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RESEARCH ARTICLE

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Phytoplanktonic diversity and their relationships with certain Physico-chemical properties of Swamp of Purnia, Bihar (India)

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ABSTRACT

The phytoplankton diversity of Harda swamp of Purnia (India) in relation to certain physicochemical factors was studied. A total of 27 genera of phytoplankton, belonging to four groups – chlorophyceae, myxophyceae, bacillariophycae and euglenophyceae were found in the swamp. The quantitative relationship amongst the groups of phytoplankton is chlorophyceae >myxophyceae > bacillariophycae > euglenophyceae. The phytoplankton density in different seasons was in order of summer > winter > monsoon. The species diversity of phytoplankton was found maximum in monsoon (H= 1.297) followed by winter (H= 1.289) and summer (H= 1.222). The species belonging to chlorophyceae were dominant. Pollution tolerant species found in swamps are stagnation of waters for the most of the period and limited water recharge. The swamp harbours many allergenic algae such as Chlorella vulgaris, Anabaena sp., Microcystis sp., Nostoc sp. and Oscillatoria sp. The swamps harbour many pollution tolerant species like Cyclotella, Fragilaria and Navicula. Phytoplanktons showed negative correlation with pH, DO and bicarbonate. On the basis of Palmer's algal index the swamp water is polluted.

Key words – Phytoplankton, seasonal variation, Pollution tolerant species, Allergenic species and Algal index.

INTRODUCTION

Phytoplankton are heterogeneous group of micro-organisms. They are floating, inconspicuous plant lives which play a major role in the food chain of aquatic ecosystem by biosynthesis of organic matter and thus they act as primary producers of food. Many herbivores, mostly zooplanktons graze upon phytoplankton thus, passing the stored energy to their subsequent trophic levels. They have revealed tremendous scope for environmental management as soil conditioners, biofertilizers, bioindicators, biomonitors, ameliorators, feed for animals, protein supplement and rehabilitators of degraded ecosystems through bioabsorption of pollutants [1]. The phytoplankton population is influenced by grazing, light, temperature and nutrients [2]. Phytoplankton are more sensitive to pollution than other organisms [3] and used for water quality characterization [4].

The study of planktonic community is of crucial importance in understanding pelagic productivity and pollution impacts probably due to following obvious reasons –

(a) They are natural inhabitants of aquatic environment.
(b) They have short life-cycle with a high metabolic activity, which facilitates them to respond to any pollution stress quickly and significantly, compared to benthic or nektonic organisms [5].
(c) Generally, an inverse relationship exists between the pollution load and diversity of phytoplankton.
(d) Phytoplanktonic investigations alone are sufficient to reveal the condition of a water body without undertaking tedious processes of physico – chemical analyses.

Keeping in mind the above points, the present work was designed to know:
(1) The phytoplanktonic flora of the swamp,
(2) The community structure of the phytoplankton,
(3) The pollution status of the swamps water and
(4) The correlation between phytoplankton and different physico – chemical parameters operating in a stretch of the study area.

MATERIALS AND METHODS

The present investigation was carried out in the river swamp of Harda (Purnia) at five sampling stations (Map 1 and 2) selected for one year (March 2007 – February 2008). Water samples were collected at monthly intervals from each sampling station in a polythene bottle of 3 liters capacity. Water temperature was recorded with an ordinary mercury thermometer graduated from 0^0C to 50^0C. The analyses of pH, dissolved oxygen, free carbon dioxide, silicate, carbonate, bicarbonate, chloride, nitrate, silicate and phosphate were done according to standard methods [6 and7].

For the phytoplankton, 50 liters of river water was taken and filtered through the bolting silk plankton net (No. 30) with 77 mesh/sq cm. The samples were taken from different areas of the stations regularly. The planktons concentrated on the plankton - net were preserved with 5% formalin. Separation and counting of the planktons were done by taking 1 ml of sub-samples into a Sedgwick Rafter plankton counting chamber of 1ml capacity. All organisms were counted according to the procedure described by Welch [8] Identification of phytoplankton were carried out according to standard literature.[9, 10, 11a, 11b, 12a and 12b].Coefficients of correlations between phytoplankton and certain physico-chemical factors were computed and season wise species diversities of phytoplankton were also calculated according to Schannon and Weavers [13].

RESULTS

The physico – chemical analyses of swamp water have been shown in Tables 1a, and1b.

Table 1a Average monthly values of Physico-chemical parameters of the swamps of Harda, (Purnia) during the year 2007-08.

Parameters → Month ↓	Atm. Temp. (°C)	Wat. Temp. (°C)	Transparency(cm.)	pH	DO_2 (Mgl^{-1})	Free CO_2 (Mgl^{-1})	HCO_3^- (Mgl^{-1})	Chloride (Mgl^{-1})	PO_4^{--} (Mgl^{-1})	NO_3^- (Mgl^{-1})	SiO_3^- (Mgl^{-1})
2007March	27.0	23.3	Tr.	7.2	7.1	19.2	137	22.8	0.81	0.152	20.2
April	32.3	28.1	Tr.	7.1	6.8	22.6	133	23.6	0.93	0.157	22.2
May	33.7	31.6	Tr.	6.8	5.9	34.0	125	26.6	0.94	0.116	22.8
June	32.5	30.2	10.00	6.7	5.5	37.2	121	29.2	0.76	0.154	24.3
July	33.2	30.0	8.5	6.6	4.8	44.4	114	21.2	0.68	0.355	33.7
Aug.	30.6	28.5	9.4	6.5	4.8	47.2	112	19.2	0.69	0.493	34.8
Sept.	29.5	27.5	12.0	6.7	4.9	43.4	122	16.4	0.69	0.490	33.0
Oct.	28.2	25.2	14.5	6.9	5.7	29.4	130	18.8	0.70	0.478	32.9
Nov.	26.6	21.2	Tr.	7.2	7.5	17.6	137	17.2	0.71	0.381	29.6
Dec.	22.2	18.9	Tr.	7.3	7.9	14.8	141	14.8	0.65	0.330	27.3
2008 Jan.	20.8	18.1	Tr.	7.6	8.2	11.2	154	16.0	0.53	0.251	24.6
Feb.	23.7	20.4	Tr.	7.3	8.1	14.6	142	18.4	0.56	0.203	22.0

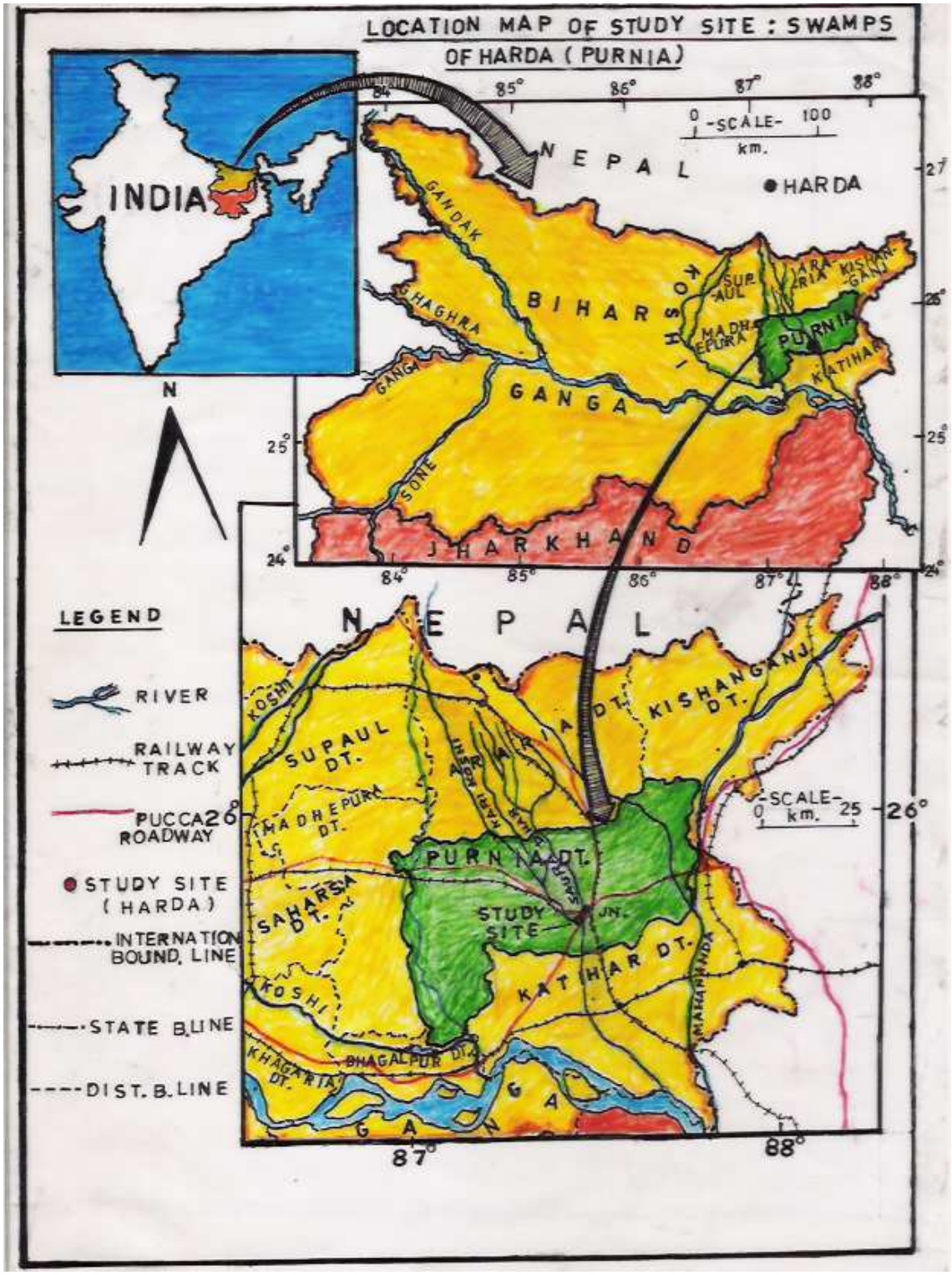
Table 1bAverage values of Physico-chemical parameters of the swamps of Harda (Purnia) in different seasons during the year 2007-08

Parameters→ Seasons ↓	Atm. Temp. (°C)	Wat. Temp. (°C)	pH	DO_2 (Mgl^{-1})	Free CO_2 (Mgl^{-1})	HCO_3^- (Mgl^{-1})	Chloride (Mgl^{-1})	PO_4^{---} (Mgl^{-1})	NO_3^- (Mgl^{-1})	SiO_3^{--} Mgl^{-1})
Summer	31.4	28.3	6.9.	6.3	28.2	129	25.2	0.86	0.145	22.4
Monsoon	30.4	27.8	6.7	5.0	41.1	119	18.9	0.69	0.454	33.6
Winter	23.3	19.6	7.3	7.9	14.5	143	16.6	0.61	0.291	25.9

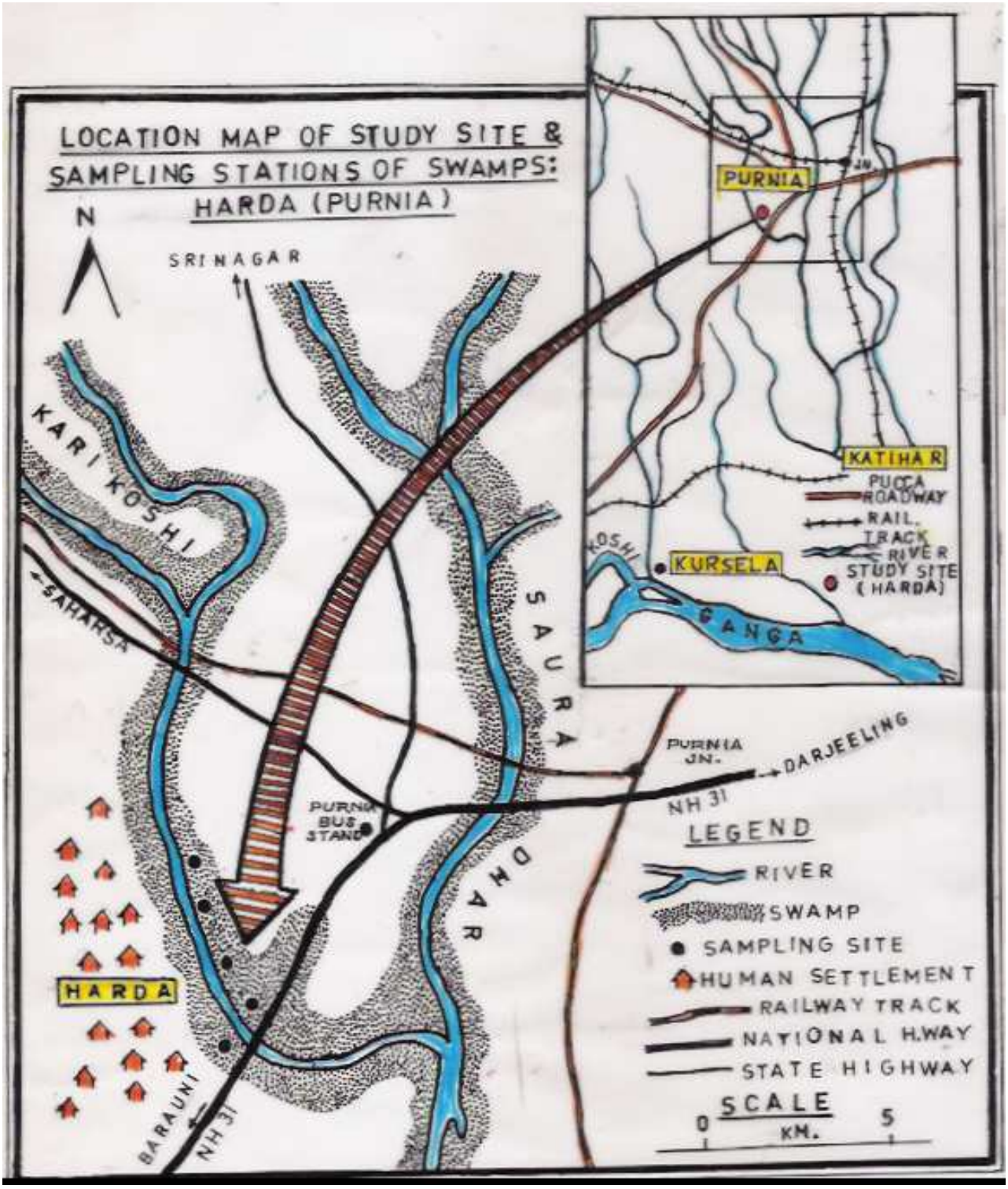
The phytoplankton communities of the swamp have been represented mainly by four groups:

(A) Chlorophyceae :-
Chlorophyceae was encountered as the most significant group of phytoplankton with a contribution of 36.21% of the total annual population. Its maximum density was found in the month of May and minimum density was observed in December (Table 2 and Fig. 1a). This group was represented by nine genera – *Spirogyra* sp., *Volvox* sp., *Ulothrix* sp., *Closteridium* sp., *Chara* sp., *Pandorina* sp., *Zygnema* sp., *Chlorella* sp. and *Chlamydomonas* sp.

Map 1


LOCATION MAP OF STUDY SITE : SWAMPS OF HARDA (PURNIA)
INDIA
NEPAL
HARDA
BIHAR
JHARKHAND
GANGA
GANDAK
GHAGHRA
KOSHI
SONE
SUPAUL
ARARIA
KISHANGANJ
MADHEPURA
PURNIA
KATIHAR
SCALE- 0 100 km.
SCALE- 0 25 km.
N
LEGEND
RIVER
RAILWAY TRACK
PUCCA ROADWAY
STUDY SITE (HARDA)
INTERNATION BOUND. LINE
STATE B.LINE
DIST. B. LINE
SAHARSA DT.
BHAGALPUR DT.
KHAGARIA DT.
STUDY SITE
JN.
84°
85°
86°
87°
88°
25°
26°
27°

Map 2


LOCATION MAP OF STUDY SITE & SAMPLING STATIONS OF SWAMPS: HARDA (PURNIA)
N
SRINAGAR
KARI KOSHI
SAHARSA
SAURA
DHAR
PURNIA BUS STAND
HARDA
BARAUNI
NH 31
PURNIA JN.
DARJEELING
NH 31
PURNIA
JN.
KATIHAR
KOSHI
KURSELA
GANGA
PUCCA ROADWAY
RAIL TRACK
RIVER
STUDY SITE (HARDA)
LEGEND
RIVER
SWAMP
SAMPLING SITE
HUMAN SETTLEMENT
RAILWAY TRACK
NATIONAL H.WAY
STATE HIGHWAY
SCALE
0
KM.
5

(B) Myxophyceae :-

It was the second significant group of phytoplankton which contributes 36.16% (Table 2) of the total population of phytoplankton. This group was represented by eight genera – *Anabaena* sp., *Oscillatoria limnetica*, *Microcystis robusta*, *M. aeruginosa*, *Spirulina* sp., *Merisomopedia* sp., *Nostoc* sp. and *Collastrum* sp. It exhibited maximum density in the month of May and least in September (Table 2).

(C) Bacillariophyceae :-

It was the third significant group accounting 18.67% of the total phytoplankton population. This group was represented by nine genera – *Cymbella* sp, *Melosira* sp, *Navicula cincta*, *Nitzchia* sp., *Diatoma* sp, *Syndera ulna*, *Fragilaria intermedia*, *Pinnularia viridis* and *Cyclotella* sp. It exhibited maximum density in May and June and minimum in December (Table 2).

(D) Euglenophyceae :-

It exhibited 8.96% of the total phytoplankton population and was represented by only one species *Euglena viridis*. Its maximum density was found in the month of October and minimum in January and June (Table 2).

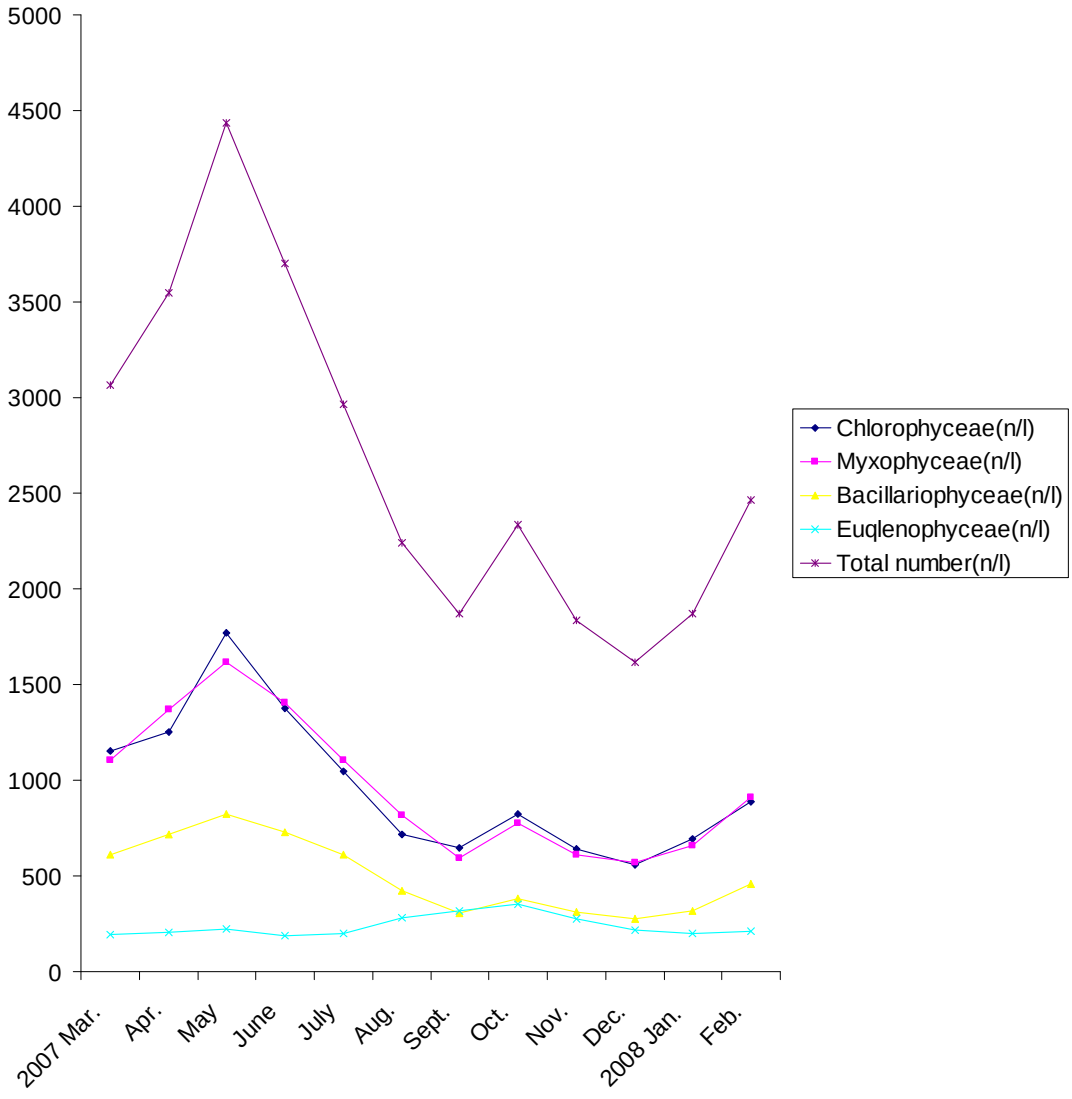
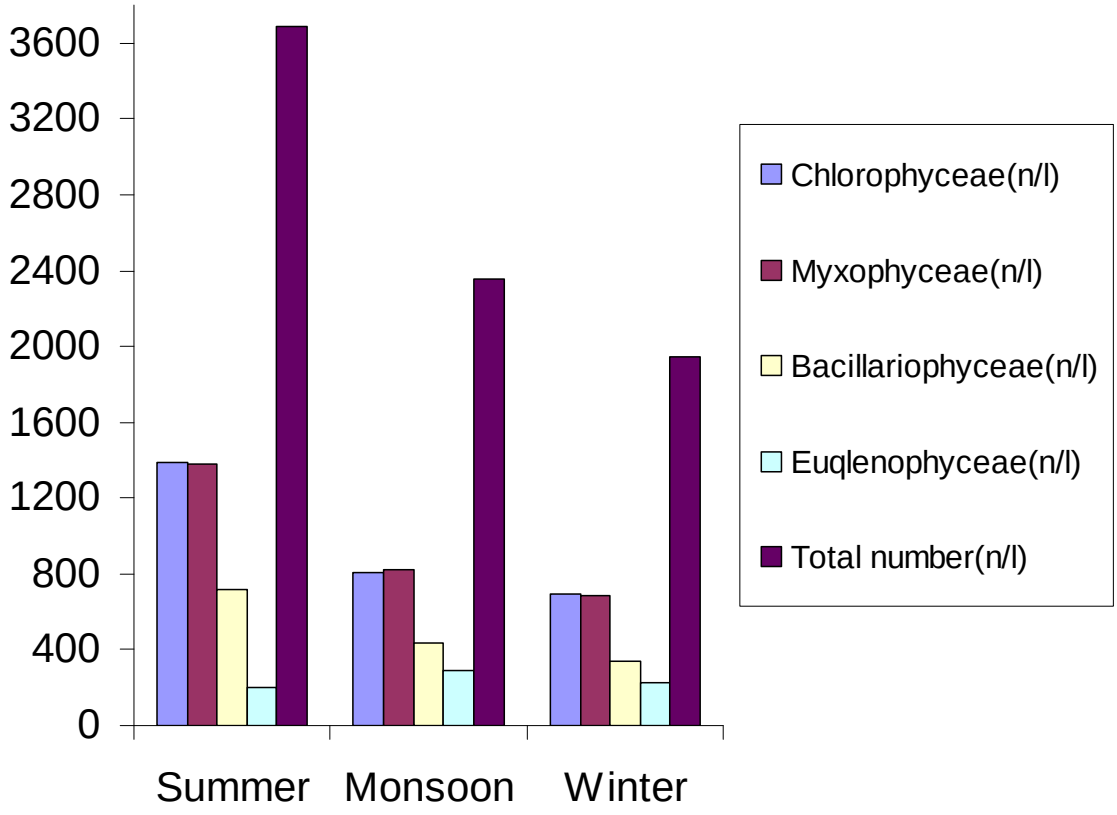


Fig. 1a Monthwise distribution of phytoplankton groups in the swamps of Harda (Purnia) during the year 2007-08.

Table 2 Monthwise distribution of phytoplankton groups in the swamp of Harda (Purnia) during the year, 2007-08.[Represented in number per litre (n/l) and per cent]

Phytoplankton→ Months ↓	Chlorophyceae		Myxophyceae		Bacillariophyceae		Euqlenophyceae		Total number	
	n/l	%	n/l	%	n/l	%	n/l	%	n/l	%
2007 Mar.	1155	37.66	1108	36.13	609	19.85	195	6.36	3067	100
Apr.	1250	35.26	1372	38.70	715	20.17	208	5.87	3545	100
May	1768	39.87	1617	36.47	824	18.58	225	5.08	4434	100
June	1378	37.22	1408	38.03	730	19.72	186	5.03	3702	100
July	1046	35.26	1108	37.34	613	20.66	200	6.74	2967	100
Aug.	719	32.04	820	36.54	425	18.94	280	12.48	2244	100
Sept.	647	34.63	595	31.85	308	16.49	318	17.03	1868	100
Oct.	825	35.36	776	33.27	382	16.37	350	15.00	2333	100
Nov.	640	34.86	609	33.17	310	16.88	277	15.09	1836	100
Dec.	558	34.49	570	35.23	275	16.99	215	13.29	1618	100
2008 Jan.	695	37.20	657	35.18	318	17.02	198	60.60	1868	100
Feb.	886	35.99	910	36.96	456	18.52	210	8.53	2462	100
Average	963	36.21	962	36.16	499	18.67	238	8.96	2662	100



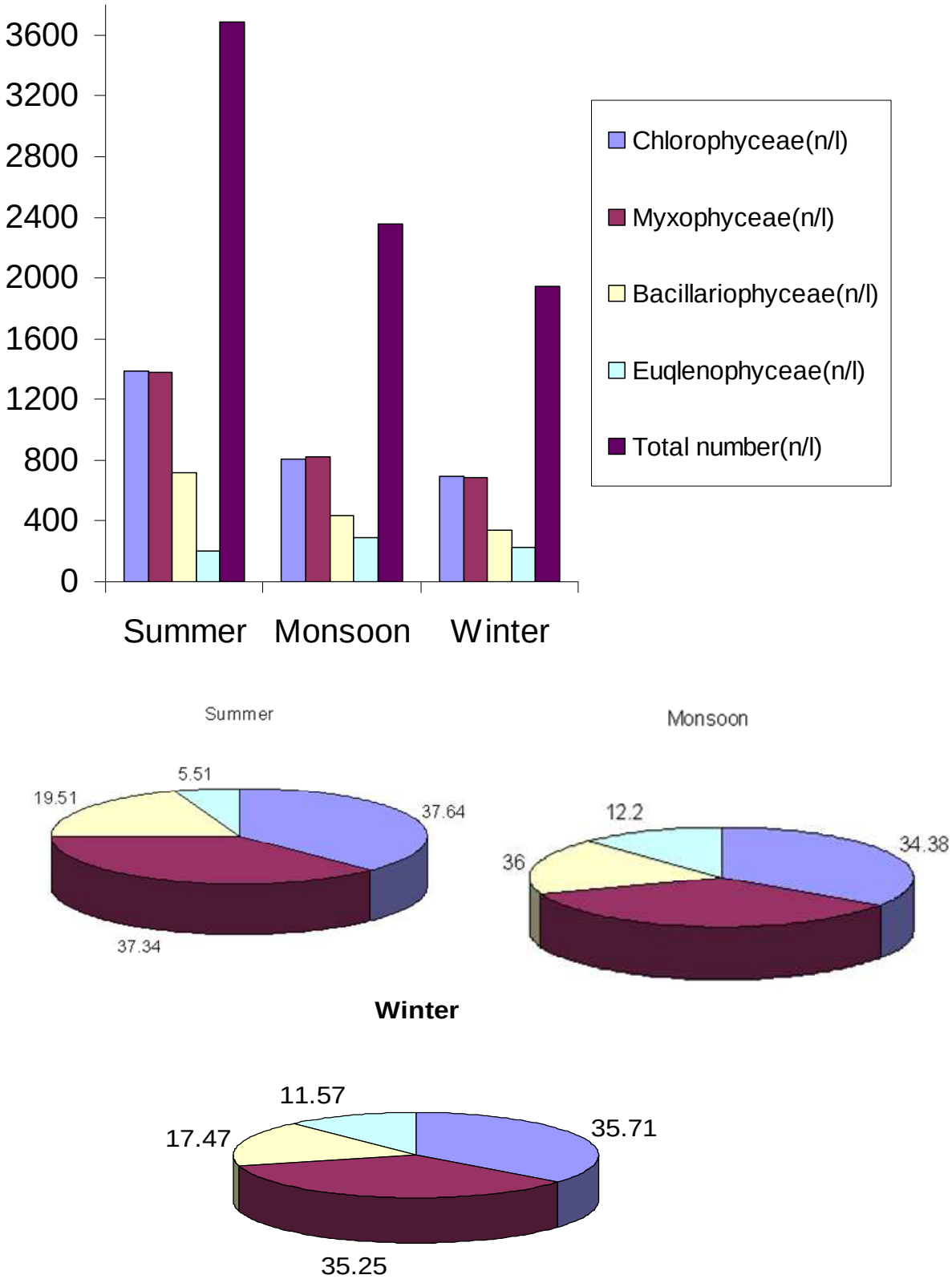


Fig. 1b Seasonwise distribution of phytoplankton groups in the swamp of Harda(Purnia) during the year 2007-08.

In the present study, a distinct seasonal variation was noted in the number of phytoplankton. It was maximum during summer season and minimum during winter season (Fig. 1a and 1b). Monthwise distribution of phytoplankton revealed highest peak in May followed by June while minimum value was found in the month of December followed by September (Table 2). Among Chlorophyceae, *Spirogyra, Zygnema, Volvox* and *Chlorella* species were recorded in higher quantity during winter season, whereas *Chara* and *Pandorina* species were higher during summer season. *Ulothrix, Chlorella* and *Closteridium* species were present in good quantity throughout the year. Among Myxophyceae, *Microcystis, Oscillatoria, Anabaena* and *Nostoc* species were present throughout the year, whereas *Spirulina* sp. was found only during rainy season. *Collastrum* sp. and *Merisomopedia* sp. were maximum during winter season. *Microcystis* sp. was dominant in all seasons. Among Bacillariophyceae *Navicula* sp. was observed throughout the year whereas *Melosira, Cyclotella, Syndera* and *Fragilaria* species were common during winter season. *Cymbella, Pinnularia* and *Syndera* species were observed most commonly during rainy and summer seasons.

DISCUSSION

The seasonal trend in total phytoplankton was reported as summer> monsoon>winter. The summer maxima and winter minima may be attributed to the effect of temperature on the production of planktons. Blooming of phytoplankton in summer season has been reported in some tropical lakes [14 and 15]. Temperature and light have been reported as factors responsible for higher production of phytoplankton population [16]. Mustafa and Zubair [17] encountered minimum number of phytoplankton in monsoon months. Review of literature reveals that there are two types of growth period for the phytoplankton .The report of some workers suggests that the maximum development of phytoplankton occurs during summer and minimum in winter [18, 19 and 20]. These observations go in agreement with the present findings. Phytoplankton density in different seasons in order of summer> winter > monsoon have been reported [21 and 22]. The species diversity of phytoplankton (Fig. 3) was found maximum in monsoon (H= 1.297) followed by winter (H= 1.289) and summer (H= 1.222).

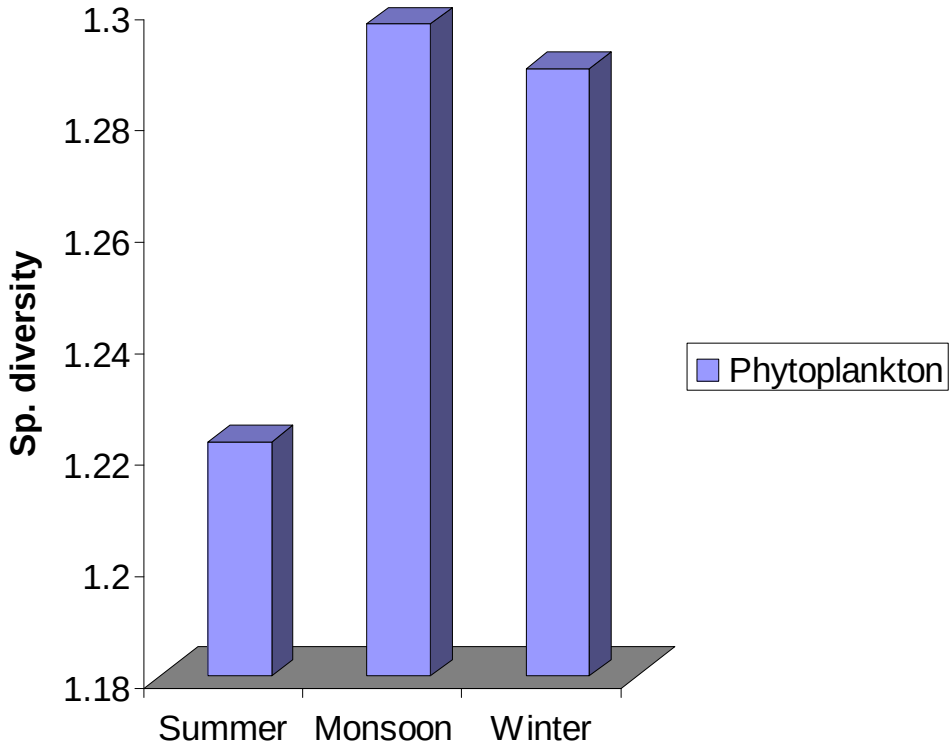


Fig. 3 Seasonal values of species diversity (H) of phytoplankton.

The chlorophyceae population in swamp showed definite seasonal trend with maximum during summer and minimum during winter. Maximum population of chlorophyceae during summer has been reported by other workers [22 and 23]. In the present investigation it was observed that high temperature and pH were favourable for rapid development of chlorophyceae. Myxophyceae constituted important part of phytoplankton in the swamp. It was maximum during summer and minimum during winter which lends support to previous findings [17, 23 and 24]. Bacillariophyceae constituted 18.67% of phytoplankton and encountered with high species diversity. Maximum population of Bacillariophyceae was observed during summer and minimum during winter. Diatoms are usually abundant in alkaline water. [18]. Diatoms such as *Melosira* sp and *Fragilaria* sp. grow well in polluted waters [25]. Euglenophycae though found in less number, showed marked periodicity and abrupt disappearance. Maximum population density of Euglenophycae was observed during monsoon and minimum during summer.

Quality of an aquatic ecosystem is dependent on the physico – chemical characteristics of water and also on the biological diversity of the system. Analysis of biological materials along with chemical factors of water, forms a valid method of water quality assessment. p^H, total solids, calcium, nitrate, phosphate and organic matter are important factors influencing the growth of algae [3].

The data indicates that, the swamp water is slightly alkaline. Higher pH values promote the growth of algae and results in bloom. [26]. In the present investigation the pH 5.0 to 8.5 is ideal for phytoplankton growth. The pH of the swamp water in the present investigation lies within this range. Alkaline pH favours the population of diatoms [27]. The observation of the present investigation agrees with this. Higher concentration of dissolved oxygen and low temperature favours the dominance of Chlorophyceae. In the present investigation oxygen ranges between 4.8 to 8.2mg/L. Green algae prefer water with higher concentration of dissolved oxygen [28]. In the present investigation members of Chlorophyceae dominated the other groups. This lends support to the previous findings. More hardness, sulphate and phosphate are favourable for the growth of diatoms [32]. *Nitzchia* appeared to be dominant genus in the present study, also reported by other workers [33, 34 and 35]. Chlorophyceae and Bacillariophyceae are the indicators of the healthiness of the system and are also responsible for high amounts of oxygen to the waters. Dominance and regular presence of *Microcystis* sp. is an indicator of pollution and eutrophication of water body [36].

Various physical, chemical and biological circumstances must be simultaneously taken into consideration for understanding the fluctuation of plankton population [37]. Temperature, pH, alkalinity and phosphate have been emphasized to be significant factors controlling the distribution of Myxophyceae [38 and 39]. Alkalinity range of 50 to 110 mg/L has been reported as optimum for the myxophycean [40 and 41]. The present study agrees with them. The rate of production is closely dependent upon temperature conditions of water body [42]. The present study showed highest phytoplankton in water, when water temperature was high. There was decline in number with decrease in temperature suggesting that phytoplankton preferred moderate temperature. Rainfall and high turbidity produced by high wind velocity during rainy season had a direct bearing on phytoplankton population reducing them to decrease number.

Blue-green algae are general indicators of polluted zones [43 and 44]. Species of *Euglena, Phacus, Lepocinclis* and *Trachelomns* are always encountered due to rich oxidizable matter in water [45]. Many pollution tolerant species like *Cyclotella, Fragilaria* and *Navicula* were found during present investigation.

Swamp harbours many allergenic algae such as *Chlorella* sp., *Anabaena* sp., *Microcystis* sp., *Nostoc* sp. and *Oscillatoria* sp. Allergenic problems caused due to such algal are rhinitis , bronchial asthma and hypersensitivity, in fish, cattle and animals coupled with symptoms of partial paralysis, loss of balance, hard stool , reduced milk yield , general weakness and photosensitization of skin [46] On the basis of the Palmer's algal index it can be concluded that the swamps water is polluted as the algal genus index was more than 20.

In order to assess the importance of abiotic interaction an attempt was made to analyze the data statistically as shown in the Table 3. Among studied parameters, DO_2 and bicarbonate manifested a very significant negative correlation with phytoplankton during summer season while free CO_2, nitrate and bicarbonate showed not a very significant negative correlation with phytoplankton during monsoon season. Free CO_2, nitrate and phosphate also manifested negative but insignificant correlation with phytoplankton during winter season.

Table 3 Coefficient of correlation (r) computed between various physico-chemical factors and Phytoplankton in different seasons of 2007-08 at Harda Swamp (d.f.=7)

Relationship	Summer		Monsoon		Winter	
	r	Prob.	r	Prob.	r	Prob.
Wat. Temp. Vs. Phytoplankton	0.794	P>0.01	0.298	Ins.	0.512	P>0.1
PO_4 Vs. Phytoplankton	0.232	Ins.	0.130	Ins.	-0.317	Ins.
NO_3 Vs. Phytoplankton	0.161	Ins.	-0.776	P<0.02	-0.470	Ins.
pH Vs. Phytoplankton	-0.679	P<0.05	0.047	Ins.	0.183	Ins.
DO_2 Vs. Phytoplankton	-0.726	P>0.02	0.075	Ins.	0.367	Ins.
Free CO_2 Vs. Phytoplankton	0.751	P<0.02	-0.095	Ins.	-0.245	Ins.
HCO_3 Vs. Phytoplankton	-0.729	P>0.02	-0.028	Ins.	0.199	Ins.

N.B. Ins. = Insignificant; Prob.= Probability level; d.f. = degree of freedom

CONCLUSION

Findings of this study can be summarized as follows:

* The quantitative relationship amongst the groups of phytoplankton is Chlorophyceae > Myxophyceae > Bacillariophycae > Euglenophyceae.
* The phytoplankton density in different seasons is in order of summer > monsoon > winter.
* The species belonging to Chlorophyceae were found dominant.
* The species diversity of phytoplankton followed as monsoon > winter > Summer.
* Pollution tolerant species found in swamps are due to stagnation of waters for the most of the period and limited water recharge.
* The swamps harbour many allergenic algae such as *Chlorella* sp., *Anabaena* sp., *Microcystis* sp., *Nostoc* sp. and *Oscillatoria* sp.
* The swamps harbour many pollution tolerant species like *Cyclotella*, *Fragilaria* and *Navicula* etc.
* On the basis of Palmer's algal index the swamp water is polluted.

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