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Impact of Instream Sand Mining on Physico-Chemical Parameters and Phytoplankton Composition in the River Sone at Koelwar, (Bihta), Bihar, India

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Abstract: ***In stream sand mining disturbs dynamic equilibrium of aquatic ecological factors which have repercussive effects on physicochemical parameters and on phytoplankton. Water samples collected on the basis of mining load at three key points, no mining sites, mining sites and down of mining sites in pre monsoon, monsoon and post monsoon. Selected physicochemical parameters were analyzed following standard protocols of APHA and phytoplankton by Sedgwick Rafter counting cell and identified with the help of Bellinger and Sigee. In the river water, measured mean value of cations TZ $^{+(}$52.96 mg/L) predominate over anions TZ-(29.35 mg/L). Hike in mean value of silica particles (33.94 mg/L) and turbidity (31.96 mg/L) also noted at sand mining sites, which attenuate transmission of sun rays in to water by reflecting most of the incident rays when it strikes on nano particles dispersed in turbid water. Phytoplankton also depleted with heaps of sand taken out from river bed. All these reduce primary productivity of the aquatic ecosystem. Bacillariophyceae identified as dominant group due to abundance of silica particles and alkaline nature of Sone water. Other genera of Chlorophyceae, Cyanophyceae and few species of Chrysophyceae were also identified.***

Keywords: Anthropogenic activities, in stream mining, phytoplankton, primary productivity, turbidity

1. Introduction

River Sone is one of the tributaries of the Ganges. It originates in Amarkantak in Madhya Pradesh and runs about 784 km to arrive in Bihar. Sone water carries silica particles with its flow due to silicate weathering (Sarin *et. al,* 1989) [1] and deposit in the catchment area. Indiscriminate scooping of sand and silica particles from river bed cause ecological effects (Sheeba 1999) [2]. In stream sand mining is rampant in the study area due to high demand of construction grade sand and this activity has also caused changes in physico-chemical parameters of sone water to some extent which adversely affected the phytoplankton communities. Minor changes in physico-chemical parameters can influence primary productivity in river ecosystem (Sharma *et. al* 2007).3

A number of studies have been conducted in relation with physico-chemical parameters and phytoplankton communities in India. Chandrabhaga River (Sharma *et. al,* 2007) [3], Yamuna River (Chopra *et. al*, 2012) [4], Jhelam River (Hafiz 2014) [5]. But no study has been conducted on in stream sand mining in relation with physico-chemical parameters and phytoplankton composition of Sone River in Koelwar area near Bihta, Bihar, India.

Aims and objectives of this study

1) To evaluate the effects of in stream sand mining on physico-chemical parameters of river water
2) To determine density & diversity of phytoplankton at reference sites, sand mining sites & downstream of sand mining site.

2. Material and Methods

(a) Study Area: Koelwar area near Bihta was selected in this study. It is situated at the junction of Bhojpur and Patna District connected with Rail Road Over Bridge called Abdul Bari Bridge. Across the River Sone, NH (National Highway) 30 passing through the Bridge. The coordinate of study area is **25^{0}35'N, 84048'E/25^{0}58'N, 84^{0}80'E,** 5.5 km away from Bihta and 29.8 km from Patna. It is an area of hectic in stream sand mining activities known for fine grade sand.

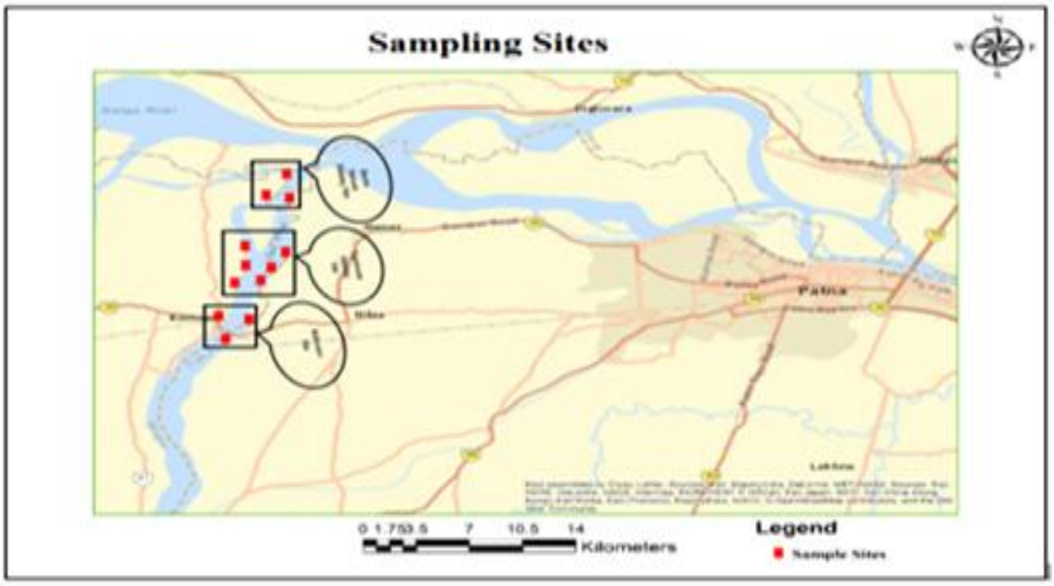


Figure 1: Sampling sites

(b) Sample Collection: The water samples were collected in three different seasons, Pre: monsoon (March-June), Monsoon (July-October) and Post Monsoon (November-January), in 1 liter sampling bottles. Sampling was done in the morning between 9 AM to 11 AM, just below the water surface to avoid surface contamination. Three sampling sites [Figure 1] were selected in the marked coordinate area based on mining load. **Site S_1:** reference site where no mining occurred, **Site S_2:** in stream mining site and **Site S_3:** downstream of mining site.

(c) Experimental: Parameters analyzed were Temperature (Tem), Hydrogen ion concentration (pH), Turbidity (TRB), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Calcium (Ca), Magnesium (Mg), Phosphate (PO_4), Nitrate, (NO_3) and Silica (Si). Water temperature, turbidity and pH were measured *in-situ* using the centigrade (0–110 °C) thermometer, Metzer Digital Turbidity Meter (Model-5D1M) and Toshcon Multiparameter Analyzer, respectively. Other physicochemical parameters were analyzed by standard methods outlined in (Trivedy and Goel, 1984; Wetzel and Likens, 1991; APHA, 2005) [6, 7, 8]. The quantitative and qualitative analysis of phytoplankton were made on the annual mean basis under a microscope in Sedgwick Rafter Counting Cell and calculated according to Welch (1952) by applying formula, n = a (1000) C a/1. Where, n = number of phytoplankton per liter of original water (units l-l), a = average number of phytoplankton in counting units of 1cu. mm capacity, C = volume of original concentration in c. c. (counting cell), l = volume of original water expressed in liter. Phytoplankton were identified with the help of Sarode and Kamat (1990) [9], Bellinger and Sigee (2010) [10].

3. Results & Discussion

(A) Physico-Chemical Parameters

Assessment of the impact of in stream sand mining on physico-chemical parameters and on the distribution of phytoplankton is essential for ascertaining the status of aquatic ecosystem. In stream sand mining, cause changes in variables of physico-chemical parameters which have marked effects on primary producers in the aquatic ecosystem. It also affects distribution of phytoplankton community (Sharma *et. al*, 2007) [4]. Sone water quality is controlled by silicate weathering, alkalinity of water which causes release of silica particles (Krauskopf K B., 1959) [11], anthropogenic activity like sand mining is the apparent cause of temporal changes in physico-chemical parameters and on phytoplankton diversity.

Temperature: Optimum temperature is essential factor which controls metabolic activities in living system. Their lower mean values recorded 15^0C during winter period and higher mean value 36.5 ^{0}C noted during summer season. More over water temperatures is related with season, geographic location, diurnal rotation of earth and sampling time

pH: pH is quantitative measure of the acidity or basicity of aqueous medium. It influences biological and chemical process in aqueous medium (Ahmed *et. al*; 2011) [12], changes in pH also influence the process of buffering of the system in the medium (Deepshikha; 2008) [13]. Maximum pH ± 8 was recorded during post monsoon and lowest pH 7.43 during monsoon. It indicates that Sone water is alkaline. Alkaline water promotes growth in primary producers (Kumar and Prabhahar 2012) [14]. The same findings were also worked out by (Ishaq & Khan 2013) [15].

Turbidity: Turbidity is an expression of amount of light scattered by material particles present in water whether in dissolved or suspended form. The higher the intensity of scattered light more the turbidity of the medium. Turbidity of the Sone water becomes higher during monsoon season ≥28.98 NTU at mining sites, much higher than the prescribed limit (5 NTU WHO) and low ≤10.63 NTU at reference sites in pre monsoon. Similar result was also found by some other workers, (Sharma *et. al*, 2009) [16], (Jindal *et. al*, 2011) [17]. Rise in turbidity during monsoon season is due to shaking of sediments by sand mining process and the flooding spate of water. (Pankaj Kumar 2015) [18]. Other causes of variations were suspension of fine particles which increase turbidity significantly. Hike in turbidity adversely effects primary productivity due to decrease in the photosynthetic activities.

Biological Oxygen Demand: Biological Oxygen Demand remains below prescribed limit (6.0 mg/L WHO) at all the sampling stations in three seasons. Its mean value during premonsoon ≥ 1.54 mg/L, monsoon ≤1.03 mg/L, in monsoon ≥1.72 mg/L to 1.35 mg/L and in postmonson ≥1.61 mg/L to ≥1.12 mg/L remains respectively. Lower BOD value indicates less organic material to be degraded.

Table 1: Mean value of physico-chemical variables

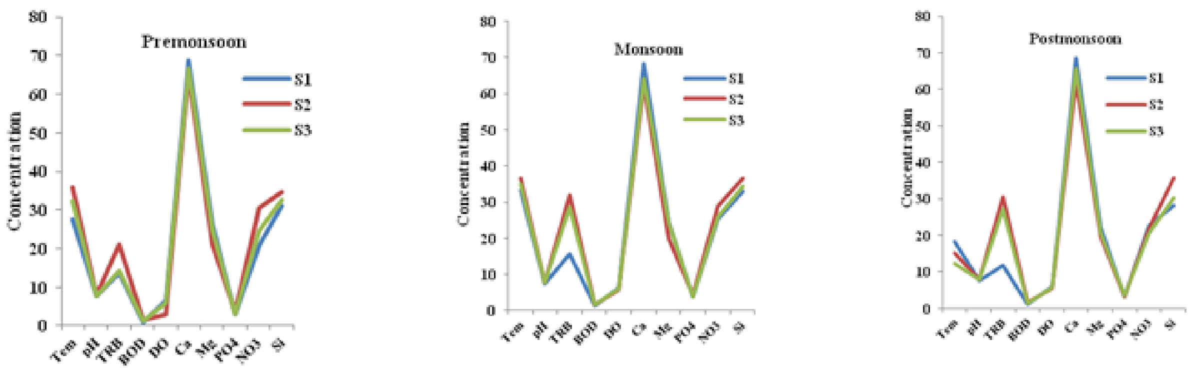
Seasons	Sampling sites	Tem	pH	TRB	BOD	DO	Ca	Mg	PO_4	NO_3	Si
Pre monsoon	S1	27	7.61	10.63	1.03	6.65	68.9	26.88	2.22	20.71	30.21
	S2	36	7.89	20.92	1.54	5.61	62.2	20.17	3.26	27.32	33.22
	S3	35	7.79	14.31	1.06	6.12	66.61	25.61	3.05	21.75	33.54
Monsoon	S1	32	7.43	15.54	1.35	6.45	65.9	24.13	3.87	25.25	32.88
	S2	36	7.96	28.98	1.72	5.85	58.6	20.44	4.74	30.52	37.19
	S3	35	7.72	28.22	1.51	5.86	65.5	24.26	4.18	26.12	34.76
Post monsoon	S1	17	7.59	11.94	1.12	6.25	69.2	18.25	2.97	22.83	28.52
	S2	15	8.06	28.9	1.61	5.45	59.2	18.68	3.25	22.44	32.51
	S3	15	7.84	26.38	1.52	5.85	65.9	20.43	3.51	20.95	31.85

Abbreviation: Tem-Temperature, pH-Hydrogen ion concentration, TRB-Turbidity, BOD-Biological Oxygen Demand, DO-Dissolved Oxygen, Ca-Calcium, Mg-Magnesium, PO_4-Phosphate, NO_3-Nitrate, Si-Silica, (Measurement scale, Tem in ^{0}C, TRB in NTU, all other parameters in mg/L)

Dissolve Oxygen: During the study period DO remains above the prescribed limit (5 mg/L WHO) at all the sampling stations in pre monsoon, monsoon and in post monsoon. Higher DO value indicates less organic matter to be degraded by biological activities and more photosynthetic activities in aquatic environment. It was ≥6.65 mg/ L during pre-monsoon and ≥5.85 mg/L at during monsoon. Higher DO during pre-monsoon was due to high photosynthetic activity (Ravindra *et. al*, 2003) [19]. High DO value was also recorded during pre-monsoon by other workers (Pejman *et, al*, 2009) [20]. Variations in the amount of DO is also related with seasonal variations in temperature, (Singh *et. al*.1999) [21].

Calcium: Calcium concentration remains below the permissible limit (75 mg/L BIS) at all the sampling sites. It varies between ±68.9 mg/L to ±62.2 mg/L during pre monsoon, ±65.9 mg /L to ±58.6 mg /L. during monsoon and ±69.2mg / L (S_1) to ±59.2 mg/ L (S_2) during post monsoon. This variation in calcium concentration was due to change in water dilution and variation in temperature.

Magnesium: Variation in magnesium concentration was also noted but it remains below standard limit (30 mg/L BIS). During premonsoon it was ±26.88 mg/L (S_1) to ±20.17 mg/L (S_2), during monsoon ±24.26 mg/L (S_3) and ±20.44 mg /L (S_2) and in post monsoon ±20.43 mg/L (S_3) to ±18.25 mg/L ($S_{1)}$ respectively. The variation was related with precipitation and evaporation effects (Kumar and Singh 2018) [22]. Magnesium is component of chlorophyll and limiting factor of photosynthesis.



Graph 1a: **Graph 1b:** **Graph 1c:**

Graph 1: Concentration of physicochemical variables during premonsoon, monsoon and postmonson at reference sites, miming sites and downstream of mining sites.

Phosphate: Mean concentrations of phosphate remains below permissible limit (5 mg/L), in all the three seasons. During premonsoon ±3.26 mg/L to ±2.22 mg/L, monsoon ±4.74 mg/L to ±3.87 mg/L and post monsoon ±3.51 mg/L to ±2.97 mg/L respectively. Concentration difference were due precipitation during rainy season, reduction in water content during summer due to evaporation and as superfluous water recedes after rainy season.

Nitrate: Nitrate concentration was below the permissible limit (45 mg/L, BIS). It varies between ≥27.32 mg/L to ≤20.71 mg/L to ≤27.32 mg/L during pre monsoon, in monsoon ≥30.52 mg /L to ≤25.25 mg /L and in post monsoon it ranges between ≥22.83 mg /L (S_1) and ≤20.95mg/L (S_3). Higher concentration of Nitrate during monsoon was due to runoff water from nearby agricultural field. (Kannel *et. al.*2007) [23].

Silica: Concentration of silica in the Sone River water is higher than the Indian standard (25 mg/L) due to hectic sand mining activities. Alkaline nature of river water also enhances the solubility of silicates and favors release of silica in water (Kraus Kopf 1959) [24]. In pre-monsoon it was higher ≥33.54 mg/L at (S_3) and lower ≤30.21 mg/L at (S_1). In monsoon season its concentration varies between ≥37.19 mg /L at (S_2) to ≤32.88 mg/L at (S_1) and in posts monsoon it was recorded ≥ 32.51 mg/L (S_2) to ≤28.52 mg/L (S_1). Concentration of silica becomes higher, due to up heaving of bed material in the mining process and flux of water in the catchment area. Turbidity is also increased in the process up to (35NTU) in comparison to permissible limit (5 NTU WHO) [25] due to dispersion of fine silica particles in the medium.

(B) Botanical Parameter

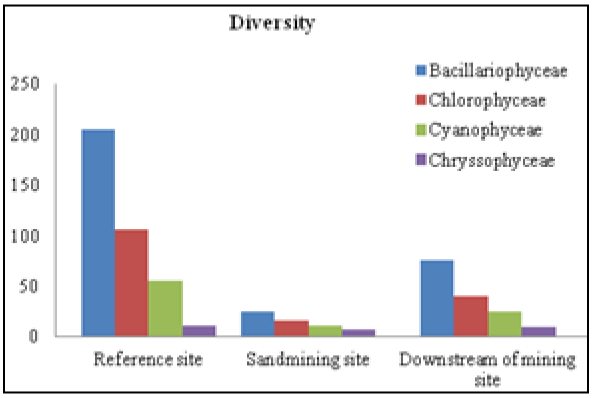
Phytoplankton are vital biological component from which the energy is transferred to higher trophic level through food chain. The environmental health of an aquatic ecosystem depends upon spatial temporal distribution, species composition, relative abundance and biomass of phytoplankton composition (Khattak *et, al*.2005). Bacillariophyceae were identified major groups of phytoplankton (55%) followed by Chlorophyceae (25%), Cyanophyceae (15%) and Chrysophyceae (05%). The density and distribution of phytoplankton in aquatic ecosystem controlled by Physico-chemical parameters (Negi *et. al*.2012) [26]. Higher density of phytop. lankton was recorded during winter 224/L at reference site where no mining take place and lower density 55/L at mining site during monsoon. Over all phytoplankton density shows similar trend in indifferent sampling sites but phytoplankton richness was different at different sampling stations. This may be due to variations in physico-chemical parameters of river water.

Bacillariophyceae

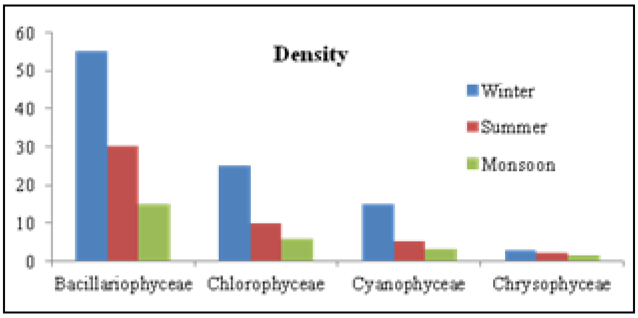
Highest richness of Bacillariophyceae was recorded in River Sone. The water stream is rich in silica particles and alkaline in nature which favors growth of Bacillariophytes. Eight species identified during study period *Fragilaria capucina, Cymbella furgidula, Cymbella fumida, Gomphonema parvulum, Gomphonema gracilis, Navicula gracilis, Nitzschia palea* and *Melosira granulate*. Maximum density of Bcillariophyceaewas during winter at reference site, 205/L (S_{1a}) and minimum 51/L during monsoon at sand mining site (S_{2b}) calculated on annual mean basis, (Fig: 1). Similar findings were also reported in River Ganga and its tributaries in the Garhwal Himalayas (Negi *et. al*.2012) [26].

Chlorophyceae

Four species of Chlorohyceae were identified in River Sone. These are *Microspora aquabilis, Closterium acerosum, Spirogyra* and *Pediastrum duplex*. Its higher density (110/L) was recorded during winter season at undisturbed reference site (S1a) and lower density (22/L) during summer and monsoon at instream mining site (S2b), calculated on annual mean basis, (Fig:-1&2). Low density during summer attributed to intense sand mining, high temperature, low nutrient availability and lower DO. Higher density during winter may be due to higher DO, low temperature naturl environment and efficient utilization of nutrients by Phytoplankton (Sharma R C, 2016) [27].



Graph 2: Diversity of phytoplankton at (1) Reference sites, (2) Sandmining sites and (3) Downstream of mining sites. Calculated on annual mean basis. (Cells/L)



Graph 3: Fig.6. Density of phytoplankton in three different seasons (1) Winter, (2) Summer and (3) Monsoon, calculated on annual mean basis, (Cells/L).

Cyanophyceae

Two dominant species of Cyanophyceae, *Microcystisaeruginosa* and *Ocillatorialimosa* were identified. Its density was highest at reference site 15/L (S_{2a}) and lowest 08/L at mining site (S_{2a}) calculated at annual mean basis, (Fig:-1). They are major components of primary producer in River Ecosystems. Cyanophyceae are very common and important member of algal communities and major functional components in several river systems throughout the world (Khattak, *et al* 2005) [28].

Chrysophyceae

Low density of Chrysophyceae was identified among the phytoplankton community in Sone water. A mixophyte *Dynobryon sertularia* was identified. *D sertularia* was also reported major chrysophytes in aquatic ecosystem by Sushil S. Dixit *et al.* in the study of Ontario lakes (Canadian Journal of Fisheries and Aquatic Science 1998). Its highest density was 08/L, at pH 8 and lowest 05/L at pH 6. *D sertularia* grow well at higher pH. (Behan Tas *et. al*, 2010) [29].

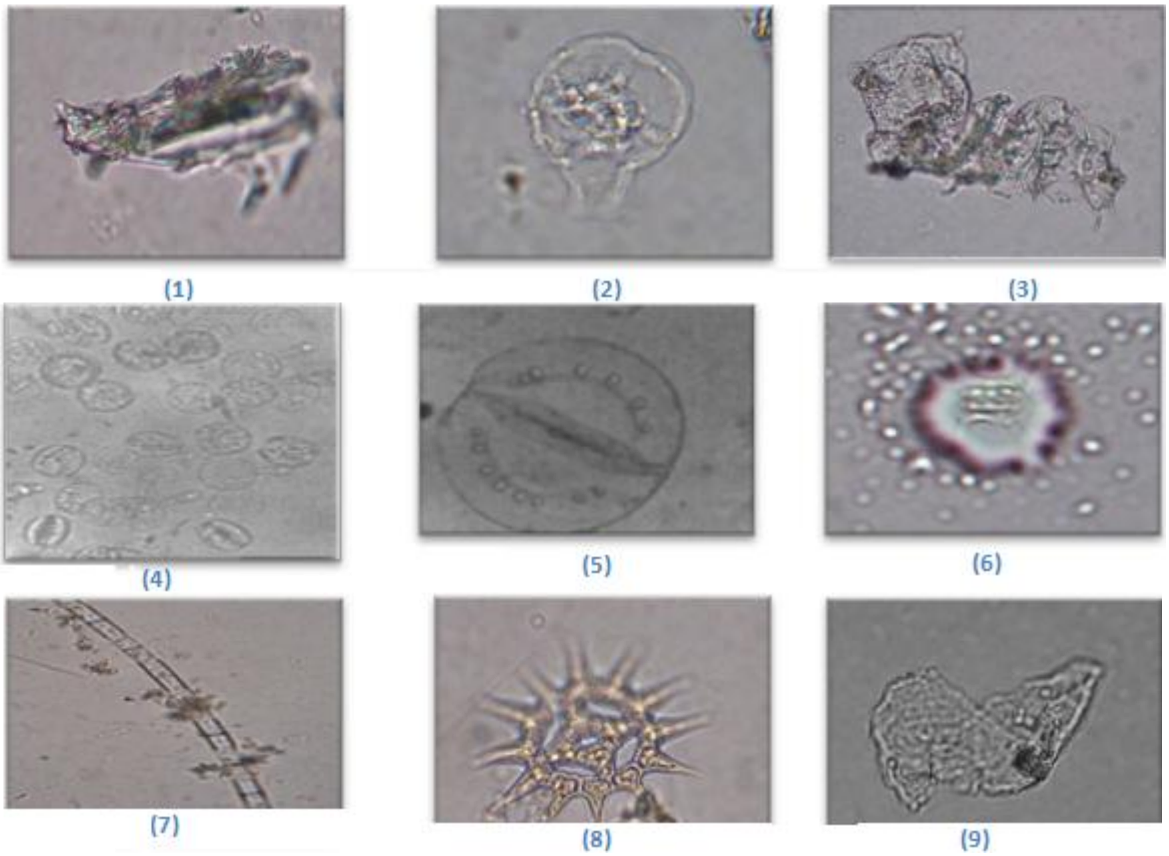


Photo: (1) Dinoflagellate with spine like extension of hypotheca. (2) Dinoflagillate with enlarged, flattened epitheca. (3) Dinoflagillate with wing like extensions of hypotheca and epitheca. (4) Gelatinous colony of diatom. (5) Diatom with ciliate extension. (6) Dinoflagellate with intercingular chamber. (7) Chain forming diatoms with long setae surrounding the cells. (8) Colonial green algae. (9) Alveolate: Dinoflagellate

4. Conclusion

The present study summaries the changes in physico-chemical parameters of Sone water due to in stream sand mining at Koelwar and their impact on phytoplankton community. Sone water is alkaline; cations predominate over anions with higher concentration of silica particles. Higher richness of Bacillariophyceae was found in presence of alkaline pH. Reference sites were undisturbed areas marked with higher phytoplankton density. Minimum density of phytoplankton was recorded at in stream mining sites; it may be due to rise in turbidity, higher concentration of silica particles, hike in suspended load, low transmittance of solar radiation and low photosynthetic activities due to in stream sand mining. Phytoplankton also depleted in the course of extraction of sand from water. Considerable recovery in water quality and phytoplankton density noted in downstream of sand mining sites. Overall the study provides an assessment of in stream sand mining in the aquatic environment of River Sone water, at Koelwar, Bihar, India.

At present sand mining has opened a new avenue of extensive economic activities. It earns huge exchequer to government in the form of royalty, generates employment to manual workers, gain in transportation and necessitated in infrastructure development. In such a condition it is inevitable to be banned but necessitates rationalizing the in stream sand mining practices scientifically in order to save aquatic environment.

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