RJC

RASĀYAN *J. Chem.*
Vol. 14 | No. 1 |439-447| January - March | 2021
ISSN: 0974-1496 | e-ISSN: 0976-0083 | CODEN: RJCABP
http://www.rasayanjournal.com
http://www.rasayanjournal.co.in

IMPACT OF SOME NATURAL HAZARDS ON THE QUALITY OF WATER: RIVER DIANA, DISTRICT JALPAIGURI, WEST BENGAL, INDIA

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ABSTRACT

A detailed study of Physico-chemical parameters of River Diana is unavailable though it is an important stream among the left bank tributaries of River Jaldhaka of district Jalpaiguri in West Bengal, India. It is a flood-prone River and channel shifting, sedimentation, erosion are the main features of the River. These natural hazards affect the quality of River water. It also becomes polluted by the Cutting of trees and unscientific dolomite mining in Bhutan hills. Diana basin is mainly a tea garden belt and the existing records showed that the people of tea garden areas in Jalpaiguri are mostly suffered from water-borne diseases. So the primary objective of this work is to make a report on the quality of water of River Diana and to verify the quality, especially to ensure the safety of local people because they use River water for daily purposes. Some preliminary parameters like pH, Temperature, Conductivity, Total Dissolved Solids, Alkalinity, Dissolved Oxygen, Chloride, Total Hardness, Magnesium-Hardness, Calcium-Hardness, Turbidity etc. which are the reflection of pollution of surface water, were measured and the values proved that River Diana is polluted but not over-polluted. Though the observed values of the parameters are within the limit the River water is not safe for everyday use.

Keywords: River Diana, Water Quality, Health, Mouzas, Pollution.

RASĀYAN *J. Chem.*, Vol. 14, No.1, 2021

INTRODUCTION

Water acts as an universal solvent and can dissolve almost all chemicals, so it gets polluted easily. Water flows from creeks, springs, Rivers, lakes and oceans[1] are called mainly surface water. Earth has about 13, 481, 96000 Km^3 of water resources.[2] Surface water becomes polluted by human activities but natural phenomena like volcanoes, algae blooms, storms, earthquakes, floods also the major cause of water pollution. Some other manmade and natural hazards which affect the surface water are River shifting, deforestation, erosion etc.[3] Degradation of water quality badly affects the living organism.[4]

Estimation of Physicochemical parameter of River chambal in kota city, rajasthan had been done by jain et al. (2011).5 Brooks et al. (2019)[6] worked under a water monitoring project by UK statutory environment agencies to do a routine checkup of the water body throughout the UK. Regular monitoring of water quality is a necessary step to understand the present pollution condition of the environment.[7] The Ramganga River is the most holy River of Ganga basin and a tributary of the Ganga River; many works had been done to evaluate the pollution of this River. Khan et al. (2015)[1] and (2017)[8] measured the water quality and status of heavy metal pollution on the Ramganga River. Khan et al. (2018)[9] also worked on the same River to assess the dissolved and suspended organic carbon. The other River of Ganga Basin is Garr River, Khan et al. (2016)[10]also measured the pollution status of this River using the PCA method. Ganga is the most sacred River of India but is heavily polluted especially in Varanasi.[11] (Lebanon). A multivariate assessment was done by Najjar et al. 2019[12] on Ibrahim River (Lebanon). Radfard et al. 2018[13] examined drinking water quality emphasizing the arsenic health risk of Sistan and Baluchistan.

The author selected River Diana in Jalpaiguri District, West Bengal for monitoring the quality of water as the Geographical importance of River Diana is exclusive. The entire area is the foothills of mountain Himalaya. The Rivers coming from hills and then becomes flattened suddenly. So they unable to carry the debris which flows from hills and deposit them according to their specific gravity i. e. they form alluvial

http://dx.doi.org/10.31788/ RJC.2021.1415974

fans[6]. The extensive materials eroded from mountains decrease the sediment transport capacity of the River. The overload of the River is the main cause of shifting its course.[14] Erosion also is a predominant problem of this River, the forest fragmentation is responsible for soil erosion. It increases the pollutants in water sources,[15,16] practically due to these consequences the River becomes a flood-prone River. However, the water quality of River Diana is affected by erosion, illegal cutting of trees, unscientific dolomite mining in Bhutan hills, channel shifting from east to west, sedimentation and heavy flood.
The work attempted to find out the quality of River water (Diana) based on some preliminary parameters like Hydrogen ion Concentration (pH), Temperature (T), Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Chloride (Cl^-), Alkalinity, Total Hardness (Total-H), Mg-Hardness (Mg-H), Ca-Hardness (Ca-H), Turbidity etc. The values obtained experimentally are compared with the desirable and permissible limits and some probable health effects caused by those pollutants are also described. Most of the areas of this River basin are covered by tea gardens (Table 3); the people living in this belt are very poor, illiterate. They do not have minimum awareness about water pollution and its effect. They use the River water for their household work daily. So another objective of this work is to draw the attention of management to take needful steps for reducing the pollution of the River and make the local people aware about the effect of using polluted water.

Study Area

The northern region of Jalpaiguri district is bounded by Himalayan ranges, Assam in the east, Bangladesh and Cooch Behar in the South and Darjeeling in the West. The southern part of the district has piedmont planes and gradually converted into alluvial plains. The area is bounded by 88º55´E - 89 º15´E and 26 º35´N to 27 º05´N approximately. The total area has 6227 sq. km. The district is characterized by uneven elevation of 62 m to 350 m above the mean sea level. The weather of the area is sub-tropical as well as humid; the maximum temperature is 41.3 ºC and the average is 27ºC ºC. The annual precipitation is 3899 mm. The heavy rainfall causes floods in this area.
River Diana is a large stream of North Bengal and is a left bank tributary of River Jaldhaka. It rises from Bhutan Hills and meets with River Jaldhaka in paragana moraghat, opposite Nathora Hat.[17] The River covers mainly the dooars area in Darjeeling and Jalpaiguri district of West Bengal. It flows through hills, Diana reserve forest, tea gardens before meeting to Jaldhaka. The River bed is characterized by huge size boulders, terraces and distributaries channels. Study area situated near Diana Bridge on NH 31. The spot had been chosen in that area because the effect of all the natural hazards on the River is prominent here and local people use the River water in this location.

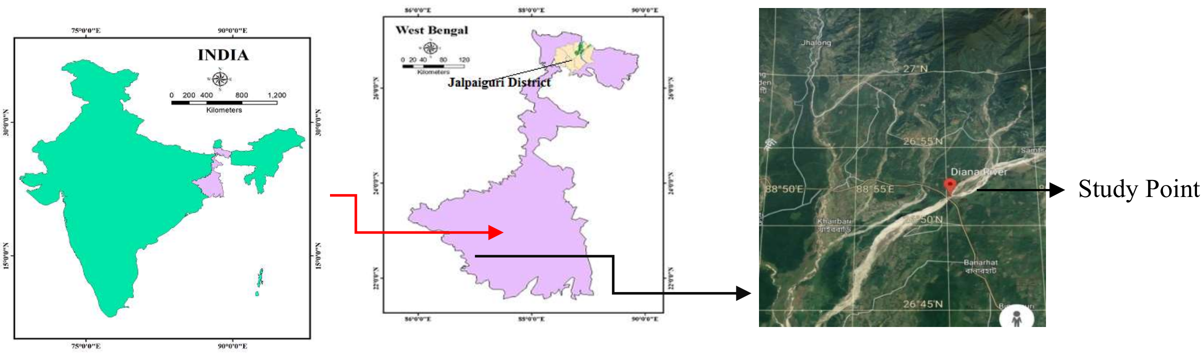

Fig.-1: River Diana, its Catchment Area and Position of the Sampling Site

EXPERIMENTAL

The sample was collected monthly to monitor the physicochemical parameters from February 2015 to January 2016. The month of July and August were excluded from the evaluation due to heavy rain and flood condition of the River.

Sampling

Samples were collected and transported by icebox. Water T and TDS were found in the spot. 500 ml Borosil bottles were used to conserve the water for the measurement of BOD_5 (Biological Oxygen Demand for 5 days) and the samples for BOD_5 and DO were collected from 0.5 meters below the surface and kept the mouth of the bottle towards the flow of direction. The cap of the bottle was closed carefully below the water surface. Water T was measured by using a centigrade thermometer. It was recorded by deeping the thermometer for about 2 minutes in the River water.[18] DO was measured instrumentally by Elico PE138 analyzer kit. The kit was attached with a membrane electrode which measured DO directly. Calibration must be done by zero DO value before analysis. The results were expressed in ppm. BOD_5 values were expressed preserving the sample at 20ºC for 5 days. The pH was recorded using the analyzer kit Elico PE138. The apparatus was supplied with a glass electrode for the measurement of pH directly; calibration was done by a fixed buffer solution supplied with the instrument. EC and TDS were determined by the same tool. The analysis done by conductivity electrode provided with the kit and direct reading of TDS was found after selection of standard conversion factor. Turbidity was examined instrumentally by Elico PE 138. The system was often standardized by KCl (Potassium Chloride) solution according to guidelines supplied in the instrument manual. The values were obtained in micromohs.

Measurement of Total-H had been done by EDTA (Ethylene di Ammine tetra Acetate) titration method using ammonia buffer and BDH (total hardness tablet). The values were also rechecked instrumentally in Jalpaiguri PHE Lab. Ca-H analyzed by titration method using EDTA and Ca- H indicator tablet.[19] Mg-H was calculated by subtraction of Ca- H values from total hardness values. The silver nitrate method was followed to estimate Cl^- ion using dichromate as an indicator. The method was done expecting that the presence of interfering ions would be in negligible amount.[15] Results were expressed in mg/l. Alkalinity was found by direct titration with 0.02 (N) H_2SO_4 (Sulphuric Acid) using phenolphthalein and mixed indicator (methyl red and bromocresol green). The potassium dichromate method was followed to determine Chemical Oxygen Demand (COD) with Ferroin indicator.

Orthophosphates (PO_4^{3-}) were determined spectrophotometrically in double beam UV-VIS spectrophotometer (model no. SL-210 Elico India) following the stannous chloride method. Ferrous ions (Fe^{2+}) were assessed spectrophotochemically by α-α bipyridyl method at 565 nm. The soluble manganese (Mn) compounds were measured photochemically at 545 nm. Mn- compounds were oxidized first to permanganate using persulphate in acid medium and then analyzed.

Fluoride (F^-) was determined by the Spands method and Arsenic (As) was measured using a density meter at Public Health Engineering Department (PHE) laboratory, Jalpaiguri. Nitrate (NO^{3-}) was estimated by analyzer kit (Photometric DMP method) in the same Lab. Total coliform and Fecal coliform were also measured at PHE Lab.

RESULTS AND DISCUSSION

Table-1 represents the monthly variation of parameters of River Diana. The correlation coefficient among the parameters is given in Table-2. The plots of monthly variation of physicochemical parameters have been represented in Fig.-2.

Floods, sedimentation and erosion have an adverse effect on water quality. Flood delivers pollutants and eroded soil from River catchments. Erosion also promotes siltation on the River bank.[20] Extreme flood increases erosion but 70% of eroded materials re-deposited within the catchment.[21] The water becomes rich with nutrients, waste, agricultural chemicals and turns it unsafe for use.[22] Excess amount of nutrients especially nitrogen has great effect to the water quality parameters.[23] Nitrite is the most toxic form of nitrogen. It can affect children, young animals and cattle by converting hemoglobin to methemoglobin. An excess amount of nutrients causes eutrophication. The desirable amount of nitrate is 45 mg/lit and permissibility is 100 mg/lit (Table-1). The maximum amount of nitrate was present 9.2 mg/lit and a minimum 4.5 mg/lit in River Diana. Nitrate had a negative correlation with pH, EC, TDS, Cl^-, Alkalinity, Hardness, DO, BOD, Mn, F^- and Fe present (Table-2). NO_3^- comes mainly from fertilizers used in tea gardens, agricultural fields etc.

The dissolved pollutants like pesticides and other chemicals contaminate water through runoff. The sediments probably absorb the unwanted materials. The turbidity of the River water indicates a high level of sedimentation and erosion.[24] Maximum value of turbidity of River Diana was 5.23 NTU just after monsoon, which was beyond the desirable limit (Table-1). Turbidity increased with decreasing value of pH i.e the solubility of colloidal particles was increased with increasing basicity of water. The other parameters like EC, TDS, hardness, F^-, Fe had a negative correlation with turbidity (Table-2).

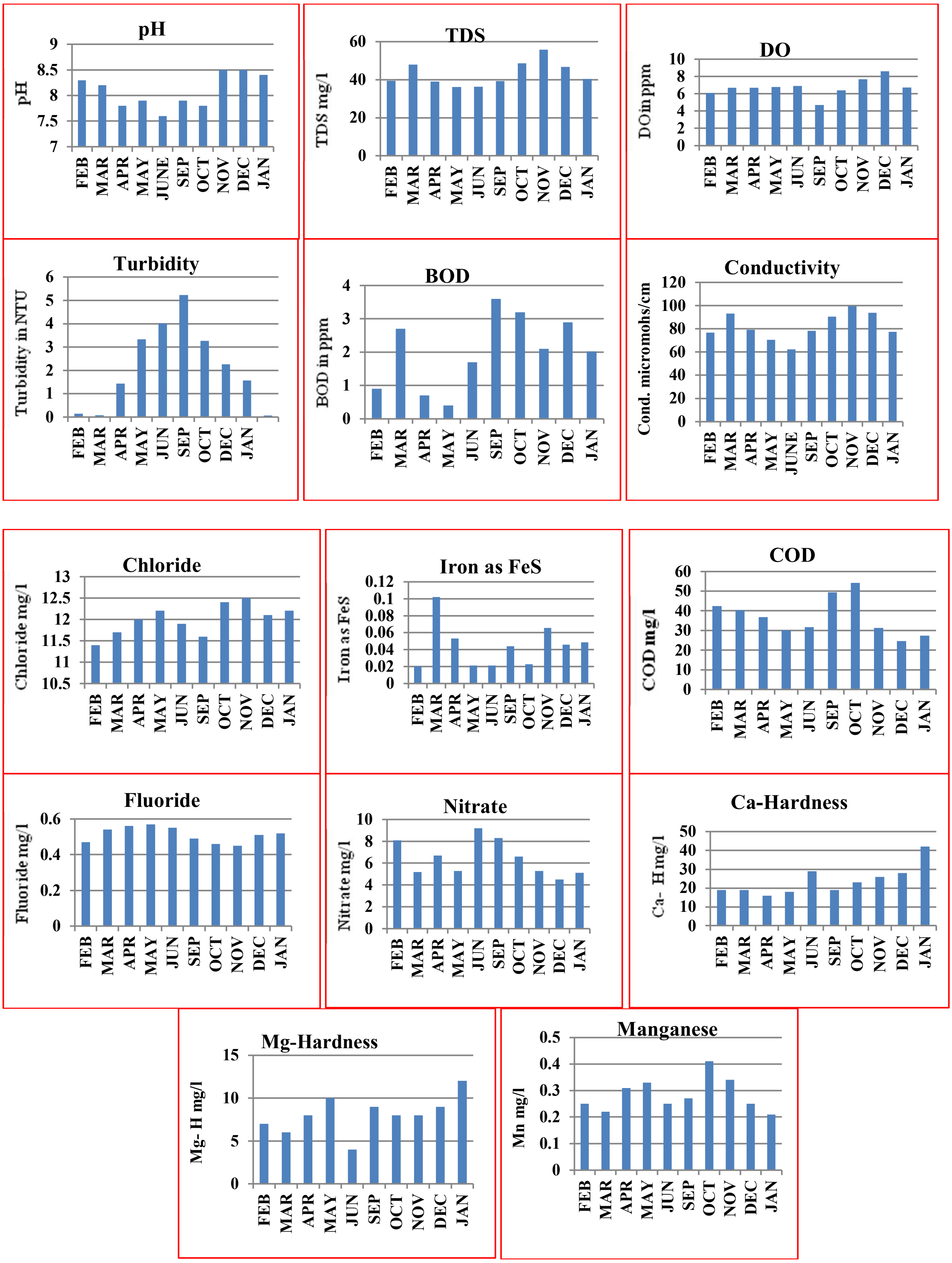

Fig.-2: Plot of Parameters showing Monthly Variation

pH of the River water affects the solubility of many materials. So with an increase of pH some pollutants become more toxic than lower pH.[25] Desirable pH range is 6.5-8.5, it depends upon authorities. The River water was slightly alkaline. Erosion of sodic soil incorporates alkalinity to water.[16] Highest pH of the River was 8.5 (Table-1). pH values reduced with the increase of T, the correlation with T supported the fact. Basic pH raised the solubility of some substances which decreased the turbidity, and water became more toxic. pH had a negative correlation with Mn, Fe and F^- present (Table-2). F^- exists as hydrofluoric acid (HF) in an acidic medium, i.e its solubility increases in lower pH.

DO, BOD_5, COD values are directly proportional to the oxygen dissolved in the water body. DO level is very important for the survival of aquatic life such as plants, fish, microorganisms, invertebrates and others. The unpolluted freshwater has DO nearer to 10 mg/l and a lower limit is 4-5 mg/l. Flood condition decreases the DO level due to high pollutant loads.[25] DO level after the flood in the present study was 4.7 ppm. The main difference between BOD_5 and COD is, BOD_5 always measures compounds that can be biologically oxidized and COD determines the amount of substances that can be chemically oxidized. So COD is always greater than BOD. The higher and lower limit of DO, BOD_5 and COD of River Diana was 8.6 ppm, 4.7 ppm, 0.4 ppm; 3.6 ppm, 54.2 ppm, 24.6 ppm respectively (Table-1). Higher values of dissolved oxygen always indicate lower values of BOD_5 and COD i.e. it follows a negative correlation. EC, TDS, Cl^- Mn and Fe had a negative relation with DO. T had the opposite effect to BOD_5 and COD, BOD_5 decreased and COD increased with elevation of T. DO was directly proportional to T and COD was indirectly proportional to Chloride, Alkalinity and Total- H (Table-2).

EC bears a significant correlation with TDS.[26] Highest EC value was 99.551 and the lowest was 62.212 μmho/cm. It was within the permissible limit. TDS varied from 36.23 to 55.83 ppm. The desirable limit is 500 ppm (Table-1). The correlation coefficient of the two parameters was positive (Table-2).

Cl^- ion concentration is very important for irrigation water; high values of Cl^- are intolerable for some plants and more toxic than sulphate.[19] The Cl^- ion concentration is mainly the measure of swage effluents present in surface water.[27] Cl^- in River Diana varied from 11.4 to12.5 mg/lit which was within the desirable limit - 250 mg/lit (Table-1). With increasing solubility of substances, EC would increase and turbidity would decrease. EC, F^-, PO_4^{3-} had negative correlation with Cl^- (Table-2).

Alkalinity is the proof of the artificial contamination of substances with surface water. Alkalinity is a very useful parameter related to irrigation. The permissible range for drinking water is less than 600 mg/lit whereas the desirable limit is 200 mg/lit. The alkalinity of this River was within 28- 52 mg/lit (Table-1). It had a negative correlation with T, F^- and Fe^{2+} (Table-2).

Calcium (Ca) and magnesium (Mg) ions in water are responsible for scale formation and hardness values greater than 300 mg/lit not suitable for industrial water.[28] Total-H of River Diana was within 24-54 mg/lit and Ca and Mg were 16-42 mg/lit and 4-12 mg/lit respectively (Table-1). Hardness decreased with increasing T and EC. Elevation of hardness lowered the concentration of Mn, F^- and Fe^{+2} (Table-2).

As is a common ingredient of surface water. It mixes naturally to water, also some amount of As is mixed through human activities, mining etc. The desirable range of As is less than 0.05 mg/lit., but it was documented that 97% of people suffered from As born diseases though they are using water contaminated by 0.01 -0.05 mg/lit of As. So it is strictly instructed to use water having less than 0.01 mg/lit of As. As contaminated water also very fatal for irrigation water because some of the vegetable plants accumulate As through water and soil, so they can be entered to the food chain.[29] As contamination of River Diana was less than 0.01 mg/lit (Table-1).

F^- is necessary for the growth of teeth and bone. The desirable limits for F^- are 1 mg/lit and the permissible limit is 1.5 mg/lit. F^- in River Diana varied from 0.47 to 0.57 mg/lit (Table-1). It may accumulate by vegetation and responsible for decreased plant growth.[30] F^- is very fatal for wildlife also. Overexposure to F^- causes fluorosis. The correlation of F^- with most of the parameters was negative (Table-2)i. e. the presence of other ions suppressed by the solubility of F^-.

Mn toxicity also a part of water pollution. It may create some serious health problems like impotence.[32] Desirable limit for Mn is 0.1 mg/lit and the permissible limit is 0.3 mg/lit. Mn present in this River was beyond the desirable limit i. e. 0.21-0.34 mg/lit (Table-1). The solubility of Mn would decrease with the increase of pH, hardness and DO of water. Alkaline water might form insoluble matter with Mn. The positive correlation of Mn with turbidity supported the fact (Table-2).

Fe is an essential element of the human body but the desirable limit for Fe in drinking water is less than 0.3 mg/lit whereas the permissible limit is 1 mg/lit. The average lethal dose of Fe is 200–250 mg/kg of body weight, but death has been occurred following the ingestion of doses as low as 40 mg/kg of body weight. Fe acts as bacteria causing slime. Chronic overload of Fe may cause the generic disorder. The Fe concentration of the present case was within 0.0201-0.0655 mg/lit as FeS (Table-1).[33] The presence of ferrous Fe decreased with raising T, DO, BOD_5, COD, turbidity, alkalinity, total-H, NO_3^- and Mn present. Ferrous Fe is unstable and oxidizes to ferric Fe easily.

Total coliform of River Diana was 25 C. F. U./ 100ml and it had no Fecal coliform (Table-1). It indicates that the River water was polluted and gastrointestinal illness might occur. Usually total coliform concentration increases by suspended sediments.[34]

Water T varied during the whole investigation period from 28.5ºC to 20.5 ºC. Water temperature is also an important factor as it enhances the growth of bacteria, decomposes oxygen and other gases.[31]

There are several mouzas (Table-3) situated in Diana catchment area and most of them are tea gardens. The natural hazards have a great impact on the water quality of River Diana and the degraded quality of water has a direct effect on the health of the people live in the catchment areas. The health conditions of the tea garden belt are poorer than the other part of the district. They are affected by Malaria, Diarrhea and other water-borne diseases. According to 2001 record- number of affected persons by Malaria was 5449 and number of death 258, number of affected persons by diarrhea 286, and number of persons affected by water-borne diseases were 195, throughout Jalpaiguri district including Diana basin. The cause was contamination of pollutants with surface water, lack of awareness, illiteracy and poverty.[3]

Table-1: Monthly Variation of Water Quality Parameters of River Diana (*BIS - *Bureau of Indian Standard*)

	FEB'15	MARH'15	APRIL' 15	MAY'15	JUNE'15	SEPT' 15	OCT'15	NOV' 15	DEC'15	JAN' 16	*PERMISSIBLE LIMIT (BIS*)*	*DESIRABLE LIMIT (BIS*)*
Water T	24	26	27.4	28.5	28.5	27.6	26.3	23	21	20.5		
pH	8.3	8.2	7.8	7.9	7.6	7.9	7.8	8.5	8.5	8.4	8.5	6.5
EC in µmho/cm	76.625	93.153	79.15	70.4	62.212	78.14	90.213	99.551	93.67	77.24	-	-
TDS in mg/l	39.43	47.863	39	36.23	36.31	39.23	48.64	55.83	46.78	40.43	2000	500
Cl^- in mg/l	11.4	11.7	12	12.2	11.9	11.6	12.4	12.5	12.1	12.2	1000	250
Alkalinity mg/l	31	33	28	47	34	38	37	41	52	39	600	200
Total-H as $CaCO_3$ mg/l	26	25	24	28	33	28	31	34	37	54	600	300
Ca-H inmg/l	19	19	16	18	29	19	23	26	28	42	-	-
Mg-H in mg/l	7	6	8	10	4	9	8	8	9	12	-	-
Ca (as Ca) mg/l	7.6	7.6	6.4	7.2	11.6	7.6	9.2	10.4	11.2	16.8	200	75
Mg (as Mg) mg/l	1.708	1.464	1.952	2.44	0.976	2.196	1.952	1.952	2.196	2.928	100	30
DO in ppm	6.1	6.7	6.7	6.8	6.9	4.7	6.4	7.7	8.6	6.73	10	4
BOD in ppm	0.9	2.7	0.7	0.4	1.7	2.1	3.2	3.6	2.9	2.02	-	-
COD mg/l	42.5	40.3	36.8	30.1	31.7	49.4	54.2	31.2	24.6	27.4		
Turbidity in NTU	0.14	0.07	1.43	3.33	4.02	5.23	3.27	2.25	1.57	0.06	10	05
NO_3^- mg/l	8.1	5.2	6.7	5.3	9.2	8.3	6.6	5.3	4.5	5.1	100	45
Mn mg/l	0.25	0.22	0.31	0.33	0.25	0.27	0.41	0.34	0.25	0.21	1.5	0.1
F^- mg/l	0.47	0.54	0.56	0.57	0.55	0.49	0.46	0.45	0.51	0.52	1.5	01
Fe as FeS mg/l	0.0201	0.1021	0.0531	0.0212	0.0212	0.0441	0.0228	0.0655	0.046	0.0485	1.00	0.3
PO_4^{3-}	0.65	0.61	0.76	0.93	0.66	0.92	0.58	0.83	0.73	0.92		

(moles/l)	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$	$\times10^{-6}$		
As (mg/l)	<0.01										No relaxation	0.05
Total Coliform C.F.U/100ml	21	22	25	19	23	42	29	25	21	23	-	-
Faecal Coliform C.F.U/100ml	nil											

Table-2: Pearson Correlation Coefficients of Water Quality Parameters of River Diana

	T	pH	EC	TDS	Cl^-	Alkalinity	Total- H	DO	BOD	COD	Turbidity	NO_3	Mn	F^-	$Fe2^+$	Po_4^{3-}
T	1	-0.90	-0.51	-0.46	-0.23	-0.37	-0.70	-0.51	-0.21	0.44	0.62	0.56	0.33	0.42	-0.22	-0.10
pH		1.00	0.63	0.56	0.12	0.40	0.44	0.48	0.14	-0.43	-0.63	-0.64	-0.33	-0.42	0.41	0.16
EC			1.00	0.94	0.36	0.24	0.00	0.40	0.50	0.08	-0.31	-0.63	0.24	-0.55	0.61	-0.22
TDS				1.00	0.49	0.21	0.07	0.44	0.48	0.06	-0.20	-0.51	0.32	-0.63	0.53	-0.27
Cl^-					1.00	0.46	0.43	0.54	0.04	-0.30	0.12	-0.55	0.60	-0.12	-0.02	0.19
Alkalinity						1.00	0.37	0.52	0.22	-0.49	0.20	-0.58	0.08	-0.04	-0.12	0.40
Total H							1.00	0.30	0.18	-0.50	-0.23	-0.35	-0.31	-0.10	-0.05	0.38
DO								1.00	-0.13	-0.50	-0.36	-0.63	0.00	0.08	0.17	-0.16
BOD									1.00	0.39	0.28	-0.05	0.00	-0.48	0.30	-0.15
COD										1.00	0.31	0.48	0.42	-0.43	-0.10	-0.37
Turbidity											1.00	0.48	0.45	-0.02	-0.43	0.24
NO_3												1.00	-0.02	-0.06	-0.49	-0.21
Mn													1.00	-0.33	-0.33	-0.10
F^-														1.00	0.07	0.17
Fe^{2+}															1.00	-0.06
Po_4^{3-}																1.00

Table-3: List of Mouzas in Diana River Basin[35]

Block Name	Mouza Name	Mouza Name
Nagrakata	Chengmari Tea Garden	Khairkata
	Tandu Tea Garden	Kalabari Tea Garden
	Bamandanga Tea Garden	Kalabari
	Diana Forest*	Upper Kalabari
	Jaldacca-Altadanga Tea Garden	Hridaypur
	Dhonda Simla	Angrabhasa
	Uttar Nunkhawadanga	
Dhupguri	Red Bank	Bhatiapara
	Red Bank Tea Garden	Fataktari
	Ambari Tea Garden	Chamtimukhi
	Chamurchi Tea Garden	Lakshmikantapur Tea Garden
	Diana Tea Garden	Bamantari
	Debpara Tea Garden	Paschim Dangapara
	D12 Prayagpur	Garialtari
	Jalapara	Ramshai Forest II
	Uttar Salbari	Chauhaddi
	Dakshin Salbari	Paschim Daukimari

	Paschim Duramari	Madhya Daukimari
	Uttar Jhar Altagram	Char Charabari
	Dakshin Nunkhawadanga	Gadhairkuthi
	Kursamari	Bagribari
	Bhandani	
Maynaguri	Purba Dobbari	

CONCLUSION

Every parameter discussed above has an important role to study the pollution level of a water body. The estimated parameters of River Diana proved that it is a polluted River, though except for manganese and turbidity (after monsoon) the other observed parameters are within the desirable limit. The Pearson correlation of the parameters also carries a significant role to evaluate the respective effect among the parameters. The natural hazards -River shifting, erosion, sedimentation and flood are the probable cause of the pollution of River Diana. There is some manmade pollution as well as forest fragmentation, mining in Bhutan hills, overuse of fertilizer, pesticide in tea gardens and agricultural fields. So the water is not safe for everyday use. The basin under River Diana is mainly the tea gardens of district Jalpaiguri. The people do not have any purification system for using water for everyday life. So it is a relevant work in respect to the present condition of environment and proved that awareness is very necessary among the people of the area. The management should come forward to take necessary steps for the local people as their health is of primary concern.

ACKNOWLEDGEMENT

The author is thankful to the Officials and Staffs of the Public Health Engineering Department, Govt. of West Bengal, Jalpaiguri, for their cooperation in the experimental section and also grateful to University Grand Commission (*Letter No.- Ref. No.: F. PSW- 109/13-14(ERO), Dated: 18-Mar-14*) for their financial help.

REFERENCES

1. M. Y. A. Khan, K. M. Gani and G. J. Chakrapani, *Arabian Journal of Geoscience,* **9**, 28(2015), **DOI:**10.1007/s12517-015-2134-7
2. P. N. Kamble, S. J. Kokate, H. R. Aher and S.R. Kuchekar, *Rasāyan Journal of Chemistry,* **1**, 63(2008)
3. S. S. Banerjee, C. B. Poddar, S. Chakraborty and M. Saha, *Geospatial World,* **(**09/15/2009)
4. N. Gupta, S.M. Nafees, M.K. Jain and S. Kalpana, *Rasāyan Journal of Chemistry,* **4**, 686(2011)
5. S. Chakrabarti and P. K. Patra, *Rasāyan Journal of Chemistry,* **9***,* 627(2016)
6. S. J. Brooks, B. Fitch, J. D. Bowker and S. A. Codesal, *Freshwater Science,* **38**, 2(2019), **DOI:**10.1086/703397
7. R. Nagalakshmi , K. Prasanna and S. P. Chandar, *Rasāyan Journal of Chemistry,* **9**,634(2016)
8. M. Y. A. Khan, K. M. Gani and G. J. Chakrapani, *Earth Science,* **76**, 231(2017), **DOI:**10.1007/s12665-017-6547-3
9. M. Y. A. Khan and F. Tian, *International Association of Hydrological Sciences,* **379**, 61(2018), **DOI:**10.5194/piahs-379-61-2018
10. M. Y. A. Khan, B. Khan and G. Chakrapani, *Arabian Journal of Geosciences*, **9**, 8(2016), **DOI:**10.1007/s12517-016-2551-2
11. N. Singh, *International Journal of Energy And Environment,* **1(5)**, 82 (2010)
12. P. E. Najjar, A. Kassouf and A. Probst, J. L. Probst, *Ecological Indicators,* **104**, 13(2019), **DOI:**10.1016/j.ecolind.2019.04.061
13. M. M. Radfard, M. Yunesian, R. N. Nodehi, B. Biglari, S. Nazmara, M. Hadi, N. Yousefi, M. Yousefi, A. Abbasnia and A. H. Mahvi, *Human And Ecological Risk Assessment,* **25(4)**, 949(2018), **DOI:**10.1080/10807039.2018.1458210
14. K. Dutta, S. Chakroborty and S. Human, *Geo-Analyst,***3(1)**, 82(2013)
15. R. Boelens and J. Vos, *Agricultural Water Management* **108**, 16(2012), **DOI:**10.1016/j.agwat.2011.06.013

16. W. Ouyang, K. Song, X. Wang and F. Hao, *Ecological Indicators,* **45**, 579(2014), **DOI:**10.1016/j.ecolind.2014.05.025
17. J. F. Grunning, Eastern Bengal and Assam District Gazetteer, N. L. Publishers with National Library, Siliguri, West Bengal, India, p.84(2008)
18. APHA, Standard methods for examination of water and waste water 17th Edition, American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC, USA, (1989)
19. N. Manivasakam, Physico-chemical examination of water, sewage and industrial effluents,6th Edition, Pragati Prakashan, Meerut, India, (1980)
20. Queensland Government, Impacts of Erosion, 2013
21. C. J. Talbot, K. Cassell, D. M. Hans, E. C. Minor, H. Paerl, P. A. Raymond, R. Vargas, P. G. Vidon, W. Wollheim and M. A. Xenopoulos, *Biogeochemistry,* **141(3)**, 439(2018)
22. D. K. McCool and K. G. Renard, Water Erosion and Water Quality, Springer-Verlag, New York, p. 31,175(1990)
23. C. H. Wadleigh, Wastes in Relation to Agriculture and Forestry, USDA Miscellaneous, Washington, D.C., p.1065 (1968)
24. D. M. Ruiz, J. P. Idrobo and J. D. Sarmiento, *Revista Internacional de Contaminacion Ambiental,* **33(3)**, 361(2017), **DOI:**10.20937/RICA.2017
25. W. C. Ching, W. H. Lee, M. E. Toriman, M. Abdullha M and B. B. Yatim, *Sustainable Water Resource Management,* **1(2)**, 97(2015)
26. P. N. Patil, D. V. Sawant and R. N. Deshmukh, *International Journal Of Environmental Science,* **3(3)**, 1194(2012)
27. Premlata and Vikal, *Biological Forum- An International Journal,* **1(2)**, 97(2009)
28. B. Bhadra, R. Chakraborty and S. Das, *Journal of Environmental Biology,* **26(2)**, 277(2005)
29. D. Nag, Prasdanga Arsenic. Mandakranta, Kolkata p.19, (2015)
30. M. F. Raisbeck, S. L. Riker, C. M. Tate, D. R. Jackson, M. A. Smith, K. J. Reddy and J. R. Zygmunt, University of Wyoming Extensions, (2008)
31. S. Patel, Md. Mohsin, M. Farooqui and S.H. Quadri, *Rasāyan Journal of Chemistry,***3***,* 420(2010)
32. https://www.lenntech.com/periodic/elements/mn.html
33. Guidelines for drinking-water quality 2nd ed. Vol. 2. Health criteria and other supporting information, World Health Organization, Geneva, (1996)
34. J. Smith, J Edwards, H Hilger and T. R. Steck, *Journal General Applied Microbiology,* **54**, 173(2008)
35. Revenue Survey Mouza Maps for 42 villages within the Diana Basin, Department of Land Records and Surveys, Government of West Bengal.

[RJC-5974/2020]