Techno-Science Research Journal 2 (2014) 30-35

Content list available at ITC

Techno-Science Research Journal

Journal Homepage: www.itc.edu.kh

Techno-Science Research Journal

Water Quality Monitoring Toward Management of Sesan River of SteungTreng Province of Cambodia after the Bloom of Toxic Cyanobacteria

Sokly Siev*, Chantol Peng, Huyleang Chheng, Raksmey Sokvong, Seingheng Hul

Department of Chemical Engineering and Food Technology, Institute of Technology of Cambodia, Russian Ferderation Blvd., P.O. Box 86, Phnom Penh, Cambodia.

Abstract: *The recent research has shown the bloom toxic of cyanobateria in Sesan River which is one of the largest tributaries of Mekong River. The bloom toxic of cyanobacteria released cyanotoxin which is the serious problem causing adverse health effects for the local people along the river since this river is the main source for daily use. Therefore, the condition growth of cyanobacteria and sources of contamination were investigated after this research which was conducted twice in rainy and dry season. 3 sampling sites along the river that were chosen to be analyzed and monitored the water quality after the occurrence of bloom of the cyanobacteria. The condition growth of cyanobacteria was conducive in term of temperature, pH, and nutrient in rainy and dry season. Data showed the concentration of Phosphate in which range from 0.05mg/l to 0.87mg/l and Nitrate range from 0.75mg/l to 1.53mg/l indicated that the river has been contaminated and it has been the best nutritional condition for its growth and bloom. Additionally, sources of contamination were shown as a result of untreated sewage, agriculture activities, fertilizer, soil erosion, material decay, mining activities and dam construction in the upstream.*

Keywords: Water quality, Cyanobacteria, Growth condition

1. INTRODUCTION

The Sesan River is one of the most important ecology systems surrounded by green forestry in the northeast region of SteungTreng and RatanakKiri provinces. It is one of the largest tributaries of the Mekong River and has a drainage area of 17,000 km^2, where of 11,000 km^2 in Vietnam and 6,000 km^2 in Cambodia. Total length of Sesanriver is 462 km, where of 210 km in Vietnam (ADB, 1994). Originating in the central highlands of Kon Tum and Galai provinces in the Central Highlands of Viet Nam, it flows from east to west through the northern part of Ratanakiri and SteungTreng provinces in northeast Cambodia. In SteungTreng, this river is joined by the Srepok River from the southeast, which itself originates in the Central Highlands in Viet Nam, in DakLak province (Baird and Meach, 2005). In 1996, Vietnam started the development of hydropower plant of Yali Falls Dam in Sesan River system (IRN, 2002). This action has changed the ecosystem, hydrology and people lives- fish decreasing, water pollution, disorder of water flow, and erosion increasing (IRN, 2002). The water released by the dam altered the quality of water downstream, and the increase in filamentous algae was one result caused by the influx of nutrient-rich water from the Yali Falls reservoir (IRN, 2002). Recent research has shown the bloom of cyanobacteria and it has been proven to have toxic algae in the Sesan River. Microcystins are also confirmed in the dry season (Tiodolf, 2009). These algae commonly referred to cyanobacteria which have been recognized as a public health issues, gastric disorders, skin eruptions and respiratory problems (WHO, 2003).

The major nutrient controlling occurrence of water blooms of cyanobacteria is phosphorus. Stagnant water bodies that are subject to high water temperatures, sufficient light and nutrients are ideal for cyanobacterial

* Corresponding author:
E-mail: sievsokly@yahoo.com

growth. Cyanobacteria out-compete other forms of algae due to their ability to fix nitrogen. In low phosphorous conditions they are able to control their buoyancy and find phosphorous in anoxic bottom waters (Tarren, 2009). Wherever conditions of growing are conducive, surface water may host increased proliferation dominated by single or a few species of cyanobacteria, the phenomenon is referred to as a cyanobacterial bloom.

Seeing adverse health effect and factors of or the thrives of cyanobacteria, it is significantly important to know what are conditions of the river in terms of water quality relating to the growth of the algae and what are the potential sources of contamination of nutrients present the river. The objective of this study is to analyze the water characteristics in term of chemical data of Sesan River serving as baseline data prior to manage and control of toxic cyanobacteria and to identify particularly Nitrate and Phosphate from some sources of pollution of the river.

2. METHODOLOGY

This research focuses heavily on water quality of SesanRiver in both seasons (Dry and Rainy) . The field of study stretched on the Sekong River till the confluence of Sesan River and Srepok River (Fig. 1). First site survey was conducted on 20th -21st August 2011 and next was on 18th-19th January 2012. Three simples were taken from the three different sites of Sesan River in SteungTreng Province. The first site (Site 1) is located in Prek Village, SteungTreng Commune, SteungTreng District (Fig. 1). It is in the city and is very active by human activities, especially on the surface water of river. It was a busy site since there was machinery boats-small and big traveling from one bank to another to take people to the city to buy food, sell fish or wild animal. The second site (Site 2) is located in Phaderm village, Phaderm Commune, Sesan District (Fig. 1). It is far from the city and is an agricultural area with a few household. People living over there are the farmer growing rice and other agricultural crop. The last sampled site (Site 3) is located in 8km far from Phlok Village, Phlok Commune, Sesan District (Fig. 1). This site is a forest where is a quiet place, no human activities and it is surrounded with trees. The samples were taken about 1 foot from the surface of river and were contained in the 500ml plastic bottle and conserved in ice-container before taken to laboratory. The parameters that were analyzed and measured on site and upon sampling were pH, Temperature (T), Conductivity (Con.), Total Dissolved Solid (TDS), Ammonia (NH3), Nitrate-nitrogen (N), Phosphate-phosphorus (P) and Turbidity (Tur.). For N was determined using Hach reagents and test kit. And P was measured using ascorbic acid method, Hach reagents and test kit.

3. RESULTS AND DISCUSSION

Generally, water quality describes the characteristics of water in term of chemical, physical and biological parameters. In table 1 presents the summarized result of water quality analyzing on pH, T, Con.,TDS,NH3, N, P and Tur.

Table 1. Water qualiy monitoring results.

N	Par.	Unit	Rainy season			Dry season		
			S1	S2	S3	S1	S2	S3
1	pH		6.74	6.83	7.1	7.42	7.19	7.27
2	Tur.	NTU	98.3	95.6	102	9.18	18.5	21.4
3	P	mg/l	0.87	0.44	0.49	0.05	0.17	0.21
4	N	mg/l	1.22	1.08	1.21	0.94	0.75	1.53
5	NH3	mg/l	0.05	0.15	0.08	0.01	0.01	0.05
6	Con.	µS/cm	46.6	45.6	61.6	43.1	45.7	51.2
7	TDS	mg/l	32	31	33	30	30	30
8	T	˚C	28	28	28	29	29	29

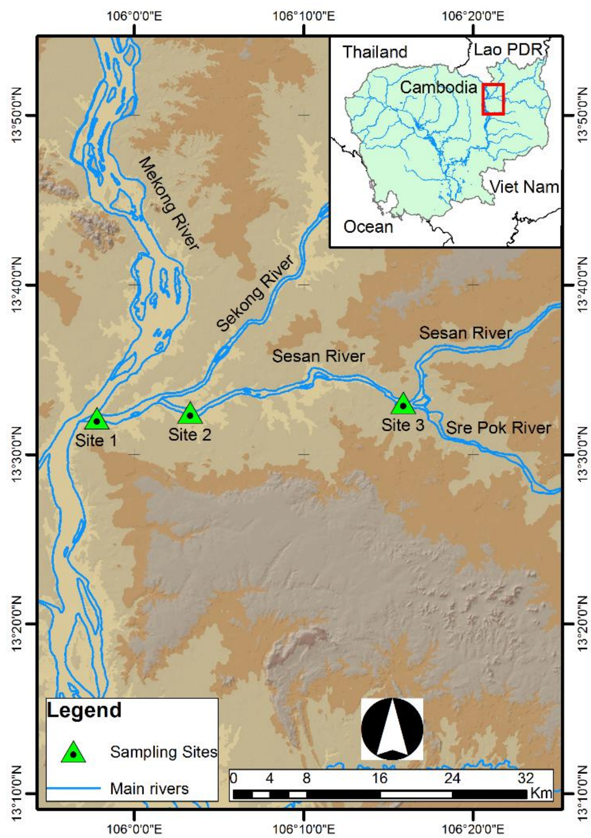

Figure 1. Study area location and water quality sampling sites.

3.1 pH

pH is a measurement of the hydrogen ion (H+) concentration. Solutions range from very acidic in which have a high concentration of H+ ions or to very basic in which have a high concentration of OH- ions. The pH scale ranges from 0 to 14, with 7 being the neutral value.

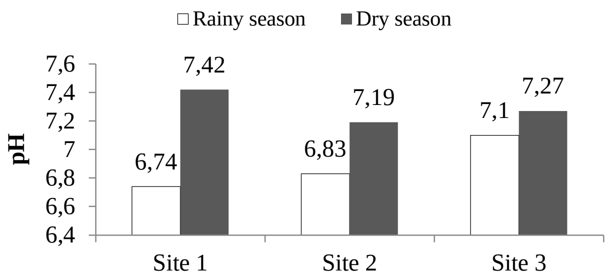

Figure 2.The pH of water in three sampling sites in rainy and dry season.

The pH is a physical indication of water which is very important for chemical reactions taking place in water. Moreover, pH values that are too high or low can inhibit the growth of microorganisms (Spellman, 2003).Therefore, pH is one of the condition growths of microorganism, especially in water. Normally, pH ranges from 6.5 to 8.5 for surface water. Certain microorganisms grow well in this condition, while other could not. Cynobacteria is one of the aquatic microorganisms where its optimum growth pH is ranged from 7.5 to 8 (Manhattanreefs, 2012). In comparison to this research (Fig. 2) in dry season the pH was ranged from 7.19 to 7.42 which was the good condition for cynobacteria while the pH ranged from 6.74 to 7.1 in rainy season which were not for its growth.

3.2 Temperature

The examination of water or wastewater quality, temperature is not important in evaluation of its quality. However, it is a main parameter in natural surface water system which mostly has the temperature variation effecting to solubility of oxygen in water, especially the rate of bacterial activity (Spellman, 2003). Certain microorganism has a high growth in the high temperature while others could not but most prefer the tropical temperature. For instance, Most cynobacteria grow in the surface water have an optimum growth rate above 25 °C are therefore favoured by higher temperatures (Sperling and Jardim, 2009; Robarts and Zohary, 1987). In figure 3 shows the temperature in rainy and dry season in three different sites presenting the temperature variation in which varied from 28 to 29 °C. Therefore, the temperature in this river is approximately to the temperature of optimum growth of cynobacteria.

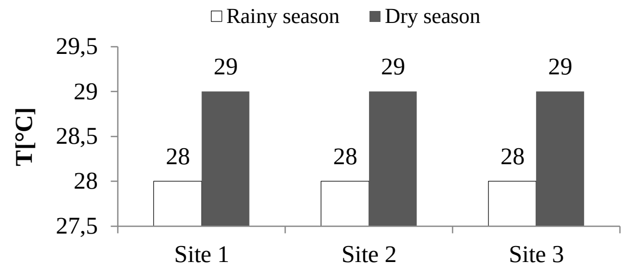

Figure 3. Different temperatures of three sampling sites during rainny and dry season.

3.3 Turbidity

Turbidity mentions on the clarity of water, in which causing by the presence of suspended matter or impurities analyzed by scattering or absorption of light rays (Spellman, 2003). These impurities cause to Turbidity may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton microorganism and other microscopic organisms (EPA, 1999). High turbidity protected Microcystis from damage to photosynthetic apparatus due to intense sunlight while also causing low-light limitation in non-buoyant phytoplankton species (Thomas et al., 2010). In Fig. 4 indicates the high turbidity especially in rainy season while in dry season the turbidity is quite low.

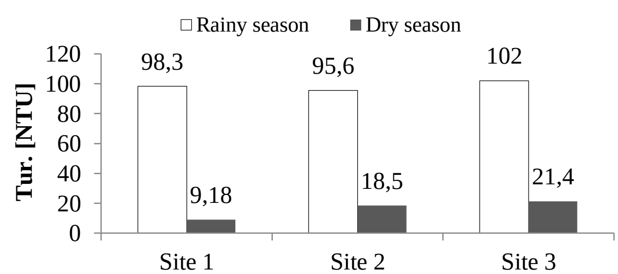

Figure 4. Turbidity of three sampling sites during rainy and dry season.

3.4 Total dissolved solids (TDS)

It refers to measurement in milligrams per liter (mg/l) of the amount of dissolved materials in the water. Some ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium all contribute to the dissolved solids in the water (Poe, 2005). TDS is monitored to define whether the water is soft or hard. As a result, in Fig. 5 shows that TDS in rainy season is higher than the dry season which mean the water in both season are soft. On the other hand cyanobacteria use some trace mental for its metabolism.

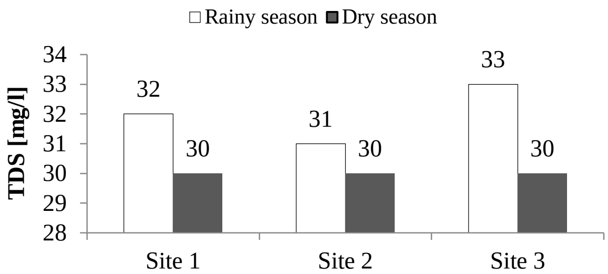

Figure 5. Total dissolved solid during rainy and dry season of three sampling sites.

3.5 Ammonia, Phosphate and Nitrate

Commonly, phosphate, nitrate and ammonia are the main nutrients for plant and animal life and growth. However, they are considered as contaminants, and high levels of nutrients can cause increased growth of algae beyond what is normal (Poe, 2005).

The concentration of ammonia was significantly varied from 0.01mg/l to 0.05mg/l and 0.05mg/l to 0.15mg/l from site 1 to site 3 in dry season and rainy season respectively (Fig. 6). 0.05mg/l of ammonia in site 3 in dry season was higher than the other sites which could be the process of denitrification. It was reasonably the concentration of nitrate was also high in site 3 while in site 2 in rainy season shows higher concentration of 0.15 mg/l of ammonia than site 1 and site 3 which indicated that the water is high contaminated. As described above site 2 is the agricultural area and fertilizer has been actively used. This action could contribute to contaminated ammonia in the water.

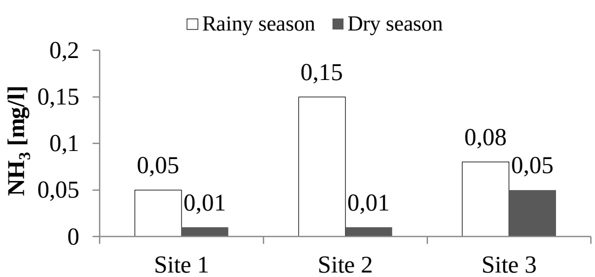

Figure 6. Ammonia concentration of three sampling sites during rainy and dry season.

The concentration of phosphate of 0.05mg/l, 0.17 mg/l and 0.21mg/l in dry season and of 0.87mg/l, 0.44mg/l and 0.49mg/l in rainy season in site 1, site 2 and site3 respectively were found (Fig. 7). This was indicated the contamination was higher in the rainy season than in dry season. In rainy season, concentration of phosphate decreased from site 1 to site 3 while the water flow from site 3 to site 1. This meant the high phosphate concentration was contaminated in site 1 whereas in the dry season, Phosphate increased from site 1 to site 3.

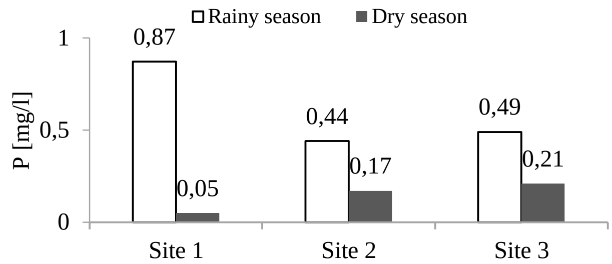

Figure 7. Phosphate concentration in three sampling sites in rainy and dry season.

Nitrate concentration is one of the main concerns of cyanobacteria's bloom. In rainy season, concentration of 1.22mg/l, 1,08mg/l and 1.21mg/l in site 1, site 2 and site 3 respectively were monitored and shown in Fig.8. This showed a little change in concentration while in dry season, concentration of 0.94 mg/l, 0.75 mg/l and 1.53mg/l in site 1, site 2 and site 3 were detected. According to these result, the site 3 showed a high in concentration of Nitrate which meant high contamination from the upstream.

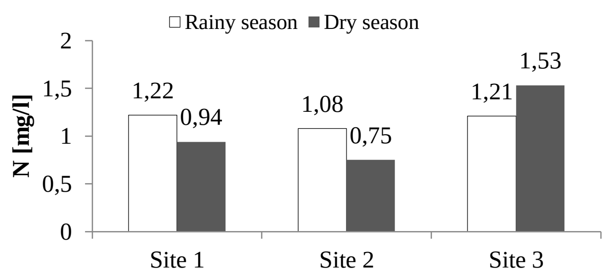

Figure 8. Nitrate concentrations in three sampling sites in rainy and dry season.

Based on recent research, 0.003mg/l and 0.14mg/l of Phosphate and Nitrate, respectively, are proven to occur the bloom and release toxic in Sesanriver in dry season (Tiodolf, 2009). On the other hand 0.001 mg/l and 0.01mg/l of Phosphate and Nitrate respectively are enough to grow and bloom in Laguna de Bay, Philippines (Baldia et al., 2007). In comparison, the concentration of Phosphate in which range from 0.05mg/l to 0.87mg/l and Nitrate range from 0.75mg/l to 1.53mg/l that have been monitored indicated that has been the best nutritional condition for cyanobateria's growth and bloom.

During field work research of site observation and literature review, one of source of contamination was the untreated sewage such as waste water, cleaning product and household waste which drain into the river, especially when the rain fall. Another important source was agricultural run-off like fertilizer, cattle manure and material decay (vegetable and death animal). The released nutrient from those materials could be contaminated by farming time with farmers' activities where the river is closed to the agriculture area. Moreover, human sanitary was note practiced well; bout 75% of the population in SteungTreng do not access to sanitary toilet (NCDD, 2009). Recent measurements carried out by STRIVER on Sesan shows some indicators of mesotrophic to eutrophic environment (indicating possible negative impacts from upstream) (Tiodolf, 2009). Although the sources of problems have not been clarified, there are many concerns related to the water quality, these include: o the discharge of municipal waste water from the dense populated towns such as in O Kansieng and O PratinhThum MSBs; the use of substances in mining activities such as heavy metals and particularly cyanide (a very highly poisonous substance) or mercury in goldmines extraction which is taking place intensively (more than 630,000 ha) in the sub-area and can be leached into the environment and eventually to the water streams; and the impact of Yali dam (ADB, 2010). The impact of Yali dam has been reported by many authors. The water released by the dam altered the quality of water downstream, and the increase in filamentous algae was one result caused by the influx of nutrient-rich water from the Yali Falls reservoir (Baird and Meach, 2005). More than 55,000 people in Cambodia and Vietnam have suffered severe impacts to their livelihoods because of the Yali Falls Dam in Vietnam. Dam operation has altered the hydrology and water quality of the Sesan River, causing deaths to villagers and livestock and the flooding of rice fields and vegetable gardens (IRN, 2011).

4. CONCLUSIONS

Sesan River has been contaminated by cynobacteria. The condition growth of cyanobacteria was conducive in term of temperature, pH, and nutrient in rainy and dry season. Data showed the concentration of Phosphate in which ranged from 0.05mg/l to 0.87mg/l and Nitrate ranged from 0.75mg/l to 1.53mg/l indicated that the river has been contaminated and it has been the best nutritional condition for its growth and bloom. Additionally, sources of contamination were shown as a result of untreated sewage, agriculture activities, fertilizer, soil erosion, material decay, mining activities and dam construction in the upstream.

ACKNOWLEDGMENTS

Authors wish to thank to JICA through the AUN/Seed-Net program for funding this research.

REFERENCES

A.M. Tiodolf (2009). A limnological study in the Se San River in Cambodia during the dry season: focus on toxic cyanobacteria and coliform bacteria, Thesis (Master), Norwegian University of Life Sciences.

ADB (1994).Subregional Energy Sector Study for the Greater Mekong Subregion, Final Report, Manila.

ADB (2010). Sesan, SrePok and Sekong River Basins Development Study in Kingdom of Cambodia, Lao People's Democratic Republic, and Socialist Republic of Viet Nam, Report of The 3Ss RETA Team.

B.B. Thomas, M.M. Christine, A.H. Scott, and W.V. Sigler (2010). Assessing the role of turbid river plumes in the development of microcystis blooms in lakeerie with molecular techniques. Report of the Lake Erie Protection Fund, Department of Environmental Sciences and Lake Erie Center, University of Toledo, Oregon, Ohio.

Commune Database (2009). Stung Treng Data Book 2009, National Committee for Sub-National Democratic Development (NCDD), Planning Department, Ministry of Planning.

E.V. Sperling, and Jardim, F.A. (2009). Influence of climatic conditions on cyanobacteria blooms in a tropical water supply river (Rio das Velhas, Brazil). 34th WEDC International Conference, Addis Ababa, Ethiopia.

EPA (1999). Important of Turbidity, Report of EPA Guidance Manual Turbidity Provisions.

F.R. Spellman (2003) Hand Book of Water and Waster Water Treatment Plant Operations. Lewis Publishers, A CRC Press Company, Boca Raton London, New York Washington, D.C., 320- 396.

I.G. Baird, and Meach M. (2005).Sesan River fisheries monitoring in Ratanakiri province, northeast Cambodia: Before and after the construction of the Yali Falls dam in the Central Highlands of Viet Nam. 3S Rivers Protection Network and the Global Association for People and the Environment. Ban Lung, Ratanakiri, Cambodia.

IRN (2011).Danming the Sesan River: Impacts in Cambodia and Vietnam, Reports documenting the impacts of Yali Falls Dam, 2002. Retrieved on 01 August 2011 from www.irn.org.

K.F. Poe (2005). Water quality and monitoring. Report of Master Watershed of Steward.

Manhanttanreefs (2012). Cyanobacteria Primer. Retrieved on 02 May 2013 from http://www.manhattanreefs.com/forum/re efs-beginners/46961-cyanobacteria-primer.html.

R. Tarren (2009).Cyanobacterial harmful algal blooms: a potential public health hazard in freshwater resources

of South-East Asia, Report of an internship undertaken with World Health HealthOrganisation.
R.D. Robarts, and T. Zohary (1987). Temperature effects on photosynthetic capacity, respiration, and growth rates of bloom- forming cyanobacteria. N.Z.J. Mar. Freshwat, 21: 391-399.
S.F. Baldia, A.D. Evangelista, E.V. Aralar, and A. E. Santiago (2007). Nitrogen and phosphorus utilization in the cyanobacteriumMicrocystisaeruginosa isolated from Laguna de Bay, Philippines. J. ApplPhycol, 19: 607-613.
WHO (2003). Algae and cyanobacteria in fresh water: Guidelines for safe recreational water environments, Vol.1: Coastal and Fresh Waters, Genova.