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Seasonal variation of phytoplankton assemblage in Hoa Binh reservoir, north of Vietnam

Biến động quần xã thực vật nổi tại hồ chứa Hòa Bình, Bắc Việt Nam

Research article

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Algae provide an important role in aquatic food web and biochemical cycles in aquatic systems. They are affected by different environmental factors, such as pH, light, temperature and nutrients. This study aimed to describe the composition abundance and density of phytoplankton in the Hoa Binh reservoir during period from March to December 2011. Phytoplankton samples were collected monthly at four sampling stations. Result obtained showed that 6 phytoplankton classes were recorded: Cyanobacteria, Chlorophyceae, Bacillariophyceae, Euglenophyceae, Dinophyceae and Cryptophyceae. Bacillariophyceae and Cyanobacteria were the most abundant phytoplankton families constituting 61% and 32% respectively of total phytoplankton community. Colony-forming and solitary filamentous-forming of Cyanobacteria group (e.g. Microcystis aeruginosa, M. wesenbergi and Oscillatoria sp. respectively) were a common component of phytoplankton community in the early summer and autumn periods (April and September). The total cell densities of phytoplankton varied seasonally from 84210 to 100x106 cell/L. Phytoplankton density varied with season with high values in early summer and winter (April and December) and low values in summer –autumn periods (from June to October)

Tảo đóng vai trò quan trọng trong mạng lưới thức ăn và chu trình sinh địa hóa của thủy vực và chúng chịu sự chi phối của nhiều yếu tố môi trường như ánh sáng, pH, nhiệt độ và dinh dưỡng. Nghiên cứu này trình bày đa dạng thành phần loài và biến động sinh khối thực vật phù du tại hồ chứa Hòa Bình từ tháng 3 đến tháng 12 năm 2011. Các mẫu thực vật nổi được thu thập hàng tháng tại 4 điểm. Kết quả đã xác định được 6 lớp tảo chính bao gồm: Vi khuẩn lam, tảo lục, tảo silic, tảo mắt, tảo giáp và tảo lông roi hai rãnh. Nhóm tảo silic và Vi khuẩn lam chiếm ưu thế với độ phong phú tương đối là 61% và 32% tương ứng trong quần xã thực vật nổi. Vi khuẩn lam dạng tập đoàn và dạng sợi (Microcystis aeruginosa, M. wesenberg, Oscillatoria sp. tương ứng) chiếm ưu thế trong quần xã thực vật nổi vào các thời điểm đầu hè và mùa thu (tháng 4 và tháng 9). Tổng mật độ tế bào thực vật nổi dao động từ 84210 đến 100 x10^6 cell/L. Mật độ thực vật nổi biến động theo mùa với sinh khối tê bào cao vào đầu hè và mùa đông (tháng 4 và tháng 12) và sinh khối tế bào thấp vào các mùa hè và thu (tháng 6 đến tháng 10).

Keywords: phytoplankton community, cyanobacteria, reservoir, Hoa Binh, Vietnam

1. Introduction

Phytoplankton are primary producers and form the base of most freshwater and marine food webs. They play important roles in carbon, nutrient, and oxygen cycling in aquatic ecosystems (Khan, 2003; Kang et al., 2006; Adon et al, 2011). Due to their abundance, wide geographical distribution, short cycle, rapid responses to a broad range of environmental perturbation, phytoplankton have been used as bioindicators for a large range of environmental and climate changes. Phytoplankton is therefore considered as an ecologically important group in most aquatic systems. In different types of fresh aquatic ecosystems, changes in phytoplankton community are

recognized as a good indicator of the trophic status and environmental quality since they usually respond rapidly to environmental changes such as eutrophication, acidificationand organic pollution (Reynolds, 1996). Moreover, phytoplankton integrates ecological variations over time and can provide the information concerning larger-scale and longer-term changes in ecosystem function, including shifts in nutrient cycles, food webs, and fisheries (Paerl and Peierls 2008). Extensive work in freshwater aquatic systems has focused on identifying factors related to phytoplankton community composition. Relationship between seasonal periodicity of phytoplankton assemblages and seasonal variations in physical forcing of mixing dynamics, temperature, nutrients and the solar cycle in freshwaters and oceans have pointed out in many studies (Anneville et al., 2002; Winder and Hunter., 2008). Several studies have focused on factors determining the temporal and spatial variability of plankton (Hamilton et al., 2011) with an emphasis on temperate lakes.

Phytoplankton assemblage structure in temperate rivers and lakes is usually controlled by factors such as water temparture, light density, nutrients and top-down control. However, hydrological mechanisms (river morphology, discharge), as well as dilution and turbidity, are fundamental to the occurrence of phytoplankton distributions in rivers (Reynolds, 2006; Soares et al., 2007). Phytoplankton successions in tropical aquatic systems are generally characterized by a distinct shift between dry and rainy seasons (Bouvy et al., 2006; Nweze., 2006). The present study aimed to determine temporal and spatial variation of phytoplankton assemblage in the reservoir Hoa Binh, north of Vietnam.

2. Materials and methods

2.1 Study site

The Hoa Binh reservoir ($20^000'$- $106^000'$) was constructed in 1989 and located on the Da River, which is the largest tributary of the Red River system. The Red River basin is located in the northern and north-eastern parts of Vietnam and has a total catchment area of 169,000 km^2. The Hoa Binh reservoir has an effective storage capacity of 9.5 Mm^3 and a surface area of 208 km^2. The major characteristics of this reservoir are described in Le et al. (2007).

Figure 1. Sampling stations in the Hoa Binh reservoir

Average annual rainfall is about 1800–2000 mm, 80% of which occurs during the rainy season from June to October. The dry season lasts from November to April–May. Phytoplankton samples were taken monthly at four sampling sites from March to December 2011 (Figure 1). For the present study, the average values of sampling sites were presented.

2.2 Sample collection and analysis

Phytoplankton samples were collected monthly using plankton net (40 μm mesh size) and immediately fixed with formaldehyde solution at a 5 % (v/v) final concentration for species identification. Phytoplankton species were identified according to its morphology using light microscopic observation (Olympus BX51). The following taxonomic literature was used for the identification of cyanobacteria: Duong (1996); Komárek and Anagnostidis (1989; 1999; 2005). Krammer and Lange-Bertalot (1986-1991) was used for diatom identification. Den Hoek et al (1995), Duong and Vo (1997) were used for other algae identification. For phytoplankton enumeration, one-liter of water was preserved with 10 ml Lugol's iodine solution and then was sedimented for 48 h prior to counting. Number of cells was counted by using a Sedgewick-Rafter cell method (Karlson et al. 2010).

3. Results and discussion

Microscopic examination of phytoplankton assemblage in Hoa Binh reservoir from March to December 2011 revealed six groups: Chlorophyceae, Bacillariophyceae, Cryptophyceae, Euglenophyceae, Dinophyceae and Cyanobacteria. Figure 2 presents the abundance of phytoplankton groups in the study area during the investigated period. Generally, diatoms (Bacillariophyeae) and Cyanobacteria accounted the highest proportions in phytoplankton community in the Hoa Binh reservoir (up to 61% and 32 %, respectively), whereas Dinophyceae and Eugenophyceae had the lowest abundance.
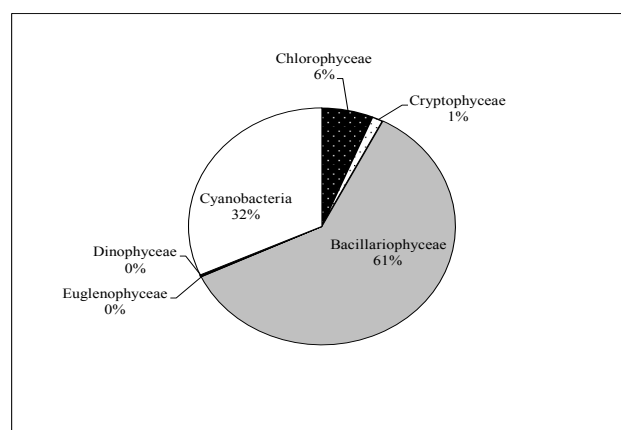

Figure 2. Percentage of 6 phytoplankton groups in the Hoa Binh reservoir (3-12/2011)

Similarly to temperate lakes, tropical aquatic ecosystems also may experience seasonal climatic variations that determine physical and chemical changes. Such variations, however, differ in amplitude and intensity (Fonseca

and Bicudo, 2008). According to Frogg, 1975), different phytoplankton groups can tolerate different ranges of temperature, light and nutrient limitation. These tolerance levels identify the abundance of different phytoplankton groups within different seasons. During the study period, the Hoa Binh reservoir phytoplankton dynamic showed strong seasonal pattern (Fig 3). In early summer and autumn (April and September) phytoplankton community in the Hoa Binh reservoir dominated by filamentous forming

Cyanobacteria (e.g. *Osillatoria*) or *Microcystis* sp. Chlorophyceae showed high development only from in summer from May to August and the phytoplankton community was then changed to be dominated by Cyanobacteria. Indeed, Cyanobacteria were the most important phytoplankton group in the eutrophic, mesotrophic temperate and trophic lake ecosystems in the summer/ autumn (Elliott, 2010).
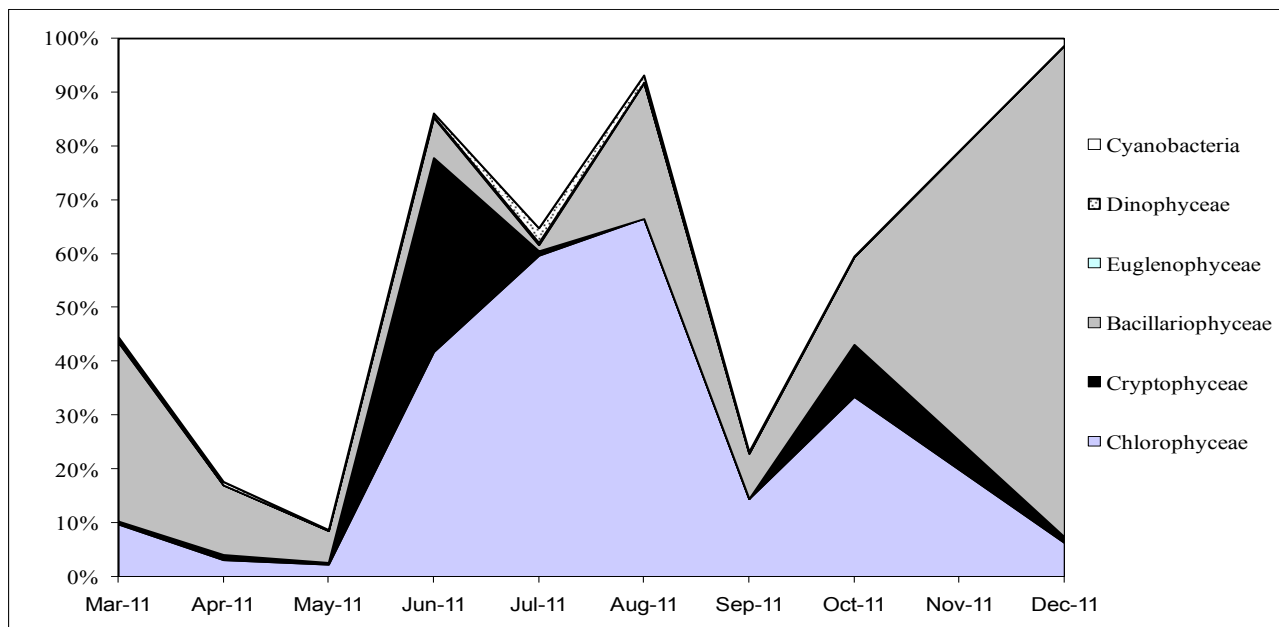

Figure 3. Seasonal variation of relative abundance of phytoplankton in the Hoa Binh reservoir during the study period from March to December 2011

Our results correspond to the observations of Salmaso (2000) who suggested that Chlorophytes and Cyanobacteria are the most typical algal groups, contributing to the aesthetic appearance and quality of the epilimnetic waters of the deep and large lakes located on the southern edge of the Alps. In fact, during cold period (in winter), Cyanobacteria and Chlorophyceae groups were replaced by diatom species (Bacillariophyceae). Phytoplankton successions in tropical aquatic systems are generally characterized by a distinct shift between dry and rainy seasons (Bouvy et al., 2006; Nweze., 2006). These results were consistent with those of other studies which found that phytoplankton succession in tropical aquatic systems was characterized by a distinct shift between dry and rainy seasons: Chlorophytes–chroococcales/ Cyanobacteria in the Lake Tanganyika (Descy et al. 2005), Diatoms/Cyanobacteria in the Lake Victoria (Kenya), the Lake Guiers (Senegal) and the Lake Dongping (Lung'ayia et al. 2000; Bouvy et al. 2006). Phytoplankton groups and dominant species in the Hoa Binh reservoir were presented in table 1. Phytoplankton composition of the Hoa Binh reservoir was cosmopolitant axa and common for freshwater and indicates eutrophic character of reservoir waters. The most frequently identified Cyanobacteria that occurred in the reservoir were colony-forming (e.g. *Microcystis aeruginosa, M. wesenbergi*) as well as the solitary filamentous-forming (e.g. *Oscillatoria sp*). These species have been previously described worldwide as potential cyanotoxin producers (Chorus and Bar-

tram1999). These species have been not only found in this study but also in several fishponds and water bodies in Vietnam from earlier investigations (Dang et al.2005; Nguyen et al.2007; Dao et al. 2010).

Table 1. Dominant phytoplankton species in the Hoa Binh reservoir

Phytoplankton groups	Dominant species
Cyanobacteria	*Microcystis aeruginosa, M. wesenbergii, Oscilatoria* sp.
Chlorophyceae	*Scenedesmus acuminatus, S. quadricauda, Pediastrum simplex, P. duplex, Staurastrum* sp. *Cosmarium* sp.
Bacillariophyceae	*Aulacoseira granulata, Melosira varians, Navicula* sp*., Cyclotella meneghiniana.*
Cryptophyceae	*Cryptomonas* sp.
Dinophyceae	*Ceratium* sp., *Peridinium* sp.
Euglenophyceae	*Euglena acus, Phacus* sp.

The dominant species found in the phytoplankton samples consist of chain-forming diatoms (e.g. *Aulacoseira granulate, Melosira variant)* and centric diatom (e.g. *Cyclotella meneghiniana*). According to the above-cited taxonomic literature, the centric diatoms of the Hoa Binh reservoir

have a preference for meso-eutrophic waters. Dominant species belonging to the Chlorophyceae group were *Scenedesmus acuminatus, S sp., Pediastrum simplex, Staurastrum* sp… Cryptophyceae, Euglenophyceae, and Dinophyceae were also observed in much lower numbers. These groups were represented mostly by *Cryptomonas* sp*., Euglena sp,* and *Ceratium* sp., respectively. Similar data were given by Duong (2013) on phytoplankton samples from Nui Coc reservoir. Cell density was taken into account to give a general pattern of the characteristics of phytoplankton communities in the Hoa Binh reservoir. The mean number of phytoplankton cell ranged from 84210 to 100.3 x10^6 cell/L (Figure 4).
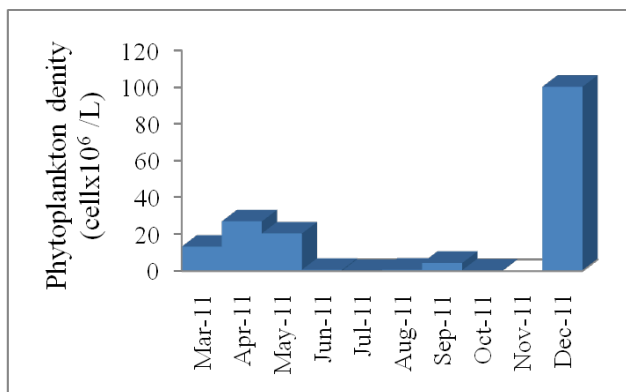

Figure 4. Density variation of phytoplankton (x10^6) in the Hoa Binh reservoir in the period from March to December 2011

Phytoplankton density varied with season with high values in early summer and winter (April and December) and low values in summer – autumn periods (from June to October) (Figure 4). The two peaks of phytoplankton biomass during the early summer period was dominated by Cyanobacteria genus such as *Microcystis and* Oscillatoria (20.2 x10^6 cell/L) and during winter period was caused by chain-forming diatoms *Aulacoseira granulate* and centric diatom *Cyclotella* (100.3 x10^6 cell/L).

4. Conclusions

In conclusion, the results of this study revealed a generally clear seasonal pattern of changes in phytoplankton communities in the Hoa Binh reservoir. 6 phytoplankton classes were recorded: Cyanobacteria, Chlorophyceae, Bacillariophyceae, Euglenophyceae, Dinophyceae and Cryptophyceae. Among them, Bacillariophyceae and Cyanobacteria were the most abundant phytoplankton families constituting 61% and 32% respectively of total phytoplankton community. Our investigation indicated that, colony-forming and filamentous-forming of Cyanobacteria (e.g. *Microcystis aeruginosa, M. wesenbergi and Oscillatoria* sp. *r*espectively) were dominated group of phytoplankton community during early summer and autumn periods (April and September). In summer, cyanobacteria were replaced by green algae (Chlorophyceae) group. There are distinctive seasonal differences of the phytoplankton abundance - higher in early summer and winter and autumn, lower in summer.

5. Acknowledgments

6. References

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