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Water quality monitoring of the river Mahananda near a sewage disposal point at Malda, West Bengal, India

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Abstract

The Mahananda river is a vital river in India and Bangladesh, because the people of both the countries use the river water continuously and other people of Malda are highly captivated with this river water. But, at this point being the river Mahananda is facing a heavy as well as microbial pollution problem thanks to several reasons. The aim of this study is to gauge that the water quality of the river and mainly to analyse the suitability for various purposes like drinking, agricultural and industrial uses. This can be why this study on the Mahananda River is extremely more important for this area. In this study, samples from disposition sampling stations of north bank of the river Mahanada near Mahananda bridge were collected in Feb. 2019 to July 2019 and evaluate the various water quality of this river. The physicochemical evaluated values of these sampling stations continuously exceeded the upper permissible limit. The bacteriological parameters are within the river Mahananda showed that the coliform organisms and a few pathogenic bacteria is extensively high within the river water which indicates that the unsuitable to use of direct water for any domestic activities by the municipality areas of Malda town.

Keywords: Water quality, River Mahananda, sewage, water pollution, pathogenic bacteria.

Introduction

The amongst three basic required natural resources for sustaining any life, water is one among the foremost natural resources further as important constituent of life support system[1,2]. It's indeed an exquisite chemical medium that has unique properties of dissolving and carrying in suspension a large verification of chemicals. Thus, it can get easily contaminated[3]. There are variety of causes answerable for polluting within the water. Polluted water doesn't come from only single source[4]. Polluted water which aren't only affected of the lifetime of present generation but it also affects within the lifetime of upcoming generations because its effect remains for long. At this time, pollution has become a significant problem across in our country, mostly thanks to the presence of untreated sewage effluents which mainly sources of chemicals and pesticides[5].

Rivers have always been the foremost important water resources and most of the developmental activities are still dependent upon them. The rivers play the main role within the carrying of industrial and municipal waste water, manure discharge and runoff water from agricultural field, road ways and mankind since it's directly linked with the human welfare society[6]. The River Mahananda plays a big role in human lifetime of Malda Municipal Corporation areas located at the bank of it. Now-a-days it's become polluted at some places thanks to small scale industrial activities and also the confluence of sewage, domestic wastes and industrial effluents of the many large, medium and little enterprises with various varieties of organic compounds and heavy metals which are mainly deteriorating human health and aquatic organisms. Urban areas, farms, factories and individual households – all contribute to the contamination of this river water[7]. Study of various physico-chemical parameters and bacteriological parameters revealed that the intensity of pollution increased as river water was subjected to sewage and industrial waste. This is often a study to aware people how they need contaminated the Mahananda river water. Considering the increased demand due to expanding needs it is of utmost importance to study the water quality of water bodies especially riverine ecosystem for proper utilization and conservation. Having assessed the importance of fine water quality of rivers of the country, Central Pollution control board (CPCB) in 1976, initiated a series of integrated basin studies everywhere India. The CPCB together with all State Pollution Control Boards (SPCB) established in the Water Quality Monitoring (WQM) network within the country[8,9] and such information gathered has been considered during this investigation for a meaningful consideration of information freshly acquired/ available through the analyses of water of the river Mahananda.

Materials and methods

For this study, the samples were collected from the north bank of the Mahananda river near Mahananda bridge sewage disposal point at Malda (25.1786°N, 88.2461°E) for various water quality monitoring like physico-chemical and bacteriological analysis.

The water samples were collected in the iodine treated polythene bottle without much disturbance at the sampling stations. These samples were collected from the experimental stations already stated for the estimation of physicochemical parameters i.e. temp., turbidity, colour, water current, total dissolved solids (TDS), total suspended solids (TSS), pH, dissolved oxygen (DO), total solids (TS), electrical conductivity (EC), total alkalinity (TA), total hardness (TH), magnesium hardness (Mg-H), chloride (Cl^-), chemical oxygen demand (COD), sulfate (SO_4^{2-}), organic carbon (OC), phosphate (PO_4^{3-}) biochemical oxygen demand (BOD), calcium hardness (Ca-H), and nitrate (NO_3^-) as well as bacteriological parameters i.e. total heterotrophic bacteria, total coliform, fecal coliform, *Streptococcus faecalis, Vibrio cholerae, Salmonella typhi and Clostridium perfringens*. Do bottles of 300ml capacity were used to collected and fix dissolved oxygen[10-12]. The temp. of the collected water was recorded at the time of sampling by mercury thermometer graduated up to accuracy 0.5℃. Turbidity was recorded by nephelometer (systonics, model no. CL82) and expressed as the nephelometric turbidity unit (NTU). The colour of sample of water was observed by visual appearance only. Water current was measured by the amechanical current meter and expressed in current cm/sec. The pH of the sample was measured with lovibond pH comparator box at the sampling stations besides it is also confirmed by pH meter in the laboratory. The TS, TDS and TSS were measured by weighing method.

The DO was estimated by Winkler's method using Alsterberg Azide modification (Ridal-Stewart modification)[13]. The samples were carefully preserved at the sampling stations and analysis was within six hours after collection to avoid any change. The BOD was estimated by the incubating the sample in BOD incubator for 5 days at 20^{oC} and after 5 days DO fixed and estimated. Difference of initial DO and final DO give the total biochemical oxygen demand. The COD is determined by potassium dichromate reflux method. The EC of the samples was measured by Conductivity meter. The total alkalinity (TA) was determined by the titrimetric method[14]. The total hardness (TH) as well as Calcium(Ca) hardness was determined titrimetrically applied by EDTA method but, magnesium (Mg) hardness is calculated by deducting values of Ca-hardness from total hardness[15]. The Cl^- was determined by Mohr's Argentometry method and salinity was calculated form chloride ion. The OC was determined by combustion-infrared method. The SO_4^{2-} was determined by turbidimetric methd[16-18]. The estimation of PO_4^{3-} was determined by stannous chloride method and NO_3^- by Phenol Disulphonic Acid (PDA) method. Extreme precaution is needed for collection of water sample for bacteriological samples. Usually the samples are collected from the surface / marginal waters which was badly contaminated and disturbed due to various activities. The chief objectives were to identify that water contains fecal population and was unsafe for consumption coliform were gram (-ve) bacteria, which were rod shaped and usually inhabited the gastrointestinal treat.

The coliform which were present in the fecal waste more called the fecal coliform. Fecal and non-fecal coliform together called total coliforms. In this procedure water samples into a number of tubes of medium (Eosin – methylene blue medium) ten ml, one ml and point one ml amount of sample inoculated into sterilized lactose broth tubes. The ignition tubes were incubated in incubator at 37^{oC} for total coliform as well as 44.5^{oC} for fecal coliform organisms. Coliform organisms were identified after 24 hrs. by their production of gas from the lactose. The water sample were inoculateddouble strength medium (Hanny and Norton's sodium azide medium) and incubated 44.5^{oC} for 24hrs. for the presence of *Streptococcus faecalis* bacterium. Thereafter, water sample inoculated for the presence of *Clostridium perfringens* using Wilson and Blair's medium, *Vibrio cholerae* using Thiosulphate Citrate Bile Salt Agar medium (TCBS medium), *Salmonella typhi* using Wilson and Blair's bismuth medium and total heterotrophic bacterium using nutrient agar medium and incubated at 37^{oC} for 24hrs. The most convenient is the most probable numbers (MPN) technique which was followed for the present work.

Results and discussion

In this present study, quality of the river water of Mahananda were calculated in these sampling stations and for Feb. 2019 to July 2019. To calculate the physicochemical variables and bacteriological characterization. In the present investigation the Table-1 showed that the current status of physicochemical quality of river Mahananda water. The water temperature is a controlling factor for aquatic life and temperature was fluctuating between 24^0 and 29^0 in the upstream (UP) sampling point, 24.50^0 and 29.20^0 in the downstream (DS) sampling point, 24.80^0 and 29.40^0 in the sewage disposal point i.e. mixing zone (MZ) and 25^0 and 29.50^0 in the crude (CD) water which discharged in the river water during the study period. However, all of the sampling station remain in the tolerance range of standard as per WHO, ICMR, CPCB and BIS. Water colour is generally natural but some time showed grey and blackish during the study period of time. Turbidity is the most important factor, during the study period are varies from 45.32 to 65.00 NTU in the UP sampling point, 47.32 to 68.20 NTU in the DS sampling point, 48.02 to 69.50 NTU in the MZ sampling point and 50.50 to 70.20 NTU in CD sampling point. Turbidity value above the all sampling are gigher than the permissible limit as per ICMR, CPCB, WHO and BIS[10,11].

Flow rate of the water i.e. Water current was fluctuating between 31 to 64cm/sec. in UP sampling point, 34 to 66 cm/sec. in the DS sampling point, 40 to 67cm/sec. in the MZ sampling point and 54 to 72cm/sec. in the CD sampling point. However, CD sampling point water current is high which indicate that high amount of waste discharged in the river water during the study period. The pH of water in the sampling stations ranging from 7.40 to 8.10 that totally remain in tolerance range of UP, DS, MZ and CD surface water standard as per BIS during the study period.

The TS, TDS and TSS evaluating result showed that the always more than the standard permissible limit in the sampling points. The dissolved oxygen (DO) varied from 1.10 to 2.60mg/L throughout the period of study. It's appear to be due to lesser solubility, increased microbial decomposition of various dead organic matter and high organism respiratory demand at the low temperature and increased in the positive growth of submerged macrophytes[25]. The result showed in the amount of DO determines that the process undergoing in water treated which are aerobic or anaerobic. In the Biochemical oxygen demand (BOD) evaluated values are ranging from 0.40 to 1.50mg/L during the time periods of the study. The BOD values clearly mention pollution indicator[19]. The Chemical Oxygen Demand (COD) fluctuated from 70.38 to 184.72mg/L during the study periods of time. Presence of the higher values of COD in water indicates that the contaminated by domestic sewage which containing various decayingorganic matters and other effluents[20-22]. The EC fluctuated from 310 to 620µS/cm throughout the period of study, these evaluating values are higher than the standard permissible limit. The total alkalinity of the river water observed values ranging from the sampling stations 198.25mg/L to 322.24mg/L, whereas standard remain 200mg/L in terms of total alkalinity.

So observed results indicates that some time showed normal water but maximum time is showed polluted water. The total hardness of the river Mahananda are ranging from 189.38mg/L to 353.85mg/L in terms of $CaCO_3$, whereas standard remain 300mg/L. So, from this observed result is cleared that the mainly crude and mixing zone sampling points are hard water and others are slightly hard water. Besides the Ca- hardness is higher than the Mg- hardness of the sampling stations of the river Mahananda. The chloride ion concentration in trace amount with respect to BIS standard, besides the salt concentration observed values ranging from 188.00mg/L to 553.73 mg/L. It's value higher than the BIS and WHO standard. The organic carbon observe values are fluctuated between 222.24 mg/L to 415.20mg/L during the time of periods, which value is more than the permissible limit by BIS and WHO standards. The SO_4^{2-}, PO_4^{3-} and NO_3^- observed values are ranging from 95.64mg/L to 262.64mg/L, 210.22mg/L to 302.42mg/L and 86.38mg/L to 265.36mg/L. The phosphate, sulfate and nitrates ion concentrations are showed more than the permissible limits of BIS, WHO, ICMR standards. Above the physico-chemical parameters most of the cases are showed more than of the permissible limit. So, the river Mahananda water are not suitable for use.

Table-1: Physicochemical Parameters of the Mahananda River Water Sample Collected from Near a Sewage Disposal Point.

Parameters	Sampling Site	Months 2019					
		February	March	April	May	June	July
Temp. (oC)	UP	27.50	24.00	27.00	28.20	29.00	28.80
	DS	27.60	24.50	27.20	28.50	29.20	29.00
	MZ	27.70	24.80	27.50	28.80	29.50	29.40
	CD	28.00	25.00	27.80	29.00	30.00	29.50
Turbidity (NTU)	UP	50.00	45.32	48.50	51.50	60.50	65.00
	DS	52.50	47.32	51.02	52.50	64.23	68.20
	MZ	54.23	48.02	55.50	54.25	68.20	69.50
	CD	60.05	50.50	60.00	62.23	70.20	70.00
Water Current (cm/sec.)	UP	38.00	32.00	31.00	42.00	52.00	64.00
	DS	46.00	39.00	34.00	44.00	54.00	66.00
	MZ	48.00	41.00	40.00	47.00	62.00	67.00
	CD	64.00	56.00	54.00	62.00	64.00	72.00
pH	UP	7.40	7.50	7.60	7.40	7.70	7.40
	DS	7.50	7.60	7.70	7.60	7.80	7.60
	MZ	7.70	7.70	7.90	7.70	7.80	7.90
	CD	7.90	7.80	8.10	8.10	8.00	8.10
TS (mg/L)	UP	3200.00	4100.00	5500.00	5400.00	3700.00	4900.00
	DS	3800.00	4400.00	5600.00	5800.00	4200.00	5500.00
	MZ	4600.00	5100.00	6800.00	6000.00	5000.00	6000.00
	CD	4900.00	5400.00	7200.00	6500.00	5400.00	6600.00
TDS (mg/L)	UP	2400.00	2800.00	3100.00	2900.00	2400.00	2800.00
	DS	2950.00	3100.00	3900.00	3000.00	2800.00	3200.00
	MZ	3600.00	3600.00	4000.00	4000.00	3200.00	3500.00
	CD	4000.00	3800.00	4200.00	4100.00	3800.00	3700.00
TSS (mg/L)	UP	800.00	1300.00	1600.00	2600.00	1300.00	2100.00
	DS	850.00	1300.00	1700.00	2800.00	1600.00	2300.00
	MZ	1000.00	1800.00	2800.00	3000.00	1800.00	2500.00
	CD	1900.00	2100.00	3000.00	3400.00	2200.00	2900.00

DO (mg/L)	UP	2.60	2.60	1.80	1.70	1.80	1.70
	DS	2.50	2.40	1.60	1.50	1.60	1.50
	MZ	2.10	2.10	1.20	1.20	1.50	1.20
	CD	1.90	1.80	1.10	1.00	1.10	1.10
BOD (mg/L)	UP	1.00	0.80	0.50	0.60	0.50	0.40
	DS	1.10	1.10	0.70	0.60	0.60	0.60
	MZ	1.30	1.20	0.80	0.70	0.70	0.70
	CD	1.50	1.40	0.90	0.90	0.90	0.80
COD (mg/L)	UP	70.28	85.34	86.40	95.23	112.20	110.24
	DS	74.28	94.36	95.50	110.25	114.65	114.02
	MZ	76.80	108.84	122.32	142.32	165.35	156.32
	CD	93.33	124.34	142.45	165.40	184.72	172.32
EC (µS/cm)	UP	340.00	310.00	330.00	360.00	420.00	480.00
	DS	370.00	360.00	360.00	380.00	480.00	510.00
	MZ	390.00	380.00	420.00	410.00	520.00	550.00
	CD	410.00	420.00	510.00	440.00	540.00	620.00
TA (mg/L)	UP	211.24	198.25	210.42	248.40	262.12	232.02
	DS	224.34	211.47	231.25	294.32	274.32	244.23
	MZ	238.20	225.00	284.24	300.42	295.23	262.35
	CD	248.96	254.24	304.72	322.24	310.55	284.56
TH (mg/L)	UP	189.28	190.00	222.42	248.42	262.24	247.81
	DS	212.18	210.00	236.65	256.24	277.77	264.37
	MZ	242.24	246.42	275.36	262.40	303.24	278.59
	CD	268.42	274.74	287.23	294.20	353.85	306.60
Ca-H (mg/L)	UP	102.00	105.50	110.25	143.18	152.32	145.58
	DS	115.90	110.30	122.85	148.66	165.32	152.32
	MZ	127.80	132.14	131.42	147.62	174.39	162.35
	CD	131.32	152.32	142.72	172.00	184.50	184.32
Mg-H (mg/L)	UP	87.28	84.50	112.17	105.42	110.32	102.23
	DS	96.38	99.70	113.80	107.58	112.45	112.05
	MZ	114.44	114.28	143.94	114.78	128.85	116.24
	CD	137.10	122.42	144.41	122.20	169.35	122.28
Cl^- (mg/L)	UP	108.24	103.30	192.32	238.42	274.25	262.45
	DS	114.24	109.36	205.54	274.34	284.64	272.60
	MZ	114.98	119.96	254.42	294.70	295.32	284.80
	CD	129.95	169.95	294.74	302.40	304.40	298.74
Salinity (mg/L)	UP	196.99	188.00	350.02	433.92	499.135	477.65
	DS	207.91	199.03	374.08	499.29	519.33	496.13
	MZ	211.08	218.32	463.04	536.35	537.33	518.33
	CD	236.51	309.30	536.52	550.36	553.73	543.70
OC (mg/L)	UP	222.24	231.45	312.45	280.40	274.25	254.32
	DS	258.28	245.44	342.12	284.72	285.35	272.40
	MZ	294.20	294.20	384.74	294.24	295.64	292.30
	CD	304.00	415.20	398.25	304.20	304.25	302.45
SO_4^{2-} (mg/L)	UP	104.20	98.32	95.64	110.45	145.25	202.40
	DS	109.56	102.44	108.42	142.42	165.85	212.52
	MZ	116.24	108.84	116.28	162.56	174.45	234.23
	CD	124.50	124.34	162.42	184.24	195.36	262.64
PO_4^{3-} (mg/L)	UP	220.24	245.55	210.22	222.64	220.02	272.32
	DS	234.28	259.25	228.50	234.24	234.52	282.35
	MZ	251.28	266.45	240.24	254.46	269.48	293.52
	CD	262.68	284.42	268.28	294.28	302.10	302.42
NO_3^- (mg/L)	UP	86.38	104.44	184.36	182.32	174.25	202.30
	DS	114.32	125.66	198.25	220.32	221.05	212.23
	MZ	172.77	185.48	211.38	238.32	245.23	231.33
	CD	194.72	216.47	237.50	242.74	265.36	251.40

Besides, the results of bacteriological parameters are presented in the Table-2. The river Mahanada water tested showed a high number of coliforms ranging from $25x10^3$ MPN/100ml to $350x10^3$ MPN/100ml and both fecal and non-fecal coliforms were detected in the water sample throughout the periods of the study. It's normally believed that the more is the MPN of coliforms. The challenge of pollution remains grim[23,24]. The number of coliforms reached maximum of the month of Feb. 2019 and minimum in the month of April 2019. During the study, the samples were inoculated in the particular medium and thereafter incubated at 37°C and 44.5°C. The pathogenic bacteria *Vibrio cholerae* was found to be varies from $11x10^3$ MPN/100ml to $110x10^3$ MPN/100mland lowest of the month of March 2019 and highest in the month May 2019,*Salmonella typhi* varies from $11x10^3$ MPN/100ml to $70x10^3$MPN/100ml, *Streptococcus faecalis* varies from $11x10^3$MPN/100ml to $40x10^3$MPN/100ml, *Clostridium perfringens* varies from $11x10^3$ MPN/100ml to $80x10^3$ MPN/100ml and the total heterotrophic bacterium was found to be$175x10^3$MPN/100ml to $1600x10^3$ MPN/100ml throughout the study period. The municipal untreated waste water and food waste to river with high biological waste/organic matter. Besides these, slum dwellers of that areas having poor sanitation system and ignorance of them is an added advantage to grow bacteriological load in the river water. The unsanitary conditions of inhabitants of that municipal area and release of untreated domestic wastewater into river are other causes to increase coliform load in river water. The sampling site near Mahananda bridge, river water quality deteriorated because untreated waste water released from municipal sewage are also added to Mahananda river water.

The coliform, both total coliform and fecal coliform are so high in content that raw water is totally unsuitable to use. The fecal coliform and fecal Streptococci ratio are shows in the Table-3. The fecal coliform and fecal *Streptococci* ratio was varies from 1.30 to 4.11 i.e. in all the month of study was found to be more than one.

Table-2: Bacteriological parameters of Mahananda River near a Sewage Disposal Area.

Bacteriological Parameters	Sampling Site	Months					
		February 2019	March 2019	April 2019	May 2019	June 2019	July 2019
Total Coliform (MPN/100 ml× 10^3)	UP	50	65	25	70	50	70
	DS	70	70	50	95	70	80
	MZ	140	110	80	130	80	95
	CD	350	140	225	275	250	170
Fecal Coliform (MPN/100 ml× 10^3)	UP	35	13	25	35	17	25
	DS	40	17	35	50	25	35
	MZ	45	35	50	70	35	50
	CD	80	50	80	95	130	130
Streptococcus faecalis (MPN/100 ml× 10^3)	UP	13	11	13	11	11	11
	DS	17	13	20	13	13	17
	MZ	25	20	25	17	17	25
	CD	40	25	40	35	35	40
Salmonella typhi (MPN/100 ml× 10^3)	UP	11	14	13	11	11	17
	DS	13	17	17	13	13	25
	MZ	17	35	35	25	25	35
	CD	35	50	50	35	35	70
Vibrio cholerae (MPN/100 ml× 10^3)	UP	25	11	11	13	25	13
	DS	40	13	17	25	45	17
	MZ	45	25	25	50	50	35
	CD	70	35	35	110	95	50
Clostridium perfringens (MPN/100 ml× 10^3)	UP	11	11	06	.8	10	13
	DS	14	23	11	11	12	17
	MZ	17	14	13	25	13	35
	CD	25	25	17	40	17	80
Total Heterotrophic Bacterium (MPN/100 ml× 10^3)	UP	175	225	175	250	250	250
	DS	225	275	225	350	350	350
	MZ	275	550	250	900	900	550
	CD	900	1600	550	1600	1600	900

Table-3: The Fecal Coliform (FC) and Fecal Streptococci (FS) Ratio in the Mahananda River near a sewage disposal point.

Months	Sampling Site	FC:FS
Feb. 2019	UP	2.69
	DS	2.35
	MZ	1.80
	CD	2.00
March 2019	UP	1.18
	DS	1.30
	MZ	1.75
	CD	2.00
April 2019	UP	1.92
	DS	1.75
	MZ	2.00
	CD	2.00
May 2019	UP	3.18
	DS	3.84
	MZ	4.11
	CD	2.71
June2019	UP	1.54
	DS	1.90
	MZ	2.05
	CD	3.71
July 2019	UP	2.27
	DS	3.18
	MZ	2.00
	CD	3.25

These values are indicating that the Mahananda river near Mahananda bridge is grossly polluted by municipal sewage. So immediate measure should be taken to stop the dumping of sewage in the river water for maintenance of the health of river Mahananda in this region. A rapid action should be taken for that area because a very higher tendency is laying to becoming a highly polluted by biological contaminants in very near future.

Conclusion

In general, river water is a good source in various purposes, but last few decades it has become polluted with growth of urbanization. Temperature of Mahananda river was not in the desirable range (10-25°C) as per Indian standard. A very special attention has to be given for bacteriological parameter (fecal coliform), since the present range is not within the desirable limit in the river. The status of water quality is characterised to be very poor in the Mahananda river sewage disposal point near the Mahananda bridge. The CPCB value for Mahananda river was 30.94 and 31.70 for two years (2008 and 2012) which was less than 38, hence the status of water quality is characterised to be in the range of bad to very bad. The present status of water pollution of Mahananda river is due to human activities like discharging of untreated municipal waste. If the present status of water pollution is continued, the river will be of no use in future further to make the river water fit for its desired end use suitable water treatment plant units need to be adopted.

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