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Water quality and red bloom algae of fish ponds in three different regions of Nepal

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Abstract

Present study determines the causes and seasonal variation of red bloom in fishponds of Eastern, Western and Central regions of Nepal. Monthly monitoring of water quality and phytoplankton was carried out for one year. Water parameters such as NH_3-N, total phosphorus, total Kjeldahl nitrogen (TKN), total dissolved solids (TDS) and conductivity were significantly higher ($p<0.05$) in red bloom fishponds than non-red bloom fishponds. The total density of euglenophytes in red-bloom fishponds was significantly higher ($P<0.05$) (1970±260 cells L^{-1}) than non-red bloom fishponds (410±30 cells L^{-1}). Euglenophyte density varied seasonally and significantly lower in spring season (1250±220 cells L^{-1}) than autumn (1950±390 cells L^{-1}), winter (2180±370 cells L^{-1}), and summer (2490±480 cells L^{-1}) in red bloom fishponds. High nutrients might favor the growth of euglenophytes (*Euglena sanguinea*) causing red bloom fish ponds of Nepal.

Key words: Conductivity, Euglenophytes, Fish production, Phytoplankton

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Introduction

Red-bloom in fishponds is a common occurrence in Nepal. Red bloom fishponds are frequently covered with brick-red colored thin film of fine dust. This thin film or scum at the surface, which gives unpleasant look, shades the lower waters, inhibit photosynthesis, deplete dissolved oxygen, brings behavioral changes in fish and sometimes results fish mortality too (Rehman, 1998; Zimba *et al*., 2004; Zimba *et al*.,

2010) which is due to euglenoid toxin functions as a neurotoxin (Costa and Garrido, 2004; Costa, 2014). The color of the red bloom is not constant, that changes from green to red, generally green at the dawn and at the dusk, when the sunrays are oblique and soft (Rehman, 1998). Red blooms occur due to abundant food and suitable environment for phytoplankton growth.

For getting higher fish production, fish farmers feed their ponds with high doses of fertilizers. As a result, the confined water of the ponds becomes eutrophic due to sedimentation of nutrients from feed and fertilizers. This condition induces toxic and noxious phytoplankton bloom including euglenophytes which causes red blooming in pond water (Ohio EPA, 2013). Euglenophytes bloom is the most common phenomenon in warmer, shallow and eutrophic water bodies in Nepal. *Euglena* assemblages are known to be widely distributed in higher eutrophic shallow ponds at elevated temperature (Wild *et al.,* 1995). Most problems occur when population of potentially toxic species increase dramatically and causes oxygen depletions killing fish, shellfish and other aquatic organisms (Lopez *et al*., 2008; Zimba *et al*., 2004; 2010; Boyd and Tucker, 2014). In Nepal, farmers generally believe that red bloom has adverse effects on fish farming such as low fish production, oxygen depletion and fish mortality; however, no scientific research is done yet to prove it. Therefore, present research was to assess causes and seasonal occurrence of red bloom in fish ponds in Nepal.

Materials and methods

Phytoplankton and water samples were collected from ten fishponds (5 red bloom and 5 non-red bloom ponds) each from 3 different regions (Morang in Eastern, Chitwan in Central and Rupandehi district in western region) of Nepal at 6 am to 8.30 am in four different seasons (spring, autumn, summer and winter) in a year.

Water quality parameters such as dissolved oxygen (DO), pH, oxidation reduction potential (ORP), temperature, conductivity, total dissolved solid (TDS) were analyzed in situ using HI-98194 Multiparameter and soluble reactive phosphorus (SRP), nitrate, nitrite, ammonia nitrogen (NH_3-N) using HI-83203-02 Multiparameter bench photometer. Total phosphorus and chlorophyll-a was analyzed by standard methods (APHA, 1985; 2012) and total Kjheldahl nitrogen (TKN) according to APHA (2005).

For phytoplankton sampling, five liters of pond water (up to 50 cm depth) was collected using graduated bucket and filtered with plankton net (mesh size 5 μm) and then preserved in 5% formaldehyde solution. Phytoplanktons were identified following Prescott (1951) and Rai and Rai (2007) and classified according to Guiry and Guiry (2016). Phytoplankton were counted using Sedgwick-Rafter (S-R) cells and quantified following APHA (1976) as.

$$\text{Number of species} = C \times 1000\ mm^3/L \times D \times W \times S$$

Where, C= Number of organisms counted, L= Length of each stripe (mm), D= Depth of each stripe (mm), W= Width of each stripe (mm), and S= Number of stripes.

Data was analyzed by one way ANOVA and significant level was considered at the level of 5% ($P<0.05$). Seasonal variation and intra-regional of red bloom fishpond and non-red fishponds were analyzed by independent simple t-test at the level of 5% ($P<0.05$).

Results

Results of region wise water quality parameters and phytoplankton density is shown in Table 1 and season wise water quality parameters and phytoplankton density is shown in Table 2. Results showed that water quality parameter such as pH, temperature, Nitrite, ORP and chlorophyll-a were not significantly different ($P>0.05$) between red bloom and non-red bloom fishponds.

Region wise water quality parameters and phytoplankton density

Dissolved oxygen was of significantly lower (2.3±0.5 mg/L) in red bloom fishponds of central region than non-red bloom fishponds of (3.1±0.3 mg/L) the same region (Tab.1). Total phosphorus in red bloom fishponds was significantly higher (1.16±0.28 mg/L) in eastern region than non-red bloom fishponds (0.55±0.16 mg/L) of same region (Tab.1). Total ammonia nitrogen (NH_3-N mg/L) in red bloom fishponds of eastern region was also significantly higher (1.48±0.30 mg/L) than non-red bloom fishponds (0.63±0.09 mg/L) of same region (Tab. 1). Total Kjheldahl nitrogen (TKN) of red bloom fishponds of eastern (1.55±0.12 mg/L), central (1.4±0.19 mg/L) and western (1.48±0.07 mg/L) regions were significantly higher ($P<0.05$) than non-red bloom fishponds of all three different regions (Tab. 1). Similarly, TDS and conductivity of red bloom fishponds of all three regions were significantly higher ($P<0.05$) than non-red bloom fishponds. Highest value of TDS and conductivity were observed in western regions of Nepal (Tab. 1). Euglenophytes was significantly higher ($P<0.05$) in red bloom fishponds of western region (2370±420 cells L^{-1}) than non-red bloom fishponds (490±70 cells L^{-1}) of the same region (Tab. 1). Bascillariophytes and cyanophytes were not significantly different ($P>0.05$) among red bloom or non-red bloom fish ponds of all three regions (Tab. 1).

Season wise water quality parameters and phytoplankton density

Seasonal combined mean DO (combined mean value of all red bloom fishponds or non-red bloom fishponds) was significantly higher in non-red bloom fishpond (3.5±0.4 mg/L) than red bloom fishponds (2.5±0.1 mg/L) (Tab. 2). Combined mean of total phosphorus also found significantly higher in red bloom fishponds (0.86±0.12 mg/L) than non-red bloom fish ponds (0.49±0.05 mg/L) (Tab. 2). Similarly combined mean of NH_3-N mg/L in red bloom fishponds was significantly higher (1.05±0.14 mg/L) than non-red bloom fishponds (0.64±0.08 mg/L). Combined mean value of total dissolve solids (TDS) of red bloom fish ponds was significantly higher (148.01±14.5 mg/L) than non-red bloom fishponds (105.01±13.10 mg/L) (Tab. 2). Similarly, combined conductivity was also significantly higher in red bloom fishponds (292.3±31.1 µS/cm) than non-red bloom fishponds (211.98±27.2 µS/cm) (Tab. 2). Combined mean nitrate value in non-red bloom fishponds was significantly higher (0.59±0.09 mg/L) than red bloom fishponds (0.36±0.03 mg/L).

Euglenophytes was significantly higher ($P<0.05$) in summer season (2490±290 cells L^{-1}), winter (2180±370 cells L^{-1}) and autumn (1950±390 cells L^{-1}), than spring (1250±220cells L^{-1}) season (Tab. 2) in red bloom fishponds. Chlorophytes was found significantly higher in summer season (1620±250 cells L^{-1}) than autumn season (650±60 cells L^{-1}) in red

Table 1. Region-wise variation of water quality parameters and phytoplankton (Mean + S.E.) of red bloom and non-red bloom fishponds.

Parameter	Eastern Nepal		Central Nepal		Western Nepal	
	Red bloom	Non-Red bloom	Red bloom	Non-Red bloom	Red bloom	Non-Red bloom
Temperature (^oC)	28.70±0.1 ^{aA}	28.32±0.1 ^{aA}	26.0±0.3 ^{bA}	25.77±0.3 ^{bA}	25.80±0.2 ^{bA}	25.96±0.2 ^{bA}
pH	7.7 (7.4-8.0)	7.4 (7.4-7.8)	7.8 (7.7-.8.0)	7.6 (7.3-8.2)	7.9 (7.7-8.2)	7.8 (7.6-8.4)
DO (mg/L)	3.0±0.2 ^{bB}	3.8±0.2 ^{aA}	2.3±0.5 ^{cB}	3.1±0.3 ^{bA}	2.4±0.4 ^{cB}	3.7±0.5 ^{aA}
ORP (mV)	110.55±12.1^{aA}	134.85±5.43^{aA}	124.35±2.83^{aA}	131.37±3.0 ^{aA}	125.85±5.41^{aA}	131.67±6.05^{aA}
NH_3-N (mg/L)	1.48±0.30 ^{aA}	0.63±0.09 ^{bB}	0.78±0.19 ^{bA}	0.53±0.16 ^{bA}	0.91±0.18 ^{bA}	0.77±0.18 ^{bA}
SRP (mg/L)	0.25±0.06 ^{aA}	0.29±0.06 ^{aA}	0.24±0.06 ^{aA}	0.15±0.02 ^{aB}	0.24±0.07 ^{aA}	0.21±0.07 ^{aA}
Nitrate (mg/L)	0.41±0.1 ^{aA}	0.52±0.16 ^{aA}	0.28±0.09 ^{aB}	0.57±0.28 ^{aA}	0.4±0.17 ^{aA}	0.69±0.29 ^{aA}
Nitrite (mg/L)	0.01±0.00 ^{bA}	0.01±0.00 ^{bA}	0.09±0.03 ^{bA}	0.05±0.02 ^{bA}	0.28±0.08 ^{aA}	0.22±0.02 ^{aA}
Ch-a (mg/L)	22.3±3.07 ^{aA}	32.05±5.30 ^{aA}	30.76±3.84 ^{aA}	27.51±4.20 ^{aA}	33.79±1.57 ^{aA}	28.57±3.64 ^{aA}
TDS (mg/L)	100.5±6.65 ^{cA}	60.81±4.42 ^{eB}	134.1±7.32 ^{cA}	84.57±11.24^{cdB}	209.43±23.60^{aA}	169.64±4.61 ^{bB}
Conductivity (µS/cm)	187.7±7.48 ^{dA}	123.60±8.43 ^{dB}	267.34±14.9^{cA}	165.35±23.5 ^{dB}	421.87±53.06^{aA}	347.0±9.65 ^{bB}
TKN (mg/L)	1.55±0.12 ^{aA}	1.1±0.07 ^{bcB}	1.4±0.19 ^{abA}	1.00±0.07 ^{cB}	1.48±0.1 ^{aA}	1.07±0.06 ^{bcB}
TP (mg/L)	1.16±0.28 ^{aA}	0.55±0.16 ^{bA}	0.59±0.12 ^{bA}	0.36±0.06 ^{bA}	0.83±0.14 ^{abA}	0.56±0.06 ^{bA}
Phytoplankton						
Euglenophytes ($X10^3$ cells/L)	1.36±0.08 ^{abA}	0.42±0.01 ^{cdB}	2.19±0.62 ^{aA}	0.34±0.06 ^{dB}	2.37±0.42 ^{aA}	0.49±0.07 ^{cdB}
Chlorophytes ($X10^3$ cells/L)	1.01±0.14 ^{bcA}	1.29±0.19 ^{abcA}	1.5±0.07 ^{abA}	1.55±0.29 ^{aA}	0.83±0.09 ^{cA}	1.3±0.08 ^{abcA}
Bascillariophytes ($X10^3$ cells/L)	0.58±0.19 ^{aA}	0.39±0.07 ^{aA}	0.48±0.07 ^{aA}	0.53±0.14 ^{aA}	0.50±0.13 ^{aA}	0.52±0.14 ^{aA}
Cyanophytes ($X10^3$ cells/L)	0.39±0.08 ^{bA}	0.63±0.10 ^{aA}	0.30±0.02 ^{bA}	0.39±0.08 ^{bA}	0.22±0.01 ^{bA}	0.39±0.08 ^{bA}

[Small letter shows regional differences while capital letter (t-test analysis) shows intra-regional differences between red bloom and non-red bloom fishponds]

Table 2. Season-wise variation of water quality parameters and phytoplankton of red bloom and non-red bloom fishponds in all three regions of country.

Parameter	Spring(M-M)		Summer (J -A)		Autumn (S -N)		Winter (D - F)		Combined	
	Red pond	**Non-Red**	**Red pond**	**Non-Red**	**Red pond**	**Non-Red**	**Red pond**	**Non-Red**	**Red pond**	**Non-Red**
Temperature (^{o}C)	30.0±0.9 ^{a}	30.3±0.9 ^{a}	31.8±0.1 ^{a}	31.3±0.01 ^{b}	26.5±0.6 ^{a}	26.1±0.6 ^{a}	18.9±0.2 ^{a}	18.9±0.3 ^{a}	26.8±0.3 ^{a}	26.6±0.3 ^{a}
pH	8.1±0.1 ^{a}	7.8±0.1^{a}	7.6±0.1 ^{a}	7.3±0.1 ^{a}	7.7±0.1 ^{a}	7.7±0.1 ^{a}	8.0±0.9 ^{a}	7.9±0.07 ^{a}	7.9±0.1 ^{a}	7.7±0.09 ^{a}
DO (mg/L)	3.0±0.4 ^{b}	3.9±0.44 ^{a}	1.8±0.1 ^{b}	2.4±0.2^{a}	2.3±0.2^{b}	3.1±0.32^{a}	3.0±0.1 ^{b}	4.7±0.2 ^{a}	2.5±0.1 ^{b}	3.5±0.4^{a}
ORP (mV)	106.52±6.6^{a}	119.17±6.81 ^{a}	113.59±5.7 ^{a}	124.1±3.4 ^{a}	139.11±6.67 ^{a}	147.59±3.39 ^{a}	133.62±8.4 ^{a}	139.69±5.9 ^{a}	120.25 ±6.0^{a}	132.63±2.89 ^{a}
NH_3-N (mg/L)	0.91±0.19 ^{a}	0.64±0.16 ^{a}	1.21±0.19 ^{a}	0.42±0.06 ^{b}	1.05±0.20 ^{a}	0.75±0.13 ^{a}	1.01±0.22 ^{a}	0.76±0.17 ^{a}	1.05±0.14 ^{a}	0.64±0.08 ^{b}
SRP (mg/L)	0.13±0.03 ^{a}	0.19±0.06 ^{a}	0.29±0.07 ^{a}	0.13±0.03 ^{a}	0.31±0.08 ^{a}	0.34±0.08 ^{a}	0.24±0.05 ^{a}	0.19±0.066 ^{a}	0.24±0.033 ^{a}	0.21±0.3 ^{a}
Nitrate (mg/L)	0.84±0.11 ^{a}	0.91±0.21 ^{a}	0.19±0.04 ^{a}	0.4±0.17 ^{a}	0.1±0.04 ^{b}	0.49±0.16 ^{a}	0.32±0.1 ^{a}	0.57±0.15 ^{a}	0.36±0.03 ^{b}	0.59±0.09 ^{a}
Nitrite (mg/L)	0.06±0.02 ^{a}	0.03±0.01 ^{a}	0.01±0.0 ^{a}	0.02±0.0 ^{a}	0.02±0.00 ^{a}	0.03±0.0 ^{a}	0.43±0.14 ^{a}	0.29±0.1 ^{a}	0.13±0.04 ^{a}	0.09±0.02 ^{a}
Ch-a (mg/L)	21.9±4.06 ^{a}	29.44±4.44 ^{a}	30.76±3.35 ^{a}	37.98±5.6 ^{a}	23.07±3.3 ^{a}	21.68±2.61 ^{a}	40.07±6.5 ^{a}	28.42±5.3 ^{a}	28.95±2.05 ^{a}	29.38±2.42 ^{a}
TDS (mg/L)	160.07±18.9^{a}	115.39±16.2^{a}	106.02±15.3^{a}	85.91±11.97 ^{a}	135.8±16.48 ^{a}	99.9±14.9 ^{a}	190.16±12.1^{a}	118.83±11.8^{b}	148.01 ±14.5^{a}	105.01±13.10 ^{b}
Conductivity (µS/cm	298.73±43.3^{a}	232.38±33.01^{a}	211.98±30.7 ^{a}	169.96±24.3^{a}	280.16±33.8^{a}	203.89±29.9^{a}	378.33±24.1 ^{a}	241.71±26.6^{b}	292.30 ±31.1^{a}	211.98±27.2^{b}
TKN (mg/L)	1.45±0.15 ^{a}	1.12±0.11 ^{a}	1.59±0.1 ^{a}	1.39±0.06 ^{a}	1.24±0.13 ^{a}	0.88±0.11 ^{b}	1.62±0.25 ^{a}	0.82±0.04 ^{b}	1.48±0.07 ^{a}	1.05±0.03 ^{b}
TP (mg/L)	1.01±0.16 ^{a}	0.62±0.09 ^{a}	0.74±0.2 ^{a}	0.38±0.06 ^{a}	0.76±0.17 ^{a}	0.40±0.08 ^{a}	0.94±0.17 ^{a}	0.55±0.08 ^{b}	0.86±0.12 ^{a}	0.49±0.05 ^{b}
Phytoplankton										
Eulenophytes (X10^{3}cells/L)	1.25±0.22 ^{aB}	0.58±0.05 ^{bX}	2.49±0.48 ^{aA}	0.29±0.04 ^{bY}	1.95±0.39 ^{aA}	0.24±0.04 ^{bY}	2.18±0.37 ^{aA}	0.56±0.07 ^{bX}	1.97±0.26 ^{a}	0.41±0.03 ^{b}
Chlorophytes (X10^{3}cells/L)	1.19±0.17 ^{aAB}	1.13±0.2 ^{bY}	1.62±0.25 ^{aA}	2.04±0.26 ^{aX}	0.65±0.06 ^{bC}	1.09±0.18 ^{aY}	0.97±0.14 ^{aBC}	1.25±0.17 ^{aT}	1.11±0.09 ^{a}	1.37±0.11 ^{a}
Bascillariophytes (X10^{3} cells/L)	0.49±0.05 ^{aAB}	0.34±0.03 ^{bY}	0.72±0.15 ^{aA}	0.92±0.17 ^{aX}	0.37±0.05 ^{aC}	0.32±0.05 ^{aY}	0.49±0.07 ^{aAB}	0.33±0.04 ^{aY}	0.52±0.06 ^{a}	0.48±0.05 ^{a}
Cyanophytes (X (10^{3}cells/ L)	0.33±0.03 ^{aAB}	0.27±0.03 ^{aY}	0.43±0.1 ^{bA}	0.98±0.18 ^{aX}	0.18±0.02 ^{bB}	0.30±0.05 ^{aY}	0.27±0.03 ^{aAB}	0.32±0.04 ^{aY}	0.30±0.03 ^{b}	0.47±0.05 ^{a}

[Small letter shows difference between red bloom and non-red bloom fishponds while capital letter shows seasonal differences between red bloom and non-red bloom fishponds] bloom fishponds (Tab. 2). Cyanophytes was found significantly higher in non-red bloom fishponds (980±180 cells L^{-1}) in summer season than non-red bloom fishponds (270±30 cells L^{-1}) of the spring season. Bascillariophytes was significantly higher non-red bloom fishponds (920±170 cells L^{-1}) in summer season than autumn (320±50 cells L^{-1}) (Tab. 2) season of non-red bloom fishponds. In red bloom fishponds, red color was depended on the presence of *Euglena sanguinea.* At least many than thousands cells per liter of water was found and if number of cells increased, intensity of red blooming also increased.

Discussion

Significantly higher euglenophyte density in red bloom fish ponds confirmed red bloom is due to euglenophytes (Rahman *et al*., 2007). The development of red bloom algae i.e., euglenophytes depend on the combination of a set of factors such as sunlight, temperature and nutrient concentrations. In accordance with Nwankwo (1995), higher number of euglenophytes species were recorded when water nutrient values were high. In the red bloom fishponds of all three regions during summer and winter seasons, the high nutrient such as TP, TKN, NH_3-N was found which is quite similar to Xavier *et al.* (1991) and Rahman *et al.* (2007). The value of dissolved oxygen during the heavy bloom in ponds of the Central and Western region were lower (2.2 and 2.4 mg L–1) than the ponds of Eastern region 3.0 mg L–1where the bloom did not occur high. High dissolved solids (TDS), high SRP, TKN and high conductivity were found to favor the abundance of euglenophytes in Western and Central regions of Nepal (Munawar, 1970; Rahman *et al.,* 2007). Nutrients enrichment in fishponds is reflected through TDS and conductivity of water.

This finding agrees fairly well with finding of Mishra and Saksena (1993) and Hosmani (1988) who reported that the percentage of euglenophytes was greater compared to chlorophytes, bacillariophytes and cyanophytes in nutrient rich water bodies (Costa and Garrido, 2004; Lopez *et al*., 2008; Costa, 2014).

Conclusions

Red algal bloom have increased during the past 20 years in Asian country (Costa and Garrido, 2004; Lopez *et al*., 2008; Costa, 2014). In Nepal, red bloom in fish ponds has become common problem especially in the terai region. Preliminary study on red bloom in fish ponds of three regions of the country has been able to identify that euglenophyte algae is the major cause of red scum and its population varies seasonally depending on nutrients content in water. The findings will help to make farmers understand that red color in fish pond is a biological activity influenced by water quality such as nutrients in water. However, further studies are needed to assess effects of red bloom on fish growth and production and its control measures.

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