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STUDY ON THE CORRELATION OF WATER QUALITY FACTORS WITH SPECIES DISTRIBUTION OF MANGANESE IN WEST LAKE

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Abstract

In this paper, changes in water quality factors of West Lake and variations in the speciation distribution of Manganese in both water and bottom sediment from June 1995 to May 1996 was reported. The correlation of manganese species distribution with water quality factors was also investigated. The results showed that besides TP, T, TIN, and chl-a etc., Manganese was also one of the main factors which affects water transparency.

Keywords: Water quality, Manganese, West Lake

INTRODUCTION

In recent years, it has become understood that more and analyses of the speciation of trace elements in water is necessary for understanding their toxicity or bioavailability. Manganese was believed to be an essential element for life. The bioavailability for aquatic plants depended on the species of manganese existed in the water body. Measurements of the total concentration of an element provide no information about its bioavailability or its interaction with suspended particulates and sediments. According to the literature (Tessler et al., 1979, Florcence, 1982a, 1982b, Wang and Tang, 1997), manganese in water and in sediment are partitioned into three fractions and six fractions, respectively.

West Lake is a shallow and highly eutrophic lake in China, and has been investigated by many people (Wang and Zhang, 1992, Xu and Zeng, 1982). In summer, algal growth reaches its highest level, as does the chlorophyll-*a* and manganese contents, while transparency is at its lowest level.

The purpose of this investigation was to show the correlation between speciation distribution of manganese in the water body and the waters quality.

MATERIALS AND METHODS

The water samples and sediment samples were taken monthly from eight points, four from the outer lake area and one from each other lake area.

The values for pH, transparency (SD), and water temperature (T) were field determined.

The analytical method of total phosphorus (TP) was the phosphatomolybdic acid blue colorimetric method; ammonium nitrogen (NH_4^+-N) was Nessler's reagent colormetric method, nitrite nitrogen (NO_2^--N) was determined by naphthyl-ethylene-diamine spectrophotometry, and the nitrate nitrogen (NO_3^--N) was measured spectrophotometrically with phenol disulfonic acid. The total inorganic nitrogen (TIN) was taken as the sum of NH_4^+-N, NO_2^--N and NO_3^--N. The chlorophyll-*a* content was determined spectrophotometrically.

The three fractions of manganese in water were dissolved, suspended particulate I (P_1) and suspended particulate II (P_2). 500 ml of the water sample was filtered through a 0.45 μm Nuclepore membrane filter. The filtrate added 5 ml of concentrated nitric acid, was transferred to a 10-ml flask, and diluted to the mark with redistilled water. Dissolved manganese was then measured in the solution by Atomic-absorption

spectrophotometry (AAS).
20 ml of 0.01mol•L^{-1} NH_2OHHCl containing 0.01mol•L^{-1} nitric acid was added to filter residue, stirred for 2530 min. and centrifuged. The up-layer liquor was analysed for Mn of suspended particulate I .
A mixture of nitric acid and perchloric acid was added to the residual solid, taken almost to dryness, cooled, washed several times with redistilled water transferred to 10-ml flask, and diluted to the mark. Mn of suspended particulate II was measured by AAS.
The sequential extraction procedure for Manganese speciation of sediment sample was carried out in accordance to the methods described by Tessler et al. (1979). The six fractions of manganese analysed for in the sediment were : dissolved, exchangeable, bound to carbonates, bound to Fe-Mn oxides, bound to organic matter, and residual. The extract liquors of each fraction was measured by AAS.

RESULTS AND DISCUSSION

The monthly variation of water quality factors (water temperature, transparency, pH value, total phosphorus, total inorganic nitrogen and chlorophyll-a), are shown in Figure 1. A general decrease was seen in the concentration of chlorophyll-*a*, the pH value and the water temperature, while the transparency appeared to increase. The correlation of transparency with each water quality factor is listed in Table 1. The coefficients in Table 1 and each poly-line regression in Table 2 revealed that total inorganic nitrogen had the greatest effect on transparency.

Table 1. The correlation coefficients of transparency with water quality factors

	X_T	X_{chla}	X_{TP}	X_{TIN}	X_{pH}
correlation coefficient	0.3484	0.6053	0.0146	0.8717	0.1980

Table 2. The poly-line regression equation of transparency with other water quality factors

poly-line regression equation	correlation coefficient
$Y_{SD} = 44.14 + 0.87 X_T - 0.17X_{chla} + 33.35 X_{TP} + 61.64 X_{TIN} - 4.34 X_{pH}$	0.972
$Y_{SD} = -0.86 + 0.87 X_T - 0.17 X_{chla} + 63.63 X_{TP} + 65.32 X_{TIN}$	0.965
$Y_{SD} = 75.98 - 0.11X_{chla} - 35.79 X_{TP} + 48.50 X_{TIN} - 4.36 X_{pH}$	0.952
$Y_{SD} = 59.52 + 0.76 X_T - 0.17X_{chla} + 58.47 X_{TIN} - 5.01 X_{pH}$	0.971
$Y_{SD} = 188.2 - 0.27 X_T - 0.33X_{chla} - 148.73 X_{TP} + - 9.07 X_{pH}$	0.839
$Y_{SD} = 27.7 - 0.11X_{chla} - 3.27 X_{TP} + 54.81 X_{TIN}$	0.944
$Y_{SD} = 17.71 + 0.64 X_T - 0.17X_{chla} + 59.56 X_{TIN}$	0.960
$Y_{SD} = 106.7 - 0.42 X_T - 0.35 X_{chla} - 105.3 X_{TP}$	0.801

Where Y_{SD} is the transparency in cm, X_Y is temperature (°C) and X_{pH} is the pH value of the water. X_{TP} , X_{TIN} and $X_{chl\text{-}a}$ are the concentration in μg/L of total phosphorous, total inorganic nitrogen, and chlorophyll-*a*, respecively.

Observed variations in manganese concentration distributions in the dissolved, suspended particulate I and suspended particulate II samples, are shown in Table 3 and Figure 2. The maximum Mn concentration of three species was founded in suspended particulate I (about 85%), and the minimum was dissolved (about 10%). The total concentration of Mn during summer and early autumn was higher than during winter and early spring, with the total concentration of manganese in winter being less than half the amount in summer. This was due to a large amount of dead algae setting to the lake bottom in winter, resulting in a decrease in chlorophyll-*a* content in the water. With the season change, the percentage of manganese in the three species underwent no marked difference. In other words, the exchange action among the three species for manganese in water was weak.

Table 3. Mn species distribution in water from June 1995 to May 1996

season	Total (ug/L)	Dissolved (%)	Particulate (%)	Particulate (%)
summer	73.90	10.38	85.31	4.31
autumn	70.00	16.93	79.62	3.46
winter	30.03	18.84	76.43	4.73
spring	57.98	15.38	80.45	4.17

Seasonal variations in the manganese concentration of the six fractions (see method section) in sediment are shown in Table 4. It was found that the main species of manganese that existed in the West Lake bottom sediment was in the form of Mn oxides bound to Fe (about 50%). The variations in temperature brought about by seasonal changes resulted in no marked differences in the percentages of neither each Mn species nor the total Mn concentration.

Table 4. Seasonal Variation of Mn (%) fractions in west Lake Sediment

season	I (%)	II (%)	III (%)	IV (%)	V (%)	VI (%)	Total (μg/g)
Spring	0.33	7.50	21.83	53.21	6.70	10.43	438.66
Summer	0.25	4.54	26.83	52.75	6.03	9.59	444.46
Autumn	0.58	9.19	23.71	50.61	5.69	10.22	433.21
Winter	0.41	7.73	25.32	49.54	6.49	10.52	447.03

Where I = dissolved, II = exchangeable, III = bound to carbonates, etc.

The correlation coefficient was 0.965. Therefore, besides TP, T, TIN, and chl-a, manganese is also one of the main factors affecting the transparency of the water body. The correlation coefficients of transparency with dissolved, suspended particulate and the total concentration of manganese in water were 0.444, 0.766 and 0.777, respectively. This suggests that suspended particulate manganese had the greatest effect on transparency.

The correlation of Manganese speciation distribution in water phases with water quality factors can be described by poly-line regression equations as shown below:

$$Y_{SD} = 46.9 - 68.1X_{TP} + 51.0\ X_{TIN} - 0.03\ X_{chla} - 2.16X_S - 0.02\ X_P$$

where X_S and X_P are the concentrations in μg/L of dissolved Mn, and suspended particulate Mn in the water phase, respectively.

The poly-line regression equations for manganese species distribution in bottom sediment with water transparency are shown in Table 5.

Table 5. The poly-line regression equations of transparency with Mn speciation in sediment.

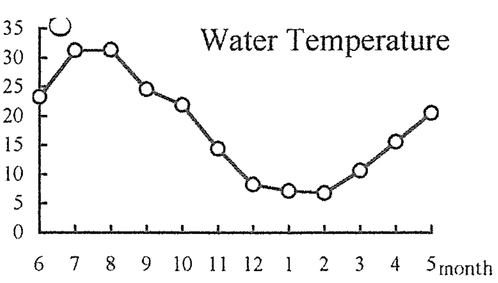
poly-line regression equation	R
$Y_{SD} = -190.7 - 1.15\ X_P - 20.1\ X_{P1} + 0.074X_{P2} - 0.59\ X_{P3} - 0.37X_{P4} + 6.84X_{P5} + 5.78X_{P6} + 3.88X_S$	1.0000
$Y_{SD} = -175.7 - 1.42\ X_P + 13.8\ X_{P1} + 1.45\ X_{P2} - 0.88\ X_{P3} + 0.51X_{P4} + 2.71X_{P5} + 3.17X_{P6}$	1.0000
$Y_{SD} = 930.9 + 315.8\ X_{P1} - 41.1\ X_{P2} - 5.83\ X_{P3} + 5.28\ X_{P4} - 86.0X_{P5} + 38.4X_{P6}$	0.9997
$Y_{SD} = 96.2 - 0.97\ X_P - 13.63\ X_{P1} + 0.73\ X_{P2} - 0.55\ X_{P3} - 0.49\ X_{P4} + 5.58X_{P5}$	1.0000
$Y_{SD} = 196.8 - X_P + 12.0\ X_{P1} - 1.67\ X_{P2} - 0.71\ X_{P3}$	1.0000
$Y_{SD} = 108.9 - 1.1\ X_P + 2.82\ X_{P1} - 0.11\ X_{P2}$	0.9353
$Y_{SD} = 104.5 - 1.1\ X_P + 1.78\ X_{P1}$	0.9345

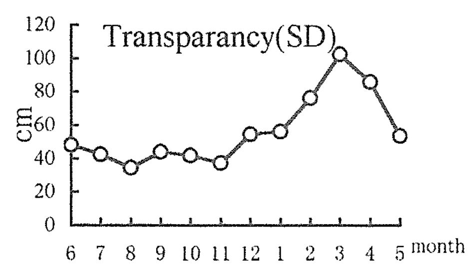
Where X_{P1}, X_{P2}, X_{P3}, X_{P4}, X_{P5}, X_{P6} are the concentrations in μg/g of six Mn states (see method section), respectively. (X_P And X_S are described above) and R is the correlation coefficient.

Table 5 shows that the transparency of water was also closely related to the speciation distribution of manganese in the bottom sediment.

CONCLUSION

The monthly variations of water quality factors and distributions of three manganese species in water, along with the seasonal variations in the distribution of six manganese species in bottom sediment of West Lake at eight sampling points were investigated. Suspended particulate I was the main species of manganese found in the water phase . The maximum Mn (P1) concentration was observed in summer. The main species found in the bottom sediment were Fe-Mn oxides, while the lowest species found were those bound to carbonates. Aside from TP, T, TIN, and chl-a, manganese content was also found to be one of the main factors affecting transparency.





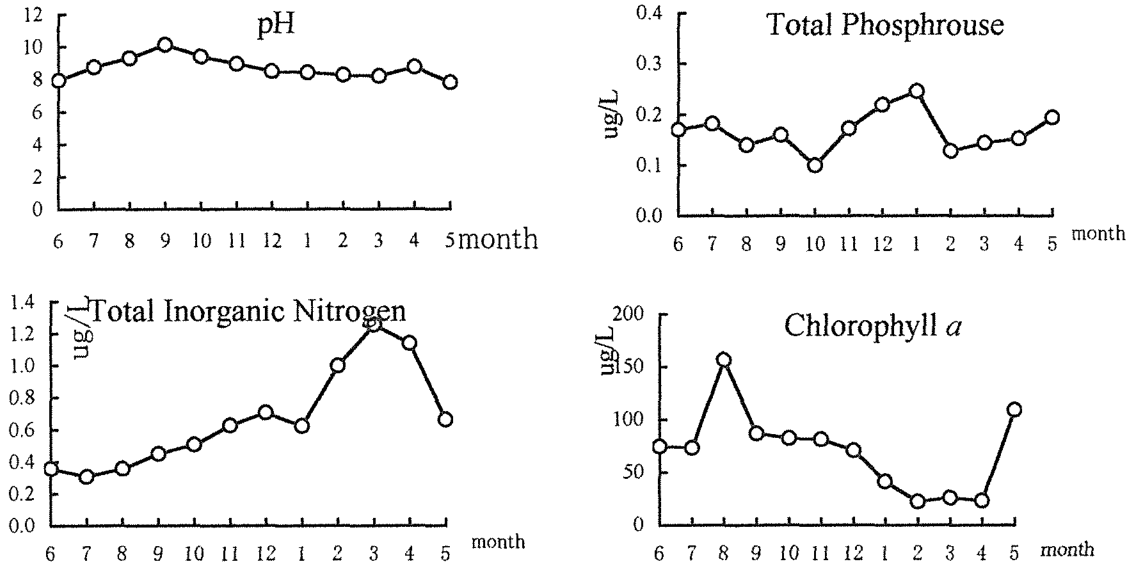


Figure 1. Monthly variations of several water quality indexes from June 1995 to May 1996.

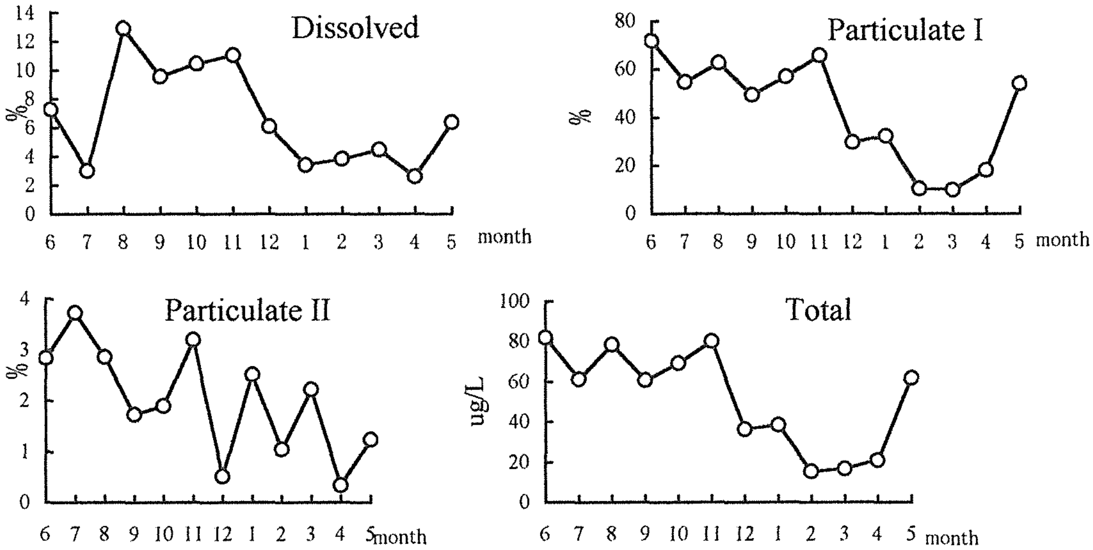


Figure 2. Monthly variations of Mn species in water samples.

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