Physicochemical profile of the river Vainganga flowing through Gondia District of Maharashtra, India

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Abstract

The present paper deals with the physicochemical parameters of the river Vainganga flowing through Gondia district of Maharashtra state. Monthly, seasonal and site wise variations in pH, temperature, electrical conductivity, turbidity, salinity, alkalinity, total hardness, calcium hardness, magnesium hardness, dissolved oxygen, biological oxygen demand, free carbon dioxide, nitrates, phosphates, sulphates and chlorides were analyzed from February 2010 to January 2012. The pH of water was alkaline throughout. Except dissolved oxygen, all other parameters increased towards downstream indicating slight organic stress. All the parameters were well within the permissible limits. However, the results indicated good water quality, acceptable for all purposes.

KEYWORDS: Gondia, physicochemical parameters, Vainganga, water quality.

1. Introduction

Life is impossible without water it initiates and grows in the lap of water. Water is an essence of life that totally dominates the chemical composition of all organisms (Wetzel, 1985). Water is the elixir of life, support and a precious gift of nature to mankind and other organisms (MoEF, 2002). Hence purity of the water should be maintained which varies from place to place. Rivers are complex and dynamic aquatic ecosystems. The origin, course of travel and the surrounding terrain determine the quality of river water (Vannote *et al.*, 1980). The density and diversity of aquatic organisms depend on availability and quality of water. The water quality affects the species composition, abundance, productivity and physiological conditions. The water quality monitoring by estimating hydro-biological parameters is among the major environmental priorities as it permits direct assessment of the status of ecosystems. The alterations in physicochemical parameters lead to water quality deterioration. Water quality is closely linked to its use and the developmental processes. Water resources have been contaminated by biological, organic and inorganic pollutants (APHA, 1998). The physiological processes may influence water quality in a river which is a very sensitive issue. The wastewaters, garbage and various other inputs are ultimately dumped into the rivers which distress and affect the water quality parameters. Thus deterioration makes this precious commodity scarce (Usharani *et al.*, 2010). Physicochemical properties of water are largely governed by the prevailing meteorological conditions and are essential for determining the structural and functional status of natural water. Availability of clean and potable water has become a key issue.

The river Vainganga forms the pivot and life line for the people living in its catchment area. It is the largest sub-basin of the river Godavari. The people in Gondia district depend on its water for all purposes. Its stretch under study has unique physical, social and political features endowed with the highest deciduous forest cover and hence rich and unique bio-diversity (Patil *et al*, 2012). It receives waters from its tributaries, streams and other inputs which may lead to the contamination and dynamically affect biodiversity. Therefore its water quality concern encouraged us to carry out this study.

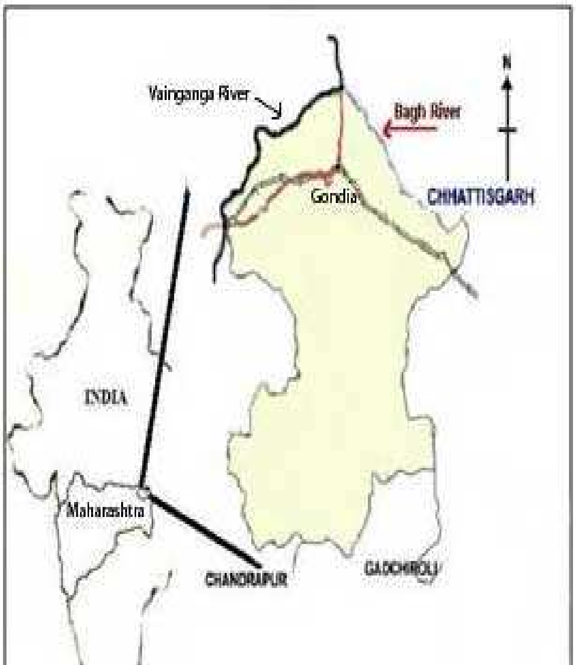

Fig 1:Map of Gondia district showing River Vainganga

2. Materials and Methods

2.1. Study area: River Vainganga originates in Mahadeo hills of the Satpura range near Mundara village in Seoni district of Madhya Pradesh. After flowing for 150 kms, it enters Gondia district. The study was carried out at five multi-habitat sites of its 120 kms stretch in Gondia district of Maharashtra state between 21^o 22'' to 21^o 38'' N and 79^o 47'' to 80^o 29'' E. Site-I is situated near the village Dangorli. Here it enters Gondia district by forming confluence with the river Bagh. Site-II is situated near the village Dhapewada having congregation site. Site-III located near the village Chandori (Kh) and forms confluence with the river Bawanthadi. Site-IV is situated near the village Kawalewada having lift irrigation project. Site-V is situated near the village Ghatkuroda where it exits Gondia district (Fig. 1).

2.2. Collection and Analysis of Data: Water samples were collected from surface and sub-surface (1 meter below) in a sterilized, black, screw capped wide mouthed glass container of 5 liters capacity at each site for physicochemical analysis once on a middle day of every month between 7 and 10 A.M. from February-2010 to January-2012. The temperature, pH, turbidity, dissolved oxygen and electrical conductivity were analyzed at the study sites while salinity, alkalinity, total hardness, calcium hardness, magnesium hardness, biochemical oxygen demand, free carbon dioxide, nitrates, phosphates, sulphates and chlorides were analyzed in the laboratory at the earliest according to methods given by APHA (1998). The permissible limits given by ICMR (1996), ISI (1991), BIS (1993), WHO (1999) and CPCB (2007) were considered. Seasonal and site wise mean±SE values of readings for each parameter were applied for the statistical analysis by using the software PAST-3.

3. Results and Discussion

Monthly, seasonal and annual mean±SE values of physicochemical parameters are summarized in Table 1 while their spatial mean±SE values are summarized in Table 2.

The pH values between 6.5 and 8.5 indicate good water quality and medium productive water body (CPCB, 2007). The buffering action of the rocks and soil rich in carbonates and silicates give rise to slightly alkaline waters (Carr and Neary, 2006) which was evident in the present study. The increased pH downstream might be due to the increased alkalinity, EC, salinity, TH and chloride. The high pH during winter and summer caused by low water levels where CO_2 is used in photosynthesis by phytoplankton and macropytes due to ample and easy penetration of sunlight. During monsoon, turbidity hinders the photosynthesis and so CO_2 cannot be utilized. Moreover, higher temperature enhanced the rate of organic decomposition that resulted in increased CO_2. This reacts with water to form organic acids due to which pH decreased (Shiddamallayya and Pratima, 2008). The observed temperature range falls within the optimal range (21^0C to 32^0C) for tropical freshwaters (APHA, 1998). Kumar and Mitra (1986) observed the temperature from 18^0C to 34.5^0C in ox-bow Lake of West Bengal with seasonal trend as monsoon > summer > winter. This range might be due to the forest and vegetation on banks and proportionate rainfall which reduce extremes of temperature by acting as buffer (Carr and Neary, 2006). Water temperature affects streams indirectly by influencing the DO concentrations as warm water holds less oxygen than cold water. The decreased temperature in upstream sites could be due to shielding of the sun by woody plants and aquatic vegetation while continuous addition of inputs increased the temperature downstream (Islam *et al.*, 2011).

Inland waters have salinity and EC values far less than marine waters (Saksena *et al.*, 2008). The EC, dissolved and suspended solids, organic matter, SO_4, Cl^- etc. brought by influx, contribute salinity and it increases along the rivers by dissolving minerals and pollutants. Freshwater has salinity below 3000 mg/L. Ecological and biotic effects are well known in the salinity range 3000-10000 mg/L. Decreased EC and salinity values during monsoon could be due to dilution by inputs and rain and increase in dry season might be due to concentration of salts and ions by evaporation (Bailey and James, 2000). The recorded EC values were < 500 µmhos/cm indicating mesotrophic water body. The slit, clay, organic and suspended matter, plankton and other microscopic organisms, erosion, agitation of sediment by natural and human activities make the water turbid. It acts as limiting factor for the productivity of aquatic bodies (USEPA, 1997). Higher turbidity during monsoon enhances temperature and lowers DO while low but clean water volume during dry season exhibit lower turbidity. Increasing organic load and human activities caused increase in turbidity downstream (Nyakeya *et al.*, 2009). The salts of carbonates, bicarbonates, PO_4, NO_3, borates, silicates etc. get hydrolyzed in solution and produce free OH^- ions, raising the pH making it alkaline (ICMR, 1996). Free CO_2 liberated during organic decomposition, reacts with water to form bicarbonates thereby increasing total alkalinity as in summer and winter while the dilution effect lowers alkalinity in monsoon. However, alkalinity resulting from CO_3 and HCO_3 ions is not considered as a health hazard for drinking purpose (Sujitha *et al.*, 2011). Hardness measures the degree of eutrophication (Rai, 1971). The river Vainganga under study was found to be soft to moderately hard (Klein, 1956). The highest TH during summer might be due to the decreased water volume, increased evaporation and temperature (Ishaq and Khan, 2013). Calcium and magnesium found naturally in waters and contribute to the hardness of the water (ICMR, 1996). Calcium is a dominating ion over magnesium and used by mollusks to make shell (Shrivastava and Patil, 2002). Sewage and industrial wastes are their important sources. Calcium >75 mg/L has no hazardous effects on human health (CPCB, 2007) as observed during the present study. Higher values during winter and monsoon might be due to inputs and lower during summer due to utilization by mollusks and evaporation. Magnesium is an essential component for chlorophyll growth thus acting as a limiting factor for phytoplanktons and macrophytes (Joshi *et al.,* 2007).

A river must have >4 mg/L of DO to sustain aquatic life (ISI, 1991). Large surface area with more agitation and flow riffles, increases DO content. As the temperature and atmospheric pressure decrease, DO increase and vice versa (Saksena *et al.,* 2008). The lower level of DO during summer and monsoon might be due to high surface water temperature, organic decomposition and discharges and hence showed decreasing trend downstream (Sujitha *et al.,* 2011). In the present study, all the sites exhibited DO level above maximum. BOD is used as an indicator of pollution by aerobically decomposing organic matter. The BOD value < 3 mg/L is supposed best for use (WHO, 1999). Its desirable limit is 4 mg/L and permissible limit is 6.0 mg/l (BIS, 1993). During monsoon, the turbidity and organic decomposition enhanced BOD values. The gradual increase in BOD downstream indicated increasing trend in slight pollution by organic matter (Sayyed and Gupta, 2010). The free CO_2 is liberated during respiration by the aquatic organisms as well as organic decomposition. It is highly soluble in natural waters and vital for aquatic plants and microorganisms. Its higher concentration indicates pollution (Saksena *et al.,* 2008). The lower values of free CO_2 indicated non-polluted nature of the river Vainganga with enhanced photosynthesis and its conversion into carbonate while higher free CO_2 values during monsoon attributed to the breakdown of organic matter as well as higher turbidity that hinders photosynthesis. In summer, the organic decomposition released CO_2 and formed bicarbonates and therefore the alkalinity and pH increased (Annalakshmi and Amsath, 2012). Nitrogen, sulphur and phosphorus are the basic nutrients which limit the productivity of a water body. Their high levels trigger eutrophication and pollution (Trivedy and Goel, 1986). Domestic wastes, open defecation, detergents, algal blooms and fertilizers, agricultural and surface runoffs deposit NO_3 and PO_4 in natural waters. The PO_4 values more than 0.5 mg/L indicates organic pollution (Kharat and Pagar, 2009). The low NO_3 level during winter might be due to its use by active N-fixing bacteria or aquatic plants (APHA, 1998). The NO_3 0.20 to 0.40 mg/L and PO_4 0.01 to 0.1 mg/L suggested mesotrophic water body and allowable for irrigation (Zhang and Chang, 1994) as observed during this study. Increased PO_4 values during summer and monsoon were due to evaporation and various influxes while decreased during winter due to its rapid absorption by microphytes and macrophytes (Kharat and Pagar, 2009). SO_4 is a key nutrient and an important constituent of hardness carried into water bodies through the rains. Its values in the present study were far below the permissible limits i.e. <400 mg/L (ICMR, 1996) indicating good water quality in the

River Vainganga. Traces of chlorine are essential for plant and animal life but, its higher levels (>250 mg/L) have detrimental toxic effects; impart a salty taste, affects solubility of the water indicating organic pollution rendering the water unacceptable (Trivedy and Goel, 1986). The terrain and agricultural runoffs and sewage are its major sources. During the monsoon, dilution effect decreases the chloride values till winter while during summer, evaporation and low water volume increases the chloride values (Ishaq and Khan, 2013).

In the present study, it was observed that the higher values of physicochemical factors might be attributed to the organic matter of both allochthonous and autochthonous origin downstream (Vannote *et al.*, 1980). Seasonal values of the physicochemical parameters showed significant variations while, their spatial variations were not significantly different. All the physicochemical parameters were found within the permissible limits. In the same river downstream in Bhandara district, Pandey and Ali (2013) also observed slight or no impact of elevated but permissible levels of physicochemical parameters on water quality. All these parameters except DO, progressively increased downstream due to the increased influx from various runoffs and widening of the river. They represented the overall summation of the prevailing water quality conditions.

Table 1: Temporal mean values of the physicochemical parameters recorded in the river Vainganga during the study

Parameter	**Summer**					**Monsoon**					**Winter**					**Ann Ave**
	Feb	**Mar**	**Apr**	**May**	**Ave**	**Jun**	**Jul**	**Aug**	**Sep**	**Ave**	**Oct**	**Nov**	**Dec**	**Jan**	**Ave**	
pH	8.4	8.2	8.3	8.3	8.3	8.1	7.8	7.7	7.9	7.9	8	8.2	8.2	8.3	8.2	8.1
Temp	20	23	25	27	23.9	27.2	24	24	23	25	24.5	22	20	19.9	21.4	23.3
EC	345	324	281	410	340	420	207	183	210	255	196	197	200	276	217	271
Turb	6.8	2.8	1.5	1.6	3.2	13	76	165	138	98	13	5.7	4.5	2.4	6.3	32
Sal	160	233	231	244	217	241	153	121	115	157	112	160	172	176	155	171
Alk	202	203	200	204	202	194	142	139	163	160	176	194	205	206	195	184
TH	79	100	102	90	93	89	53	58	71	68	86	96	89	74	86	83
CaH	22	21	19	17	20	18	18	23	28	22	22	27	25	20	23	22
MgH	14	19	20	18	18	17	8.5	8.6	11	11	16	17	15	13	15	15
DO	10	7.9	7.4	6.1	7.8	6	5.7	4.1	4	5	12	12	10	9.8	11	7.9
BOD	3.2	4	2.7	3.1	3.2	3.1	5.2	6.7	11	6.4	5	3.3	2.2	2.5	3.3	4.2
CO_2	2.1	1.5	0.4	0.7	1.2	0.9	1.9	2	2.2	1.7	2.5	1.7	1.2	1.2	1.6	1.6
NO_3	0.29	0.29	0.27	0.29	0.28	0.25	0.26	0.21	0.25	0.24	0.3	0.29	0.29	0.27	0.29	0.25
PO_4	0.0	0.0	0.0	0.0	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	3	5	5	5		6	3	2	1	3	2	2	2	2	2	3
SO_4	22	36	35	39	33	37	20	25	18	25	16	21	20	34	23	27
Cl^-	28	38	30	39	34	54	18	17	20	27	19	27	31	32	27	29

pH = Hydrogen ion concentration, Temp = Temperature, EC = Electrical Conductivity, Turb = Turbidity,
Sal = Salinity, Alk = Total Alkalinity, TH = Total Hardness, CaH = Calcium Hardness, MgH = Magnesium Hardness, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, CO_2 = Free Carbon Dioxide, NO_3 = Nitrate, PO_4 = Phosphate, SO_4 = Sulphate, Cl^- = Chloride, Ann = annual, Ave = Average

Table 2: Sitewise seasonal mean±SE values of physicochemical parameters recorded in the river Vainganga

Parameter	**Site-I**	**Site-II**	**Site-III**	**Site-IV**	**Site-V**
Ph	8.1±0.1	8.1±0.1	8.1±0.1	8.2±0.1	8.1±0.1
Temp (^oC)	22.9±1	23.1±0.9	23.1±0.9	23.6±0.6	23.5±1
EC (µmhos/cm)	258.5±34.3	263.7±36.9	270.2±36.8	279.2±36.9	282.5±36.8
Turb (NTU)	33.1±29	35.2±30.5	36±31	38.1±33.1	37±31.9
Sal (mg/L)	171.2±17.6	174.8±21.3	178.2±17	178.6±24	180.1±21.6
Alk (mg/L)	182.7±13.5	184.3±13.8	186.3±14.4	187.5±12.5	188.5±12.6
TH (mg/L)	68.1±8.1	72.2±7.5	82.4±6	91.5±8.1	97±8.4
CaH (mg/L)	19.1±1.3	20.2±0.9	21.7±1	23±1.1	23.9±1.4
MgH (mg/L)	11.9±1.8	12.7±1.9	14.8±1.6	16.7±2.1	17.7±2.1
DO (mg/L)	8.7±1.8	8.5±1.8	8.3±1.8	7.3±1.7	7.1±1.8
BOD (mg/L)	3.8±1	3.8±0.9	4.3±1.1	4.8±1.2	5.1±1.2
CO_2 (mg/L)	1.4±0.2	1.6±0.1	1.5±0.2	1.6±0.2	1.7±0.1
NO_3 (mg/L)	0.26±0	0.26±0	0.28±0	0.29±0	0.29±0
PO_4 (mg/L)	0.03±0	0.03±0	0.03±0	0.03±0	0.03±0
SO_4 (mg/L)	24.2±3.5	25.8±3.1	27.2±2.8	28.5±3.1	28.4±1.6
Cl^- (mg/L)	27.3±2.3	28.8±2.2	29±2.1	30.7±2.2	31.2±2.4

The continuous addition of inputs caused increase in temperature, EC, pH, turbidity, total hardness, Mg-hardness, salinity, NO_3, PO_4, SO_4 and BOD (Saksena *et al.*, 2008). The increased organic pollution downstream might be due to various chemicals, effluents, sewage and solid wastes that resulted in the changes in physiochemical parameters (Usharani *et al.*, 2010). The activities such as washing of clothes, insecticide containers, cattle and vehicles as well as open defecation, agriculture, human settlement causes stress on aquatic ecosystem. In addition, the intensive grazing and brick manufacturing, industrialization, urbanization, deforestation, landscape modification, the unsustainable and carefree use of aquatic resources and introduction of invasive species also significantly affect the abiotic parameters (Carr and Neary, 2006).

4. Conclusion

Physicochemical analysis provided converging lines of evaluation of water quality. It can be concluded that the physiochemical parameters showed their levels within permissible limits except for the monsoon months. They were recorded slightly elevated downstream. However, the overall water quality was found to good and acceptable for all purposes.

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