1.57	2.30 ± 1.54	4.52 ± 2.41	0.93 ± 0.50	81.72 ± 14.59
S6	16.75 ± 8.14	7.85 ± 0.04	3.0 ± 0.5	6.52 ± 1.81	1.97 ± 0.61	2.29 ± 0.42	0.79 ± 0.53	64.74 ± 9.94

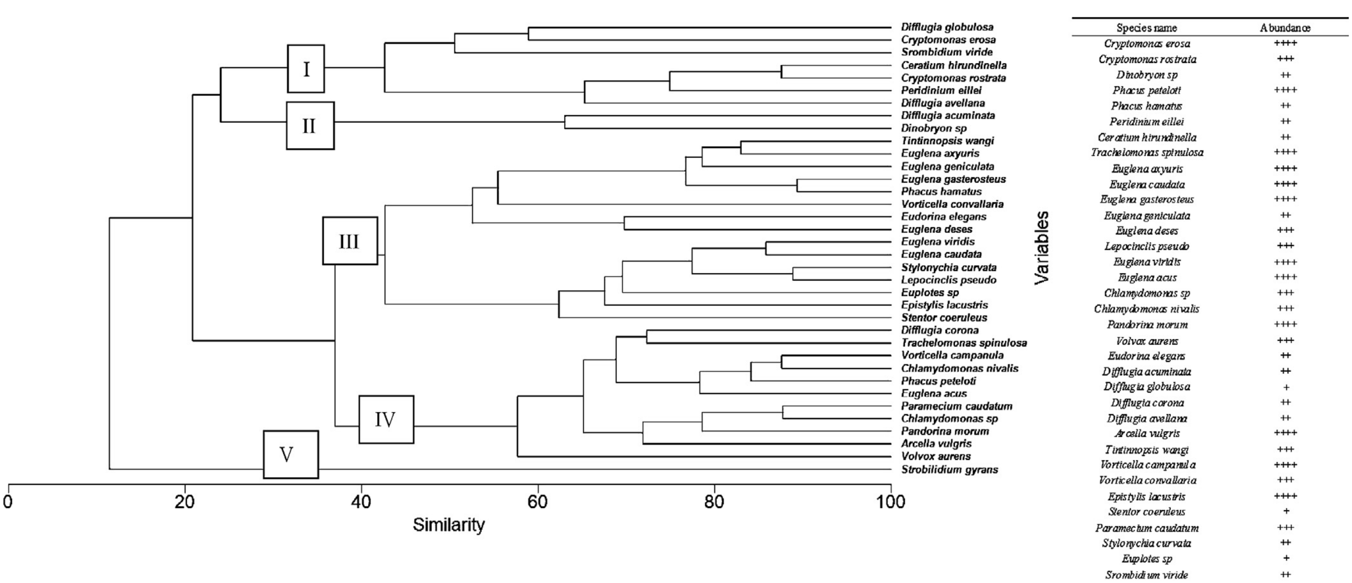

Fig. 1. Species distribution of 36 protozoa found from water samples of the six sites, plotted using group-average clustering on Bray–Curtis similarities from log-transformed species abundance data. I–V = group I–V. +:1–10, ++:10–10^2, +++:10^2–10^3, ++++:10^3–10^4.

Longfeng Wetland. These specific protozoan species can be used as bioindicator for polluted waters.

2. Material and methods

2.1. Sampling and chemical analysis

The water was sampled at six sites from the wetland (S1–S6 in Supplementaty Materials) (46°28′–46°32′N, 125°07′–125°15′E), at a depth of 1.5 m during April–October 2014, using the plankton sample net. The wetland is continuously fed by two streams located S1 and S5, by 6000 m^3/d and 9000 m^3/d, respectively. The only outlet is at S3. Therefore, the flow is directed by either via S1-S2-S3 or S5-S4-S3. The point S6 is comparably far away from the main stream flows. Industrial and municipal wastewaters which are disposed by sewage treatment plant flow into S1. S5 accepts industrial and municipal wastewater without treatment. The pollutant concentrations in S1 were higher than S5 (Table 2).