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TEMPORAL CHANGES CAUSED BY SAND MINING IN RIVER SONE AT KOELWAR, BIHTA, BIHAR, INDIA

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Abstract: Dynamic equilibrium in the aquatic ecological factors was being disturbed by anthropogenic activities, in stream sand mining is one of them. River Sone at Koelwar near Bihta, Bihar, India, is heavily intervened for in stream sand mining. This study was to assess the impact of sand mining on physicochemical parameters of Sone water. For chemical analysis samples were collected in three seasons, pre monsoon, monsoon and post monsoon on the basis of mining load at three sites, 1st Reference site - upstream where sand mining doesn't take place, 2nd sand mining site - where intensive sand mining take place, and 3rd downstream of sand mining site. Measured mean value of cations TZ^+ (52.96 mg/L) predominate over anions TZ^- (29.35 mg/L) in Sone water. Mean hike in silica particles (33.94 mg/L) and turbidity (31.96 mg/L) were noted at sand mining sites which augments fluvial load and also 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 and decreases primary productivity. Concentration of DO was found higher at some sampling stations. All other parameters were within prescribed limit.
Keywords: Anthropogenic activities, aquatic ecosystem, in stream mining, primary productivity, turbidity

1. INTRODUCTION

River systems are mighty resources of water to sustain the life process and also responsible for geochemical cycling of elements. The literatures are available which explains the origin of elements, water chemistry of elements and also explaining the exogenic cycling of elements by the flowing water streams [25, 28]. Components of river water include weathering products and anthropogenic inputs in the form of dissolved and particulate loads. River Sone is one of the tributaries of the Ganges originates in Amarkantak in Madhya Pradesh and runs about 784 km to arrive in Bihar. Sone water carries a number of chemical components which includes weathering products and outcome of anthropogenic activities. A major anthropogenic activity in the study area is in stream sand mining. Human intervention cause changes in physicochemical characteristic of water in the long run also affect riverine biota [24]. Riverine biota is indicator of aquatic environment [5, 23]. River Sone has shallow water in pre monsoon and post monsoon periods, but during monsoon season with heavy flux of water it carries abundance of silica particles due to silicate weathering [21], which in turn deposited in river bed in the catchment area. During in stream miming process as the heaps of sand taken out from water, clay part is removed, left into the water stream and high quality washed sand is obtained. In order to meet wide scale developmental activities indiscriminate scooping of construction grade sand from river bed has caused ecological effects in the study area.

Aims and objective of the study: This study was to assess the impact of in stream sand mining on physico-chemical parameters and quality of Sone water at Koelwar, Bihta, Bihar, India.

2. MATERIALS AND METHODS

Study Area: Koelwar 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. NH 30 passing through the bridge across the River Sone. The coordinate of study area is 25⁰35'N, 84⁰48'E / 25⁰58'N, 84⁰80'E, 5 km away from Bihta and 28 km from Patna. It is an area of hectic in stream sand mining activities known for fine grade sand.

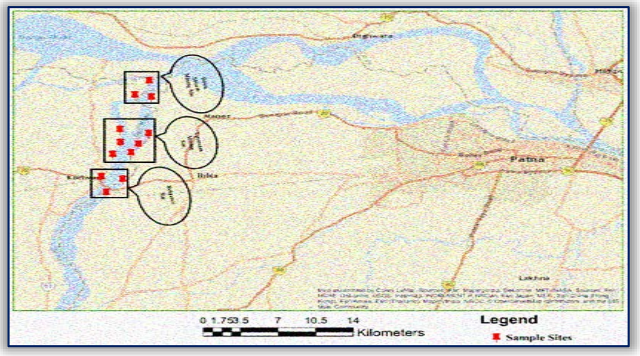


Figure 1. Sampling Suites

Sample collection: The sampling was done in the morning between 8 AM to 11 AM, just below the water surface to avoid surface contamination. Three sampling sites were selected based on mining load. Site1 (S_1), Reference site where no mining occurred, samples were collected at 3 different coordinates. (S_1a, S_1b, S_1c), Site2 (S_2), In stream mining site. Samples were collected at 6 different coordinates. (S_2a, S_2b, S_2c, S_2d, S_2e, S_2f), Site3 (S_3), Downstream of mining sites, samples were collected at 3 different coordinates. (S_3a, S_3b, S_3c), (Fig-1). Samples were collected in three different seasons, Pre monsoon (March-June), Monsoon (July-October) and Post monsoon (November-January) in 2019, in 1 lit sampling bottle. Physico-chemical analysis has been done as per APHA (2005), [3]. Parameters analyzed were Temperature, pH, Turbidity, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Calcium (Ca), Magnesium (Mg), Phosphate (PO_4), Nitrate (NO_3) and Silica (Si). Temperature measured at sites. Data generated in physico-chemical analysis of Sone water in the laboratory, used in ascertaining the suitability of Sone water for domestic purposes, in agriculture and to assess the aquatic health of the system.

3. RESULTS AND DISCUSSION

— **Temperature** - Temperature controls chemical and biological process in aquatic system. Optimum temperature is essential factor which controls metabolic activities in living system (Ishaq & Khan 2013). Its lower mean value recorded 15° C during winter period and higher mean value 35°C recorded during summer season.

— **pH** - It remain high at all the sampling stations. Highest pH 8.35 (S_{2a}) noted during pre-monsoon (Data-1) and lowest pH 7.15 (S_{1a}) during monsoon (Data-2). pH influence biological and chemical process in aqueous medium [5] and pH is also related with the process of buffering of the system in the medium [8]. Similar findings were also reported by [2,4]. Over all sone water is alkaline. Alkaline water promotes growth of primary producers in aquatic medium [15] which indicates water quality

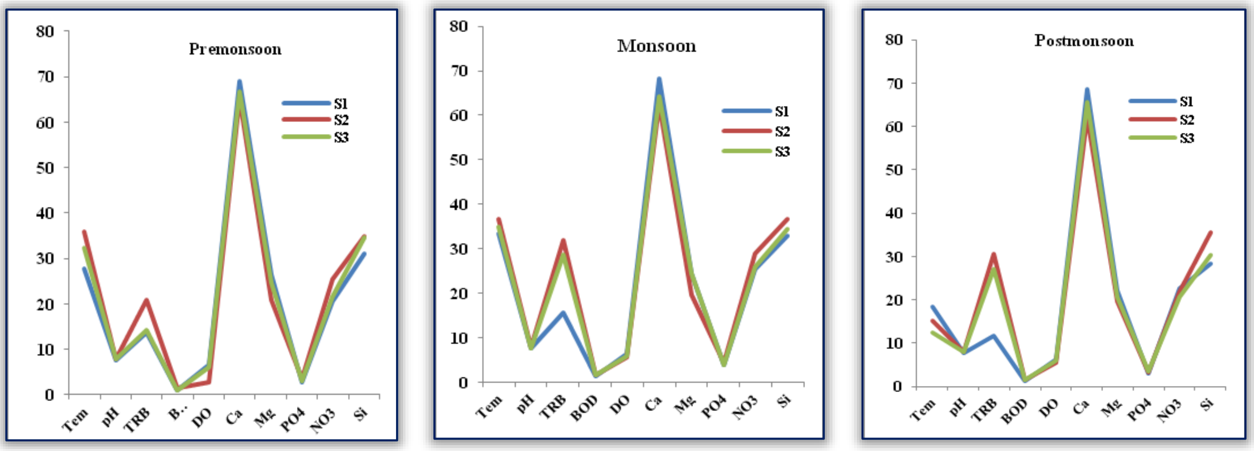
— **Turbidity** - Turbidity is an expression of amount of light scattered by material particles dispersed in aqueous medium. It was higher at all the sampling sites. During monsoon it was noted much higher 35.82 NTU (S_{2b}), (Data-2), than permissible limit 5.0 NTU (BIS). Rise in turbidity during monsoon season is due to shaking of sediments by sand mining process and the flooding spate of water [17]. Lowest value 11.32 NTU (S_{1a}), recorded during pre-monsoon (Data-1). Similar findings were also reported by Sharma *et al* (2009) [22], Jindal *et al* (2011) [11].Turbidity attenuate penetration of sun ray in to aqueous medium and retards photochemical activity of phytoplankton [14].

— **BOD - Biological Oxygen Demand** was noted below prescribed limit (6.0 mg/L WHO) at all sampling stations. In pre :monsoon it ranges from 1.6 mg/L (S_{2b}) to 0.6 mg/L (S_{1b}), (Data-1), during monsoon varies between 1.9 mg/L (S_{2b}) to 1.2 mg/L (S_{1c}), (Data-2) and in post monsoon it was 1.8 mg/L (S_{2f}) to 0.7 mg/L (S_{1c}), (Data-3). Lower BOD value indicates less organic material to be degraded [1].

— **DO - Dissolved Oxygen** was above the prescribed limit 5 mg/L (WHO 1984) at certain sampling stations. Higher DO value indicates better aquatic environment. In pre monsoon it ranges from 6.9 mg/L (S_{3b}) to 1.4. mg/L (S_{2f}), (Data-1), during monsoon 6.8 mg/L (S_{2b}) to 5.1 mg/L (S_{2e}) (Data-2) and in post monsoon from 6.7 mg/L (S_{1b}) to 5.3 mg/L (S_{3c}) (Data-3). Higher DO value was also recorded during pre-monsoon by [18].

— **Calcium** - Calcium concentration remains below the permissible limit (75 mg/L, BIS) at all the sampling sites. It varies between 72.7 mg/L (S_{1a}) to 55.4 mg/L (S_{2a}), (Data-1) during pre-monsoon, 71.5 mg /L (S_{1c}) to 50.6 mg /L (S_{2a}), (Data-2) during monsoon and 71.7 mg / L (S_{1c}) to 52.5 mg/ L (S_{2a}), (Data-3) during post monsoon in Sone water. This variation in calcium concentration was due to changes in water dilution [21].

— **Magnesium** - Variations in magnesium concentration was also noted below standard limit (30 mg/L, BIS). During pre-monsoon it was 28.64 mg/L (S_{1b}) to 16 mg/L (S_{2a}), (Data-1), during monsoon 26.66 mg/L (S_{1a}) to 16.76 mg /L (S_{2e}), (Data-2) and 27.21mg/L (S_{1a}) to 15 mg /L (S_{2a}), (Data-3) during post monsoon respectively. Variations in magnesium concentration have been related with precipitation and evaporation effects [14].



Figures 2, 3, & 4. Concentration of variables in Pre monsoon, Monsoon & Post monsoon.

Data 1. Pre monsoon:

Premonsoon	Sample codes	GPS Locations	Temp	pH	TRB	BOD	DO	Ca	Mg	PO_4	NO_3	Si
Reference sites-$S1_r$	S_{1a}	25.5109,84.7527	28	7.25	11.32	0.8	6.8	72.7	25.62	3.58	20.15	31
	S_{1b}	25.5516,84.7727	26	7.81	15.31	0.6	6.4	68.6	28.64	2.54	21.25	30
	S_1C	25.5678,84.7922	29	7.78	14.27	1.7	6.5	65.5	25.11	2.35	20.45	32
Sand mining sites- S2	S_2a	25.6088,84.5037	41	8.35	18.28	1.5	4.6	55.4	16	3.65	26.12	35
	S_2b	25.6617,84.7997	31	7.82	20.11	1.9	2.9	67.5	17.52	3.71	21.15	38
	S_2c	25.6848,84.2931	35	7.86	22.29	1.6	2.5	68.7	24.22	3.55	34.43	37
	S_2d	25.5142,84.7751	32	7.79	21.28	1.4	3.2	66.9	22.72	2.76	27.25	35
	S_2e	25.5426,84.7867	35	7.78t	24.31	1.4	2.9	68.5	23.54	3.77	23.25	31
	S_2f	25.5670,84.8005	36	7.78	19.28	1.4	1.4	64.6	21.67	3.68	20.22	33
Down of mining sites-S	S_3a	25.5966,84.8266	37	7.78	12.35	0.7	5.6	67.2	23.25	2.45	21.27	35
	S_3b	25.6298,84.8343	34	7.8	14.32	1.3	6.9	64.5	25.11	3.65	22.26	33
	S_3c	25.6748,84.8366	35	7.79	16.28	1.2	5.7	68.7	26.12	2.75	21.25	36

Data 2. Monsoon:

Monsoon	Sample codes	GPS Locations	Temp	pH	TRB	BOD	DO	Ca	Mg	PO_4	NO_3	Si
Reference sites-S1	S_{1a}	25.5109,84.7527	31	7.15	15.57	1.4	6.7	68.2	26.66	3.81	25.76	34
	S_{1b}	25.5516,84.7727	33	7.72	12.57	1.4	6.4	65.2	21.62	4.6	26.21	32
	S_{1c}	25.5678,84.7922	36	7.71	18.54	1.2	6.2	71.5	25	3.25	24.31	33
Sand mining sites-S2	S_{2a}	25.6088,84.5037	38	7.74	26.45	1.5	5.6	50.6	24.14	4.75	28.27	34
	S_{2b}	25.6617,84.7997	36	7.72	35.82	1.9	6.8	65.7	18	4..21	27.12	35
	S_{2c}	25.6848,84.2931	34	8.22	30.75	1.7	5.3	61.5	18.52	4.37	30.51	34
	S_{2d}	25.5142,84.7751	37	7.72	34.75	1.8	5.2	66.8	21.44	4.42	35.45	36
	S_{2e}	25.5426,84.7867	39	7.72	32.55	1.6	5.1	65.6	16.76	4..35	25.58	35
	S_{2f}	25.5670,84.8005	36	7.71	31.75	1.7	6.5	65.4	19.77	3.57	26.15	40
Down of mining sites-S3	S_{3a}	25.5966,84.8266	39	7.71	26.61	1.4	5.1	62.5	24.5	4.52	25.62	33
	S_{3b}	25.6298,84.8343	32	7.72	28.65	1.5	6.4	65.7	24	3.86	26.12	36
	S_{3c}	25.6748,84.8366	34	7.71	30.74	1.7	6.5	64.5	24.6	3.55	26.15	34

Data3. Post monsoon

Postmonson	Sample codes	GPS Locations	Temp	pH	TRB	BOD	DO	Ca	Mg	PO_4	NO_3	Si
Reference sites-S1	S_{1a}	25.5109,84.7527	16	7.35	11.45	1.4	5.7	67.6	27.21	2.21	22.5	28
	S_{1b}	25.5516,84.7727	17	7.85	11.35	1.5	6.7	66.7	22	3.73	24.4	30
	S_{1c}	25.5678,84.7922	19	7.89.	12.47	0.7	6.2	71.7	17.15	3.37	21.15	27
Sand mining sites-S2	S_{2a}	25.6088,84.5037	14	7.87	25.37	1.2	5.6	52.5	15	2.27	20.24	33
	S_{2b}	25.6617,84.7997	18	7.88	31.22	1.7	5.5	64.7	18	4.25	21.25	34
	S_{2c}	25.6848,84.2931	13	7.89	32.45	1.6	5.4	62	21	2.73	22.21	35
	S_{2d}	25.5142,84.7751	14	8.27	30.25	1.5	5.7	65.7	20	3.55	21.15	36
	S_{2e}	25.5426,84.7867	15	7.85	32.35	1.7	5.4	62.6	21	3.52	24.62	28
	S_{2f}	25.5670,84.8005	17	7.89	31.52	1.8	5.5	65.7	22.12	3.27	22	30
Down of mining sites-S3	S_{3a}	25.5966,84.8266	14	7.82	28.25	1.4	6	65	21	3.79	19.45	30
	S_{3b}	25.6298,84.8343	16	7.85	30.35	1.5	6.4	66.5	19	3.35	20.26	32
	S_{3c}	25.6748,84.8366	13	7.89	22.81	1.6	5.3	65.7	22.12	3.25	22.46	29

— **PO_4 - Phosphate** level was below the IS standard (5 mg/L) at all the sampling stations. It was higher during monsoon season 4.75 mg/L (S_{2a}) in comparison to pre monsoon 3.77 mg/L (S_{2e}) and post monsoon season 2.21 mg/L (S_{1a}). Higher phosphate concentration during monsoon was also reported in the study of Ghagra and Gandak Rivers [19], Rapti River [24] and Gharhwal Himalayas [22].

— **Nitrate** - Nitrate concentration was below the permissible limit (45 mg/L, BIS). It varies between 34.43 mg/L (S_{2c}) to 20.45 mg/L (S_{1a}), (Data-1) during pre-monsoon, during monsoon 35.45 mg /L (S_{2d}) to 24.31 mg /L (S_{1c}), (Data-2) and during post monsoon it ranges between 24.62 mg/L (S_{2e}) to19.45 mg /L (S_{3a}) , (Data-3. Higher concentration of Nitrate during monsoon was due to runoff water from nearby agricultural field [12].

— **Silica** - Concentration of Silica in the Sone River water was higher than the Indian average (25 mg/L). In pre monsoon it range from 38 mg/L (S_{2b}) to 30 mg/L (S_{1b}), in monsoon 40 mg/L (S_{2f}) to 32 mg/L (S_{1b}). In post monsoon it varies between 36 mg/L (S_{2d}) to 27 mg/L (S_{1c}). During monsoon concentration of silica becomes higher; it was due to sand mining. Most of the mining locations in this period remain shifting and illegal because sand mining is restricted in monsoon by Government order. Alkaline nature of river water also enhances the solubility of silicates and favors release of silica in water [13].Turbidity also increased in this process (Fig-2).

Table-1. Inter-elemental correlation matrix of River Sone water at Koelwar: Pre monsoon.

Pre monsoon	Temp	pH	Trb	BOD	DO	Ca	Mg	PO_4	NO_3	Si
Temp	1									
pH	0.3115	1								
Trb	0.4682	0.4009	1							
BOD	-0.0417	0.1245	-0.0201	1						
DO	-0.1445	-0.1207	-0.1012	0.9832	1					
Ca	0.3647	0.4857	0.3135	0.1728	0.42984	1				
Mg	0.2414	0.9199	0.3621	0.4235	0..33517	0.69245	1			
PO_4	0.0235	0.8986	0.4021	0.4945	0.42082	-0.5003	-0.7524	1		
NO_3	0.1058	-0.4165	0.3455	0.5589	0.50034	-0.6475	-0.80892	0.8599	1	
Si	0.47113	0.2574	0.2718	0.51583	0.37408	0.29025	4.5488	-0.2746	-0.5527	1

Table-2. Inter-elemental correlation matrix of River Sone water at Koelwar: Monsoon.

Monsoon	Tem	pH	Trb	BOD	DO	Ca	Mg	PO_4	NO_3	Si
Tem	1									
pH	0.4265	1								
Trb	0.9785	0.9040	1							
BOD	0.2516	0.4241	-0.5412	1						
DO	-0.3244	-0.3207	-0.3012	0.6232	1					
Ca	0.5713	0.2757	.0.2435	0.1425	0.3574	1				
Mg	0.6135	0.8743	0.4521	0.3232	0..4672	0.7313	1			
PO_4	0.1242	0.7466	0.3011	0.3745	0.3517	-0.5003	-0.9624	1		
NO_3	0.1759	-0.7325	0.5525	0.6585	0.6425	-0.6595	-0.9089	0.9499	1	
Si	0.54167	0.6432	0.5718	0.4236	0..4241	0.1902	0.4488	-0.2746	-0.1537	1

Table-3. Inter-elemental correlation matrix of River Sone water at Koelwar: Post monsoon

Post Monsoon	Tem	pH	Trb	BOD	DO	Ca	Mg	PO_4	NO_3	Si
Temp	1									
pH	0.2214	1								
Trb	0.5572	0.7435	1							
BOD	-0.1216	0.3245	-0.2202	1						
DO	-0.2448	-0.2207	-0.2012	0.7832	1					
Ca	0.2547	0.1857	.0.1354	0.1228	0.1298	1				
Mg	0.1234	0.5199	0.3012	0.2535	0..3351	0.6724	1			
PO_4	0.0112	0.3986	0.4021	0.4945	0.4208	0.4803	-0.7524	1		
NO_3	0.1362	-0.5165	0.4155	0.5589	0.5003	-0.6241	-0.7089	0.72852	1	
Si	0.4416	0.4574	0.3212	0.5158	0.3740	0.2602	32475	-0.5746	-0.4526	1

Abbreviation:Tem -Temperature, Trb -Turbidity, BOD - Biological Oxygen Demand, DO - Dissolved Oxygen, Ca - Calcium, Mg - Magnesium, PO_4 - Phosphate, NO_3 - Nitrate, Cl - Chloride, Si - Silica.

4. CORRELATION MATRIX ANALYSIS

The correlation matrix data (Table-1) of geochemical parameters substantiate the results of physicochemical analysis. The observed good correlation between Cations; Ca-Mg (Premonsoon-0.69, Monsoon-0.73, Post-monsoon-0.69) and anions; NO_3-Cl (Premonsoon-0.74, Monsoon-0.82, Post-monsoon-0.72) suggests a common source, which may be due to weathering of mineral rocks, mobilization of ions and anthropogenic inputs [16]. Higher load of silica at certain locations, indicates anthropogenic intervention in natural environment.

5. CONCLUSIONS

The paper summaries the temporal changes in physicochemical parameters of River Sone arising out of in stream sand mining. Sone water is alkaline, cations Ca^{2+}, Mg^{2+} predominates over anions NO^{3-}, Cl^{-}. Reference sites were undisturbed areas with optimum physicochemical parameters. Sand mining sites were highly disturbed areas with high turbidity, fluvial load, higher concentration of silica particles, low transmittance of solar radiation, all resulting in the decrease of primary productivity and degradation of water quality. However considerable recovery in water quality noted in downstream of sand mining sites where sand mining doesn't take place. This study indicates the potential of further water quality degradation, if irrational in stream mining is not checked in time.

At present, sand mining has opened a new avenue of extensive economic activities. It collects huge exchequer to the government in terms of royalty, generates employment for manual workers, earns profit in transportation of sand and sand is also required in infrastructure development. In such a condition it is inevitable to be banned sand mining, but to rationalize the mining practices scientifically, in order to save aquatic environment.

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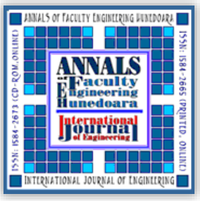

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