Dhaka Univ. J. Biol. Sci. **29**(1): 9-18, 2020 (January)

PHYTOPLANKTON IN RELATION TO WATER QUALITY OF TANGUAR HAOR ECOSYSTEM, BANGLADESH: 2. WATCH TOWER STATION

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Key words: Physicochemical factor, Phytoplankton density, Water quality, Chlorophyll-a,

Abstract

Phytoplankton biomass in relation to some environmental and nutritional parameters at Watch Tower Station of Tanguar and Rauar Station has been studied. Since the Haor is a Ramsar Site, it is a globally important aquatic ecosystem. In the present investigation, the structure of the phytoplankton and the water quality factors were worked out and the data were compared Rauar Station with having the same ecosystem. Though weaker, a difference among alkalinity, total dissolved solids (TDS), conductivity, dissolved oxygen (DO), Secchi disc transparency, soluble reactive phosphorous (SRP), soluble reactive silicate (SRS), NO_3-N, NH_4^+, chlorophyll-a and phytoplankton population density was found between the Watch Tower and the Rauar Station of Tanguar Haor. The mean values of the aforsaid parameters were found to some extent higher in the Watch Tower Station. The Watch Tower Station was deeper and perennial, where the depth of water varied from 3.0 - 9.5 m annually with a mean of 6.72 m. In the studied station, air and water temperature varied from 22.6 - 30.6 and 22.7 - 30.3°C, respectively. Water transparency ranged from 2.08 - 3.0 m. From December to March the pH remained 8.1-9.7 and alkalinity from 0.73 - 1.35 meq/l. However, from April to September these two parameters ranged from 7.5 - 7.7 and 0.33 - 1.35 meq/l, respectively. Dissolved oxygen (DO) and free CO_2 concentration ranged from 2.5 - 6.09 and 0.084 - 0.087 mg/l, respectively. During April to September the Chlorophyll-a value ranged from 5.5 - 7.5 μg/l while the range of SRP was 24.23 - 30.05 μg/l during the same period. At the latter part of the study year i.e., during the dry period (December to March) those two parameters were relatively low in concentration. In April a high concentration of NH_4^+ (1380 μg/l) was reported from the haor, at other times this parameter ranged from 690 - 820 μg/l. The NO_3-N ranged from 0.25 - 0.75 mg/l. High density of phytoplankton population (2690 ind./l) was reported at the time of high concentration of SRP (30.05 μg/l) of the haor water. The chlorophyll-a value (7.5 μg/l) was also highest at that time. So, it could be said that SRP concentration in Tanguar haor has been playing a vital role in regulating the standing crop of phytoplankton. To find the variation on a spatial scale, the data of the present investigation were compared with another study station of the haor namely, Rauar Station. No significant difference was observed among the concentrations of different parameters. However, a slight increasing trend in the concentrations of DO, alkalinity, SRP, NO_3-N, SRS, NH_4^+ and total phytoplankton density was observed in the Watch Tower Station compared to Rauar Station. Watch Tower Station is also relatively deeper with an improved light climate as it had been revealed by the mean value of the Secchi depth. The water quality of Tanguar Haor has been classified as mesotrophic.

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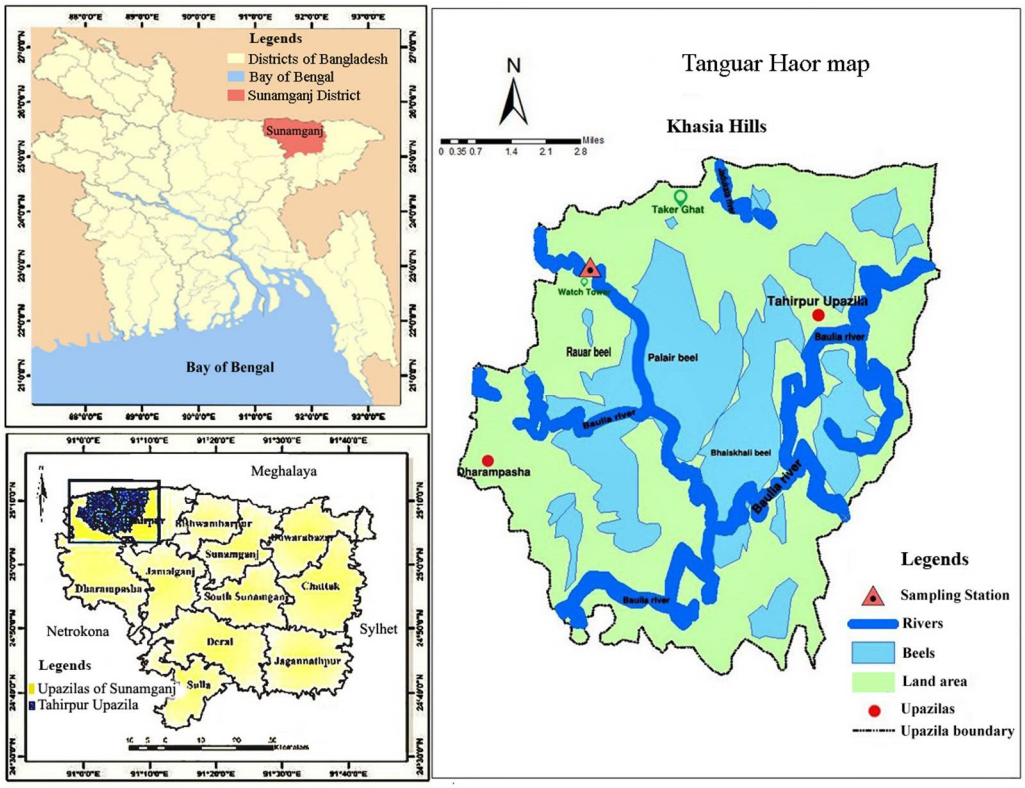
Introduction

Tanguar Haor of Sunamganj district, Bangladesh is a unique natural shallow-lake type water body. The haor has got some similarities of shallow lakes situated elsewhere[1-5]. Shallow lakes have immense ecological and economic benefits[6]. Therefore, their water quality and biodiversity play vital roles in the environmental balance of the locality as well as on the intensity of the harvesting secondary productivity. Tanguar Haor has a surface area of 100 km^2 and is very famous for its biodiversity. It is situated in the south-eastern fringe of Bangladesh near the Indian border of Meghalaya. The distance of the Haor from the capital city of Dhaka, Bangladesh by road is about 400 km. The Haor is located in a remote area and nearly 30 km traveling by local vehicles from the district headquarter of Sunamganj. Owing to its greater distance from the city of Dhaka, the Haor was not frequently visited and studied from the water quality stand point and plankton. Recently, a research initiative was ventured under the auspices of the Ministry of Science and Information Technology, Government of the People's Republic of Bangladesh to carry out an investigation on the water quality and planktonic association of the Tanguar Haor. To study the spatial distribution of water quality and plankton related parameters, two sampling stations were selected, namely Watch Tower and Rauar Station. The results from the Rauar Station have already been presented elsewhere[7]. The present paper deals with the results obtained from the water samples collected from the Watch Tower Station of Tanguar Haor, Sunamganj District of Bangladesh. One of the objectives of the present work was to study the spatial variation of phytoplankton density and different water quality parameters of Tanguar Haor. The studied stations of the Haor (Rauar and Watch Tower) are the two perennial basins, so phytoplankton dynamics and water quality were also compared.

Materials and Methods

Tanguar Haor is located within Dharmapasha and Tahirpur Upazila of Sunamganj district (Fig. 1). Watch Tower of Tanguar Haor is situated between 25°06′ - 25°11′ N and 91°01′ - 91°06′ E and is about two km away from the earlier studied station of the Haor, namely Rauar Station (also locally called Hatigara Station, Fig. 2). A high wooden watch tower was constructed by the Forest Department of Bangladesh for the tourists to watch the natural beauty of the Haor.

The objective of the research was to carry out a limnological investigation on an annual scale and for that two perennial as well as deeper parts of the Haor were identified by interviewing local people, fishermen and boatmen. So, Rauar Station and Watch Tower Station are the two finally selected stations for the present investigation. Bimonthly sampling protocol was prepared. In the morning, trip to the haor started from Tahirpur Upozila Headquarter by boat. At first the Watch Tower Station was reached,



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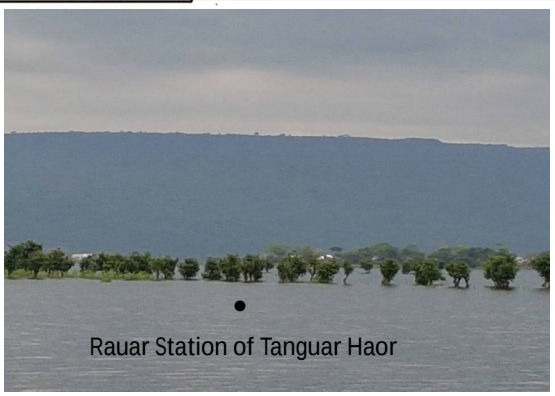

Fig. 2. Rauar Station and Watch Tower Station of Tanguar Haor showing sampling points (●).

the boat was anchored and the measurements of some physicochemical parameters were made *in situ* (Table 1). One meter depth integrated 5 liter water sample was collected with the help of a transparent Schindler's sampler. For the quantification of phytoplankton, sedimentation technique was used with Lugol's solution. However, for qualitative purpose, concentrated plankton sample was obtained by filtering 100 liter Haor water via a plankton net (mesh aperture 25 µm). This sample was preserved in 4% formaldehyde for further analysis. Five liter water sample collected using Schindler's sampler was poured into a screw capped black plastic container and transported to the laboratory putting into an ice box. Measurement of all the water quality parameters were completed within the next 24 hours following the methodologies as presented in Table 1. However, for measuring the concentration of nitrate nitrogen, an overnight digestion of the sample was required and the measurement was completed in the next day morning.

Table 1. Showing the methodology for measuring the water quality and phytoplankton parameters.

Parameter	Units of measurement	Equipment and methods
Water depth (Z)	Meter (m)	Using a graduated rope carrying a weight at the end
Secchi depth (Zs)	"	Secchi disc[8]
Air temperature (Air temp.)	°C	*In situ*, using mercury thermometer
Water temperature	"	*In situ*, using mercury thermometer housed in a 5 liter cap. Schindler's water sampler[9]
Total dissolved solids (TDS)	Mg/l	*In situ,* using Hanna Multi Instruments Code-HI9813-6, S/N-D0108196, Romania
Electrical conductivity (cond.)	Micro-Siemens per centimeter (µS/cm)	Same as above
pH	-	Same as above
Dissolved oxygen (DO)	Mg/l	Winklers method, sample fixed in the field[9]
Free carbon dioxide (CO_2)	"	Titration[8]
Alkalinity (Alkal.)	Meq/l	Titration[10]
Soluble reactive phosphorus (SRP)	µg/l	Spectrophotometric[11] (Schimadzu, Japan)
Soluble reactive silicate (SRS)	Mg/l	Same as above[9]
Nitrate nitrogen (NO_3-N)	"	Same as above[12]
Ammonia (NH_4+)	µg/l	Microdistillation with Devardays alloy
Chlorophyll a (chl.-a)	"	Same as Spectrophotometric[13] (Schimadzu, Japan)
Phaeopigment (Phaeo.)	"	Same as above
Phytoplankton density (PP tot)	Ind/l	Helber bacteria counting chamber, Thoma ruling, Hawksley Technology, UK[9]

Details on the location map of the studied station, other morphometric features of the Tanguar Haor ecosystem and the sampling procedure have been published elsewhere[7]. The study period continued from 1916-1917 at bimonthly intervals harmonized with the

climatic seasons of Bangladesh[14]. During each sampling event the Watch Tower Station was sampled first followed by Rauar Station.

Results and Discussion

Data recorded on 17 water quality parameters from the Watch Tower Station of Tanguar Haor has been presented in Table 1. Water temperature ranged from 22.7 - 30.3°C with an annual mean of 26.52°C. While the range of air temperature was 22.6 - 30.7°C showing an annual mean of 26.57°C. So, the temperature from both the air and water was very close to each other. Although highest air temperature was recorded in March but the same for water temperature was recorded in the month of September. December showed the occurrence of lower temperature in both air and water. The deepest basin of the Tanguar Haor is located near the Watch Tower Station and as such the water depth was high in April (9.5 m). In March, the water depth dropped to 3 m. The average values of the water depth were recorded as 6.72 m at this station. The depth of visibility (Secchi depth) in the present study site of the Haor ranged from 2.4 - 3.0 m. The mean visibility of water was however recorded as 2.54 m. After the Secchi disc transparency values, it could be said that in the months of January and March, the water was clearer than September (Table 1). Total dissolved solids (TDS) and the electrical conductivity (cond.) of water showed close relationship with each other (Table 1). The lowest values of both TDS and conductivity were shown in the month of January, while the highest values of both the parameters were shown together in the month of September. Starting from December onward, the pH of water showed clear alkaline condition (Table 1). Whereas, from April to September the pH ranged from 7.5 - 7.7. The mean pH is closer to one shallow lake Tai of China [2]. The dissolved oxygen value of Tanguar Haor showed a relatively lower range (2.5 - 5.2 mg/l), except in the month of December when the value of dissolved oxygen was recorded as 6.09 mg/l. The concentration of free carbon dioxide was found always low (0.077 - 0.099 mg/l). Alkalinity of the water during September, December and March remained in between 1.03 and 1.35 meq/l. However, in other sampling periods (April, July and August) the recorded values of this parameter were 0.33 - 0.89 meq/l. The range of alkalinity fitted quite well with the shallow lake Tai[2].

The water of Tanguar Haor was found nutrient poor. The SRP ranged from 9.76 - 30.05 μg/l and the soluble reactive silicate (SRS) from 4.45 - 16.14 mg/l. Highest concentration of SRP was found in September and the silicate in March. Nitrate nitrogen ranged from 0.25 - 0.48 mg/l. NH_4^+ was high (1.38 mg/l) in April, at other times this parameter ranged from 0.71 - 0.84 mg/l (Table 1). The concentration of chl-a varied from 5.1 - 7.5 μg/l while its degraded product, i.e., phaeopigment ranged from 1.50 - 3.98 μg/l. On the other hand, the total density of phytoplankton, ranged from 807 - 2690 × 10^3 ind./l. There was a close relationship between the chl-a concentration and the phytoplankton.

Highest chl-a and phytoplankton density were recorded in the month of September, while both the parameters showed their lowest concentration in the month of December (Table 1).

Table 2. Environmental, physicochemical and biological variables measured from the water samples at Watch Tower Station of Tanguar Haor.

Date	Air temp. (°C)	Water temp. (°C)	Z (m)	Zs (m)	TDS (mg/l)	Cond. (μS/cm)	pH	DO (mg/l)	CO_2 (mg/l)
22 Apr., 2017	23.0	24.4	9.5	2.08	58	70	7.6	3.0	0.097
09 July, 2017	29.1	29	9	2.28	56	72	7.5	3.04	0.077
30 Sept., 2017	30.6	29.5	7.8	2.4	79	100	7.7	4.0	0.097
09 Dec., 2017	22.6	22.7	6	2.5	51	67	9.7	6.09	0.084
22 Jan., 2017	23.4	23.2	5	3	56	70	9.4	5.2	0.099
25 Mar., 2018	30.7	30.3	3	3	77	100	8.1	2.5	0.096
Annual mean	26.57	26.52	6.72	2.54	62.83	79.83	8.33	3.97	0.09
Sd ±	3.97	3.45	2.51	0.38	11.99	15.70	0.97	1.41	0.008

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Alkal. (meq/l)	SRP (μg/l)	SRS (mg/l)	NO_3-N (mg/l)	NH_4^+ (μg/l)	Chl-a (μg/l)	Phaeo. (μg/l)	Tot. PP $\times 10^3$ ind./l
0.33	22.75	10.94	0.33	1380	5.5	3.81	1255
0.54	24.23	8.38	0.25	750	6	3.95	1345
1.35	30.05	8.24	0.42	710	7.5	3.98	2690
1.35	9.76	11.36	0.75	820	4.3	1.98	807
0.73	9.98	4.45	0.48	690	5.5	2.25	1564
1.03	11.66	16.14	0.34	690	5.1	1.50	1337
0.89	18.07	9.92	0.43	840	5.65	2.91	1499
0.42	8.71	3.92	0.18	270	1.07	1.12	634

Spatial variation of water quality parameters of Tanguar Haor was considered in the present investigation. The data in the form of mean values of various water quality parameters for both the studied stations, namely Watch Tower and Rauar Station have been presented in Table 2. The data are quite comparable to each other (Table 2).

However, a closer look to the data sets of Watch Tower and Rauar Station revealed that, the water depth of the former was little higher than the latter. TDS and conductivity of Watch Tower was lower than the Rauar Station. This might have resulted a relatively higher Secchi depth. It means the water of the Watch Tower on an average clearer than the Rauar Station with an improved light climate. The concentration of chl-a and the abundance of phytoplankton total density is also higher compared with the Rauar Station. The concentration of key nutrients namely, SRP, NO_3-N, SRS and NH_4^+ in Watch

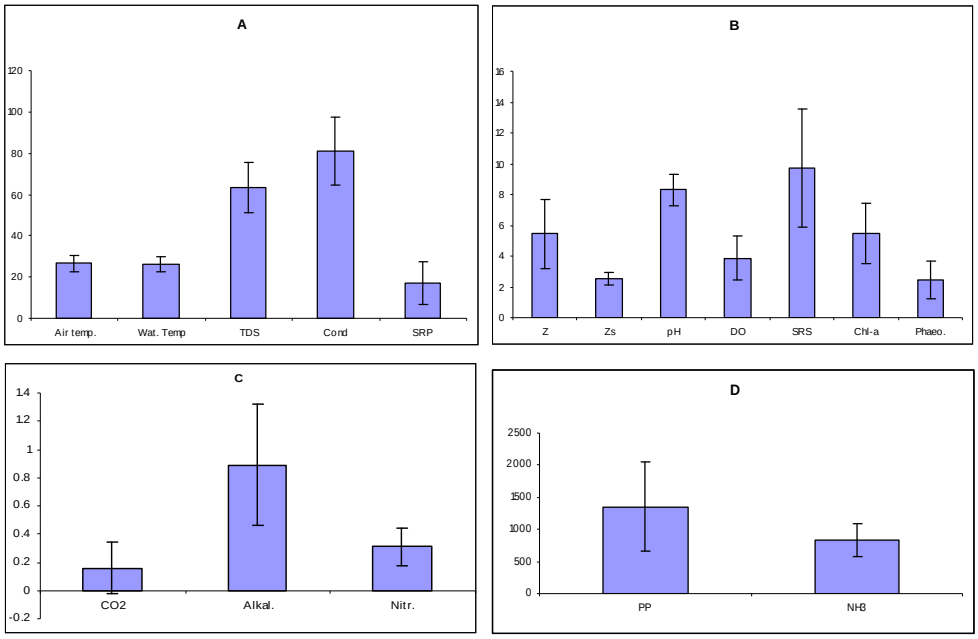
Tower Station are relatively higher than the Rauar Station. Relatively higher chl-a has resulted a higher mean DO at the Watch Tower compared to the Rauar Station.

Table 3. Showing the comparative mean values of different water quality parameters from the Watch Tower and Rauar Station of Tanguar Haor.

Parameters	Watch Tower Station (present investigation)		Rauar Station[7]	
	Mean (n = 6)	Sd	Mean (n = 6)	Sd
Air temp. (°C)	26.57	3.97	26.67	4.08
Water temp.(°C)	26.52	3.45	26.33	3.89
Z (m)	6.72	2.51	4.18	1.95
Zs (m)	2.54	0.38	2.48	0.43
TDS (mg/l)	62.83	11.99	64.17	12.27
Cond. (µS/cm)	79.83	15.70	81.67	17.22
pH	8.33	0.97	8.30	1.04
DO (mg/l)	3.97	1.41	3.77	1.39
CO_2 (mg/l)	0.09	0.008	0.22	0.36
Alkal. (meq/l)	0.89	0.42	0.88	0.43
SRP (µg/l)	18.07	8.71	16.30	12.11
SRS (mg/l)	9.92	3.92	9.55	3.75
NO_3-N (mg/l)	0.43	0.18	0.18	0.08
NH_4^+ (µg/l)	840	270	813	238
Chl-a (µg/l)	5.65	1.07	5.28	2.78
Phaeo. (µg/l)	2.91	1.12	1.94	1.32
Tot. PP $\times 10^3$ ind./l	1499	634	1213	755

Annual mean values of different water quality parameters have been calculated using the values recorded for Rauar and Watch Tower Stations and plotted in Fig. 3. Mean air (26.62°C) and water temperature (26.42°C) remained almost closer to each other. Similar variation was also seen in another shallow conserved manmade lake (Begum *et al.* 2012)[15], where the annual mean air and water temperatures showed 24.83 and 24.09°C, respectively. The mean water depth 5.45 m of Tanguar Haor is nearly double than another vast shallow lake of Europe Neusiedlersee[1]. The latter shallow lake has an area of 315 sq. km with a maximum depth of 2 m[16]. The mean Secchi depth (Fig. 2) is nearly double than a mesotrophic water body of Dhaka[17]. Tanguar Haor has got a relatively lower TDS (mean = 63.5 mg/l) compared to other water body of Bangladesh. The mean conductivity of water of Tanguar Haor (80.75 µS/cm) recorded was closer to that of Ramsagar[18]. The mean value of conductivity of Ramsagar was 73.66 µS/cm. Almost alkaline pH (8.31) of Tanguar Haor was similar to those recorded for shallow lakes of China[2] and Germany[3]. As revealed from Fig. 3, the mean alkalinity of Tanguar Haor (0.89 meq/l) is slightly lower than lake Tai (1.22 meq/l) reported by Shi and Liang

(1987)[2]. The mean SRP and SRS concentrations of Tanguar haor showed a relatively lower value but the mean concentration of nitrate was nearly double in the latter water body compared to the former (Fig. 3).



Figs 3. A-D. Showing the annual mean values of different water quality parameters for Tanguar Haor. (Bar indicates standard error of mean). A, air and water temperature in °C, TDS mg/l, conductivity µS/cm, SRP µg/l). B, water (Z) and Secchi depth (Zs) in meter, DO mg/l, SRS mg/l, chl-a and phaeopigment (phaeo.) µg/l. C, CO_2 (CO_2) and nitrate (Nitr.) mg/l, alkalinity (alkal.) meq/l, ammonia (NH_3) µg/l. D, total phytoplankton concentration (PP) as ind/l, and NH_4 µg/l.

In North America a vast majority of shallow lakes were studied where very low chl-a concentration was observed[5]. Their data for Lake Cedar and Clark fitted well with the mean chl-a concentration recorded for Tanguar Haor (Fig. 3). Mean chl-a concentration of a shallow water body of Bangladesh, namely Ramsagar of Dinajpur yielded 5.92 µg/l[18]. The value is very closer to that recorded for Tanguar Haor (Fig. 3). A mean value of chl-a, 4.70 µg/l has been used to characterize water body as mesotrophic[19]. The mean chl-a recorded for Tanguar Haor was 5.47 µg/l (Fig. 3). Since the reported value of chl-a for mesotrophicity[19] was closer to that reported for Tanguar Haor, the latter water body could be said as mesotrophic. Eutrophic shallow lake Grimnitzee in Germany showed a range of chl-a 17 and 14 µg/l for 1994 and 1995, respectively[3]. Carlson and Simpson[20] designated lakes having chl-a 3 - 7 µg/l and Secchi depth 2.13 - 3.96 m as mesotrophic. The range of these two parameters in respect of the trophic index for water bodies fitted well with those reported for Tanguar Haor (Table 2).

Considering the concept of phytoplankton biomass as a function of phosphorus concentration of pelagic water, an analysis of these two water quality factors was carried out[5]. In the present study, data obtained has been plotted in Fig. 4. The calculated quotients i.e., phosphorus versus chlorophyll-a for Tanguar Haor yielded a range ~2 - 4 at different months of the year, being the highest during April, July and September and lowest in December, January and March. It meant relatively low phosphorus during December, January and March supported a moderate biomass (Fig. 4).

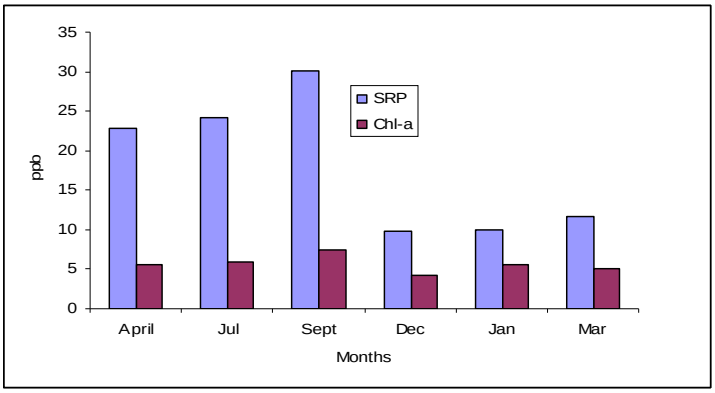


Fig. 4. Relationship between soluble reactive phosphorus (SRP) and chl-a data of Tanguar Haor (ppb or µg/l).

The present comparative analysis of the selected water quality parameters from the two stations of Tanguar Haor did not reveal significant differences among the concentrations. However, a slight increasing trended in the concentrations of DO, alkalinity, SRP, NO_3-N, SRS, NH_4^+ and total phytoplankton density had been observed in the Watch Tower Station compared to Rauar Station. Watch Tower Station was also relatively deeper with an improved light climate as it had been revealed by the mean value of the Secchi depth. The mean values of different physicochemical parameters were found comparable to other shallow lakes or similar water bodies in Bangladesh and elsewhere. Considering the mean values of chl-a, SRP and Secchi disc visibility, the trophic index of Tanguar Haor has been calculated as mesotrophic.

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(Manuscript received on 8 January, 2019; revised on 3 March, 2019)