Spatio-Temporal Pattern and Physio-Chemical Chemical Characteristics of Wetlands of Mithila Plain

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Abstract:

Water is undoubtedly considered as home to many aquatic flora and fauna in both lentic and lotic ecosystems. Universally, rivers are acknowledged as a primary source of surface water and play a crucial role among many other natural water resources (Mirza et al. 2014; Eliku and Leta 2018). Rivers serve several purposes, including household water supply for drinking, transportation, agricultural irrigation, recreational activities, fishing and aquaculture production as well as the generation of electricity (Mirza et al. 2014; Boyd 2015; Eliku and Leta 2018). It is essential to recognize that water quality plays a crucial role in safeguarding the whole environment, particularly in maintaining the soundness of the public health system (Rajini et al. 2010; Arafat et al. 2022). The existence of resilient riverine ecosystems is correlated with the profusion of aquatic flora and fauna, thus enhancing the overall biodiversity of the region (Lawal et al. 2023).

Before the initiation of this study, no prior studies were conducted regarding the spatial and temporal fluctuations in the physico-chemical properties of Mithila Wetland. Simultaneously, it is worth mentioning that this plain accommodates a considerable populace of the most coveted game fish of the globe, the imperiled makhana, and jute. Therefore, considering the economic vitality of the Mithila Plain, the current study was carried out to evaluate the physico-chemical parameters in relation to spatial and seasonal fluctuations. This study utilized a range of statistical methods to establish a comprehensive dataset that can be used for the efficient management and conservation of the Mithila Wetland Plain, in addition to detecting pollution sources and other water quality issues. This study provides valuable insights that might enhance the quality of physico-chemical parameters, which, in turn, may aid in preserving and managing resident fish species, which are essential for the local economy.

Keywords: aquatic, flora and fauna, ecosystem, surface water, transportation, agricultural irrigation, recreational activities, fishing and aquaculture production

Introduction:

Precipitation is the prime source of flow in the River Ganga. The contribution of Plateau Rivers, which experience slightly different rainfall patterns, is also significant. Snow-melt water from the Himalayas and Himalayan tributaries are also an important source of flow. The percentage contribution of each of these sources varies throughout the year, and this has a significant impact on the water quality and sediment profile of the River Ganga. Variation in velocity and channel regime is primarily due to the change in topographical features. Rivers Koshi and Gandak pierce their way through the loose alluvial sedimentary formations of the Himalayas with great velocity and turbulence due to the steep slope of Mithila Plain. The width of the channel in this region, where the River flows for approximately 100 km, varies from about 5m at gorges to about 30m in wider and shallow sections. The width increases significantly in the flow regime downstream of dams. The mean annual flow rate in this region is about 850 m3/s. Considering 90 percentile volumes, March records lowest flow at about 140 m3/s and highest flow is usually in the month of August, which is about 2000 m3/s. (Ray, 1998).

The mean annual flow rate in Mithila Plain is about 850-1700 m3/s and the 90 percentile flows during the lean flow and monsoon period are about 160 m3/s and 6200 m3/s respectively. There are many tributaries which join the Ganga and contribute to the flow of the River in the section from Sangam in Patna, where the River Gandak joins the Ganga, till Farakka barrage, where the River forms a distributary. The slope of the channel reduces further in this section with an average slope of about 1:13000. It is at this point where there is significant difference in the velocity of the river through lateral and vertical dimensions. Nutrient and pollutant dispersion vary significantly from the middle section of the River to the sections near the banks. The mean flow rate in this region is about 10,200 m3/s (Ray, 1998). Increased siltation and large flow volumes result in an increase in the width of the River, and the zone is prone to flooding.

Table 1. Water quality parameter of Mithila Plain

Characteristic	Water Samples taken from Different Places of Mithila Plain					
	At the right end of bank	At the Bathing Ghat	At the Boating Ghat	At picnic spot	At the place near rotting of jute	Near the place of irrigation
pH Value	7.74	7.79	9.06	7.30	7.35	7.24
Turbidity, NTU	26.1	6.8	9.9	7.60	17.30	15.90
Total Dissolved Solids, mg/L, Max	128	124	98	160	152	178
Total Suspended Solid, mg/L	63.5	10.0	5.5	<02.00	14.00	15.5
Chemical Oxygen Demand, mg/L	<8.0	<8.0	<8.0	14.0	5.70	29.0
Biochemical Oxygen Demand , 3 Days at 27ºC, mg/L	1.2	<1.0	<1.0	4.60	15.0	7.40
Sulphate (as SO4), mg/L	6.0	4.5	4.5	<05.0	<05.0	<05.0
Phosphate (as PO4) , mg/L	0.03	0.03	0.03	0.04	0.02	0.02
Nitrate (as NO3), mg/L	0.49	<0.2	0.23	<0.50	<0.50	0.61
Nitrite (as NO2),mg/L	<0.05	<0.05	<0.05	0.20	0.20	0.30
Total Hardness (as CaCO3), mg/L	116.4	116.4	85.4	36.0	99.8	113.3
Total Coliform Count, MPN/100 mL	4.7×10^4	4.0×10^4	2.4×10^4	4.9×10^4	3.1×10^4	2.9×10^4

Fecal Coliform, MPN/100 mL	$9.2x10^3$	$6.8x10^3$	$1.1x10^3$	$9.8x10^3$	$3.4x10^3$	$3.0x10^3$

The velocity of the river is extremely reduced in this stretch, and is below the threshold limit for transport of sediments. Massive loads of sediment are deposited in the stretch and tidal variation dominates river hydrology. The Central Water Commission of India (CWC) monitors the flow of the River Ganga, and has a strategic network of 316 gauging stations across the Ganga Basin (National Remote Sensing Centre, 2014). As is the case with many of the trans-boundary river systems, data pertaining to the flow in the River Gandak and Koshi is not publicly released. The present study examines critical parameters pertaining to water quality of the Mithila Wetland Plain, for which information about the flow is invaluable. Information pertaining to the flow of the Rivers has been obtained from CWC and has been used suitably to interpret the findings from this study.

Physio-chemical structure:

Kabar Tal is situated in Begusari district of Bihar, which is one of the numerous wetlands of Mithila Plain. This plain is situated in the north central part of Bihar. The region is limited by the Gandak River on the west, the Kosi River on the east, the Ganga River on the south and the Indo-Nepal boundary on the north. The region is a product of continuous deposition from the Ganga River and its tributaries.

Structurally, the plain is a part of Great Indo-Ganga trough, filled by deep alluvium carried by various rivers. It is dotted with abandoned beds, cutoff meanders, numerous lakes and elongated *chaurs*. These lakes and *chaurs* were formed by meanders of rivers and are now residual oxbow lakes. Almost all the rivers in the region develop a capacity to spill over in the monsoon period and are notoriously dynamic in character, particularly the Gandak, the Kosi and the Ganga. These rivers have shifted their courses frequently covering wide areas throughout the historic time as is reflected by the remnants of their former beds in the form of oxbow lakes, meander loops, dead channels, *"chaurs"* and *"tals".*

Seasonal and Spatial Variation of Water

Water exhibits both seasonal and spatial variations, meaning its characteristics (like temperature, pH, and nutrient levels) differ based on time of year and location. For example, water quality is often better during rainy seasons and varies along flow directions in cascading systems.

Table 2: Yearly round fluctuation of Physicochemical characters in Mithila Wetland Plain

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan. 21	21.8	22	150	90	706	10.4	0	12	96	108	142	0.2	0.44	56	10.42	7.29
Feb. 21	22	22.6	140	82	7.4	9.6	0	22	80	102	168	0.27	0.56	52	14.42	3.89
Mar. 21	25.3	24.8	124	95	7.4	8.6	0	18	130	148	180	0.35	0.64	60	12.82	6.80
Apr. 21	30.5	28.2	110	90	7.5	7	10	0	236	236	190	0.48	0.72	64	15.23	6.31
May 21	34.5	33	95	85	7.2	6.8	17	0	302	302	185	0.51	0.96	72	15.23	8.25
June 21	36.2	34.2	115	70	7.6	5.6	13	0	310	310	220	0.76	1.3	76	21.64	5.34

July 21	32.8	30.5	120	60	7.5	5.4	12	0	270	270	128	1.22	1.58	66	17.64	5.33
Aug 21	30.5	28.7	110	72	7.7	5.6	14	0	72	72	130	1.65	2.11	64	16.03	5.33
Sept. 21	29.5	27.2	104	75	7.8	7.2	0	10	80	90	198	1.5	2.17	60	14.42	5.83
Oct. 21	27.7	26	95	70	7.6	6.8	10	0	102	102	210	0.92	1.42	62	13.62	6.80
Nov. 21	26.5	24.9	82	64	7.7	6.4	12	0	190	190	196	0.9	1.25	60	12.82	6.80
Dec. 21	24	23.3	70	70	7.3	5.2	14	0	220	220	185	0.76	0.95	62	22.44	1.45
Jan. 22	20.8	22.1	57	57	7.2	5.4	20	0	218	218	205	0.62	0.71	60	15.33	5.34
Feb. 22	22.5	23.2	40	40	7.6	6.4	18	0	194	194	190	0.6	0.74	58	14.42	5.34
Aug 22	31.2	29.5	150	60	7.4	4.6	10	0	62	62	128	0.7	0.72	76	18.44	7.28
Sept. 22	29	27.4	160	65	7.5	6.4	12	0	102	102	185	0.62	0.9	74	16.03	8.26
Oct. 22	27.2	25.7	145	60	7.8	8.2	14	0	114	114	205	0.62	1.02	70	17.64	6.31
Nov. 22	25.8	24.2	120	80	8	8.6	12	0	210	210	240	0.55	0.7	66	16.03	6.31
Dec. 22	23.5	23.8	106	77	8.1	9.8	10	0	188	188	273	0.39	0.46	62	15.23	5.82
Jan. 23	20.2	22.3	90	52	8	8.2	0	18	150	168	257	0.22	0.52	60	14.23	5.65
Feb. 23	21.9	23	78	45	7.6	6.8	0	26	218	244	215	0.27	0.66	64	17.64	4.85
Mar. 23	24.7	24.2	64	50	7.1	5.6	10	0	258	258	290	0.32	0.85	76	19.43	6.68
Apr. 23	29.5	27.5	40	32	7.2	3.6	20	0	290	290	320	0.44	1.15	80	20.84	6.79
May 23	33.5	31.7	35	35	7.1	3.8	24	0	314	314	360	0.82	1.22	90	23.25	7.76
June 23	35	33.8	60	33	7.3	4.6	22	0	278	278	260	0.85	1.42	98	23.24	9.71
July 23	33.1	31	125	80	7.4	5.8	16	0	110	110	190	0.9	1.45	82	20.84	7.28
Aug 23	29.5	27.8	170	104	7.5	6.6	12	0	72	72	125	1.04	1.92	86	21.64	7.77
Sept. 23	28.3	26.5	146	110	7.6	8.8	0	12	96	108	180	0.96	1.72	84	20.84	7.77
Oct. 23	26.5	24.7	134	112	7.8	9.6	8	0	130	130	218	0.68	1.02	78	19.24	7.28
Nov. 23	24.7	23.6	120	101	8.1	10.2	12	0	220	220	296	0.4	0.65	74	14.43	9.23
Dec. 23	23	23.2	105	90	8.2	10.6	0	8	170	178	270	0.35	0.42	72	13.63	9.23

1. Air temperature (^{0}C)
2. Water temperature (^{0}C)
3. Depth (cm)
4. Transparency (cm)
5. pH
6. DO (ppm)
7. Fee CO_2 (ppm)
8. Carbonate alkalinity
9. Bicarbonate alkalinity
10. Total alkalinity (ppm)

11. Specific conductivity (µS/cm)
12. Phosphate (ppm)
13. Total Kjeldhal nitrogen (ppm)
14. Total hardness (ppm)
15. Ca (ppm)
16. Mg (ppm)

Table 3 : Correlation matrix between Physico-chemical parameters in Mithila Wetland Plain

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	-															
2	0.981															
3	0.065	-.003														
4	-.082	-.169	0.713													
5	-.362	-.397	.338	.391												
6	-.551	-.578	.506	.691	.717											
7	.491	.504	-476	-.485	-.453	.717										
8	-.489	-.426	.136	.103	.136	.420	-.790									
9	.273	.332	-.673	-.454	-.308	-.398	.529	-.290								
10	.232	.299	-.676	-.455	-.302	-.367	.465	-.200	.996							
11	-.062	-.036	-.598	-.371	-.063	-.050	.270	-.109	.576	.579						
12	.550	.483	.072	.020	-.061	-.409	.250	-.368	-.217	-.258	-.364					
13	.610	.546	.074	.029	-.172	-.426	.211	-.269	-.167	-.197	-.267	.921				
14	.635	.637	-.029	-.091	-.280	-.378	.458	-.388	.263	.231	.342	.195	.360			

15	.546	.553	-.176	-.251	-.453	-.593	.494	-.327	.333	.309	.226	.277	.410	.786		
16	.328	.322	.180	.176	.127	.147	.108	-.209	-.002	-.022	.264	-.040	.057	.612	-.007	-

Table 4 : Diurnal variations in physic-chemical parameters of water

Time → / Parameters ↓		9:00	13:00	17:00	21:00	1:00	5:00
WINTER	Water Temp (^{0}C)	21.5	23.8	22.6	21.2	19.3	18.6
	pH	8	8.2	7.9	7.7	7.6	7.8
	DO (ppm)	7.8	10.2	9.8	8.4	7	5.8
	Free CO_2	0	0	1.2	1.8	2.8	3.6
	Total alkanity (ppm)	104	102	108	114	116	108
	Conductivity (µS cm^{-1})	255	260	270	264	240	235
	Total Hardness (ppm)	68	64	62	66	68	70
PRE MONSOON	Water Temp (^{0}C)	31.5	33.2	31.7	30.1	28.5	27.4
	pH	7.5	7.9	7.8	7.8	7.6	7.4
	DO (ppm)	3	4.8	4.6	3.2	3.8	2.4
	Free CO_2	20	16	10	12	18	24
	Total alkanity (ppm)	290	280	302	304	322	308
	Conductivity (µS cm^{-1})	320	330	342	325	315	300
	Total Hardness (ppm)	90	84	78	80	82	86
MONSOON	Water Temp (^{0}C)	29.3	31.5	30.6	29.3	28	27.5
	pH	7.4	7.6	7.5	7.4	7.3	7.2
	DO (ppm)	5.4	6.6	5.8	4.6	3.8	3.6
	Free CO_2	20	14	10	12	16	18
	Total alkanity (ppm)	124	132	136	140	138	130
	Conductivity (µS cm^{-1})	180	190	185	170	164	160
	Total Hardness (ppm)	82	78	74	76	78	80
AFTER MONSOON	Water Temp (^{0}C)	24.5	26.7	24.9	24.4	23.9	22.6
	pH	7.6	8	7.8	7.7	7.5	7.4
	DO (ppm)	8.4	9.6	8.8	7.4	6.8	6.4
	Free CO_2	6	0	4	8	10	8

	Total alkanity (ppm)	182	190	198	206	200	192
	Conductivity (µS cm-¹)	256	270	280	265	250	240
	Total Hardness (ppm)	74	70	64	66	68	72

In the development of wetland, the ecology of the water plays an important role, since ecology determines the habitability and abundance of flora and fauna of the wetland. In the limnological study the physic-chemical factors must be taken into consideration in understanding the eco-composition of the natural bodies of water. Each factor contributes in making of the specific ecosystem and thus determines the trophic dynamics of the aquatic body.

Conclusion:

Therefore any change in one factor directly or indirectly alerts the other factors. Hence, the study of the physic-chemical characteristics of aquatic system is significant for the proper understanding of various limnological phenomena.

Physico-chemical characteristics not only reflect the quality of an aquatic ecosystem but also its biological diversity. The success of fish culture mostly depends on the physiochemical parameters of the water. It is an established fact that maintenance of healthy aquatic ecosystem is dependent on the physiochemical properties of water and biodiversity.

In Mithila wetland plain, any quality of water that influence the growth reproduction, survival and management of aquatic organism including fish in any way is a water quality variable. Since the impact of human intervention is growing on the wetlands, so the present limonological investigations were carried out in Mithila Plain.

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