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Research Article

Biotic Index Studies in Relation to Organic Pollution: A Case Study of Huluka River, Ambo, Ethiopia

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Abstract: In the present study, an attempt was made to assess the quality of the Huluka river, one of the biggest aquatic body in Ambo, Ethiopia in terms of phytoplankton community and organic pollution. The results in the present study revealed important aspects like status of organic pollution in Huluka with respect to presence and absences of indicator species and productivity levels of Huluka river which in turn depends on phytoplankton community. Results have revealed that there is a clear evidence of heavy organic pollution in the Huluka river. This was supported by the composition in algal genera in Huluka river water samples. In the two sample stations i.e., upstream and mid-point showed very sensitive algal genera with few types is a clear indication of organic pollution. Important sensitive algal genera identified were Euglena, Oscillatoria, Chlamydomonas, Scenedesmus, Chlorella, Navicula, Micractinium, Microcystis, and Ulothrix. The Palmer pollution index at upstream side was found to be 28 which is far from the safe limit of 20. At the midpoint, the palmer index was found to be 23 which indicate presence of organic pollution while sample station 3 (down-stream side) Palmer pollution index was found to be 17 which indicates relatively less pollution status. Important algal genera present in the sample station 2 includes Oscillatoria, Chlamydomonas, Navicula,

Ankistrodesmus, Phacus, Phormidium, Gomphonema, Cyclotella, Closterium, Micractinium, Pandorina, Lepocinclis, Spirogyra, Fragilaria, Asterionella. The productivity studies of Huluka river indicated that primarily Huluka river is of autotrophic nature indicated by positive values (67.185) of net ecosystem productivity (NEP). This autotrophic nature of Huluka river may be attributed to the presence of phytoplankton at the sampling station.

Keywords: Biotic index, Huluka river, Phytoplankton, Organic pollution, Productivity

INTRODUCTION

Tropical African lakes display a considerable range in phytoplankton production which reflects their trophic state. Lake Kainji is a typical example of a nutrient-poor (oligotrophic) African lake with a low phytoplankton production of 0.3 gCm2/h [1]. Towards the upper end of the production scale, is the nutrient-rich (eutrophic) Lake Nasser, whose phytoplankton production has been reported to average 4.48 gCm2/h [2].Increased nutrient inflows resulting from expanding urbanization and agriculture have elevated primary production levels in many African lakes. A good example is Lake Chivero, whose primary production levels have increased by over 10 orders of magnitude from its previously reported range of 1.64 gCm2/h to 6.03 gCm2/h in 1979 to its current range of 18.5 gCm2/h to 140 gCm2/h [3]. Similarly, in the physionomically similar Hartbeespoort Dam, primary production levels, which normally range between 0.40 gCm2/h and 30.90 gCm2/h, have risen to as high as 185 gCm2/h[4]. These elevated primary production levels correspond with algal blooms and are a direct consequence of high nutrient inflows which overburden the lakes' natural purification systems[5]. In deeper African lakes, nutrient inflows also exert prominent effects on primary production. Examples include Lake Malawi, where primary production levels of 0.24 gCm2/h and 1.14 gCm2/h have risen to between 14.04 gCm2/h and 26.20 gCm2/h in recent years[6] and Lake Victoria where primary production of 3.30 gCm2/h to 13.50 gCm2/h has risen to as high as 234 gCm2/h[7]. Primary production in tropical African lakes is often low at or near the water surface due to photo-inhibition. The optimal habitat for phytoplankton is in the first 3 m – 5 m of the water column. Production tends to decrease with depth, until light becomes the limiting factor after the euphotic depth. Light is the primary limiting factor to the growth of phytoplankton in Lake Chivero, whereas conductivity and trophic status (measured as chlorophyll a) are the most important environmental variables influencing the distribution of ciliate species in this and other African lakes[8]. These variables are compliant with a classification of 17 east African lakes on the basis of water conductivity and associated phytoplankton species. Environmental factors such as water pH, conductivity, dissolved oxygen and nutrient concentration and light intensity influence primary production and these in turn are affected by thermal stratification, which is a common feature of tropical African lakes. In Lake Tanganyika, a fairly stable stratification is established during the wet season, which is generated by increased water temperatures and diminished wind intensities. However, currents and internal waves, as well as coastal jets and return flows, do cause localised up-welling, which may partly disrupt this stratification[9]. As water temperatures increase, algal succession follows a progression – from diatoms to chlorophytes to cyanobacteria[10]. In Lake Victoria, the phytoplankton blooms observed during February and August comprised over 90% Microcystis at concentrations of 34 000 colonies per millilitre (77.6 mg/L), the blooms corresponding with high temperatures, discharge of nutrients from river inflows, nutrient upwelling and nutrient release from sediments. The preponderance of cyanobacteria at higher water temperatures (> 25 °C) has led to concerns that in a decline in the production of palatable chlorophytes, leading to decreased zooplankton production and a consequent decline in fish stocks. Indeed, fisheries data from Lake

Tanganyika show significant correlations with climatic (ENSO) data over the last 40 years.58 This suggests that moderate warming could destabilise plankton dynamics, thereby potentially reducing water quality and food resources for higher trophic levels such as planktivorous fish as seen in shallow cold-water ecosystems[11]. Also, oxygen depletion and release of toxins caused by algal bloom die-off may lead to massive fish mortalities, as reported in Lake Chivero. In this lake, the dissolved oxygen concentrations following an algal bloom die-off, ranged from 2 mg/L at a depth of 5 m to 3.9 mg/L at the lake surface. These oxygen concentrations were even lower than those (3.2 mg/L to 4.8 mg/L) measured in the Nyanza Gulf of Lake Victoria, following the collapse of a phytoplankton bloom and associated with high fish mortalities of Oreochromis niloticus. Algal toxins caused by algal bloom die-off have also been previously detected in Lake Chivero and in tap water emanating from the lake but it has not been established whether these are toxic to humans and other fauna. However, toxic strains of Microcystis have been identified in other African fresh water bodies, as well as in fresh water systems elsewhere in the world[12].

Ambo, one of the biggest developing towns in West Shoa zone of Ethiopia, is located 110 km from the western direction of Addis Ababa, the capital city. The water content of the river varies from season to season with a mean daily water flow of about 15,000 and 75,000 m3/day during dry and rainy season respectively. In rural areas, the river water is used for drinking, sanitation, livestock, and agricultural purposes. However, sewage from residential areas near the river is directly expelled into the river and dense weeds have occupied the riverside, thus affecting the water flow. Despite of its foul odor and toxicity caused by intensive exploitation by domestic and agricultural activities, the river is still used for various purposes including irrigation, recreation, and cattle washing. These observations may reveal the absence of policies protecting the water systems and/or of overt monitoring studies on Huluka River.

At present no reports dealing with the status of organic pollution in Huluka River with respect to biotic indexes have appeared in the literature. Hence, with the aims of assessing water quality status in relation to phytoplankton community and organic pollution of Huluka river is undertaken in the present study.

MATERIALS & METHODS

Collection of Samples: From each station water samples were collected from 1, 2m depths were used for the identification of species of phytoplankton and for the estimation of productivity of Huluka river.

Depth profiles of oxygen and temperature were determined up to a depth of 2m with a digital Oxygen meter. Water samples were collected from open water sources (OWSs) by dragging plankton net of 70 meshes/cm2 in the water and concentrating the collected samples to 50 mL. Ten liters of the water samples from wells (RWSs) were collected and concentrated to 50 mL. by filtering through 70 meshes per cm2 plankton net. Samples for phytoplankton identification and enumeration were p reserved in Lugol's solution.

Identification of Phytoplankton: Samples for Algal identification were collected from the Huluka river using Plankton net. Subsamples for phytoplankton counting and identification were also preserved with Lugol's iodine. The major phytoplankton species were identified with microscope, at a magnification of x40 in random fields after sedimentation of 50 mL of the sample in a graduated cylinder overnight. The supernatant water was removed by a syringe leaving 5mL of the sample in the graduated cylinder. From the concentrated sample, 1 mL subsample was taken with a pipette to

identify phytoplankton communities. The phytoplanktons were identified to genus level using concentrated samples on the basis of various taxonomic literatures available on phytoplankton.

Palmer Pollution Index Studies: Palmer (1969) proposed a pollution index based on algal genus and species used in the rating water sample for high or low organic pollution. The pollution tolerant genera and species of algae were recorded from selected sampling stations. A list of most pollution tolerant genera and species according to Palmers index were calculated for all sampling stations. A pollution index factor was assigned to each genus and species by determining the relative number of total points scored by each alga.

A pollution index factor of 1 through 5 has been assigned to each of the 20 types of algae that are most tolerant to organic pollution. Types of algae most tolerant of organic pollution were assigned a factor of 5. Less tolerant types were assigned a lower number. If the pollution index score is 20 or more, the score is evidence of high organic pollution. A score of 15-19 indicates probable organic pollution.

Palmer Pollution Index (Based on Algal genus, Palmer, 1969)

Genus	Pollution Index
Anacystis	1
Ankistrodesmus	2
Chlamydomonas	4
Chlorella	3
Closterium	1
Cyclotella	1
Euglena	5
Gomphonema	1
Lepocinclis	1
Melosira	1
Micractinium	1
Navicula	3
Nitzschia	3
Oscillatoria	5
Pandorina	1
Phacus	2
Phormidium	1
Scenedesmus	4
Stigeoclonium	2
Stigeoclonium	2

Following numerical values for pollution classification of Palmer (1969),

S. No.	Biotic Index	Quality Status
1	0-10	Lack of organic pollution
2	10-15	Moderate pollution
3	15-20	Probable high organic pollution
4	More than 20	Confirms high organic pollution

Estimation of Primary Productivity: Primary productivity in Huluka River was determined by the Light and Dark Bottle Technique. Composite water samples were siphoned into light (clear) and dark (covered with black cloth) bottles. Duplicate light bottles were incubated at 1m and 2m depths distributed within the euphotic zone for a period of 2hours around mid-day (10.00 am-2.00 pm). Dark bottles were also incubated at same depths. The bottles were attached to a suspension line prepared for this purpose. Samples in a pair of bottles were fixed with Winkler reagents immediately after incubating the light and dark bottles and used as initial bottles. At the end of the incubation period, the bottles were rapidly withdrawn and dissolved oxygen fixed immediately with the Winkler reagents. Treatment of bottles before and after incubation was made under a cover of dark cloth. On returning to the laboratory, the concentration of dissolved oxygen in the incubation bottles was measured using a dissolved oxygen meter.

Measurement of Productivity: Calculations of gross and net photosynthetic rates and respiration rates were done based on the change in oxygen concentration between initial (I), light (L) and dark (D) bottles.

Gross primary productivity (GPP) = (L-D)/2h = mg O2/ L/h

Net primary productivity (NPP) = (L-I)/2h = mg O2/ L/h

Respiration rate (R) = (I-D)/2h = mg O2/ L/h

RESULTS & DISCUSSIONS

Biotic Index Studies of Huluka River: Table-1 shows the pollution tolerant genera of algae from three stations of Huluka River in order of decreasing emphasis. At station S1 (Upstream side of the river), the major dominant genera of algae are Euglena, Oscillatoria, Chlamydomonas, Scenedesmus, Chlorella, Navicula, Micractinium, Microcystis, and Ulothrix. At station S2 (Midpoint), Oscillatoria, Chlamydomonas, Navicula, Ankistrodesmus, Phacus, Phormidium, Gomphonema, Cyclotella, Closterium, Micractinium, Pandorina, Lepocinclis, Spirogyra, Fragilaria, Asterionella were found to be the dominant groups of algae. Whereas at station S3 which is downstream side of the Huluka river, the major dominant groups were identified as Scenedesmus, Chlorella, Navicula, Phacus, Phormidium, Gomphonema, Cyclotella, Pandorina, Lepocinclis, Fragilaria, Lyngbya, Spirulina, Pinnularia.

The number of species at each station observed may be correlated to the extent of pollution in the Huluka river. As a general rule, the higher the river pollution, the smaller the number of tolerant species. In the present study, same trend was observed with all the three stations. At station S1 which is upstream side of the river, due to heavy pollution a very relatively small number of algal genera were found when compared other station S2 which are away from the pollution source. At station S1 a total number of 9 tolerant species were observed while at station S2 the number species observed were 15 which are less pollution tolerant while at stations S3 the number species observed were 13.

Table-1: Pollution tolerant genera of algae from three stations of Huluka River in order of decreasing emphasis (Palmer, 1969).

S. No.	Name of Algal Genera	Group	Sampling stations		
			S1	S2	S3
1	Euglena	F	+		
2	Oscillatoria	B	+	+	
3	Chlamydomonas	F	+	+	
4	Scenedesmus	G	+		+
5	Chlorella	G	+		+
6	Nitzschia	D			
7	Navicula	D	+	+	+
8	Synedra	D			
9	Ankistrodesmus	G		+	
10	Phacus	F		+	+
11	Phormidium	B		+	+
12	Melosira	D			
13	Gomphonema	D		+	+
14	Cyclotella	D		+	+
15	Closterium	G		+	
16	Micractinium	G	+	+	
17	Pandorina	F		+	+
18	Microcystis	B	+		
19	Lepocinclis	F		+	+
20	Spirogyra	G		+	
21	Anabaena	B			
22	Pediastrum	G			
23	Arthrospira	B			
24	Trachelomonas	F			
25	Fragilaria	D		+	+
26	Ulothrix	G	+		
27	Surirella	D			
28	Eudorina	F			
29	Lyngbya	B			+
30	Oocystis	G			
31	Spirulina	B			+
32	Cymbella	D			
33	Actinastrum	G			
34	Coelastrum	G			
35	Hantzschia	D			
36	Golenkinia	G			
37	Achnanthes	D			
38	Pinnularia	D			+
39	Chlorococcum	G			
40	Asterionella	D		+	
41	Cocconeis	D			
42	Cosmarium	G			
43	Selenastrum	G			

44	Dictyosphaerium	G			
45	Crucigenia	G			

Key: + = present; F = Flagellates; B = Blue green algae; G=Green algae; D=Diatoms; S1 = Upstream; S2= Mid-point; S3 = Downstrean

The status of Huluka river water quality in terms of Palmer Algal biotic index was represented in the **Table-2** and results have shown that at station S1, there was a clear indication of Heavy organic pollution as was evident by the algal index of 28. According to Palmer, if index is above 20, it is an indication of heavy organic pollution. At sites S2, pollution index value of 23 was observed. The relatively low biotic index value (17) at station S3 may be attributed to the self purification process of river waters. With the time and distance away from the origin of the pollution source, rivers have self purification capacity which reduces the pollution loads due to factors like dilution of pollutants, regeneration of oxygen concentration, reduction in number of bacteria etc.

Table-2: Pollution index of Algal genera according to Palmer, (1969) at three stations of Huluka River, Ambo

S. No.	Algal genera	Pollution Index	Sampling stations		
			S1	S2	S3
	CHLOROPHYCEAE				
1	Chlamydomonas	4	4	4	
2	Pandorina	1		1	1
3	Chlorella	3	3		3
4	Ankistrodesmus	2		2	
5	Scenedesmus	4	4		4
6	Micractinium	1	1	1	
7	Closterium	1		1	
8	Stigeoclonium	2			
	CYANOPHYCEAE				
9	Oscillatoria	5	5	5	
10	Phormidium	1		1	1
	EUGLENOPHYCEAE				
11	Euglena	5	5		
12	Lepocinclis	1		1	1
13	Phacus	2		2	2
	BACILLARIOPHYCEAE				
14	Melosira	1			
15	Cyclotella	1		1	1
16	Synedra	2			
17	Navicula	3	3	3	3
18	Gomphonema	1		1	1
19	Nitzschia	3	3		
		Total Score	28	23	17

Table-3 shows the water quality status of Huluka River. The water quality of the river shows a pattern of behavior linked to human pressure associated with domestic, municipal sewage wastewater and agricultural activities. Traversing downstream the value of dissolved oxygen (DO) steadily decreases with values ranging from 7.9-3.4 and 6.5-3.0 mgL-1 during the rainy and dry season respectively,

which is an indicator that the quality of water increasingly worsens as it travels further downstream. All the samples are found critically low in DO and do not conform to the value in the CCME guideline for the protection of aquatic life, i.e. 5.5-9.5 mgL-1. The low DO level causes anaerobic conditions resulting in foul odour of the Huluka River. The lower levels of DO downstream may be attributed to the microbial utilization of DO in the breakdown of organic compounds introduced by the discharge of domestic and sewage wastewater. The pollution profile as indicated by BOD and COD and their average values range from 256ppm and 540ppm respectively. These values are not within acceptable ranges (BOD < 200 mgL-1, COD < 500 mgL-1) according to the provisional discharge limits set by Ethiopian EPA and the downstream samples are approximately eight times higher in BOD, and ten times higher in COD than the upstream samples.

Table-3: Physico-chemical characteristics of Huluka River water

Water Quality Parameter	Average Concentration in ppm
Dissolved Oxygen	3.7
BOD	256
COD	540
Total Dissolved Solids	225.1
Nitrate	1.98
Phosphate	0.98
Sulphate	34.46

Oxygen profiles of Huluka River were depicted in **Tables 4 & 5**. Dissolved oxygen values were measured at two different depths of 1m and 2m. At 1m depth as indicated in table 4, the oxygen concentrations in initial light and dark bottles were found to be 4.7ppm. After incubation for 2hrs, the oxygen levels in light bottle and dark bottles were found to be 5.2 and 4.3 respectively. The decrease in oxygen concentration was attributed to no photosynthesis owing to the dark conditions in the bottle FD. The oxygen levels were actually increased in bottle ID owing to the photosynthesis due to light penetration.

Table-4: Dissolved oxygen values at depth 1

Bottle Depth 1	1m
Incubation period	2hrs
Light bottle initial (IL)	4.7ppm
Dark bottle initial (ID)	4.7ppm
Light bottle final (FL)	5.2ppm
Dark Bottle final (FD)	4.3ppm

At 2m depth as indicated in **Table-5**, same trend was observed as at 1m depth but the oxygen concentration profiles in vertical direction of water column showed decreasing trend due to less penetration of light owing to the turbid conditions of the river. These turbid conditions may be attributed to pollution of river from anthropogenic sources. The oxygen concentrations in initial light and dark bottles were found to be 4.4ppm. After incubation for 2hrs, the oxygen levels in light bottle and dark bottles were found to be 4.9 and 4.1 respectively. The decrease in oxygen concentration was attributed to no photosynthesis owing to the dark conditions in the bottle FD. The oxygen levels were actually increased in bottle ID owing to the photosynthesis due to light penetration.

Table-5: Dissolved oxygen values at depth 2

Bottle Depth 2	2m
Incubation period	2hrs
Light bottle initial (IL)	4.4ppm
Dark bottle initial (ID)	4.4ppm
Light bottle final (FL)	4.9ppm
Dark Bottle final (FD)	4.1ppm

Productivity Calculations of Huluka River: Table-6 shows productivity of Huluka river at 1m depth. Respiration and Gross primary productivity was found to be 0.075gC/m^2/hr and 0.14062gC/m^2/hr respectively. Net ecosystem productivity was found to be at 0.0656gC/m^2/hr and the positive value indicates the autotrophic nature of the Huluka river.

Table-6: Productivity at Depth 1

Bottle Depth 1 =	mgC /m^3/hr	gC/m^2/hr
Length of water column represented = _____1__(m)	-	-
Ecosystem Respiration (RT) (375 * (ID - FD) * 1.0) / 2hours	75.00	0.075
GPP (375 * (FL - FD)) / 1.2 x 2hours	140.62	0.14062
NEP = GPP - RT	65.62	0.06562
P:R for depth 1 (GPP: RT)	1.87	1.87

Table-7 shows productivity of Huluka river at 2m depth. Respiration and Gross primary productivity was found to be 0.05625gC/m^2/hr and 0.125gC/m^2/hr respectively. Net ecosystem productivity was found to be at 0.06875gC/m^2/hr and the positive value of NEP may be attributed to autotrophic nature of the Huluka river.

Table-7: Productivity at Depth 2

Bottle Depth 2 =	mgC/m^3/hr	gC/m^2/hr
Length of water column represented = _____2___(m)	-	-
Ecosystem Respiration (RT) (375 * (ID - FD) * 1.0) / hours	56.25	0.05625
GPP (375 * (FL - FD)) / 1.2 x hours	125.00	0.125
NEP = GPP - RT	68.75	0.06875
P:R for depth 2 (GPP: RT)	2.22	2.22

Average productivity across the water column of Huluka river is represented in **Table-8**. The respiration, gross primary productivity and net primary productivity were found to be at the tune of 65.625mgC/m^3/hr, 132.81625mgC/m^3/hr and 67.185625mgC/m^3/hr respectively. This positive productivity of Huluka river can be attributed to the availability of ample light conditions and the phytoplankton community in the river.

Table-8: Average productivity of Huluka River

Final Average Data across the entire water column	mgC / m3 water / hr	gC/ m2 / hr
RT	65.625	0.065
GPP	132.81	0.132
NEP	67.185	0.067
P:R	2.04	2.04

CONCLUSIONS

From the foregoing analysis it was concluded that there is a clear evidence of heavy organic pollution in the Huluka river. This was supported by the composition in algal genera in Huluka river water samples. The two sample stations i.e., Upstream and mid-point showed very sensitive algal genera with few types is a clear indication of organic pollution. Important sensitive algal genera identified were Euglena, Oscillatoria, Chlamydomonas, Scenedesmus, Chlorella, Navicula, Micractinium, Microcystis, and Ulothrix. The Palmer pollution index at upstream side was found to be 28 which is far from the safe limit of 20. If the pollution index exceeds 20, it indicates clear organic pollution. At the midpoint, the palmer index was found to be 23 which indicate presence of organic pollution. At downstream side the pollution index was found to be 17 which indicates self-purification ability of this river system. Important algal genera present in the sample station includes Oscillatoria, Chlamydomonas, Navicula, Ankistrodesmus, Phacus, Phormidium, Gomphonema, Cyclotella, Closterium, Micractinium, Pandorina, Lepocinclis, Spirogyra, Fragilaria, Asterionella. The productivity studies of Huluka river indicated that primarily Huluka river is of autotrophic nature indicated by positive values (67.185) of net ecosystem productivity (NEP). This autotrophic nature of Huluka river may be attributed to the presence of phytoplankton at the sampling station.

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REFERENCES

1. S.G. The annual flood regime as a regulatory mechanism for phytoplankton production in Kainji Lake, Nigeria, *Arch. Hydr.* 1982, 86, 93–97.
2. A.A. Samaan. Report on the trip of Lake Nasser to investigate its primary productivity during March 1971. Report to Lake Nasser Development Centre Project, Aswan (mimeo).
3. M.R. Ndebele. Some aspects of the phytoplankton community of Lake Chivero, Harare, Zimbabwe. MSc. thesis, University of Zimbabwe, Harare, 2003.
4. R.D. Robarts. Factors controlling primary productivity in a hypereutrophic lake (Hartbeespoort Dam, South Africa). *J Plankton Res*, 1984, 6, 91–105
5. L. Mhlanga, J. Day, C. Cronberg, M. Chimbari, N. Siziba, H. Annadotter, Observations on limnological conditions associated with a fish kill of Oreochromis niloticus in Lake Chivero following collapse of an algal bloom. *African Journal of Ecology*, 2006, 44,199–208.

6. S.J. Guildford, H.A. Bootsman, W.D. Taylor, R.E. Hecky. High variability of phytoplankton photosynthesis in response to environmental forcing in an oligotrophic Lake Malawi/ Nyasa. *J Great Lakes Res*, 2007, 33,170–185.
7. R. Mugidde. The increase in phytoplankton activity in Lake Victoria (Uganda). Verh. *Int. Ver. Limnol*, 1993, 25, 846–849.
8. A.W. Yasindi, W.D. Taylor. The abundance, biomass and composition of pelagic ciliates in East African lakes of different salinity and trophy. *Aquat Ecosyst Health Manage*, 2003, 6, 289–297.
9. F.M.M. Chale, Inorganic nutrient concentrations and chlorophyll in the euphotic zone of Lake Tanganyika. *Hydrobiologia*, 2004, 00, 1–9.
10. H. Sarmento, M. Isumbisho, J.P. Descy. Phytoplankton ecology of Lake Kivu (eastern Africa). *J Plankton Res*, 2006, 28,815–829.
11. A.L. Strecker, T.P. Cobb, R.D. Vinebrooke. Effects of experimental greenhouse warming on phytoplankton and zooplankton communities in fishless alpine ponds. *Limnol and Oceanogr*, 2004, 49, 1182–1190.
12. J. Chen, P. Xie, J. Xu. First identification of the hepatotoxic microcystin in the serum of a chronically exposed human population together with indication of hepatocellular damage. *Toxicol Science*, 2009, 108, 81–89.

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