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INTRODUCTION

The First International Conference on Environmental Science and Technology 2005 was held in New Orleans, Louisiana, January 23-26, 2005. The Program included 14 sections, containing 59 sessions with approximately 600 platform and poster presentations.

Authors of the presentations accepted for the program were invited to submit their papers to the Conference Organizing Committee. More than 200 papers were received and then reviewed by the editors, session chairs, and the members of the Scientific/Technical Committee of the conference. Those papers and abstracts accepted for publication were assembled into two volumes.

Sections are arranged basically according to their order listed in the original program except the session entitled *Bio-Assessment and Toxicology*. This exception was made to balance the length of the two volumes.

Proceedings of Environmental Science and Technology 2005 (I) contains the following sections:

- Water Pollution and Water Quality Control
- Air Pollution and Air Quality Control
- Bio-Assessment and Toxicology

Papers of more sections are included in *Proceedings of Environmental Science and Technology 2005 (II)*:

- Land (Soil, Waste Solid) Pollution and Remediation
- Ecosystem Restoration
- Wetlands
- Sediments
- Global Change
- Metals
- Organic Pollutants
- Modeling
- GIS, Statistics, and Remote Sensing
- Society and the Environment
- Environmental Analysis and Measurements

We would like to thank the session chairs, who not only presided over their sessions during the conference, but also contributed their time to review papers, suggesting corrections or directly correcting the papers submitted by the presenters in their sessions.

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WATER POLLUTION
AND
WATER QUALITY CONTROL

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PERSISTENCE OF BLUE-GREEN ALGAE IN INSHORE WATERS OF LAKE VICTORIA, KENYA

Lewis Sitoki, Albert Getabu, Wilfred Osumo
(Kenya Marine and Fisheries Research Institute, Kisumu, Kenya)

ABSTRACT: Frequency and seasonality of algal blooms have been studied during the period 1994 – 2004, along with environmental factors during bloom times in Lake Victoria. Blue-greens were found to predominate by over 50% of the algal composition, particularly in inshore areas. The most common species of blue-greens found include *Microcystis aeruginosa, Anabaena flos-aquae, A. sporoides*, *Planktolyngbya* sp.*, Cylindrospemopsis africana,* and *Merismopedia tenuissima*, all of which form blooms and produce toxins. Emerging trends show species variation between inshore and offshore waters with heterocystous species being most abundant in offshore waters.

Algal cell density was recorded as being approximately 3000 cells/mL in many inshore stations almost throughout the year. Similarly, algal biomass measured as chlorophyll-*a* was equally high at an average of 31 µg/L. Measurement of key physical and chemical variables indicate a conducive environment for the proliferation of the blue-green algae. Soluble reactive phosphorus average concentration was 29 µg/L and temperatures were rarely below 23 ^{o}C; thus supporting fast growth.

Proliferation of blue-green algae in recent years has resulted in the deterioration of water quality and potable water production. Blooms have frequently interfered with abstraction of water from the lake resulting in the breakdown of water treatment works at Kisumu city. Communities have complained about problems of algal blooms effecting livestock and fishing. Other problems associated with the blooms include fouling, anoxia and algal toxins causing fish kills and contaminating the food web.

The problem of blue-green algae is attributed to high nutrient enrichments in the waters, particularly in the Kenyan Waters of Lake Victoria from effluents of surrounding towns and farms thus creating an enabling environment for their proliferation. The potential for contamination of drinking water and other effects of blue-green algae need to be understood and mitigation processes initiated to control their proliferation.

INTRODUCTION

Lake Victoria, the largest lake in Africa (68,800 km^2) is an important fresh water and food resource for people living in its vicinity. Despite the reliance of communities on this resource, insufficient attention has been given towards conservation of the lake. Anthropogenic activities in its catchment have continued to degrade water through contamination by surface runoff, airborne pollutants and river discharge. The drainage of raw sewage into the lake and rivers from the

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expanding urban, agricultural and industrial sectors coupled with an ever-increasing human population continue to affect the water quality in the lake.

In the past decade, eutrophication of Lake Victoria has resulted in the increase of phytoplankton biomass (by a factor of 7), increased primary production (by a factor of 2), a dramatic decrease in dissolved silicon concentrations (by a factor of 10) and a significant decrease in ratio of N and P (Kling et al., 2001). More recent studies (Muggide, 1993; Lung'ayia et al., 2001) have shown a shift in phytoplankton species composition from a moderate mix of diatoms, greens and blue-greens to the predominatly bloom forming and nitrogen fixing Cyanobacteria.

Cyanobacterial blooms have become an increasingly common phenomenon near the shores of Lake Victora (Ochumba and Kibaara, 1989). Their effects are diverse and include frequent anoxia due to algal respiration and decomposition. Some of these changes have been studied and reported (Ochumba and Kibaara, 1989; Hecky, 1993 and Lung'aiya et al., 2001). Cyanotoxins are a health hazard and have serious ecological impacts on aquatic food webs. The toxins cause skin irritations, stomach upsets and make water unsuitable for domestic, agricultural and industrial use. The blooms clog fishnets making them heavy and inefficient for fishing. Recent fish kills in Lake Victoria have been attributed to the occurrence of dense cyanobacterial blooms (Ochumba, 1990). Effects of the toxins on fish, aquatic ecosystems, public health and livestock have not received much attention in Lake Victoria. This study examined the prevailing physical and chemical conditions of the inshore areas of Lake Victoria, Kenya and algal species composition, abundance, distribution, frequency and seasonality.

MATERIAL AND METHODS

Light penetration was estimated with a Secchi disk while turbidity was measured with a Hach Turbidimeter 2100P. *In situ* measurements were made for temperature, dissolved oxygen, conductivity, pH automatically using a Hydrolab Surveyor II connected to an SVR 2- DU display and a 401 - CA circulator assembly. Water samples were collected and a portion of it analyzed for total alkalinity and total hardness by titration as outlined in GEMS (1992). Spectrophotometric methods were used to determine the soluble reactive phosphorous (PO_4-P) and nitrate nitrogen (NO_3-N) as outlined by Mackereth *et al*., (1978) and soluble reactive silica (SiO_2-Si) according to APHA (1985). Chlorophyll-*a* was extracted and determined according to Strickland and Parsons (1968) as presented in Wetzel and Likens (1979). For the analysis of algae, 250 mL of the water was placed in polyethylene bottle and fixed immediately with Lugol's solution and stored in a dark cool box for analysis in the laboratory. Identification and counting of the algae was done with an inverted microscope.

RESULTS

There was little variation in temperature between and within stations. This suggests that there was no thermal stratification in the sampled sites. Dissolved oxygen concentrations were relatively high in surface waters (7.3 ± 0.12), and in

bottom waters (5.28 ± 0.33), rarely going below 3 mg L^{-1}. Other physico-chemical parameters showed similar trends (Table 1)

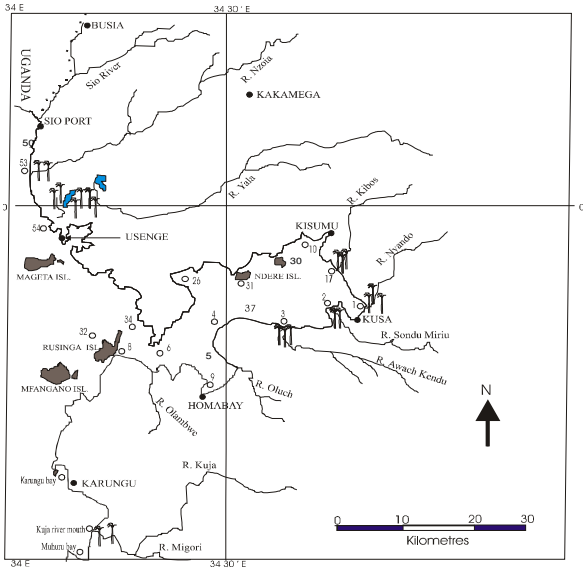

Fig. 1. Map of Lake Victoria, Kenya sector, showing sampling stations

Table 1. Mean ± SE of surface physico-chemical parameters and nutrients of bloom environment in L. Victoria, 2000- 2001, September 2003 and July 2004.

Parameter	2000 – 2001	n	Sept 2003	n	July 2004	n
Temperature (^{o}C)	26.8 (0.2)	23	25.98 (0.16)	30	25.4 (0.12)	20
DO (mg L^{-1})	7.3 (0.2)	23	8.18 (0.35)	30	7.3 (0.12)	20
PH	6.5 (0.1)	23	7.76 (0.05)	30	7.6 (0.04)	20
ORP (mV)			170 (10)	30	148 (6.77)	20
Chloro- *a* (µg L^{-1})		23	15.8 (4.4)	30	31.6 (12.6)	17
Phosphate (µg L^{-1})	45 (9.1)	22	34.9 (24)	30	14.9 (5.2)	17
Nitrate (µg L^{-1})	1 (0.6)	22	14.9 (2.7)	30	7.9 (1.0)	17
Silicates (mg L^{-1})	9.8 (1.4)	22	6.2 (5.3)	30	8 (0.8)	17
Turbidity (NTU)			28.17 (3.47)	28	23 (5.07)	7
Transparency (M)	0.9 (0.1)	22			0.6 (0.07)	9

Nutrient concentrations and physico-chemical parameters had a near uniform distribution. High concentration of phosphate-phosphorus and nitrate-nitrogen were recorded in river mouths with Kuja and Nzoia having

concentrations of 69 and 62 µg PO_4-P L^{-1} respectively. Awach river mouth had the highest nitrate-nitrogen of 123 µg NO_3-N L^{-1}. The seasonality of nutrients depicted higher concentrations during the rains and low during the dry season except for phosphorous. Mean offshore phosphate-phosphorus was 58 µg L^{-1}, which was twice the average concentration in inshore waters during the dry season. Silica concentrations were generally low especially in offshore areas. Algal biomass measured as chlorophyll-*a* was generally high averaging 23 µg L^{-1} in inshore areas as opposed to 15 µg L^{-1} in offshore stations. The high concentrations of plant nutrients may explain the increase in chlorophyll-*a* concentrations and the enhanced algal blooms.

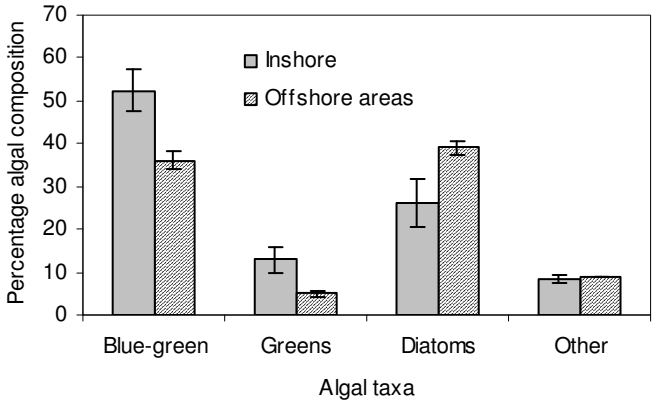

Fig. 2 Mean percentage composition of major algal taxa in surface waters of inshore and offshore ecological zones, September 2003.

Table 2: Algal group dominance expressed as % abundance in May 1994 during the wet season and November 1994, during the dry season

Stations	Season	Blue-green (Cyanophyceae)	Green algae (Chlorophyceae)	Diatoms (Bacilariophyceae)
10	Dry season	82.50	10.0	7.50
2, 3	”	74.63	0.58	24.79
9, 17	”	80.00	11.31	8.69
53, 54	”	12.70	0.98	86.32
10	Wet season	40.88	8.40	50.72
2, 3	”	37.12	8.79	54.09
9, 17	”	32.85	12.28	54.87
4, 30, 31, 37	”	47.96	7.30	44.74
53, 54	”	33.26	7.32	59.85

Table 3: Occurrence of algal blooms at some sampling sites in the Kenyan waters of Lake Victoria during certain periods of the year

Major Algae Causing blooms	Similar species present in the composition	Sites where blooms occurred	Periods when blooms occurred
Microcystis aeruginosa	*M. pulveria*	2	March, July, November
	M. gravillei	4, 5	March, April, September
	M. wessenbergi	8	January, March, September,
	M. viridis	9, 10	October, November,
		26, 50	January, May, March, July,
		3, 53, 54	September
			July, October
			January, March, May, July, September, November
Planktolyngbya circumreta	*P. contorta*	17	March
	P. talingii	26	April, September
		30, 31, 37	May
Anabaena flos-aquae	*A. sporoides*	2, 3	March, May, August
	A. circinalis	4, 5	April, May, July, October
	Pseudoanabaena spp	9	May
		17	January, March, June
	Anabaenopsis tanganyikae	26, 50	July, October
		10, 53, 54	January, March, May, July, September, November
Cylindrospermpsis africana	*Merismopedia tennuissima*	4, 8	March, April
		26, 50	February, May, September,
	Coelomoron spp.	53, 54	November
	Chroococcus spp.		May

Algal blooms have been found to be widespread in the Nyanza Gulf and occur almost through out the dry and wet seasons of the year, November and May respectively. Inshore stations had the highest percentage composition (>55 %) of Cyanophytes (Fig. 2 and Table 2). Over 90 species were identified with Cyanophytes having the highest species diversity. Of the 40 different species of Cyanophytes encountered, *Anabaena, Cylindrospermopsis, Microcystis* and *Planktolygbya* were the most dominant (Table 3).

DISCUSSION

Habitat characteristics of bloom environment exhibit wide variations in the parameters measured especially with regard to nutrient concentrations. With regard to physico-chemical parameters, the high turbidity is as result of a combination of high algal densities and suspended materials. The high oxidation-reduction potentials indicate presence of reducing conditions which are associated with the decomposition of organic matter and the release of nutrients. These

variations are brought about by seasonal fluctuations of inputs of organic matter both from the catchment and internal (self) loading, high nutrient loads and algal respiration and decomposition.

The prevailing environmental conditions are ideal for the proliferation and persistence of the blue-greens (Table 1). Cyanobacteria attain high growth rates at temperatures above 25 °C (Robarts & Zohary, 1987) as found in the study area (Fig. 1 & Table 1). These optimum temperatures are higher than for other forms of algae. Since all inshore stations in the Nyanza Gulf have a mean depth of less than 6M with euphotic depth being less than the epilimnion algal cells spend part of the daylight period in the dark. Thus, light becomes a limiting factor for algal growth. This situation favors the blue-greens over other algal groups because they have phycobiliproteins in addition to chlorophyll-*a*, which enable them capture light energy more efficiently and to live in a highly turbid environment (Paerl *et al*. 1983).

Cyanobacteria have been found to have a favorable energy balance which means that they require little energy to maintain cell function and structure in comparison to other genera (Gons, 1977). As a result, Cyanobacteria maintain a higher growth rate than other algae in highly turbid environments. Similarly, blue-greens have a higher tolerance for high light intensities. This enables the group to resist photoinhibition from the high light intensities and temperatures (Paerl et al. 1983) that characterize the inshore areas of Lake Victoria, Kenya.

The nutrient status depicts an increase of key plant nutrients especially P resulting in a significant decrease in the ratio of N and P (Kling et al., 2001), which is known to favor the development of Cyanobacterial blooms. This is particularly evident in offshore waters where N fixing from the atmosphere plays an important role. This is due to the fact that high numbers of heterocystous Cyanobacteria are present in offshore waters. In addition, Cyanobacteria out-compete other phytoplankton organisms under conditions of phosphorus or nitrogen limitation due to their high affinity for these nutrients. Similarly, Cyanobacteria can store enough phosphorus to perform two to four cell divisions, which corresponds to a 4-32 fold increase in biomass. The low concentration of silicates indicates that it is the nutrient limiting primary production in the lake. Hence, efforts should be made to prevent any increase in silicate concentration as this will enhance eutrophication in Lake Victoria.

While many algae are grazed by zooplankton and juvenile fish, Cyanobacteria are not grazed to the same extent, and the impact of grazing by some specialized organisms is not substantial. Subsequently, lack of natural enemies for the blue-greens coupled with the well-known fact of buoyancy regulation, means that the loss rates are generally low. As a result Cyanobacteria have now become a very dominant part of the algal flora of lake Victoria occurring throughout the year in most inshore stations. Thus, blue-greens will persist and continue to have a competitive advantage particularly in the inshore areas unless measures are taken to control nutrient loads and pollution in general.

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EFFECT OF RARE EARTH ELEMENTS ON GROWTH CHARACTERISTICS OF *MICROCYSTIS AERUGINOSA* FACHB526

QIAN Yun, LIU Guang-liang, ***DAI Shu-gui***, GE Wei-dong, ZHUANG Yuan-yi, WU Yu-jie
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ABSTRACT: At present, lakes and reservoirs in China are severely eutrophicated so that the deteriorated water quality poses a serious hazard to human health. Besides nutrients including nitrogen and phosphorous, other chemicals such as rare earth elements, potassium salts, selenium, iron, and so on, were also believed to have great influence on the growth of cyanobacteria, which are one of the prevalent water bloom-forming inhabitants. In China, rare earth elements, especially light and medium rare earth elements, such as lanthanum and europium, are widely used in agriculture, forestry, animal husbandry and aqua-culture where they are additives in micro-element fertilizers or animal food. As a result, this use has led to ubiquitous occurrence and ecotoxicological effects of these chemicals both in soil and in the aquatic environment.

The growth characteristics of *Microcystis aeruginosa* FACHB526 in BG_{11} medium containing different levels of lanthanum nitrate or europium oxide were studied in the laboratory. From maximum specific growth rate and maximum subsistent amount of algae expressed with counts of algal cell and content of chlorophyll-a, it was concluded that: 1) lanthanum nitrate at low concentration would stimulate the growth of *Microcystis aeruginosa* remarkably, while inhibiting the growth of algae completely at high concentration such as 125 mg/L in this test; and 2) Europium oxide would inhibit the growth of *Microcystis aeruginosa* both at low and high concentrations, but a remarkable inhibition effect was observed when the concentration of europium oxide was higher than 20 mg/L. These findings will benefit exploration of the mechanism of eutrophication, as well as potentially allowing control and restoration of eutrophicated water bodies, but more detailed, comprehensive, and systematic field studies than those presented here, which were limited to laboratory culture tests, are needed.

INTRODUCTION

The cyanobacterium *Microcystis aeruginosa* is a prevalent inhabitant of water bloom-forming organisms among which are *Microcystis*, *Anabaena*, *Nostoc, Flos-aquae,* and *Oscillatoria* species, and so on (Lawrence, et al., 2000). Excessive input of nutrition elements such as nitrogen and phosphorous into lakes or reservoirs causes algal explosive growth and water blooms; however, some other elements such as potassium, selenium, sodium, silicon, and rare earth elements are also suspected of playing a role during water blooms (Lawrence et al., 2000; Yin et al., 1998; Hu et al., 1996; Parker et al., 1997).

In China, rare earth elements, especially light and medium rare earth elements such as lanthanum and europium, are widely used in agriculture, forestry, animal husbandry and aqua-culture in which they are additives in micro-element fertilizers or animal food, resulting in their ubiquitous occurrence in the

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environment. However, the fate and ecotoxicological effects of such rare earth elements are not clear. Recent research has dealt with the influence of rare earth elements on algal growth and production mainly among green algae (Yin et al., 1998; Hu et al., 1996), while few studies focused on their effect on the growth of cyanobacteria.

The influence of lanthanum nitrate and europium oxide at various concentrations on growth of a common *Microcystis aeruginosa* FACHB526 was studied. Such studies on growth characteristics of algae under different chemical stresses will benefit investigations of the mechanism of eutrophication, as well as helping with controlling and restoring eutrophicated water bodies.

MATERIAL AND METHODS

Materials. The strain, *Microcystis aeruginosa* FACHB526, was purchased from the Institute of Hydrophytic Biology, Chinese Academy of Science, Wuhan, China. The culture of strain was grown in a BG_{11} growth medium and maintained in a growth chamber at 25 ˚C under white light (2500 lux) and dark for 12/12 h a day.

Analytical grade lanthanum nitrate ($La(NO_3)_3 \cdot 6H_2O$) and europium oxide (Eu_2O_3) were purchased from Shanghai Chemical Reagents Company, Chinese Medical and Medicine Group. The stock solutions were prepared in 1M HCl.

Procedures. The cyanobacteria strains were cultured in BG_{11} growth medium containing the desired concentration of lanthanum nitrate or europium oxide (varying from 0 to 100 mg/L). Each treatment was duplicated. The biomass yield was determined in cell counts per mL by microscopic counting. The content of chlorophyll-a was determined according to literature (Zhou and Zhang, 1989).

RESULTS AND DISCUSSION

The maximum specific growth rate and maximum subsistent biomass were used to characterize the growth of microcystis at different levels of lanthanum nitrate or europium oxide. The maximum specific growth rate, μ_{max}, calculated from cell counts or chlorophyll-a content, denoted as follows (Zhou and Zhang, 1989),

$$\mu_{max} = \text{Max}\ [\ln (X_i/X_j) / (i-j)]$$

where X_i is the cell count or chlorophyll-a content on the day i after logarithmic growth started ($i = j+1$, $j+2,\ldots$), X_j is the cell count or chlorophyll-a content on the day j when logarithmic growth just began.

In some cases, the maximum subsistent biomass, referring to the biomass on a specific day after which the growth rate of algae declined or increased by less than 5%, can also be used to describe the growth of algae.

Effect of Lanthanum Nitrate on *Microcystis Aeruginosa* FACHB526 Growth. During the culturing period the algal cell counts in the flask containing 125 mg/L

of lanthanum nitrate showed no increase, which demonstrated that algal growth was completely inhibited by lanthanum nitrate at high concentrations. The algal cell counts in other culturing flasks increased during the logarithmic growth phase as shown in Fig. 1. The growth curve of FACHB526 at high concentration of lanthanum nitrate was above that at low concentration, except the one at 125 mg/L which was not plotted in Fig 1. This showed that lanthanum nitrate in the test range stimulated the growth of *Microcystis aeruginosa* FACHB526. Due to the large excess of nitrate anion in BG_{11} medium, it could be extrapolated that this kind of stimulation or inhibition effect was caused by the rare earth lanthanum.

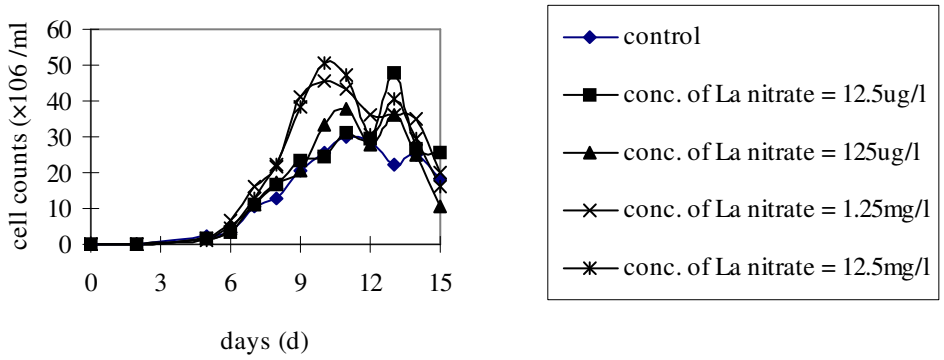

Fig 1 The cell counts of microcystis FACHB526 at different levels of lanthanum nitrate during culturing period

The maximum specific growth rate of *Microcystis aeruginosa* FACHB526, listed in Table 1, was increased with the concentration of lanthanum nitrate at the range of 0-12500 μg/L. A nearly twofold increase for the maximum specific growth rate at 12500 μg/L of lanthanum nitrate over the control was observed, showing a strong stimulation effect of lanthanum nitrate on growth of *Microcystis aeruginosa* FACHB526.

TABLE 1 The maximum specific growth rate (μ_{max}) of *Microcystis aeruginosa* FACHB526 at different concentration of lanthanum nitrate

	Concentration of $La(NO_3)_3$ (μg/L)				
	0	12.5	125	1250	12500
μ_{max} (d^{-1})	0.801	1.002	1.003	1.276	1.591
Percentage over control (%)	0	25.1	25.1	59.3	98.6

Showing the similar trend with maximum specific growth rate, the maximum subsistent biomass of *Microcystis aeruginosa* FACHB526 also increased with the concentration of lanthanum nitrate as listed in Table 2.

As mentioned above, the maximum specific growth rate and subsistent biomass can also be expressed with chlorophyll-a content in the algal cells. It also showed that lanthanum nitrate had an inhibition effect on the growth of *Microcystis aeruginosa* FACHB526 as seen in Table 3. However, the data in Table 3 showed an inhibition with smaller extent than that indicated by the algal cell counts in Table 1 and Table 2. The reason is that the chlorophyll-a content is not only related to the total counts of algal cells, but also to the cell size and other

synthesis processes. In a study on thermal tolerance of cyanobacteria, similar phenomena that increased chlorophyll-a content but did not follow cell dry weight increases were also observed. Weissman et al., 1998 noticed that although the cultures grew rapidly during the exponential phase and continued to increase in dry weight during a 48 h experiment at 30 °C, cellular chlorophyll-a content decreased during growth.

TABLE 2 The maximum subsistent biomass of *Microcystis aeruginosa* FACHB526 at different concentration of lanthanum nitrate

	Concentration of $La(NO_3)_3$ (μg/L)				
	0	12.5	125	1250	12500
The maximum subsistent biomass (10^6 cell/mL)	30	31.2	37.6	45.6	50.4
Percentage over control (%)	0	4.0	25.3	52.0	68.0

TABLE 3 The maximum specific growth rate and subsistent biomass expressed with chlorophyll-a content of *Microcystis aeruginosa* FACHB526 at different concentration of lanthanum nitrate

	Concentration of $La(NO_3)_3$ (μg/L)				
	0	12.5	125	1250	12500
The maximum specific growth rate (d^{-1})	0.685	0.693	0.969	0.788	0.794
Percentage over control (%)	0	1.2	41.5	15.0	15.9
The maximum subsistent biomass (μg/mL)	0.691	0.827	0.705	0.816	0.838
Percentage over control (%)	0	19.7	2.0	18.1	21.3

Effect of Europium Oxide on *Microcystis Aeruginosa* FACHB526 Growth. Two tests, with low and high concentrations of europium oxide, were carried out. Growth curves were shown in Figure 2 and Figure 3, respectively. During high concentration test, complete inhibition effect of europium oxide on *Microcystis aeruginosa* FACHB526 growth was observed when the concentration was equal to or more than 40 mg/L (40, 60, 80, and 100 mg/L in this test). Rare earth elements at high concentration possibly inhibited the growth of microcystis completely.

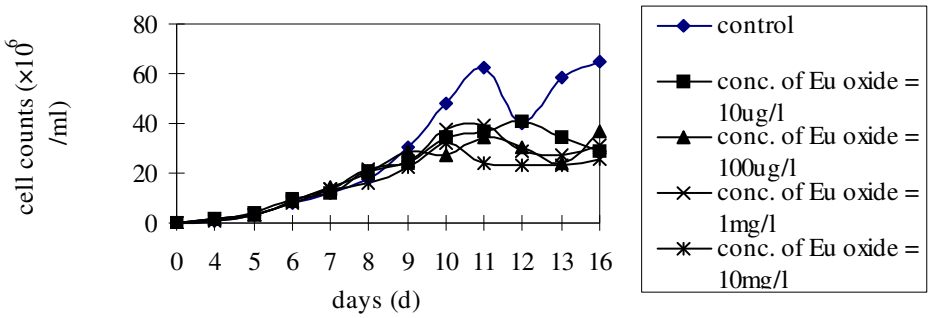

Fig 2 The cell counts of microcystis FACHB526 at lower concentrations (<10 mg/L) of europium oxide during culturing period

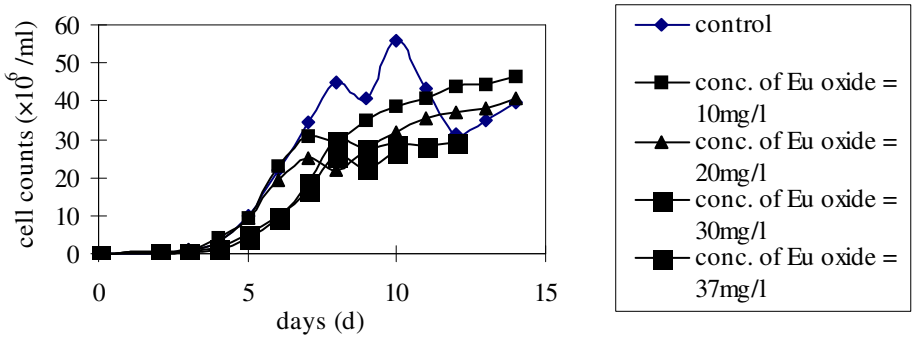

Fig 3 The cell counts of microcystis FACHB526 at high concentrations (10-37 mg/L) of Eu oxide during culturing period

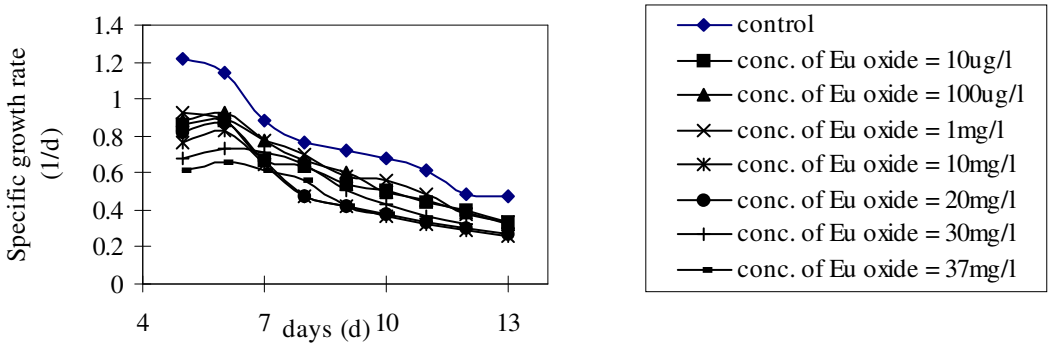

Fig 4 Change of specific growth rate of FACHB526 with time at various concentration of europium oxide

In Figure 2 and Figure 3 all growth curves of FACHB526 in BG11 medium containing europium oxide, either low or high concentration, were beneath that of the control, which suggested that europium oxide treatment produced slower growth. Differently from lanthanum nitrate, europium oxide showed no stimulation effect on microcystis growth, even at low concentration. Both high and low concentration of europium oxide showed only inhibition effect on microcystis growth. Basically, the higher the europium oxide concentration,

the greater the extent of inhibition, although this trend was not very clear at low concentration, as seen in Figure 2. The change of specific growth rate in the culture test showed this trend visually (Figure 4).

The maximum specific growth rate and subsistent biomass, both expressed with algal cell counts and with chlorophyll-a content (data were not shown here), also showed that the higher concentration of europium oxide treatment produced slower growth of *Microcystis aeruginosa* FACHB526, especially for the concentrations more than 20 mg/L.

The Implication of the Effect of Rare Earth Elements on *Microcystis Aeruginosa* Growth. The mechanism of eutrophication is rather complicated. Besides regular nutrition elements such as nitrogen and phosphorous, some other elements, rare earth elements as an example, are beyond doubt concerned with the water blooming process. As growing regulators for agricultural plants and aqua-culture organisms, rare earth elements showed complex effects on aquatic organisms including algae. In addition to *Microcystis aeruginosa* FACHB526 used in this study, growth of several other species such as *Chlorella* were observed being suppressed by lanthanum or other rare earth elements (Sun et al., 1997; Wang et al., 1996). All these studies showed that rare earth elements indeed influenced the growth and production of water-blooming algae such as green alga and blue-green alga (cyanobacteria). In the natural aquatic environment where rare earth elements are practically used the concentration was around several mg/L which has largely exceeded the level showing stimulation or inhibition effect observed in this study. Therefore much attention should be paid to the fate and effect of rare earth elements in the water bodies surrounded by agricultural areas in which fertilizer containing rare earth elements was applied.

On the other hand, given that the rare earth concentrations that are toxic to microcystis are not harmful to most other organisms, the rare earth elements can be proposed as a safer alternative to copper sulfate or to other biocides that are currently added to water supplies to limit *Microcystis* blooms. However, this just offers a new possibility for the regulation of *Microcystis* blooms. An accurate assessment of the environmental role of rare earth elements and of their potential for the control of *Microcystis* blooms needs more detailed, comprehensive, and systematic field studies than those presented here, which were limited to laboratory culture tests.

CONCLUSIONS

At low concentration lanthanum nitrate would stimulate the growth of *Microcystis aeruginosa* FACHB526 remarkably while inhibiting the growth of algae completely at high concentration such as 125 mg/L in this test. Different from this, europium oxide showed no stimulating effect, but inhibited the growth of *Microcystis aeruginosa* both at low and high concentration, and a remarkable inhibition effect was observed when the concentration of europium oxide was higher than 20 mg/L.

REFERENCES