Chapter- Water Quality Status of Shiva River, Mandsaur

1.0 Introduction

Shivna River is an important tributary of Chambal River. It is originated in Rajasthan and flows along border of Madhya Pradesh and enters in Mandsaur district near Achera. The famous temple of lord Shiva is situated form Mandsaur of the river Shivna[1].

The Shivna Basin belongs to the North-Western region of Madhya Pradesh; covering an area of 3361.52 sq. km. geologically this region is occupied by rock formations of different geological periods and bounded by the basaltic rocks of Deccan traps. The River Basin is characterized by the existence of the oldest rock unit belongs to Neo Proterozoic to Recent[2]

1.1 Description of the Project Area

The present study area is located within the Latitudes 23º 32' to 24º 15' N and Longitudes 74º 47' E to 75º 22' E (Survey of India, Toposheet No 46 I/13 and 14, 46 M/ 1, 2 and 5, 45 L/ 16, 45 P/4, 7 and 8 on the scale of 1: 50,000, Figure -1). The River originates from the Sevna village, (230 42'30.6" N: 740 48' 91.4" E) at an elevation of about 524 m. in Pratapgarh District of Rajasthan, It is the main tributary of Chambal River, which extends over 103.4 km covering parts of Madhya Pradesh and Rajasthan, the River Basin covers a total area of 3361.52 sq. km.

The study area constitutes a part of Malwa Plateau of the Deccan Volcanic Province. It is approachable both by road and rail throughout the year. The temperature ranges from 4.1 ^{0}C to 45 ^{0}C with an average of 24.3 ^{0}C. The minimum rainfall has been recorded as 227.30 mm and the maximum rainfall has been noted as 1441.80 mm. Annual average rainfalls has been computed as 734.00 mm.

1.2 Environmental Problems

Shivna River is the life line of Mandsaur town as this river plays important role in social, religioustic, cultural activities of Mandsaur town besides providing potable water to the city dwellers. The river has become a severe victim of both natural and anthropogenic problems.

The regular flow of the river is interrupted due to scanty rainfall and unwise use of the water. The catchment area within the city limit is densely polluted and inflow of untreated sewage, dumping of solid wastes directly in the river has resulted in severe deterioration of water quality. The irregular flow of river has resulted in accumulation of nutrient from biodegradable materials as well as silt has resulted proliferation of algal mass, thereafter further degrading the water quality.

The major Environmental Problems of the River are:-

- Inflow of sewage
- Dumping of Solid waste
- Siltation from the eroded banks
- Weed infestation
- Anthropogenic activities
- Poor Biodiversity

1.3 Methods Used for Collection of Water and Wastewater

A. Sample Collection: Water Samples were collected on 20th to 21st June, 2019 from following identified points/areas (Table-1) based on the primary survey carried out by the EPCO team on 4th & 5th February, 2019 for pre monsoon study and on 18-21st December, 2019.

Table- 1 Sampling stations of Shivna River, Mandsaur

S No	St. Name & No
1	Atal Sager Dam (Surface)
2	Atal Sager Dam (Bottom))
3	Ram Ghat
4	Bugaliya Nalla
5	Pashupati Nath Mandir Nalla (Upstream)
6	Pashupati Nath Mandir River (Downstream)
7	Shamsan Ghat
8	Starch Factory Nalla
9	Raja Ram Ghat

The samples were collected from different locations within the Mandsaur town originating from Atal Sagar Dam (Kalabhata Dam) up to the downstream of 10 Km ending at Raja Ram bundh. In all nine samples were collected from the identified pressure points in presence of Health Officer, Nagar Palika, Mandsaur.

The water samples were collected using Ruttner Water sampler while plankton samples were collected with plankton net of mess size 25. Collection, preservation and transportation of water samples for various physico-chemical and biological analysis were done as per the standard method prescribed in APHA (1995). Following parameters are selected as per the guidelines of NRCD, MOEF.

S. No.	Parameter		
1	Air Temp. (^oC)	15	Calcium Content (mg/l)
2	Water Temp. (^oC)	16	Magnesium Content (mg/l)
3	Turbidity (JTU)	17	Chloride (mg/l)
4	pH	18	Total Phosphorus (mg/l)
5	Total Dissolved Solids (mg/l)	19	Orthophosphate (Inorganic) (mg/l)
6	Free CO_2 (mg/l)	20	Organic Phosphorus (mg/l)
7	Dissolved Oxygen (mg/l)	21	Nitrate (mg/l)
8	Conductivity (µS/cm)	22	Biochemical Oxygen Demand (mg/l)
9	Total Alkalinity (mg/l)	23	Chemical Oxygen Demand (mg/l)
10	Carbonate Alkalinity (mg/l)	24	Sulphate (mg/l)
11	Bi-carbonate Alkalinity (mg/l)	25	Sodium (mg/l)
12	Total Hardness (mg/l)	26	Potassium (mg/l)
13	Calcium Hardness (mg/l)		
14	Magnesium Hardness (mg/l)		

B. Analysis of Water & Waste Water

Analysis of all other parameters were performed as per the manual " Standard methods for the examination of water and wastewater" published jointly by American Public Health Association, American Water Works Association & Water Environment Federation, 19th Edition – 1995. Details of methodology for analysis of identified parameters are given below:

Air and water Temperature:

Atmospheric temperature at the time of sampling was determined by a 0.1^0 Centigrade thermometer. Temperature of surface and bottom water was recorded by dipping the thermometer directly into the water, keeping it steady for about a minute and then noting the temperature. Temperature at two to three places at the same sampling station was recorded and means water temperature was noted. The result has been expressed as ^{O}C.

Turbidity

Turbidity was measured by Jackson Turbidity Tube. Results are expressed as **JTU.**

pH

pH is the logarithm in base 10 of the reciprocal of the hydrogen ion concentration given in moles per liter. The pH scale of values extends from 0 (very acidic) to 14 (very alkaline), with the middle value (pH=7) corresponding to exact neutrality at 25^{o}C. The pH value represents the hydrogen ion activity, while values of “alkalinity” and “acidity” represent the buffering capacity of the sampled water. During present investigation pH was measured by electrochemical method with the help of pH meter.

Total Dissolved Solids

A large number of salts are found dissolved in natural water, the common ones are carbonates, bicarbonates, chlorides, sulphates, phosphates, and nitrates of calcium, magnesium, sodium, potassium, iron, and manganese etc. A high content of dissolved solids elevates the density of water, influences osmoregulation of freshwater organisms, and reduces solubility of gases (like oxygen) and utility of water for drinking, irrigational, and industrial purposes. It is especially an important parameter in the analysis of saline lakes, coastal, estuarine, and marine water. TDS was measured using the electronic TDS meter (ELE) and was reported as mg/liter or parts per million (ppm).

Conductivity

The ability of water to conduct an electric current is known as conductivity or specific conductance, which depends on the concentration of ions in solution. Conductivity is measured in mili siemens per centimeter square. The measurement we made in the field immediately after water sample has been obtained, because conductivity changes with storage time. Conductivity is also temperature-dependent; thus, the conductivity meter is used for measuring conductivity is not equipped with automatic temperature correction; the temperature of the sample should be measured and recorded.

The conductivity meter consists of a conductivity cell containing two rigidly attached electrodes, which are connected by cables to the body of the meter. The meter contains a source of electric current (battery), a Whetstone Bridge (a device for measuring electrical resistance) and a small indicator (usually a galvanometer). Some meters are arranged to provide a reading in units of conductance (mhos). The conductivity cell forms one arm of the Whetstone Bridge. The design of the electrodes, i.e. shape, size and relative position, determines the value of the cell constant, K_C, which is usually in the range 0 to 2.0. During present period of investigation conductivity was measured with the help of conductivity meter. The result has been expressed as mS/cm^2.

Free CO_2 (mg/l)

Free CO_2 in water is derived from many sources, such as directly from atmosphere, respiratory activities of animals, bacterial decomposition of organic matter etc. The presence or absence of the free CO_2 in the water is mostly governed by the metabolic activities of the living organisms and also through its diffusion to air.

Free Carbon Dioxide in water is the main source of carbon, which is utilized by the aquatic plants and aquatic weeds for the photosynthesis. It was determined by titration method. One or two drops of phenolphthalein indicator was added to 50 ml of sample, if pink colour develops then free CO_2 is absent, in case sample remains colourless, the free CO_2 is present which was then titrated with standard alkaline titrant and quantified using the following formula:

$$\text{Free } CO_2 \text{ (mg/1)} = \frac{\text{vol (ml) of titrant used}}{\text{vol (ml) of sample taken}} \times 1000$$

Dissolved Oxygen

Dissolved oxygen is the most significant parameter, because it regulates the metabolic processes of the organisms. It acts as an indicator of water quality, trophic status and magnitude of eutrophication. The rate at which atmospheric oxygen dissolves in water depends upon temperature, partial pressure of gases in the atmosphere, concentration of dissolved salts, wave action, relative solubility, pollution, photosynthetic activity of plant and respiration by bacteria, plant and animal etc. in an aquatic ecosystem.

The dissolved oxygen concentration depends on the physical, chemical and biological activities in the water body, and its measurement provides a good indicator of water quality. Changes in dissolved oxygen concentration can be an early indication of changing condition in the water body. Dissolved oxygen was determined by Winkler's method with Azide modification. The water samples were collected in the 125 ml glass stoppered bottles without bubbling and were immediately fixed with the addition of 1 ml each of Manganous sulphate and alkaline iodide azide reagent respectively. After thorough mixing of the reagents in sample, a flocculent precipitate was formed which settled down at the bottom.

For qualitative estimation, 1ml of concentrated H_2SO_4 was added to dissolve the brown precipitate. 50 ml of this solution was transferred to a conical flask and titrated against 0.025N solution of sodium thiosulphate ($Na_2S_2O_3$) titrant until the disappearance of blue colour by using starch as an indicator. The Dissolved Oxygen concentration was calculated using the following formula.

$$\text{Dissolved oxygen (mg/l)} = \frac{\text{vol (ml) of titrant x N x 8}}{\text{vol (ml) of sample taken}} \times 1000$$

Where, N = Normality of $Na_2S_2O_3$

Total Alkalinity

Alkalinity is measured by the ability of water to neutralize or assimilate acids. In other words alkalinity of a water sample is reflection of the buffering capacity of that sample. While pH of a sample indicates the state of the H–OH equilibrium, alkalinity indicates the capacity of the sample to maintain this equilibrium in addition of acids.

The minerals which dissolve in water from soil, atmospheric inputs and waste-discharge provide the source of alkalinity; various ionic species that contribute to alkalinity include HCO_3^{-1}, CO_3^{-2}, OH^{-1}, HPO_4^{-1}, and NH_3. Respiration and microbial decomposition of organic matter also contribute to the alkalinity in the form of salts of weak acids such as acetic, propionic and hydro-sulphuric acids. Though various ionic species contribute to alkalinity, in most of the natural water, the alkalinity is almost entirely due to bicarbonates and carbonates. For example, in unpolluted natural water most of the alkalinity is due to bicarbonates or, if algae are flourishing, due to carbonates and hydroxides. These contributions are pH dependent, because the relative concentration of the carbonate and bicarbonate ions with respect to other species involved, are influenced by pH. Alkalinity is therefore a gross property- like pH, acidity, conductivity, and hardness and may result from one or more sources.

The total alkalinity is the sum of carbonate and bicarbonate alkalinity, so it will be calculated separately then addition of both the results is the total alkalinity.

Carbonate Alkalinity

The carbonate alkalinity absence is caused by low photosynthetic rate of phytoplankton. The carbonate alkalinity was determined by titrimetric method using phenolphthalein as indicator. It was analyzed by adding two drops of phenophthalein indicator in the 50 ml water sample and titrated the sample with standard acid solution (0.02 N H_2SO_4) till change of colour from yellow to orange.

$$\text{Carbonate Alalinity (mg/l)} = \frac{\text{vol (ml) of titrant used}}{\text{vol (ml) of sample taken}} \times 1000$$

Bi-carbonate Alkalinity

The carbonate and bicarbonate alkalinity constituted the total alkalinity. The bicarbonate alkalinity was determined by titrating sample with standard acid solution (0.02 N H_2SO_4) using methyl orange as indicator.

$$\text{Bicarbonate Alkalinity (mg/l)} = \frac{\text{vol (ml) of titrant used}}{\text{vol (ml) of sample taken}} \times 1000$$

Total Hardness

The hardness of water is not a pollution parameter but indicates water quality, mainly in terms of Ca^{2+} and Mg^{2+}. The analysis is done by complexometric titration.

For determining the total hardness of water 50ml of water sample is taken in a conical flask. To this sample 5ml of buffer solution was added and 1-2 drops of Eriochrome Black-T was also added as an indicator. The solution was titrated with N/50 solution of Ethylene diamine tetraacetic acid (EDTA) upto the appearance of blue colour. The values of total hardness were computed using following formula.

$$\text{Total hardness (mg/l)} = \frac{\text{vol (ml) of titrant used}}{\text{vol (ml) of sample taken}} \times 1000$$

Calcium Hardness

To determine the calcium hardness 50 ml of water sample was taken in a conical flask and add 2-3 ml of 8% NaOH as an intermediate solution by using Ammonium purpurate as indicator. Then the mixture was titrated with EDTA titrant with continuous stirring upto the violet end point. The value of calcium hardness was computed as

$$\text{Calcium hardness (mg/l)} = \frac{\text{vol (ml) of titrant used}}{\text{vol (ml) of sample taken}} \times 1000$$

Magnesium Hardness

Magnesium Hardness was calculated by subtracting the values of **Calcium Hardness from** Total hardness. Results are expressed as (mg/l)

Calcium Content

Calcium Content was determined by multiplying the value of Calcium Hardness with a factor of 0.243. Results are expressed as (mg/l)

Magnesium Content

Magnesium Content (mg/l) was determined by multiplying the value of Magnesium Hardness with a factor of 8.41. Results are expressed as (mg/l)

Chloride

Chlorides were determined by Mohr's argentometry method. The sample was titrated using standard solution of $AgNO_3$ of N/50 strength as titrant. Potassium chromate was used as indicator.

$$\text{Chloride (mg/l)} = \frac{\text{ml of titrant used x N x 35.46}}{\text{ml of sample}} \times 1000$$

Phosphorus

Phosphorus bound in rocks is generally insoluble in water, so in natural water its concentration is very low. Domestic and industrial effluents and agricultural runoff are major sources of phosphorus in water; hence its high concentration is indicative of pollution. In water phosphorus occurs in both inorganic and organic forms. About 85% of total phosphorus is usually in the organic forms. Total phosphorus is a measure of all forms of phosphorus including organic and inorganic phosphorus.

Total phosphorus was determined after digestion of the sample by Hach (DR-4000) UV Visual Spectrophotometer.

Orthophosphate (Inorganic)

Orthophosphate was determined by UV visible Spectrophotometer. Results are expressed as (mg/l)

Organic Phosphorus

Organic Phosphorus was calculated by subtracting the values of in- organic Phosphorus from Total Phosphorus.

Nitrate

Nitrate is the highest oxidized form of nitrogen and in water it's most important source is biological oxidation of nitrogenous organic matter of both autochthonous and allochthonus. In ground water nitrates may find way through leaching from soil and at times by contamination. The high concentration of nitrate in water is indicative of pollution. It is an important plant nutrient, when present in excess it causes ubiquitous growth of algae. Nitrate was determined spectrophotometrically using the phenol disulphonic acid method on HACH DR 4000 UV-Vis spectrophotometer.

25 ml of sample was evaporated to dryness on a hot plate. To the residue 0.5 ml of phenol disulphonnic acid was added to dissolve the solids, later on 5 ml distilled water and 1.5 ml concentrated NH_4OH were added respectively and stirred. A yellow colour developed. Optical density of the colour was measured at 410nm in a spectrophotometer against distilled water blank and the values were computed using calibration curve. Results were expressed as mg/lit

Biochemical Oxygen Demand

BOD may be defined as the amount of dissolved oxygen demanded by bacteria during the stabilization action of the decomposable organic matter under aerobic conditions. This test, therefore, is a bioassay procedure to measure the oxygen consumed by living organisms utilizing the organic matter content in the sample and the dissolved oxygen of the liquid.

Biochemical oxygen demand (BOD) is an empirical test, in which standardized laboratory procedures are used to estimate the relative oxygen requirements of wastewater, effluents and polluted waters. Microorganisms use the atmospheric oxygen dissolved in the water for biochemical oxidation of organic matter, which is the source of carbon. The BOD is used as an approximate measure of the amount of biochemical degradable organic matter present in a sample. The five days incubation period has been accepted as the standard for this test.

During present investigation, BOD was analyzed by subtracting the value of final concentration of DO (after 5 days of incubation at 20^{o}C) from the initial concentration of DO. Dissolved oxygen was analyzed using Wrinklers method with azide modification as described above.

Chemical Oxygen Demand

As mentioned earlier that BOD is measured for assessment of biodegradable organic compound that forms a reasonable fraction of organic matter in lakes. In recent times, with the increase of pollution by large amount of various chemically oxidisable organic substances of different nature entering in the aquatic system, BOD alone does not give a clear picture of the organic matter contents of the sample. Furthermore, the presence of various toxicants in the sample may severally affect the validity of the BOD test. Hence, chemical oxygen demand is a better estimate of the organic matter, which needs no sophistication and is time saving.

However COD i.e. the oxygen consumed (OC) does not differentiate the stable organic matter from the unstable form. Therefore, the COD values are not directly comparable to that of BOD. Furthermore, some cyclic organic compounds are not oxidized; whereas, on the other hand, many inorganic compounds like nitrites, sulphites and reduced metal ions get oxidized. Samples containing chlorides more than 2 gm/l, the chloride ions are oxidized to chlorine giving erratic results. Despite of these limitations COD is still an important parameter for estimating the carbonaceous fraction of the organic matter much closer to the actual amount.

During present investigation, Chemical Oxygen Demand (COD) was determined by potassium dichromate open reflux method in which 20ml of water sample was taken in a 100 ml flask, then, 10 ml of potassium dichromate (0.25N) and 30 ml of COD reagent (concentrated sulphuric acid and pinch of silver sulphate) and 0.4 gm. of mercuric sulphate were added & refluxed for two hours on a hot plate. After two hours it was cooled down and distilled water was added to make the volume up to 140 ml. And 2 or 3 drops of ferroin indicator were added to refluxed sample, mixed thoroughly and titrated with. 0.1N ferrous ammonium sulphate to a brick red color end point. A blank was also run with distilled water.

$$\text{COD mg/lit} = \frac{(B-A) \times N \times 1000 \times 8}{\text{ml of sample}}$$

Where A = ml of titrant used with sample

B = ml of titrant used with blank

N = Normality of titrant

Sulphate

Sulphate was determined by UV visible Spectrophotometer. Results are expressed as (mg/l)

Sodium

Sodium was determined by Flame Photometer. Results are expressed as (mg/l)

Potassium

Potassium was determined by Flame Photometer. Results are expressed as (mg/l)

Methods for Analysis of Biological Parameters

Phytoplankton

For quantitative and qualitative evaluation of phytoplankton, one litre of water sample was collected and kept for sedimentation in a glass bottle, after adding 10 ml.of Lugols iodine. If necessary, it was centrifuged for total sedimentation .Supernatant liquid was taken out with the help of a pipette and the remaining sample was further concentrated upto 50 to 100 ml depending on the number of plankton present. The results are expressed as average catch in different quarters.

For the counting, drop count method was preferred using a standard calibrated dropper .Total number of units per drop were enumerated and results as units per litre were calculated. Identification was helped with Ward and Whipple (1959), Palmer (1980), Adoni, et.al. (1985).

Zooplankton

Zooplanktons were collected by using a small meshed plankton net mode of bolting silk No. 25, fitted with a demarcated collecting test tube of plastic. One liter of tank water was filtered and the collected plankton form was preserved in 5% formalin. For the counting, drop count method was preferred using a standard calibrated dropper. Identification was done using standard literature such as Pennak (1989), Needham and Needham (1962), Michael (1973) etc. the result were expressed as organisms per litre.The results are expressed as average catch in different seasons.

Collection of Macrophytes

To enumerate the types and number of species of macrophytes of Shivna River, samples were collected from the identified sampling spots at regular intervals. The collected samples of macrophytes were sorted out species wise from the river. The samples were washed thoroughly to make them free from animals and debris attached with them. Sorted species were brought to the laboratory in high-density polythene bags and preserved as a herbarium. Identification of the species was done with the help of different standards texts and monographs. Ward and Whipple, (1959) and Needham and Needham (1962).

1.4 Description of Sampling Stations

Station-1 (Kalabhata Dam): This is the first sampling station. This is the place from where partial water supply to Mandsaur town is done. The River bank on one side at this area is mostly occupied with government offices while the other side (across the river) is being used for agriculture purpose.

Salient Features:

- The entire catchment is rocky
- Water colour is greenish/ muddy
- Water flow moderate
- Total number of Gate eight
- A stop Dam (Mirjapur Dam) is situated approximately half kilometre at upstream




Station-2: Ram Ghat near Water Treatment Intake Point

This is the second sampling station from where majority of the water supply for Mandsaur town is done. A stop dam is constructed on this river and a water treatment plant is established to supply potable water to the town. The natural water flow at this point is disrupted and in downstream of the river the flow is very poor. The water is being supplied every alternate day as per the information provided by the Nakar Palika Officials.

Salient Features:

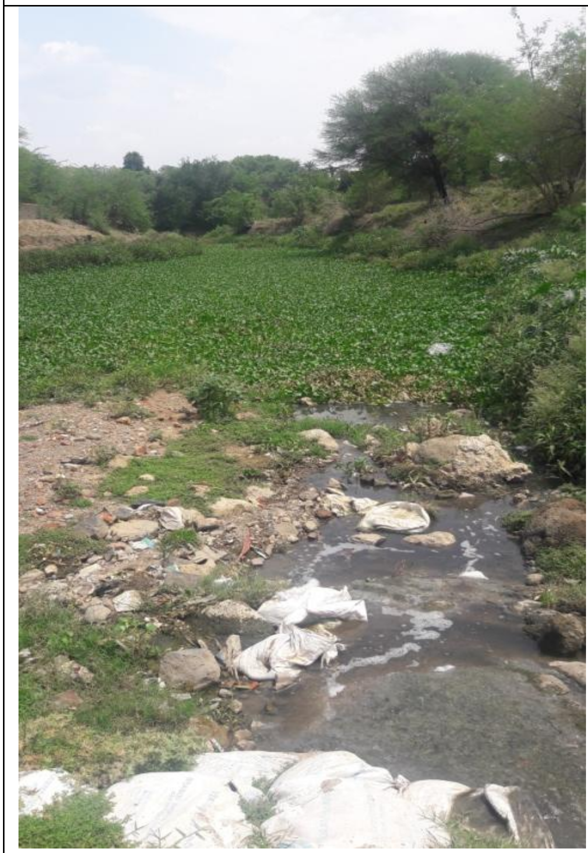
- Water colour is greenish,
- River bed rocky.
- Catchment rural highly eroded.
- Emergent weeds like *Potamogeton spiralis*
- WTP is of 28 MLD (older one of 13 MLD upgraded with another 15 MLD capacity

- Alternative day water supply at this point of time.
- All the wards of the town is supplied from this supply station

Station-3: Bugaliya Nalla: This is one of the major Nalla carrying maximum sewage from the adjacent residential areas. The Nalla meets Shivna River approximately 100 meter downstream. The sewage from the adjacent areas is diverted through this Nalla. This is also situated at upstream of famous Pashupatinath Temple

Salient Features:

- Highly polluted
- Inflow of raw sewage
- Illegal establishment of Brick kiln
- Heavily entirely infested with water hyacinth
- Foul smell
- Heaps of solid waste

Station-4: Pashupatinath Upstream: Mixing Point

This is the conjunction point of Bugaliya Nalla and the Shivna River. The river at this point is severely polluted due to mixing of city sewage with the river water. The sewage channel is opened within the Shivna River running parallel about 300-400 meters within the river front.

Salient Features:

- Discharge of city sewage
- Extremely turbid in colour with stringent foul smell
- Heavily infested with weeds and silt load from its eroded banks.
- Regular flow disrupted at many places.
- Inner fringe area of the river is also heavily silted.

Station-5: Pashupatinath Temple Downstream: This sampling point is situated at downstream of the temple and is a victim of severe siltation as well as weed infestation. The fringe area on both side of the bank is alarmingly eroded.

Salient Features:

- Severe infestation of weed : *Eichhornia crassipes*
- Erosion of river banks
- Heavy siltation in river bed
- Water colour dark
- Cattle wallowing and grazing.
- Anthropogenic activities


Station-6: Shamsan Ghat

This sampling station is situated near Shamsan Ghat and grossly infested with water hyacinth. The river front along this station is influenced by severe anthropogenic activities which has manifested in poor water quality of the river.

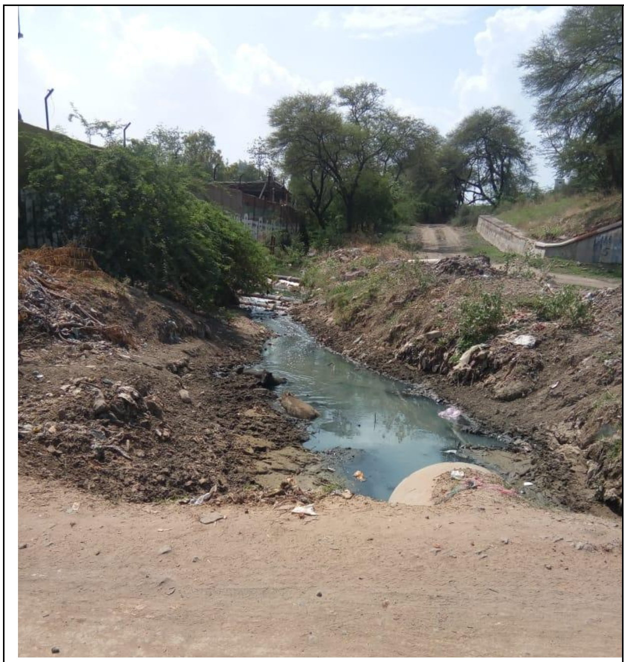
Salient Features:

- Extremely poor water
- Highly turbid
- Stagnant water with no flow


Station-7: Ram Raja Starch Factory: This station is one of the major victims of anthropogenic activities. A Starch factory is operational just adjacent to the river. Impact of discharge of effluent from the factory is manifested the severe degradation of water quality at this point of the river.

Salient Features:

- Highly polluted
- Bed Smell of Starch and bi-products
- High turbidity



Station-8: **Ram Raja Bundh:** This sampling station is situated in downstream of the Mandsaur town and is primarily occupied with agricultural fields and rural human habitations. The regular flow of the river is disrupted.

Salient Features:

- Stagnant water
- Entire catchment is rural
- Weed infestation

Water Quality

The water quality of Shivna River was assessed to evaluate the characteristics of the river at its different places, especially to study the effect of the industries, urban development and modern intensive agriculture farming and its biodiversity. The results obtained for various physico-chemical and biological parameters is described below are discussed below:-

I. Physico-chemical parameters (Field analysis)

A. Pre-monsoon Period

Table- Water Quality at different locations of Shivana River Mandsaur(Field Analysis) June,2019

S. No	St. Name & No.	Air Temp. °C	Water Temp. °C	pH	Free CO_2 (mg/l)	Dissolved Oxygen (mg./l)	Conductivity (mS/cm)	TDS (mg/l)	Turbidity (JTU)
1	Atal Sager Dam (Surface)	35.6	34.2	8.5	Abs	8	0.70	427	70

2	Atal Sager Dam (Bottom))	35.5	34.0	8.6	Abs	7.2	0.81	494	83
3	Ram Ghat	35.3	33.8	8.4	Abs	6.8	0.69	421	15
4	Bugaliya Nalla	35.2	33.7	7.8	10	0	1.55	946	100
5	Pashupati Nath Mandir Nalla (Upstream)	35	33.5	7.6	8	0	1.65	1007	100
6	Pashupati Nath Mandir River (Downstream)	35	33.4	7.7	4	0	2.36	1440	80
7	Shamsan Ghat	34.8	33.2	7.5	6	0	1.52	927	300
8	Starch Factory Nalla	34.6	33.0	7.6	10	0	1.73	1055	150
9	Raja Ram Ghat	34.5	33.0	7.4	6	0	2.10	1281	300

B. Post-monsoon Period

***Water Quality at different locations of Shivana River Mandsaur(Field Analysis) December,2019**

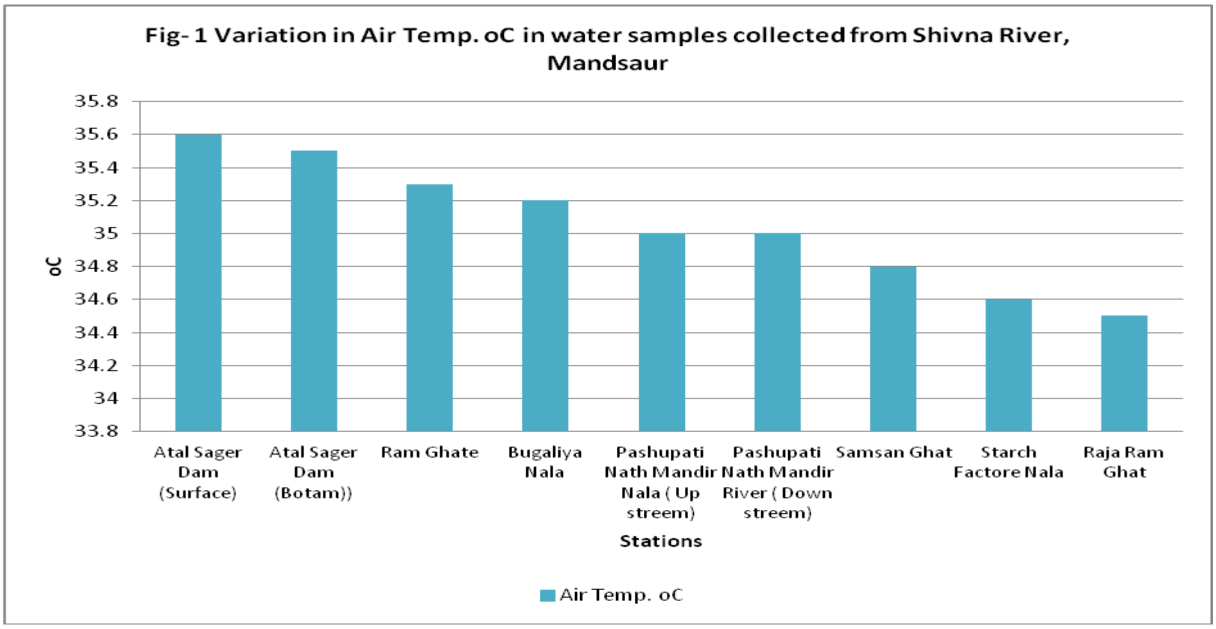
S. No	St.Name & No.	Air Temp. °C	Water Temp. °C	pH	Free CO_2 (mg/l)	Dissolved Oxygen (mg./l)	Conductivity (mS/cm)	TDS (mg/l)	Turbidity (JTU)
1	Atal Sager Dam (Surface)	21.3	16.6	7.7	Abs	6.8	0.68	415	64
2	Atal Sager Dam (Botam))	21.1	16.5	7.8	4.0	5.2	0.76	464	75
3	Ram Ghate	20.9	16.3	7.7	Abs	7.2	0.65	397	12
4	Bugaliya Nala	20.8	16.2	7.4	1.2	0.8	1.23	750	140
5	Pashupati Nath Mandir Nala (Up streem)	19.2	15.5	7.5	6.0	0	1.60	976	130
6	Pashupati Nath Mandir River (Down streem)	19	15.3	7.6	8.0	1.2	2.25	1373	100
7	Samsan Ghat	20.4	15.7	7.4	10	0	1.47	897	445
8	Starch Factore Nala	20.6	15.9	7.5	10	0	1.64	1000	180
9	Raja Ram Ghat	20.7	16.0	7.5	8.0	0.8	1.94	1183	185

1. Air temperature:

Temperature is one of the most important ecological features and its measurement is useful indicator of biochemical and biological activity in a water body. Variation in air temperature at different stations of Shivna River during the year 2007-2009 is depicted in Table-A, Figure -1

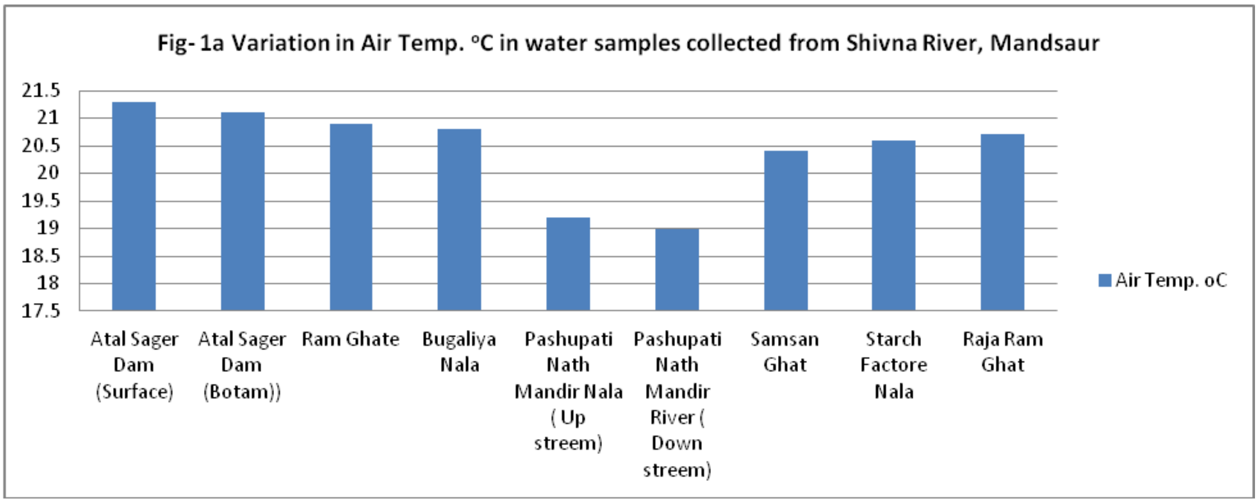
A. Pre-monsoon Period

Air temperature during the period of Pre monsoon investigation were found within the range of 34.5 ^{0}C to 35.6 ^{0}C. The minimum value was observed at station - 9 while maximum value was recorded at station-1.



B. Post-monsoon Period

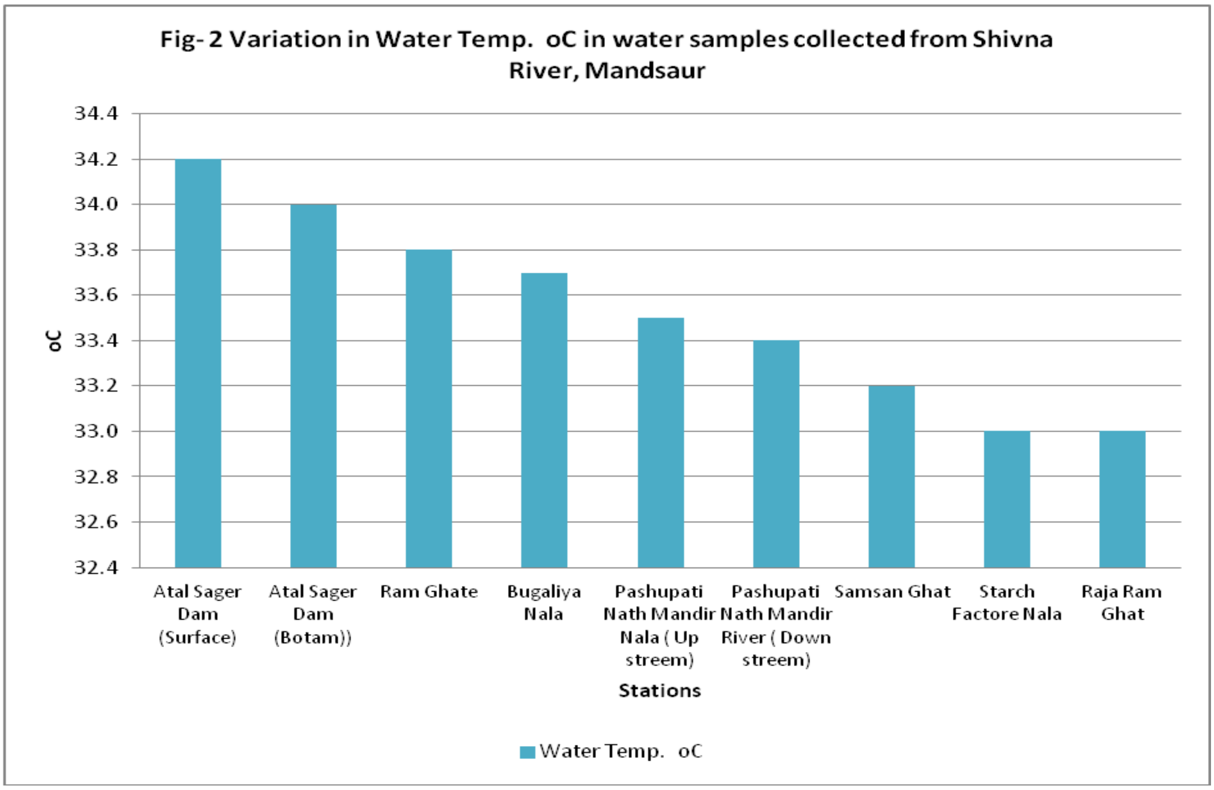
Air temperature during the post monsoon period of investigation were found within the range of 19 ^{0}C to 21.3 ^{0}C. The minimum value was observed at station - 9 while maximum value was recorded at station-1.



2. Water temperature:

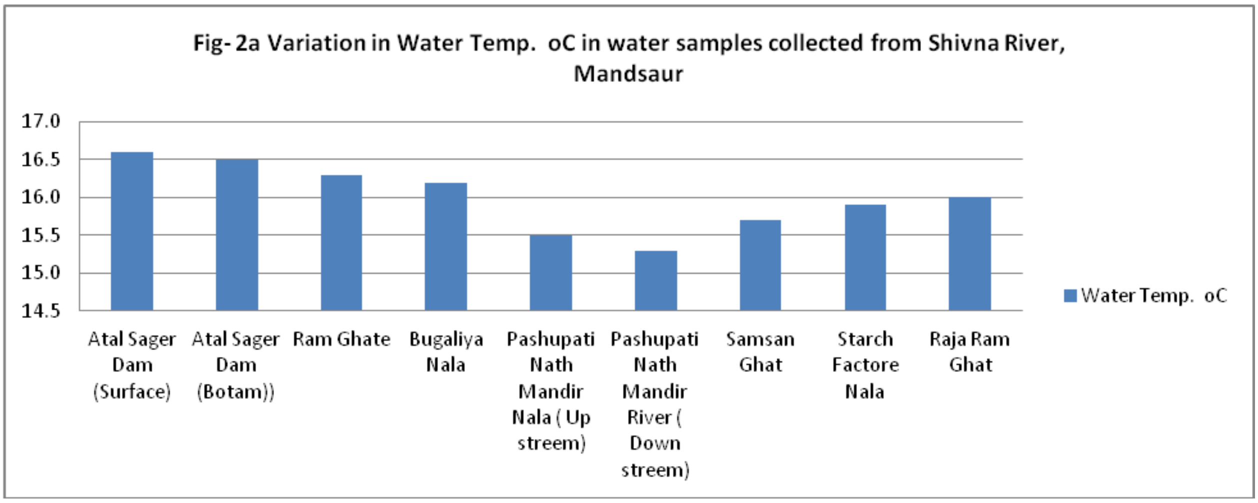
A. Pre-monsoon Period

Water temperature during the period of Pre monsoon investigation were found within the range of 33.0 ^{0}C to 34.2 ^{0}C. The minimum value was observed at station -8 & 9 while the maximum value was recorded at station-1.



B. Post-monsoon Period

Water temperature during the period of post monsoon investigation were found within the range of 15.3 ^{0}C to 16.6 ^{0}C. The minimum value was observed at station - 5 & 9 while the maximum value was recorded at station-1.



While comparing the water temperature values in both the seasons , it was observed that summer season recorded higher temperature than rest of the seasons. The air temperature in turn influenced the water temperature at the adjoining areas.

Water temperature can influence oxygen concentration, metabolism (body functions), reproduction and growth. Water temperature is also influenced by the seasons, the amount of sunlight reaching the water, amount and flow of the water, the source of the water (springs or runoff) and the amount of material suspended in the water.

3. pH :

Hydrogen ion concentration (pH) is the most important and commonly studied property of natural water and wastewater. The measurement of pH is of great importance because chemical and biochemical reaction in an aquatic body takes place at a particular pH and plays an important role in productivity of waterbody.

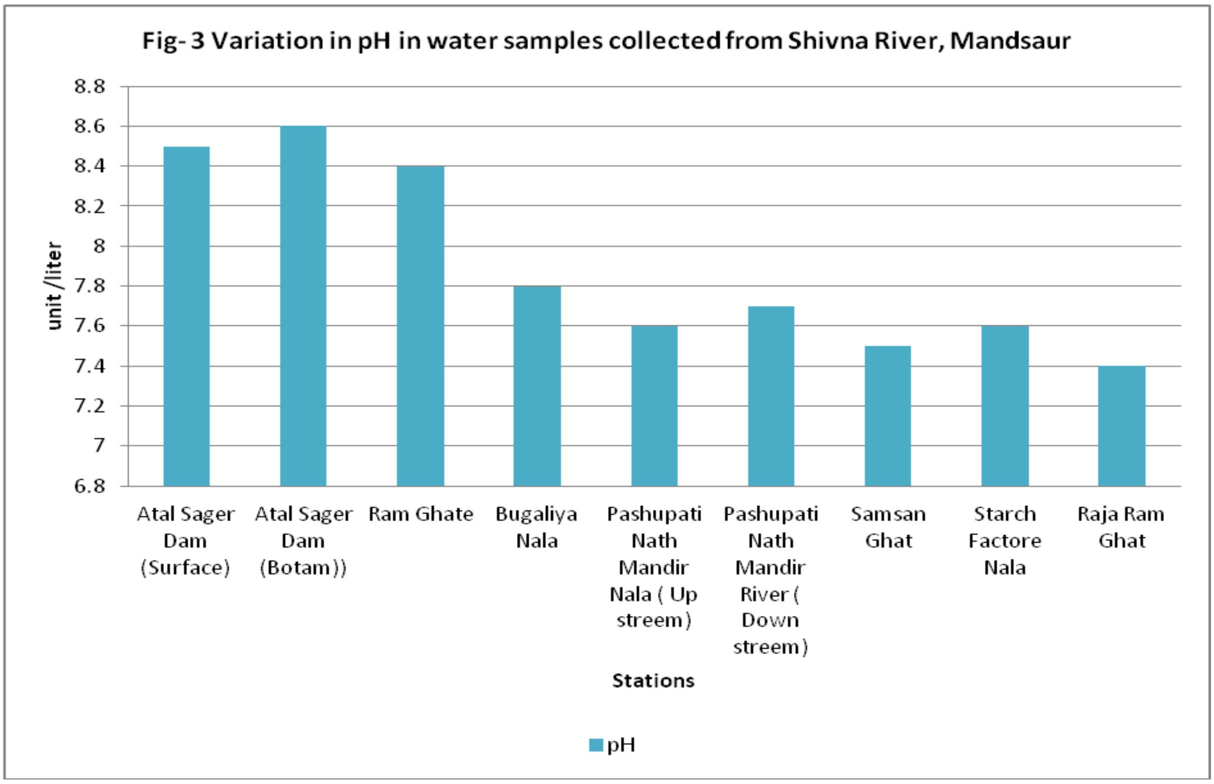
In a lotic ecosystem, the pH is influenced by the age of the waterbody and the chemicals discharged by communities and industries and geo-chemical characteristics of its catchment. Most of the water bodies are usually basic (alkaline) when they are first formed and become more acidic in course of time due to the build-up of organic materials. As organic substances decay, carbon dioxide (CO_2) forms and combines with water to produce a weak acid, called "carbonic" acid.

In aquatic habitats, pH has a strong effect on fish, amphibians, invertebrates and plants community. The pH of a stream or river depends on the water source and the kinds of rocks and soil that water contacts. pH is an important life requirement for all aquatic organisms. Developing eggs and larvae also have specific, narrower pH requirements. However, even at the high and low ends of pH tolerance, fish become stressed. Aquatic invertebrates, with external skeletons or shells made of calcium, are extremely sensitive to pH below neutral. These organisms are important members of aquatic food chain. In Betwa River the pH values in most of the places were observed to be slightly alkaline.

Variation in pH in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -3& 3a.

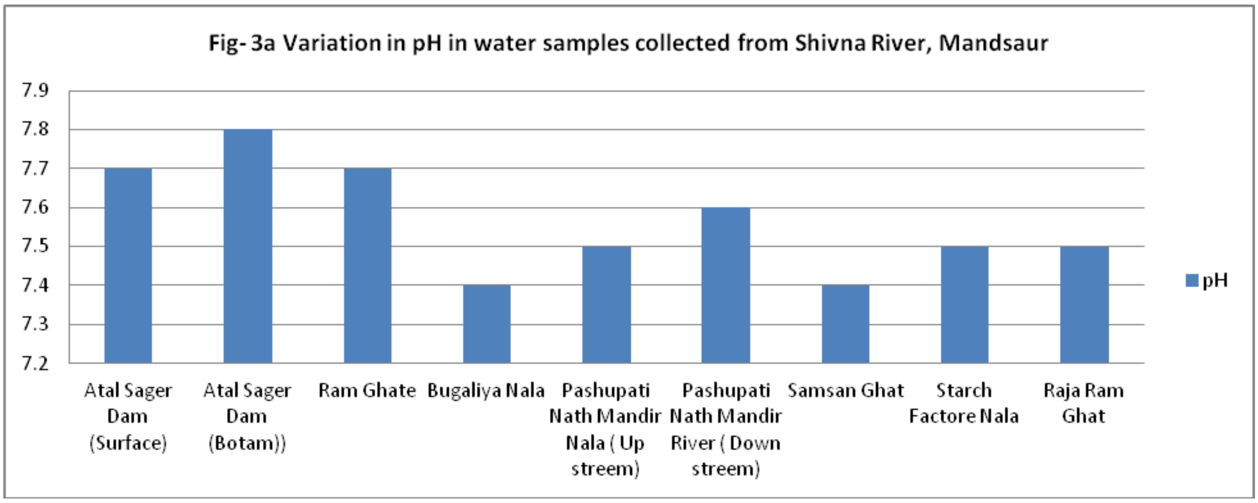
A. Pre-monsoon Period

pH during the period of Pre monsoon investigation was found within the range of 7.4 to 8.6. The minimum value was observed at station - 9 while the maximum value was recorded at station-2.



B. Post-monsoon Period

pH during the period of post monsoon investigation was found within the range of 7.4 to 7.8. The minimum value was observed at station - 9 while the maximum value was recorded at station-2.



The measurement of pH has great importance because chemical and biochemical reactions in aquatic body take place at particular pH, Basu et. al. (1973). Seasonal variation also depicted slightly higher values of pH may be during the summer months compared to monsoon and winter months. Bajpai (1994) found similar result in case of Upper lake i.e. slightly alkaline nature and pH varied from 7.1 to 9.5.

In Shivna River the epilimnion shows higher pH values than bottom water. The difference in pH profile between surface and bottom water may be on account of trophogenic and tropholytic activity, Kannan and Job, (1980). Bajpai et. al. (2007) recorded the similar findings in upper lake. According to Spence (1967), the pH of a typical oligotropic lake ranges from 4.8 to 8.0 and of a eutrophic lake from 7.7 to 9.6. The UPSH (United state Public Health Standard) limit of pH of drinking water 6.0 to 8.5, De, (2002). Low pH is due to influence of fresh water influx, dilution, low temperature and organic matter decomposition, Chaurasia and Pandey, (2007). It regulates most of the biological processes and biochemical reaction, Verma, et.al. (2006).

4. Free CO_2:

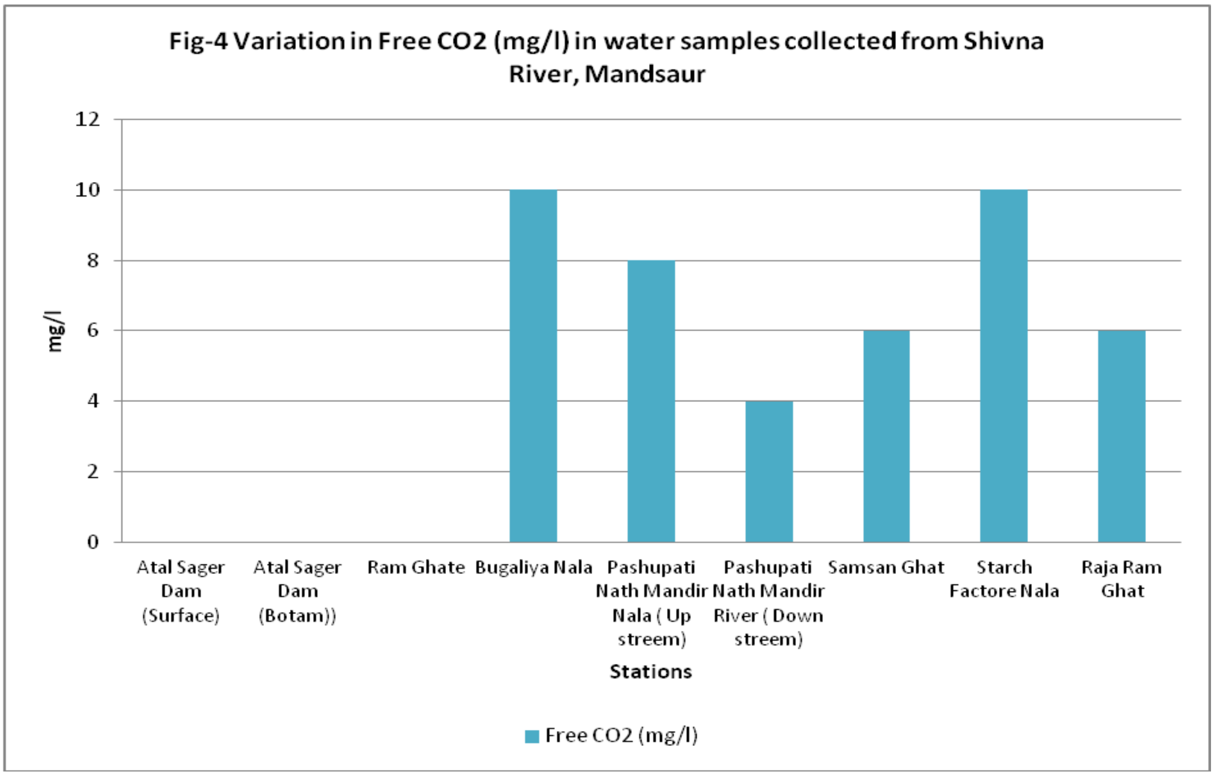
The availability of hydrogen ion concentration also influences the free CO2 in water. Free carbon dioxide is an odorless, colorless gas produced during the respiration cycle of animals, plants and bacteria. All animals and many bacteria use oxygen and release carbon dioxide. Green plants, in turn, absorb the carbon dioxide and, by the process of photosynthesis, produce oxygen and make carbon-rich foods. Green plants carry on photosynthesis only in the presence of light. At night, they respire and burn the food they made during the day. Consequently, more oxygen is used and more carbon dioxide enters waterways at night than during the day time. When carbon dioxide levels are high and oxygen levels are low, fish have trouble in respiring (taking up oxygen), and their problems become worse as water temperature rises.

Free carbon dioxide quickly combines with water to form carbonic acid, which is a weak acid. The presence of carbonic acid in waterways may be good or bad depending on the water's pH and alkalinity. If the water is alkaline (high pH), the carbonic acid will act to neutralize it, but if the water is already acidic (low pH), the carbonic acid will only make things worse by making it even more acidic.

Variation in free CO2 in surface water of various stations of Shivna River during the study period is shown in Table- A, Figure- 4& 4a.

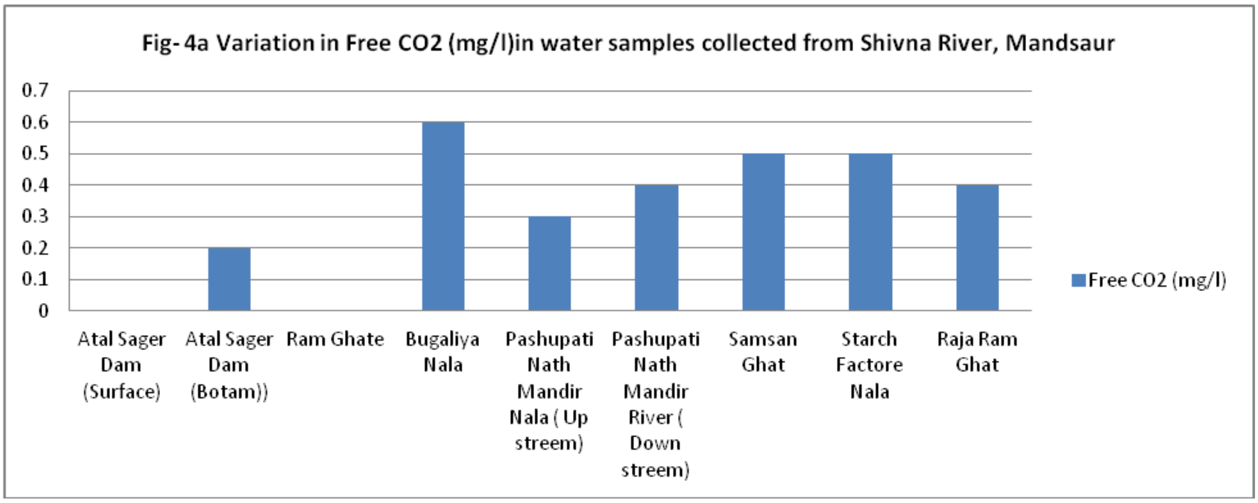
A. Pre-monsoon Period

Free CO_2 during the period of Pre monsoon investigation were found within the range of 0 to 10. The minimum value was observed at station – 1, 2 &3 while the maximum value was recorded at station-4&8.



B. Post-monsoon Period

Free CO_2 during the period of post monsoon investigation were also found within the range of 0 to 10 like that of Pre monsoon. The minimum value was observed at station – 1, 2 &3 while the maximum value was recorded at station-4&8.



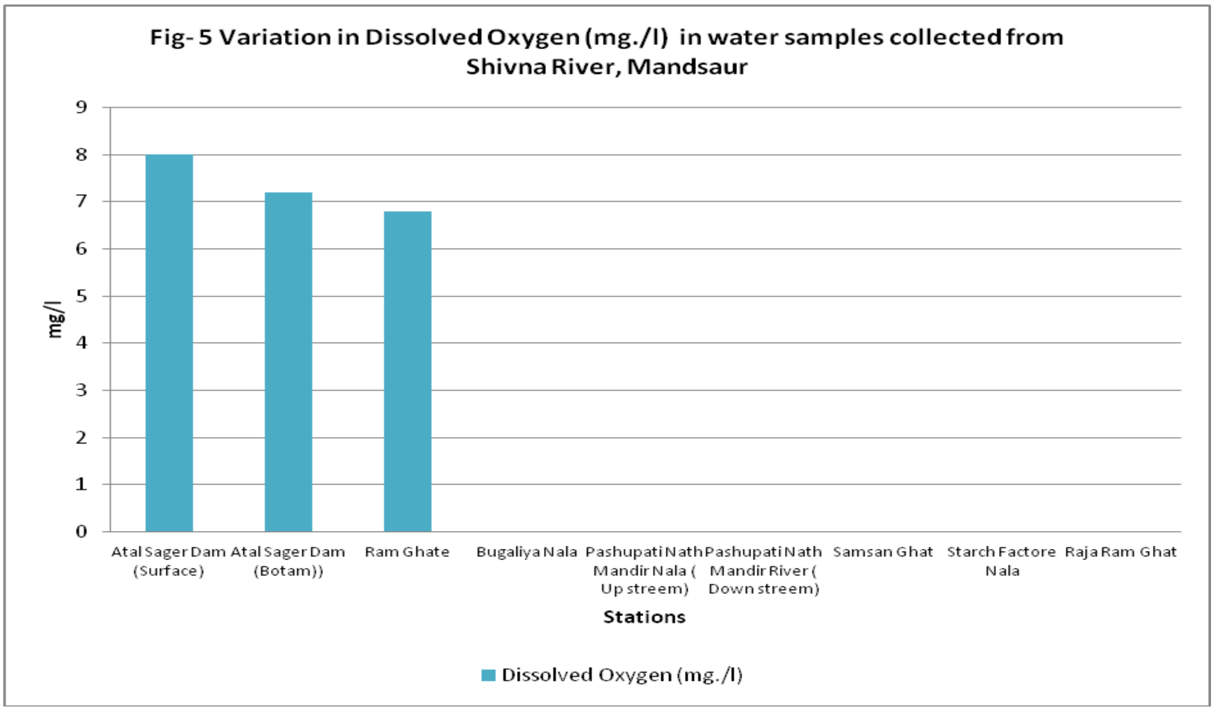
The higher values of free CO_2 was recorded at Station-4, indicates that Station 4 is greatly affected by the decomposition activities of the organic matters. The direct absorption of free carbon dioxide from atmosphere provides presence of epilimnion is in unstable form. Free CO_2, dissolved in water is the source of carbon that can be assimilated and incorporated into living matter of all the aquatic autotrophs **Hutchinson, (1957).** Similar trend was observed by **Salve, et .al. (2009)**.

5. Dissolved Oxygen:

Variation in dissolved oxygen in surface water at different stations of Shivna River during the period of investigation is depicted in Table-A, Figure -7a and Figure-5&5a.

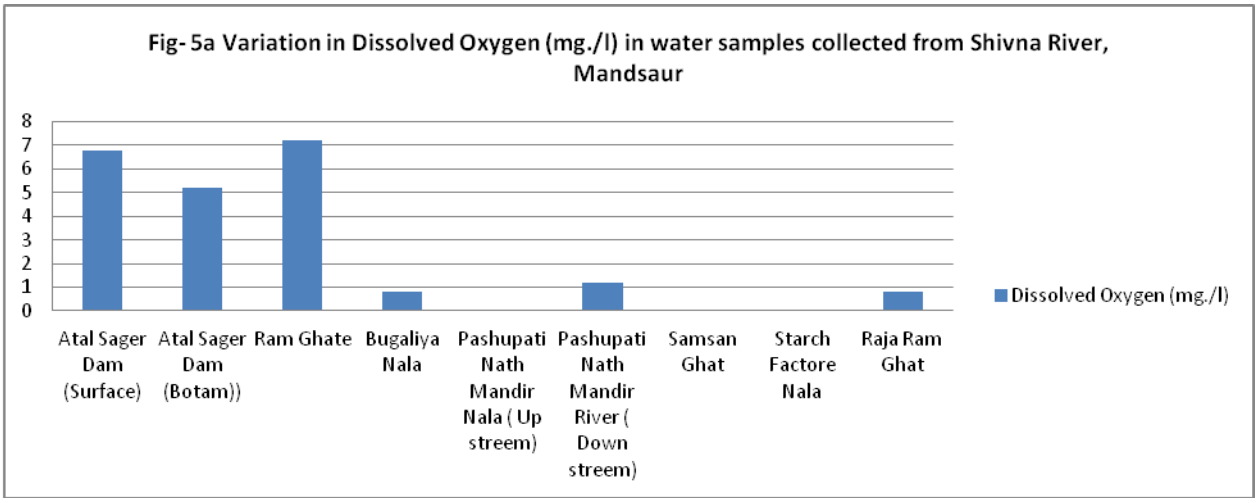
A. Pre-monsoon Period

Dissolved Oxygen values during the period of Pre monsoon investigation were found within the range of 0 to 8 mg/liter. Dissolved oxygen remained absent at all stations except stations 1, 2 &3.



B. Post-monsoon Period

Dissolved Oxygen values during the period of post monsoon investigation were found within the range of 0 to 7.2 mg/liter. Dissolved oxygen remained absent at all stations except stations 1, 2 &3.



The value of DO was mostly found to be high at station 1,2 &3. This may be due to higher dissolution of atmospheric oxygen in the river water through agitation. High dissolved oxygen concentration during summer months in epilimnic water could be on account of high photosynthetic activity by the standing phytoplankton crop and macrophytic vegetation in presence of optimum light.

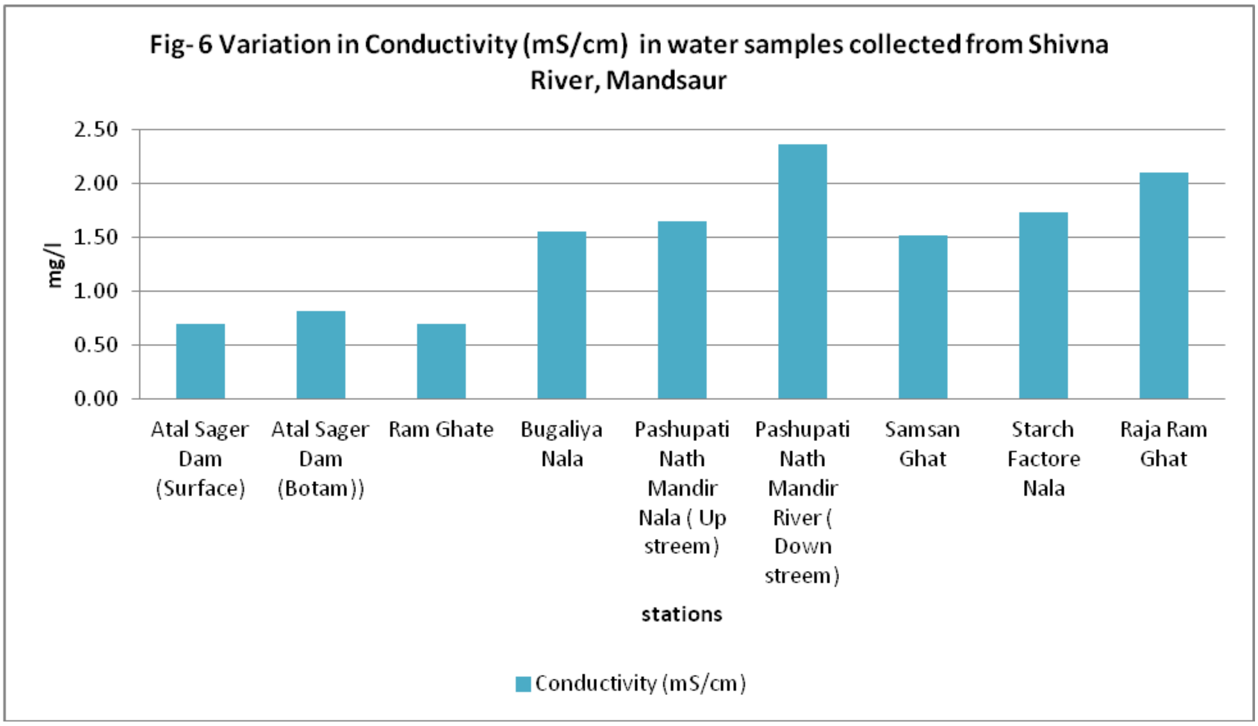
5. Conductivity:

Conductivity is a measurement used to determine a number of applications related to water quality like determining mineralization. Total dissolved solids information is used to determine the overall ionic effect in a water source. Certain physiological effects on plants and animals are often affected by the number of available ions in the water. Conductivity is a numerical expression of the ability of an aqueous solution to carry on electric current. This ability depends on the presence of ions, their total concentration and temperature variations. Conductivity depends on the ionic strength of the water. Inorganic salts, acids and bases show better conductance while organic compounds do not show much conductance.

Variation in conductivity in surface water at different stations of Betwa River during the year 2007-2009 is depicted in Table- A, Figure 6 &6a.

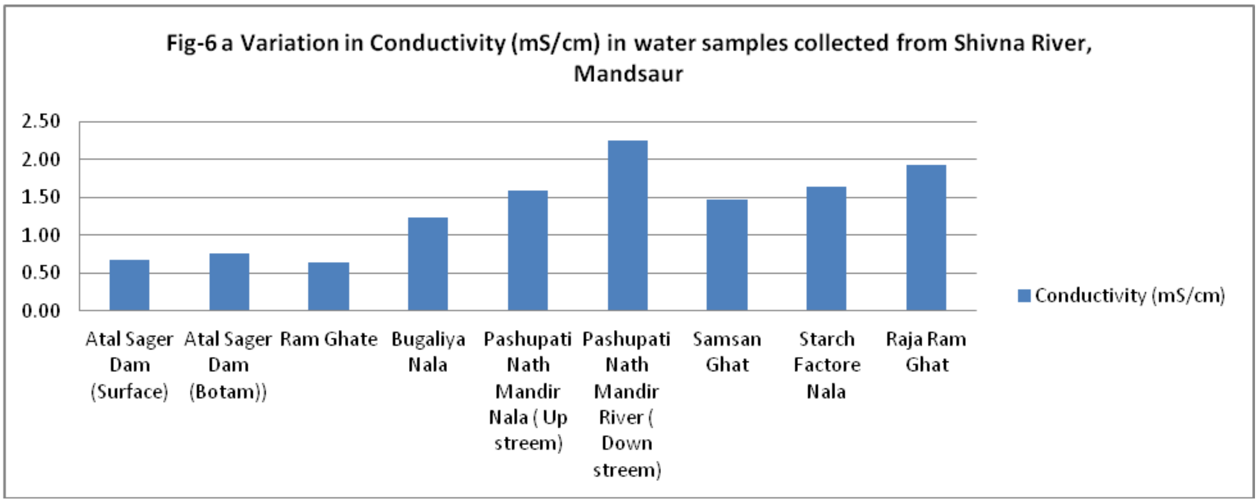
A. Pre-monsoon Period

Conductivity during the period of Pre monsoon investigation was found within the range of 0.69 mS/cm to 2.36 mS/cm. The minimum value was observed at station –3 while the maximum value was recorded at station-6.



B. Post-monsoon Period

Conductivity during the period of post monsoon investigation was found within the range of 0.65 **mS/cm** to 2.25 **mS/cm**. The minimum value was observed at station – 3 while the maximum value was recorded at station-6.



Chemically pure water has low electrical conductivity, high values of electrical conductance show presence of ionic solids in water**.** Similar observations were recorded by **Sipauba Tavares et. al. (1999). Jain (1995)** found conductivity of Lower Lake sometimes high in surface water and as well as in bottom water also. **Tiwari et. al., (2004)** recorded the conductivity of the lake water samples in the range of 0.60 to 0.72 mS/cm^2.

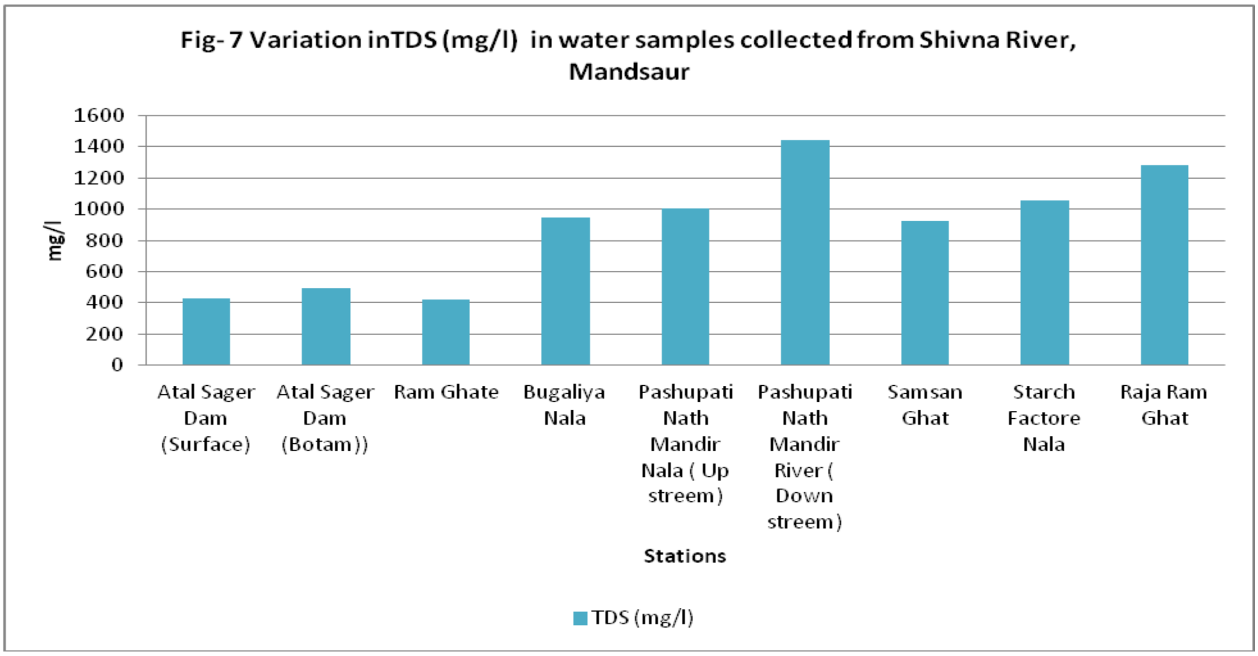
7. Total Dissolved Solids (TDS):

In natural water total dissolved solids are mainly composed of a large variety of salts and Inorganic minerals i.e., dissolved solids such as chlorides, carbonates, bicarbonates, nitrate, phosphates of calcium, magnesium, sodium ,potassium etc. which impart particular taste to water at higher concentration. TDS when present in excess in the water may create an imbalance for aquatic life.

Variation in total dissolved solids in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -7&7a.

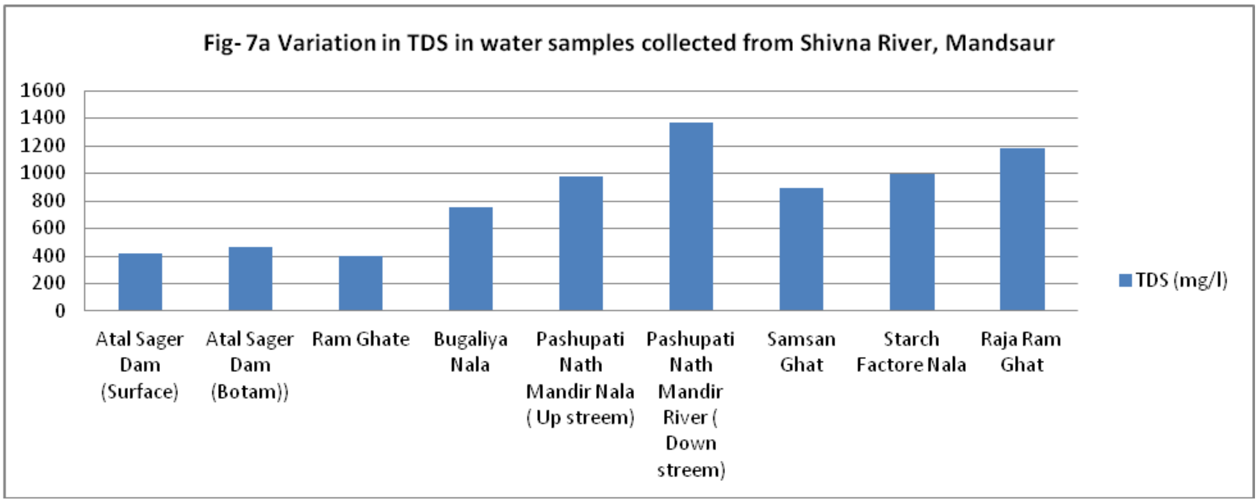
A. Pre-monsoon Period

TDS during the period of Pre monsoon investigation were found within the range of 421mg/liter to 1440 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-7&9.



B. Post-monsoon Period

TDS during the period of post monsoon investigation were found within the range of 397mg/liter to 1373 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-6&9.



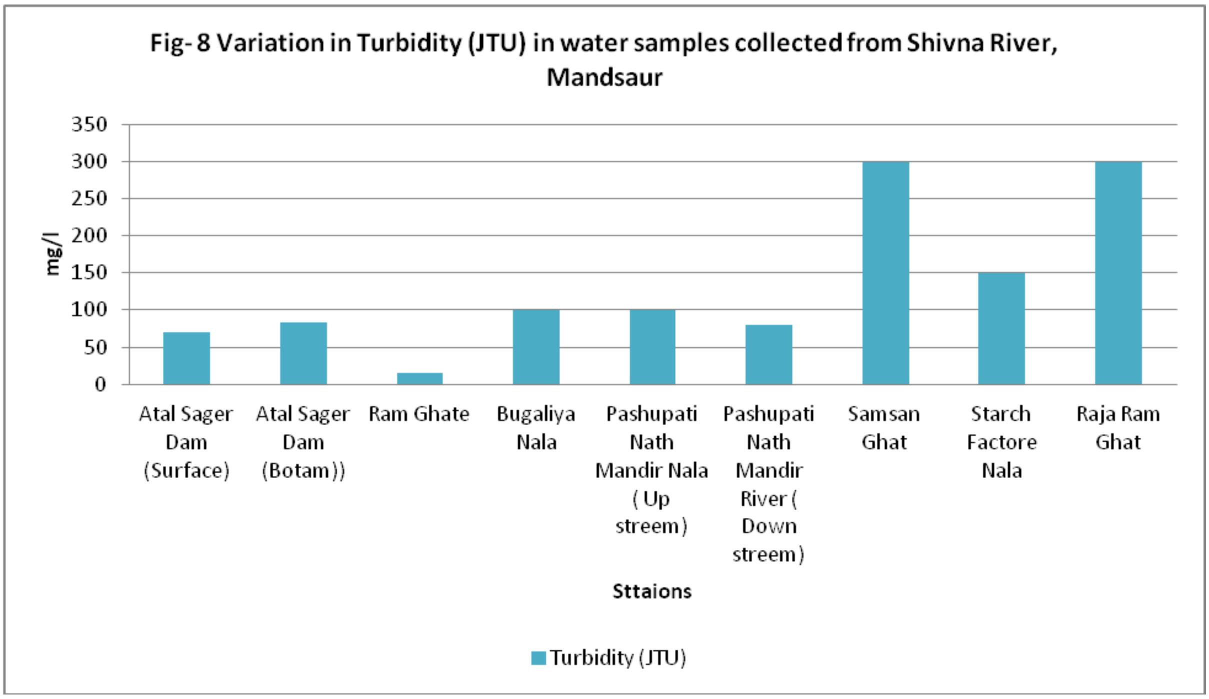
At some stations higher values of TDS were recorded because of dumping of solid wastes. TDS is an important parameter for productivity of the aquatic environment. Khan and Khan (1985) found higher values of TDS during rainy season. High values of TDS due to rains were also reported by Verma et. al. (2006). Similar observations were found by Dubey (2003) and reported TDS value in upper lake surface water between 163mg/L to 216mg/L.

8. Turbidity:

Variation in Turbidity in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -8&8a.

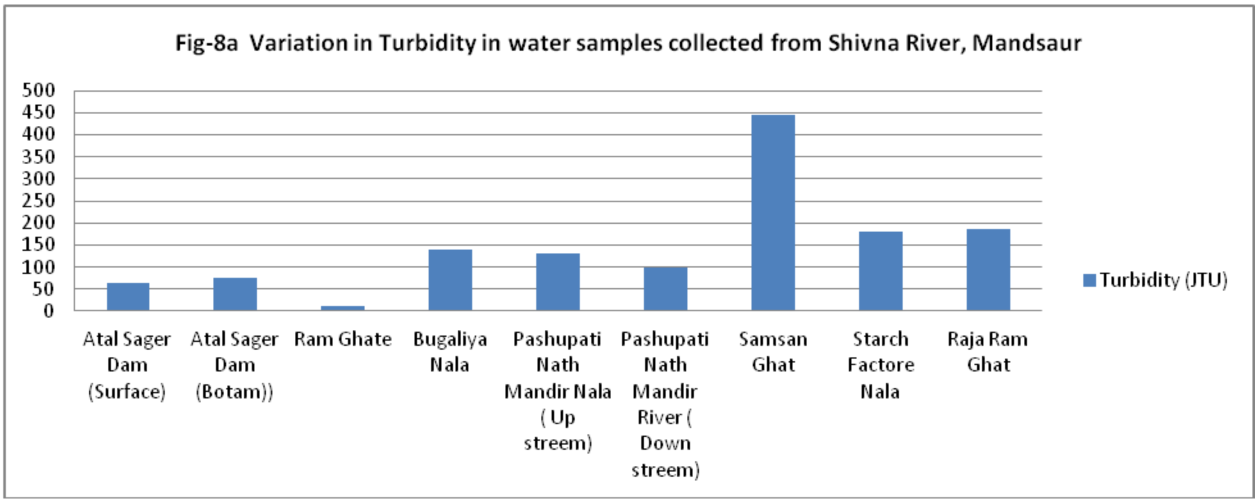
A. Pre-monsoon Period

Turbidity during the period of Pre monsoon investigation was found within the range of 15 JTU to 300JTU. The minimum value was observed at station –3 while the maximum value was recorded at station-7&9.



B. Post-monsoon Period

Turbidity during the period of post monsoon investigation was found within the range of 12 JTU to 445 JTU. The minimum value was observed at station –3 while the maximum value was recorded at station-7&9.



II Physico-chemical parameters (Laboratory analysis)

A. Pre-monsoon Period

	Variation in Physico-chemical parameters (mg/litre) at different stations of Shivna River, Mandsaur, June ,2019																		
S. No		**Total Alkalinity**	**Carbonate alkalinity**	**Bi-Carbonate alkalinity**	**Total Hardness**	**Ca hardness**	**Mg hardness**	**Calcium content**	**Magnesium content**	**Chloride**	**Sodium**	**Potassium**	**Total Phosphorus**	**Ortho Phosphorus**	**Organic Phosphorus**	**Nitrate**	**Sulphate**	**BOD**	**COD**
1	Atal Sagar Dam (Surface)	142	4	138	110	65.1	44.9	27.3	10.9	63.9	52	4	2.3	1.0	1.3	2.8	21.0	16	64
2	Atal Sagar Dam (Bottom))	162	6	156	134	69.3	64.7	29.1	15.7	73.9	64	8	2.8	1.0	1.8	2.6	24.0	24	68
3	Ram Ghat	130	4	126	116	67.2	48.8	28.2	11.9	59.9	54	4	2.3	1.3	1.0	2.2	44.0	20	60
4	Bugaliya Nalla	168	0	168	196	126	70.0	52.9	17	164.8	116	31	3.3	1.1	2.1	5.6	38.0	24	96
5	Pashupati Nath Mandir Nalla (Upstream)	216	0	216	216	151.2	64.8	63.5	15.7	95.9	161	32	3.3	1.3	2.0	4.4	42.0	28	84
6	Pashupati Nath Mandir River (Downstream)	252	0	252	280	214.2	65.8	90.0	16	319.7	145	33	4.6	1.8	2.8	4.1	36.0	26	80
7	Shamsan Ghat	172	0	172	190	151.2	38.8	63.5	9.4	267.7	117	37	4.1	1.2	3.0	5.2	64.0	24	84
8	Starch Factory Nalla	256	0	256	210	115.5	94.5	48.5	23	194.8	155	22	3.6	1.2	2.5	4.2	32.0	34	104
9	Raja Ram Ghat	252	0	252	320	189	131.0	79.4	31.8	314.7	157	56	3.2	1.3	1.9	4.1	28.0	26	80

B. Post-monsoon Period

	Variation in Physico-chemical parameters (mg/liter) at different stations of Shivna River, Mandsuar, December ,2019																		
S. No		Total Alkalinity	Carbonate alkalinity	Bi-Carbonate alkalinity	Total Hardness	Ca hardness	Mg hardness	Calcium content	Magnesium content	Chloride	Sodium	potassium	Total Phosphorus	Ortho Phosphorus	Organic Phosphorus	Nitrate	Sulphate	BOD	COD
1	Atal Sagar Dam (Surface)	124	8	116	88	44.3	43.7	19.3	8.7	34.9	36	6	2.2	1.0	1.2	2.2	16.8	8	28
2	Atal Sagar Dam (Bottom))	128	10	118	92	45.6	46.4	21.7	8.1	37.9	42	10	2.2	1.0	1.2	2.2	18.4	4	20
3	Ram Ghat	120	8	112	86	39.8	46.2	22.4	9.2	29.9	32	8	2.2	1.0	1.2	2.1	22.6	2	16
4	Bugaliya Nala	148	0	148	140	92.1	47.9	47.3	9.7	47.9	90	22	2.9	1.2	1.7	4.2	28.6	16	60
5	Pashupati Nath Mandir Nala (Up stream)	156	0	156	146	96.7	49.3	37.3	10.9	41.9	78	26	2.9	1.3	1.6	3.8	34.4	20	72
6	Pashupati Nath Mandir River (Down stream)	160	0	160	148	97.5	50.5	38.6	11.3	43.9	82	28	3.4	1.8	1.6	3.4	38.6	24	76
7	Samsan Ghat	184	0	184	138	91.3	46.7	56.3	19.7	143.9	110	44	4.0	1.2	2.8	4.4	54.8	16	88
8	Starch Factore Nala	180	0	180	144	93.8	50.2	39.7	17.9	123.9	120	18	4.2	1.2	3.0	4.8	30.6	40	128
9	Raja Ram Ghat	164	0	164	140	92.4	47.6	37.8	17.3	97.9	118	22	4.1	1.3	2.8	3.7	24.2	36	120

9. Total Alkalinity:

Alkalinity is an important parameter for fish and aquatic life because it protects or buffers against pH changes (keeps the pH fairly constant) and makes water less vulnerable to acid rain. The main sources of natural alkalinity are rocks, which contain mainly carbonate and bicarbonate compounds. Borates, silicates, and phosphates may also contribute to alkalinity.

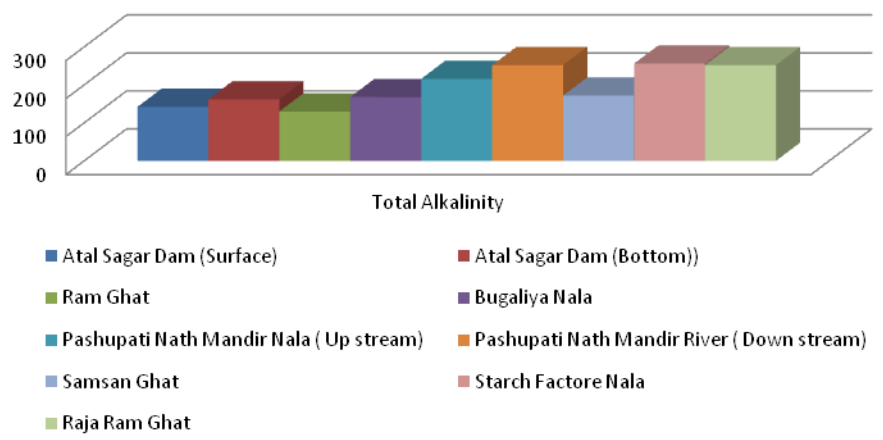
The total alkalinity indicates the capacity of water to neutralize acids. It is the sum of all the titratable bases. As total alkalinity is the sum of carbonates and bicarbonates alkalinity and when either of the two ($C0_3$ or $HC0_3$) is absent, the value of the remaining is equal to total alkalinity. This may be used as a tool for the measurement of productivity conditions of water bodies..

Variation in total alkalinity at different stations of Shivna River during the study period is depicted in Table-A, Figure –9&9a.

A. Pre-monsoon Period

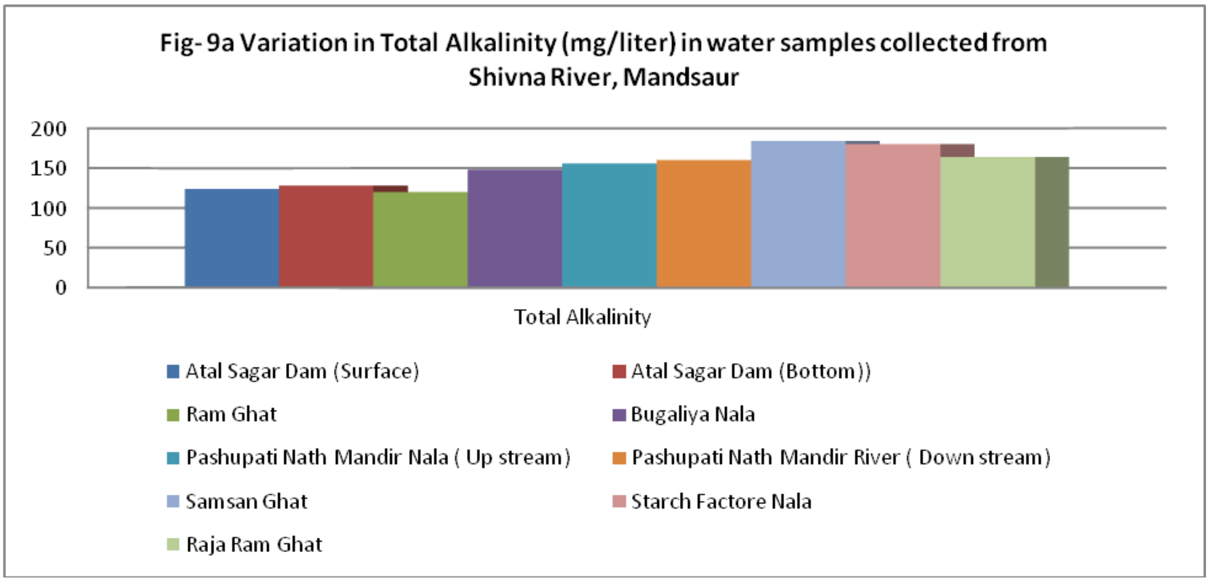
Total Alkalinity during the period of Pre monsoon investigation was found within the range of 130mg/liter to 256 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-8.

Fig- 9 Variation in Total Alkalinity (mg/liter) in water samples collected from Shivna River, Mandsaur



B. Post-monsoon Period

Total Alkalinity during the period of post monsoon investigation was found within the range of 120mg/liter to 184 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-8.



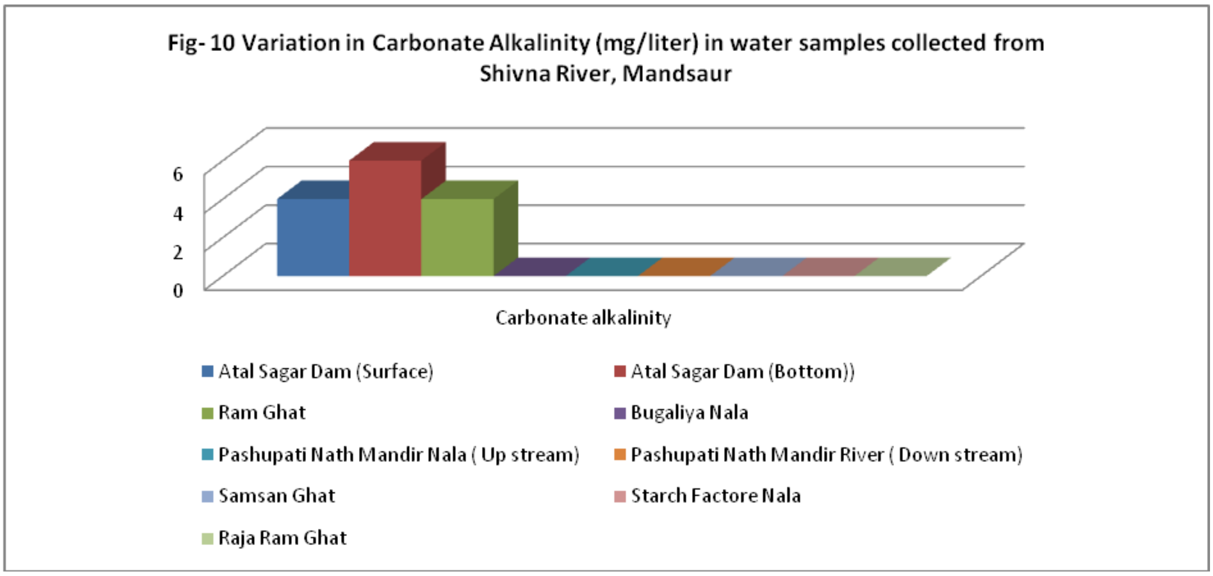
Alkalinity in river water increases due to inflow of water because of rains. Aboo and Bullue (1965), Sastry et. al., (1970), Bajpai et.al.(1993), Dubey, (2003) found alkalinity in the range of 120mg/L to 146 mg/L in two ponds at Nayachar island, West Bengal. Vyas, (2007) also observed that when dilution increases, total alkalinity increases.

10. Carbonate Alkalinity:

Carbonate alkalinity is a part of total alkalinity. Variation in carbonate alkalinity in surface water at different stations of Shivna River during the period of study is depicted in Table-A and Figure -10&10 a.

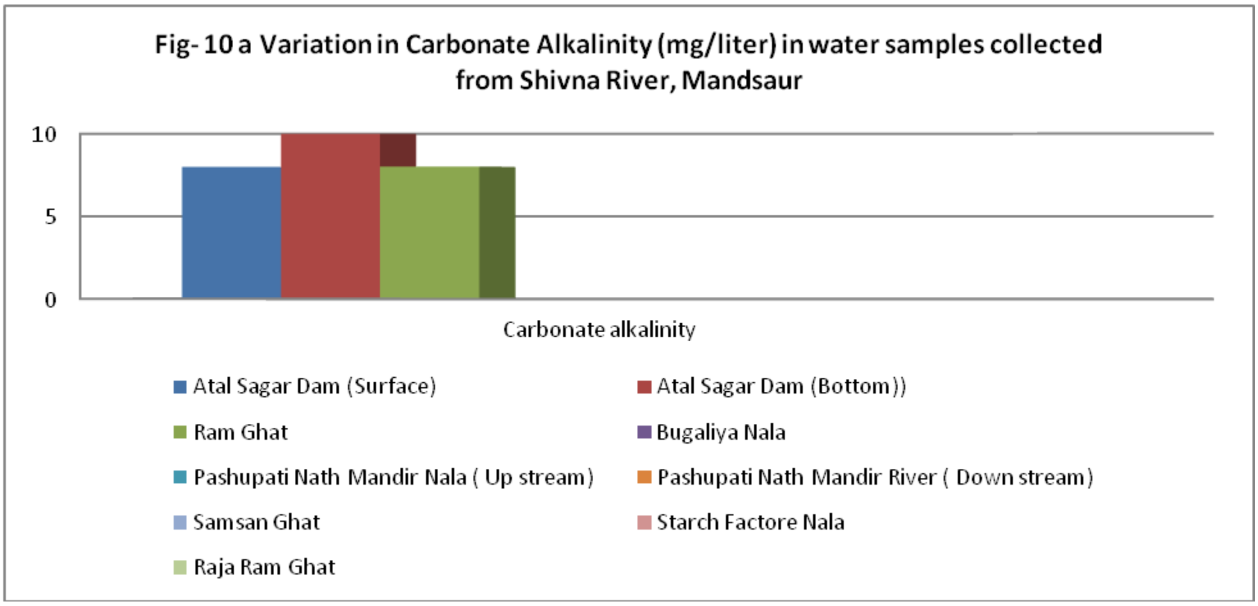
A. Pre-monsoon Period

Carbonate Alkalinity during the period of Pre monsoon investigation was found within the range of 0 to 6 mg/liter. The minimum value was observed at all the stations except 1, 2 & 3 while the maximum value was recorded at station-2.



B. Post-monsoon Period

Carbonate Alkalinity during the period of post monsoon investigation was found within the range of 0 to 10 mg/liter. The minimum value was observed at all the stations except 1, 2 & 3 while the maximum value was recorded at station-2



The carbonate alkalinity is a part of total alkalinity and may be used as a tool for the measurement of the productivity conditions of water bodies, Bajpai (1994). Mishra, et. al. (2006), also find low carbonate alkalinity in comparison to bi-carbonate alkalinity.

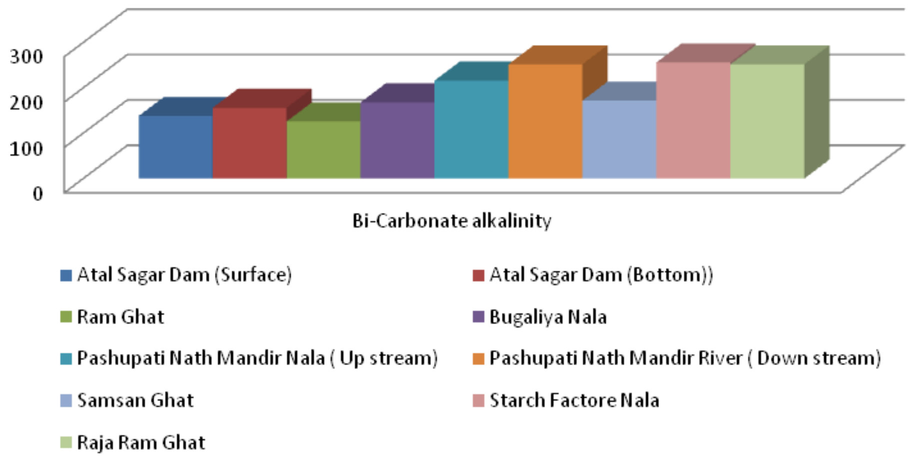
11. Bi-carbonate Alkalinity:

Variation in bicarbonate alkalinity in surface water at different stations of Betwa River during the year 2007-2009 is depicted in Table-A, Figure -11 & 11a.

A. Pre-monsoon Period

Bi-carbonate Alkalinity during the period of Pre monsoon investigation was found within the range of 138mg/liter to 256 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-8.

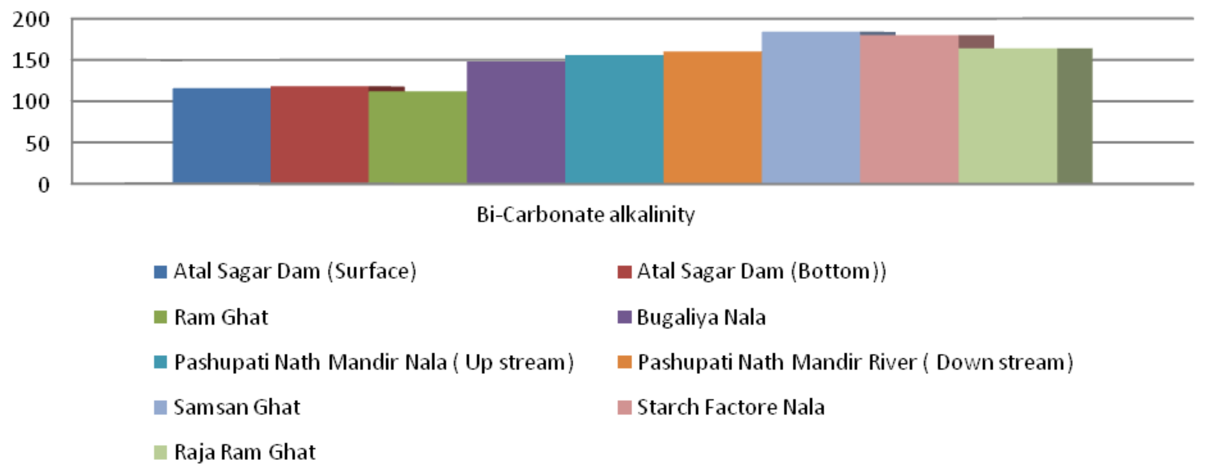
Fig- 11 Variation in Bi-Carbonate Alkalinity (mg/liter) in water samples collected from Shivna River, Mandsaur



B. Post-monsoon Period

Bi-carbonate Alkalinity during the period of post monsoon investigation was found within the range of 112 mg/liter to 184 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-8.

Fig- 11 a Variation in Bicarbonate Alkalinity (mg/liter) in water samples collected from Shivna River, Mandsaur



Among the inorganic form bi carbonate was dominant because of the alkanity predominance in the system .Same findings are reported by Aboo and Bullue (1965), Sastry et. al., (1970), Bajpai et.al.(1993), Dubey (2003) .

12. Total Hardness:

Total hardness in water is the sum of the concentrations of alkaline earth metal (eg. Ca^{++}, Mg^{++}). In most fresh water nearly all the hardness is imparted by the calcium and magnesium ions which are in combination with bicarbonates and carbonates (temporary hardness) apart from sulphates, chlorides and nitrates.

Variation in total hardness in surface water at different stations of Betwa River during the year 2007-2009 is depicted in Table-A, Figure -12&12a.

A. Pre-monsoon Period

Total Hardness during the period of Pre monsoon investigation was found within the range of 110 mg/liter to 320 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

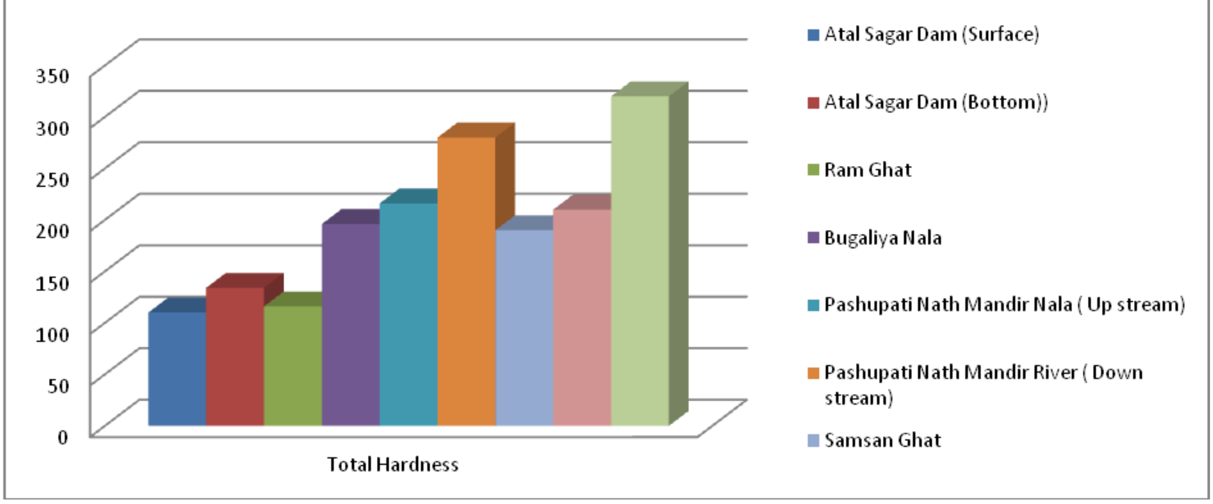


Fig- 12 Variation in Total Hardness (mg/liter) in water samples collected from Shivna River, Mandsaur

B. Post-monsoon Period

Total Hardness during the period of post monsoon investigation was found within the range of 86 mg/liter to 148 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

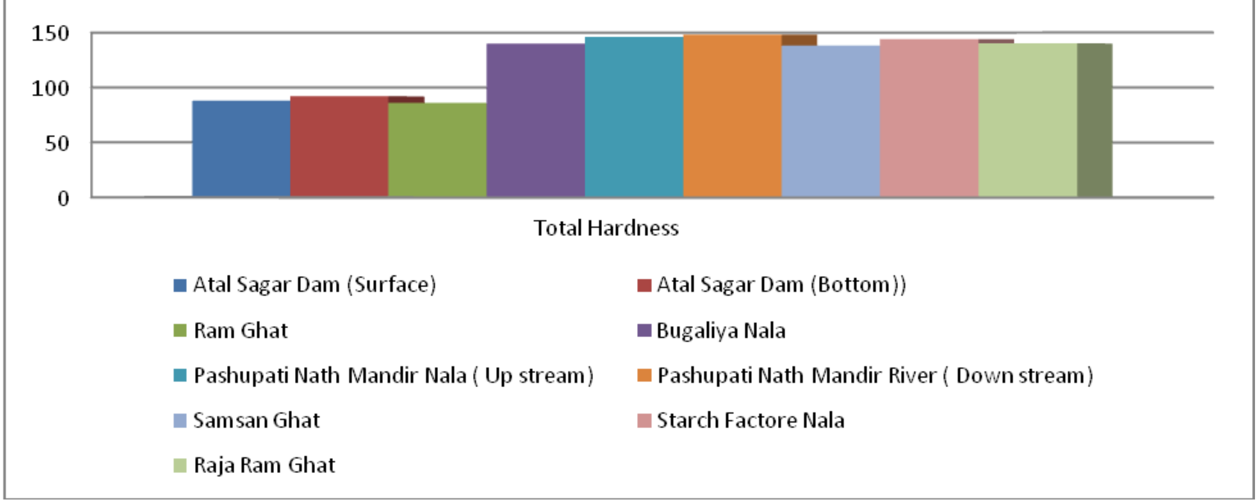


Fig- 12a Variation in Total Hardness (mg/liter) in water samples collected from Shivna River, Mandsaur

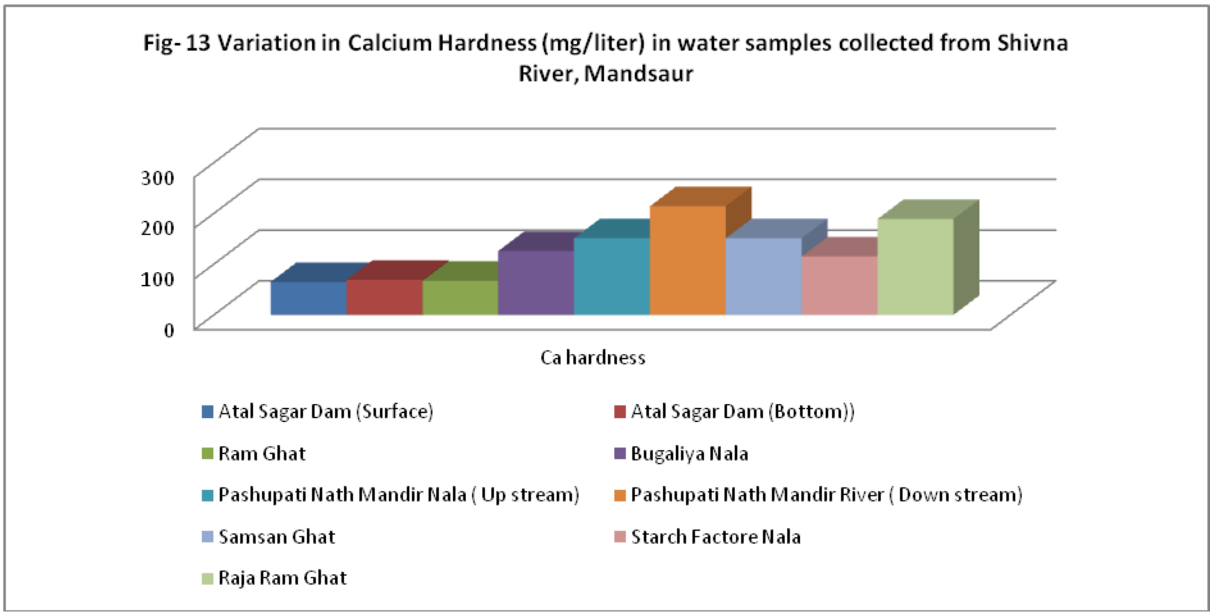
Salve et.al. (2009), reported the values of total hardness between 62 to 236 mg/ liter in Betwa River. Vyas, A. (2007) found similar results with study of Upper and Lower lake Bhopal. Hirekhan and Patil (2003) stated that in the hardness of water, CaC03 is an important measure of pollution and its increase pertains to the excess presence of Ca, Mg and Fe. Nirmal et.al (2003) studied that elevated concentrations of nitrates, phosphates, pH, hardness causing ions, conductivity causes depletion in water quality. Bajpai et. al. (1993) and Tamot et. al. (2006) supports the above observations. Dhamaji et. al. (1995) reported hardness between 94.0 and 167.3 mg/l in Hanuman Tal , Jabalpur. Verma M. N., (1984), conducted a study on Upper Lake Bhopal and found total hardness values between 48.0 and 160.0mg/l. Verma, et. al. (2006) conducted a study on upper lake, Bhopal and found total hardness values between 48 mg/l to 160 mg/l.

13. Calcium Hardness:

Calcium is essential for all organisms, being an important cell wall constituent and regulates physiological functions in animal too. It has direct effect on pH and carbonate system. In most fresh water approximate all the hardness is due to the ions of calcium and magnesium. Hirekhan and Patil (2003) stated that CaCO3 plays an important role in hardness of water. Variation in calcium hardness in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -13&13a.

A. Pre-monsoon Period

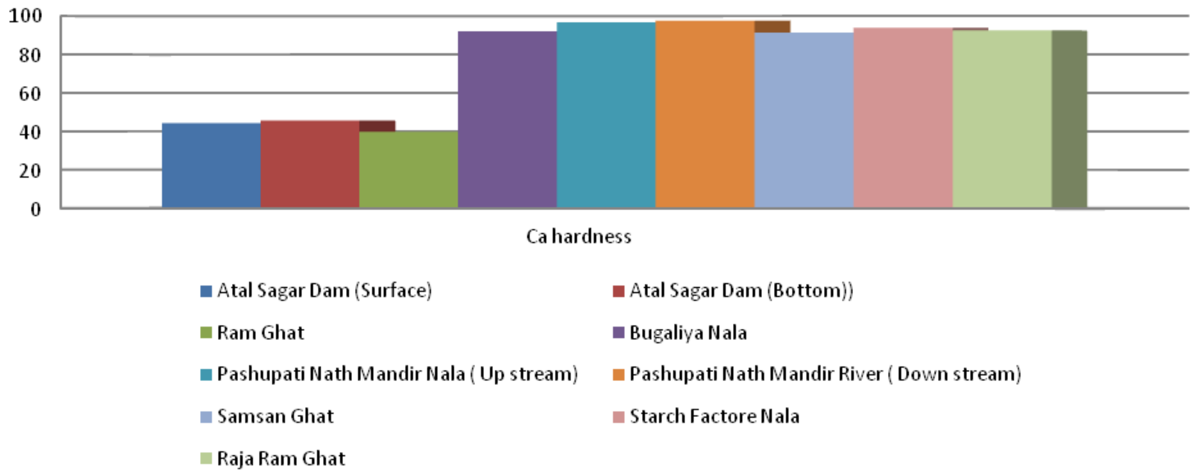
Calcium Hardness during the period of Pre monsoon investigation was found within the range of 65.1 mg/liter to 189 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.



B. Post-monsoon Period

Calcium Hardness during the period of post monsoon investigation was found within the range of 44.3 mg/liter to 97.5 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

Fig- 13a Variation in Calcium Hardness (mg/liter) in water samples collected from Shivna River, Mandsaur



Verma, et. al. (2006) reported calcium hardness in the range of 25.0 and 98.0mg/l in upper lake. The association of calcium with photosynthesis is reported by Wetzel (1975). Similar observations were recorded by Salve, et. al. (2009).

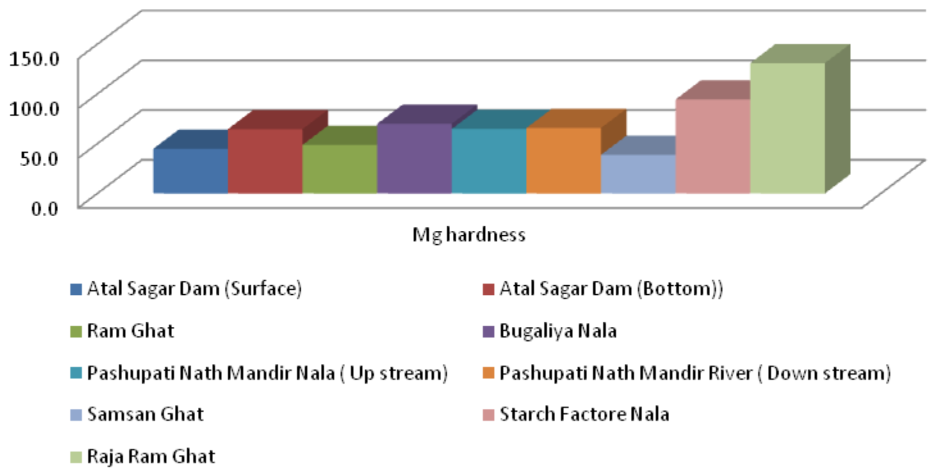
14. Magnesium Hardness:

Variation in Magnesium hardness in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -14&14a.

A. Pre-monsoon Period

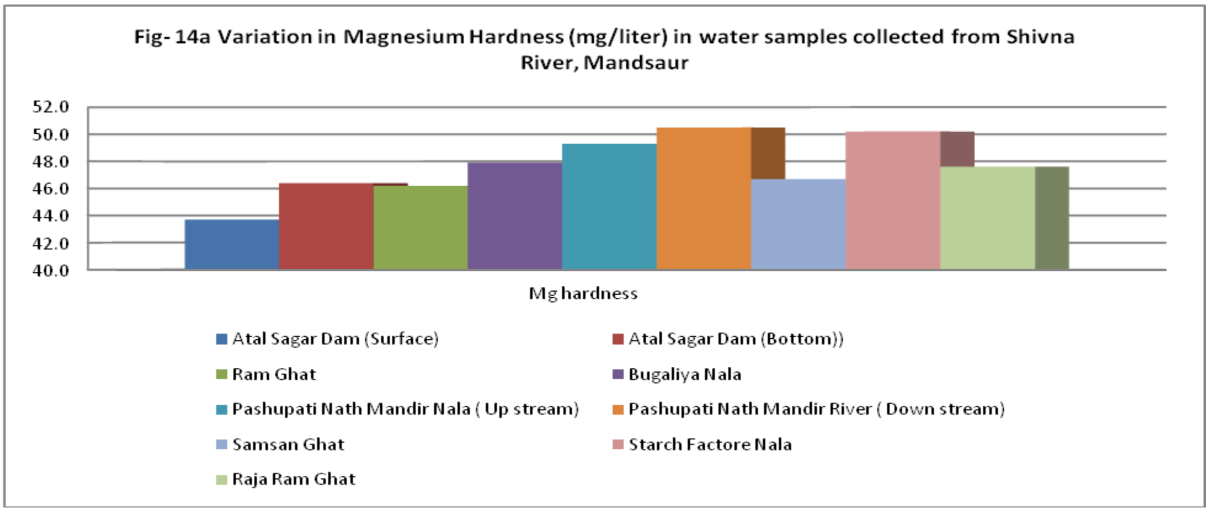
Magnesium Hardness during the period of Pre monsoon investigation was found within the range of 44.9 mg/liter to 131 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

Fig- 14 Variation in Magnesium Hardness (mg/liter) in water samples collected from Shivna River, Mandsaur



B. Post-monsoon Period

Magnesium Hardness during the period of post monsoon investigation was found within the range of 43.7 mg/liter to 50.5 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

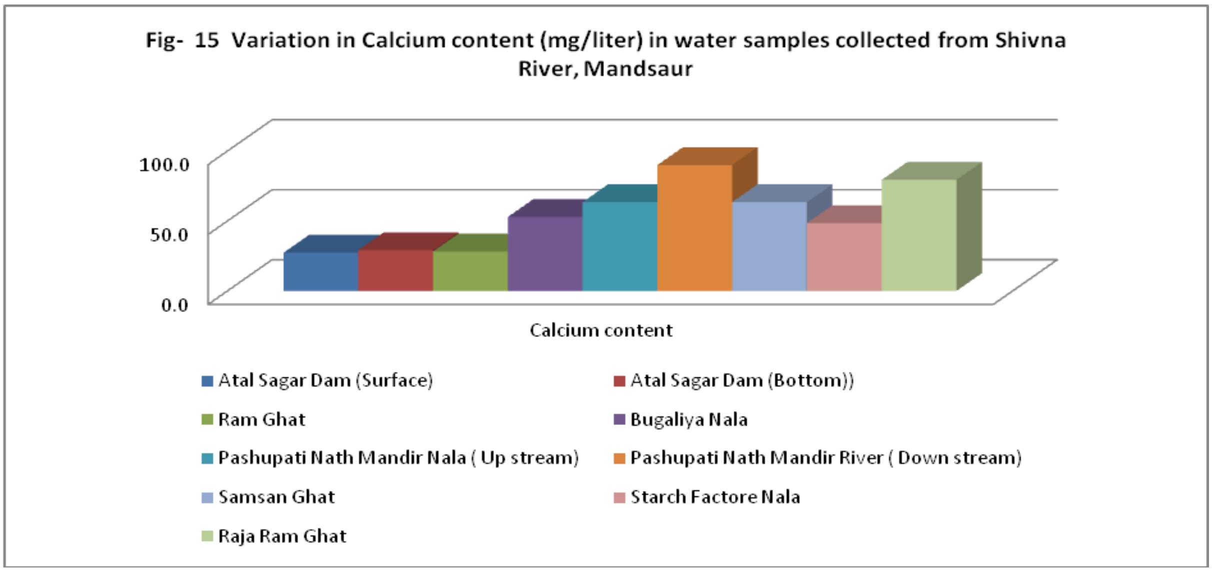


15. Calcium Content:

Variation in Calcium Content in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -15&15a.

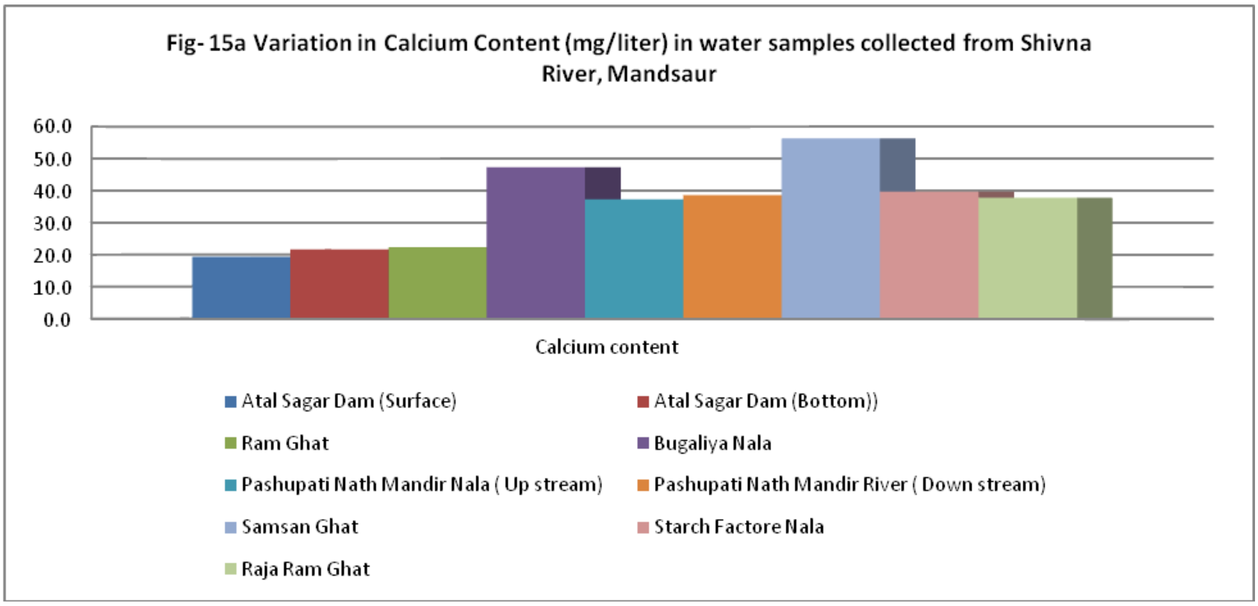
A. Pre-monsoon Period

Calcium Content during the period of Pre monsoon investigation was found within the range of 27.3 mg/liter to 90 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.



B. Post-monsoon Period

Calcium Content during the period of post monsoon investigation was found within the range of 19.3 mg/liter to 56.3 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.

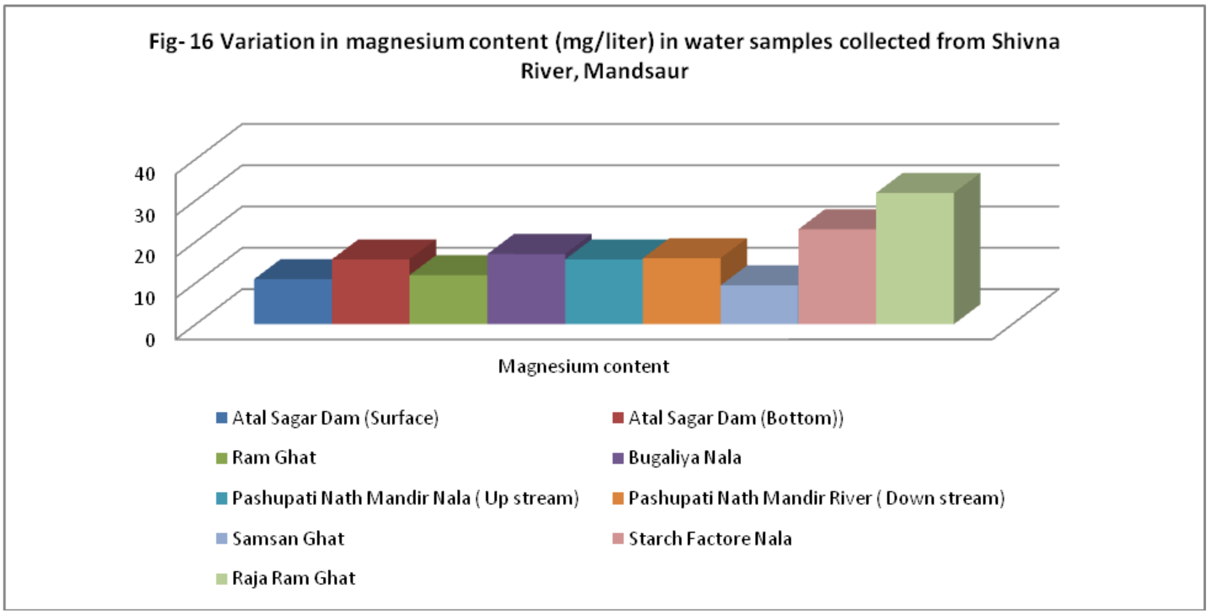


16. Magnesium Content:

Variation in Calcium Content in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -16&16a.

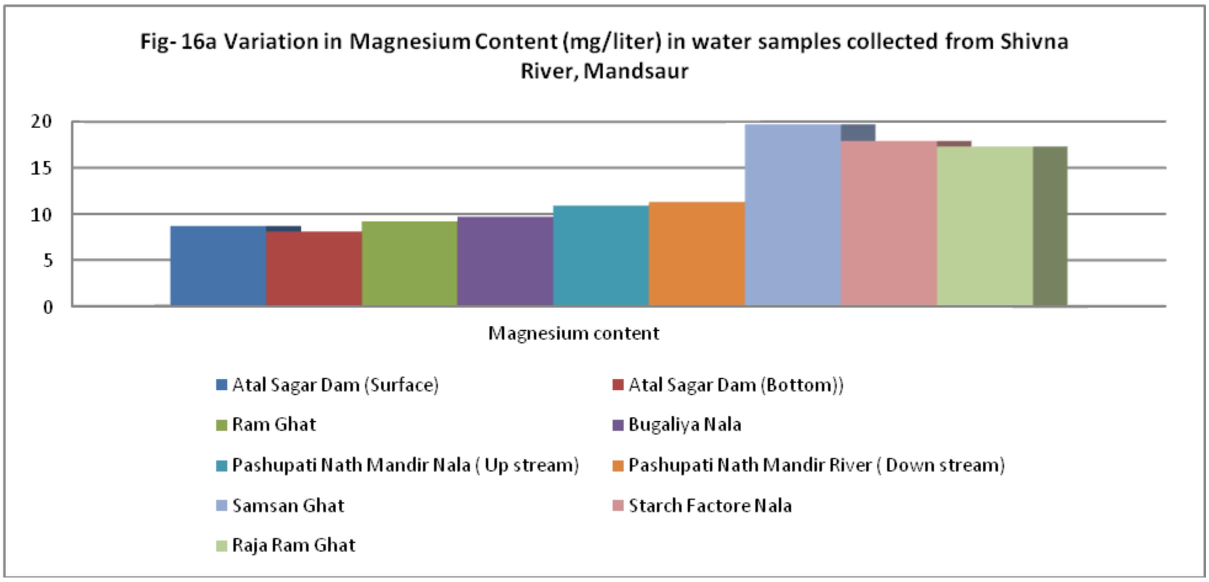
A. Pre-monsoon Period

Magnesium Content during the period of Pre monsoon investigation was found within the range of 10.9 mg/liter to 31.8 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.



B. Post-monsoon Period

Magnesium Content during the period of post monsoon investigation was found within the range of 8.1 mg/liter to 19.7 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.



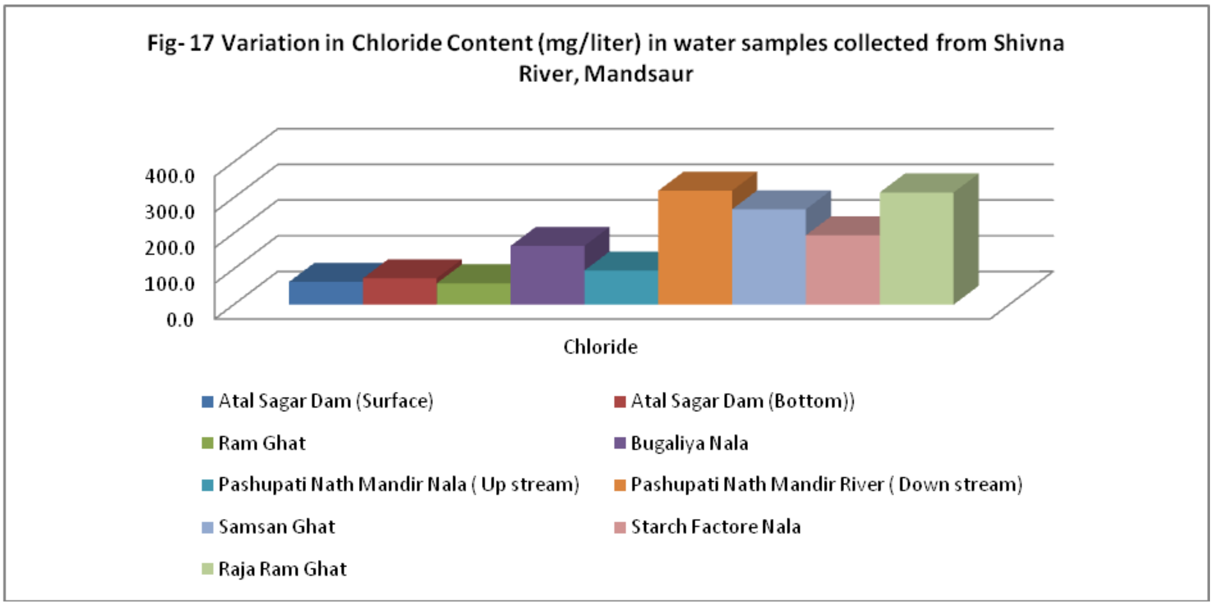
17. Chloride:

Chloride occurs in all natural water in widely varying concentration. As the mineral content increases chloride content also increases. In rivers distinct contamination from domestic sewage can be monitored by chloride test.

Variation in Chloride in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -17&17a.

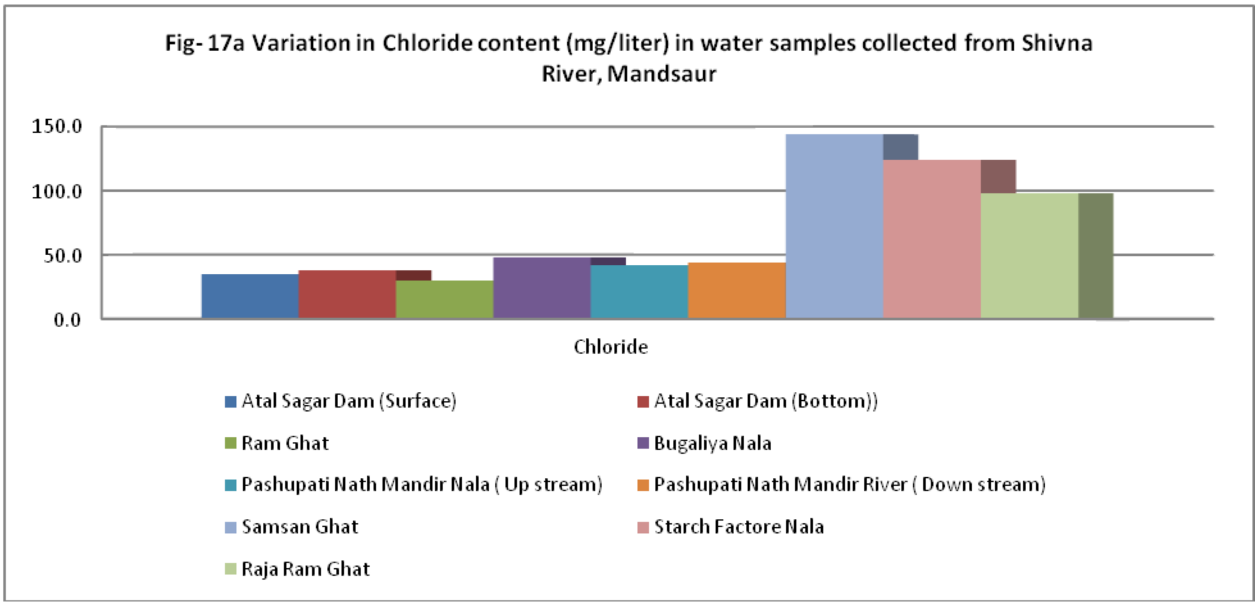
A. Pre-monsoon Period

Chloride values during the period of Pre monsoon investigation were found within the range of 63.9 mg/liter to 319.7 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.



B. Post-monsoon Period

Chloride values during the period of post monsoon investigation were found within the range of 34.9 mg/liter to 143.9 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.



High chloride content indicates pollution in river. High chloride content may also be attributed to quantity of domestic sewage. This observation was also in agreement with Zafar (1959), Shrivastava (1984), Tiwari (2005). Shrivastava (1990) commented that a high value of chloride gives indication of pollution due to sewage and more than 5 to 10 ppm of chloride indicates pollution. Sreenivasan (1968) has also remarked that low chloride value indicates absence of any pollution.

Important contributor of chloride in water is the decomposition of dead aquatic organisms Parvateesam and Gupta (1994) and pollution especially through domestic sewage of the city Ramana et. at. (1994). Bajpai et.al.(1993) observed similar findings of chloride in Upper lake and reported the values in the range of 15.0 mg/L to 42.0 mg/L. Harapanahalli (1994) studied chloride contents in Tawa reservoir in the range of 26.0 mg/L to 140.0 mg/L

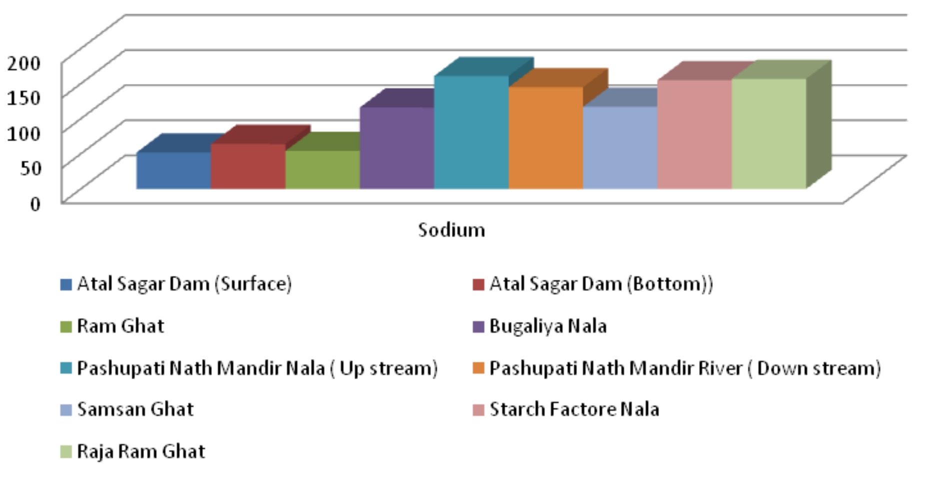
18. Sodium:

Variation in Sodium in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -18&18a.

A. Pre-monsoon Period

Sodium values during the period of Pre monsoon investigation were found within the range of 52.0 mg/liter to 157.0 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

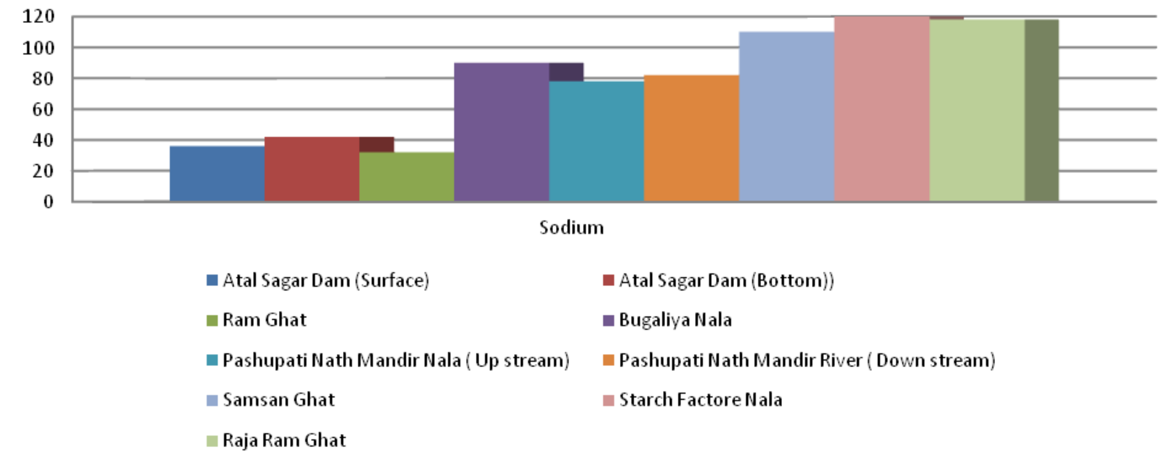
Fig- 18 Variation in Sodium (mg/liter) in water samples collected from Shivna River, Mandsaur



B. Post-monsoon Period

Sodium values during the period of post monsoon investigation were found within the range of 36 .0 mg/liter to 120.0 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

Fig- 18a Variation in Sodium concentration (mg/liter) in water samples collected from Shivna River, Mandsaur



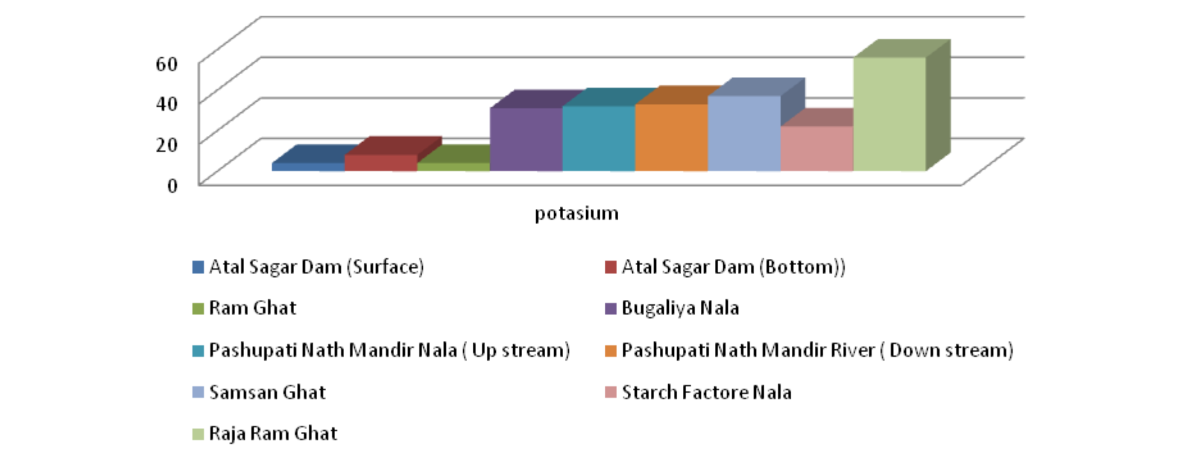
19. Potassium:

Variation in Potassium in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -19&19a.

A. Pre-monsoon Period

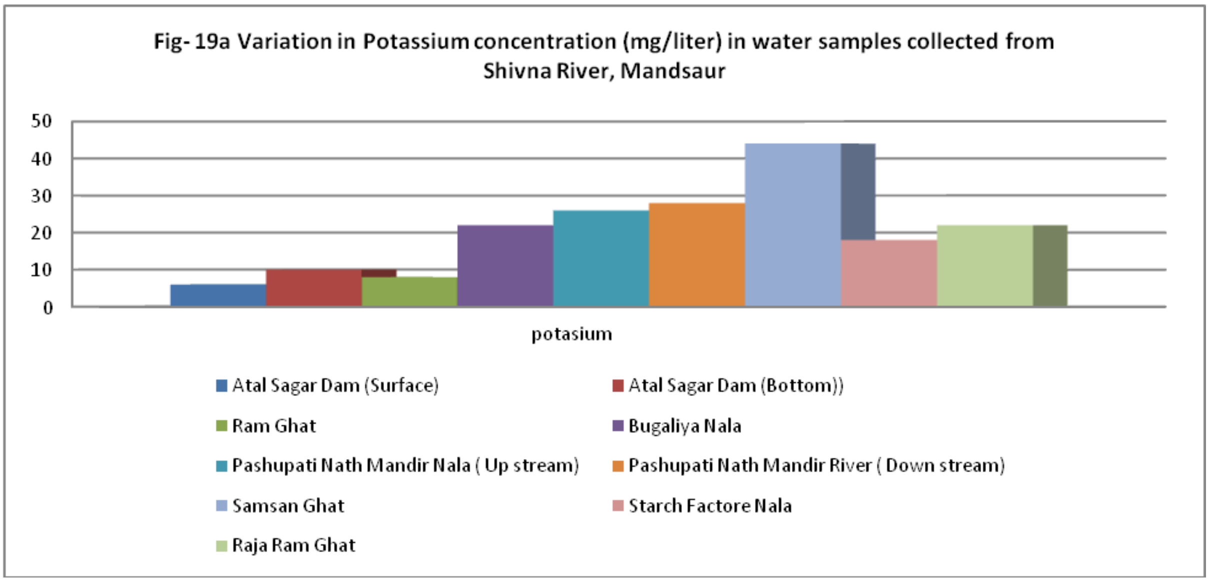
Potassium values during the period of Pre monsoon investigation were found within the range of 4.0 mg/liter to 56.0 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

Fig- 19 Variation in Potassium content (mg/liter) in water samples collected from Shivna River, Mandsaur



B. Post-monsoon Period

Potassium values during the period of post monsoon investigation were found within the range of 6.0 mg/liter to 44.0 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-9.

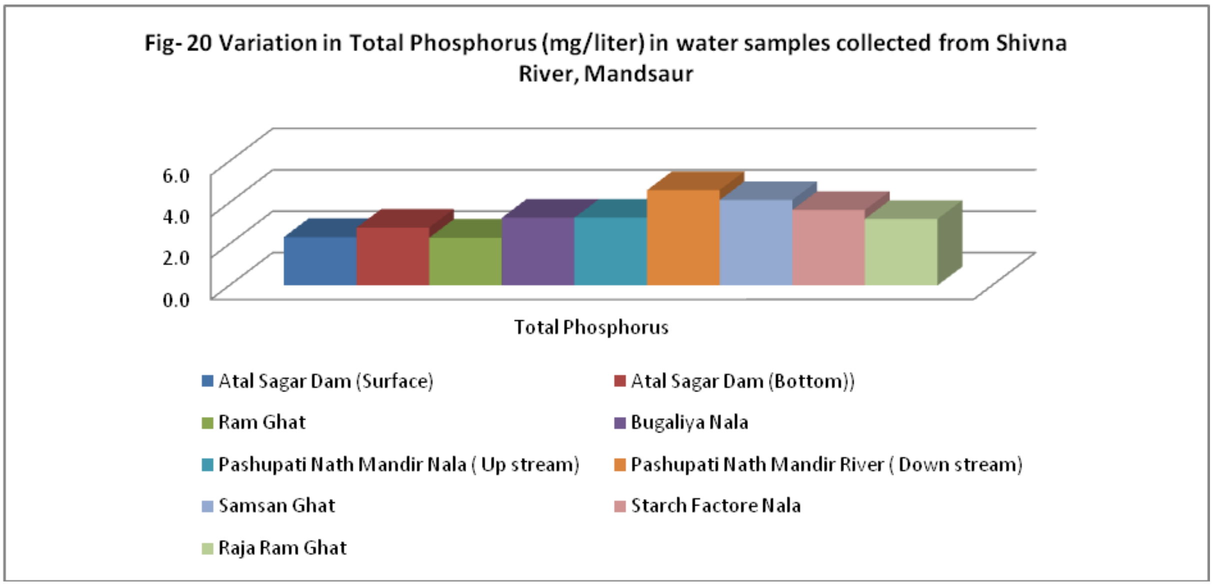


20. Total Phosphorus:

Variation in Total Phosphorus in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -20&20a.

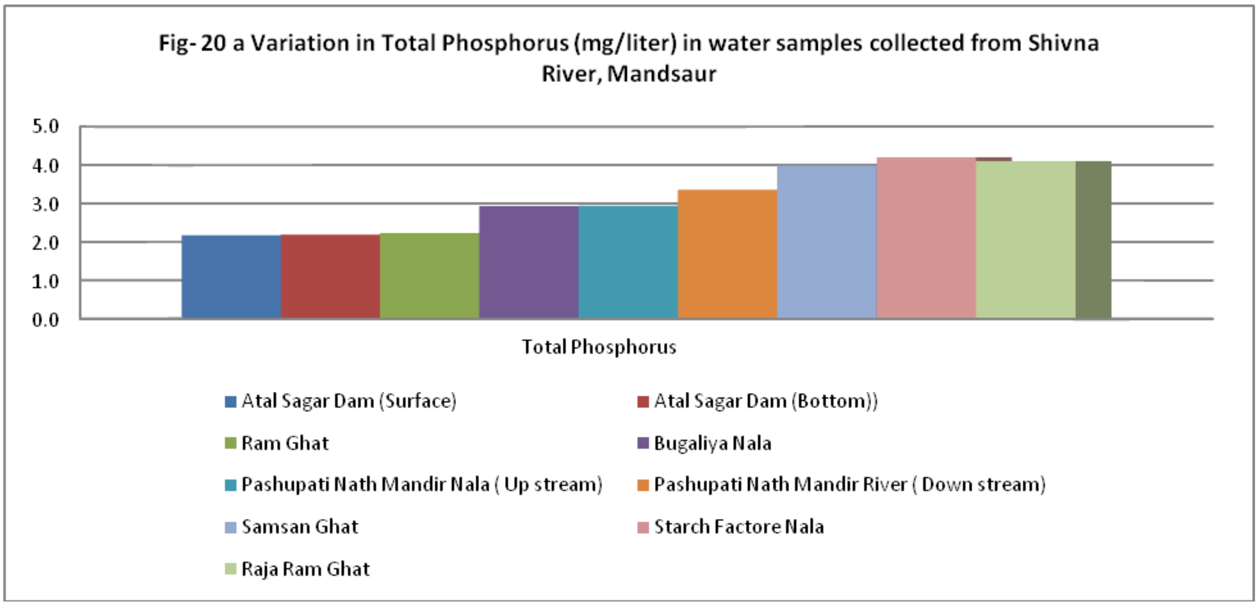
A. Pre-monsoon Period

Total Phosphorus values during the period of Pre monsoon investigation were found within the range of 2.3 mg/liter to 4.6 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.



B. Post-monsoon Period

Potassium values during the period of post monsoon investigation were found within the range of 2.3 mg/liter to 4.6 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.

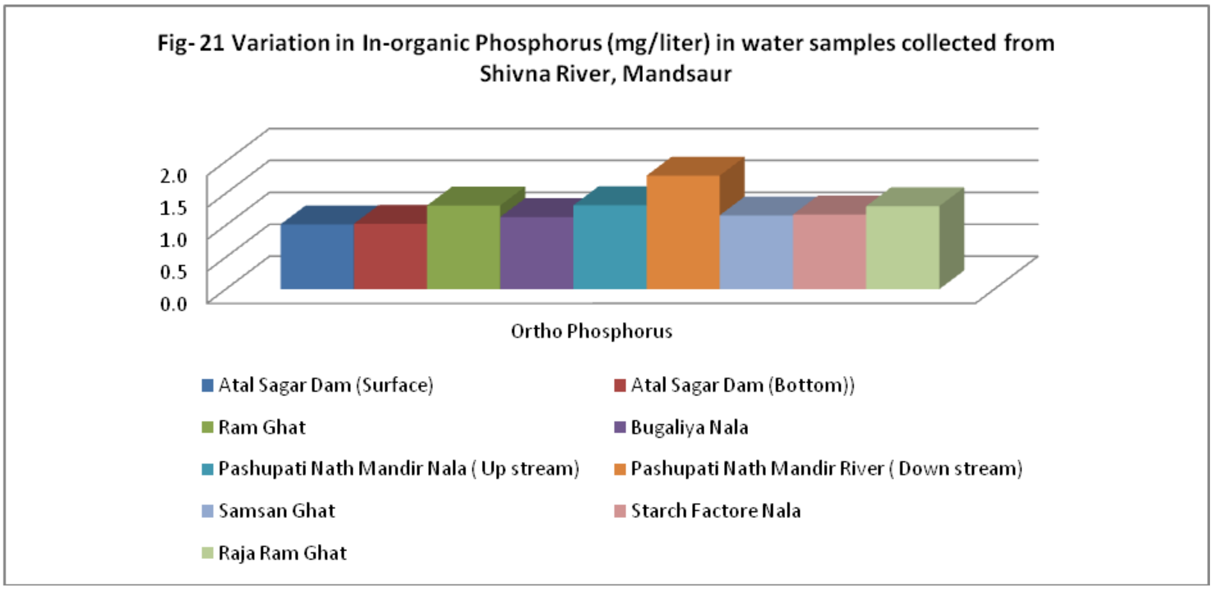


21. In-organic Phosphorus:

Variation in In-organic Phosphorus in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -21&21a.

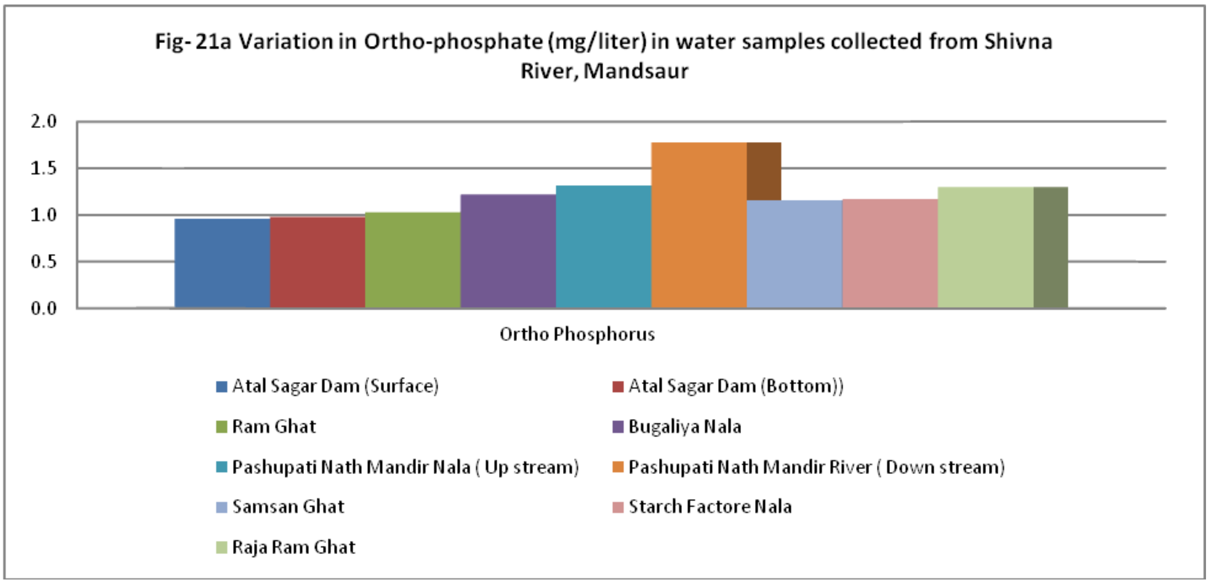
A. Pre-monsoon Period

In-organic Phosphorus during the period of Pre monsoon investigation was found within the range of 1.0 mg/liter to 1.8 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.



B. Post-monsoon Period

In-organic Phosphorus during the period of post monsoon investigation was found within the range of 1.0 mg/liter to 1.8 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-6.

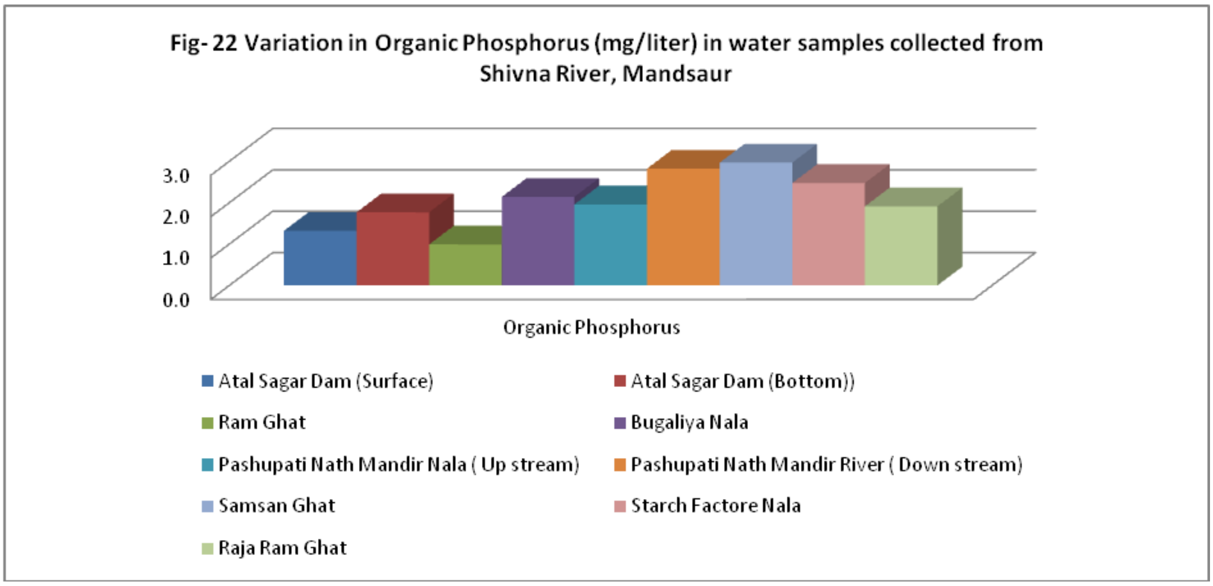


22. Organic Phosphorus:

Variation in In-organic Phosphorus in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -22&22a.

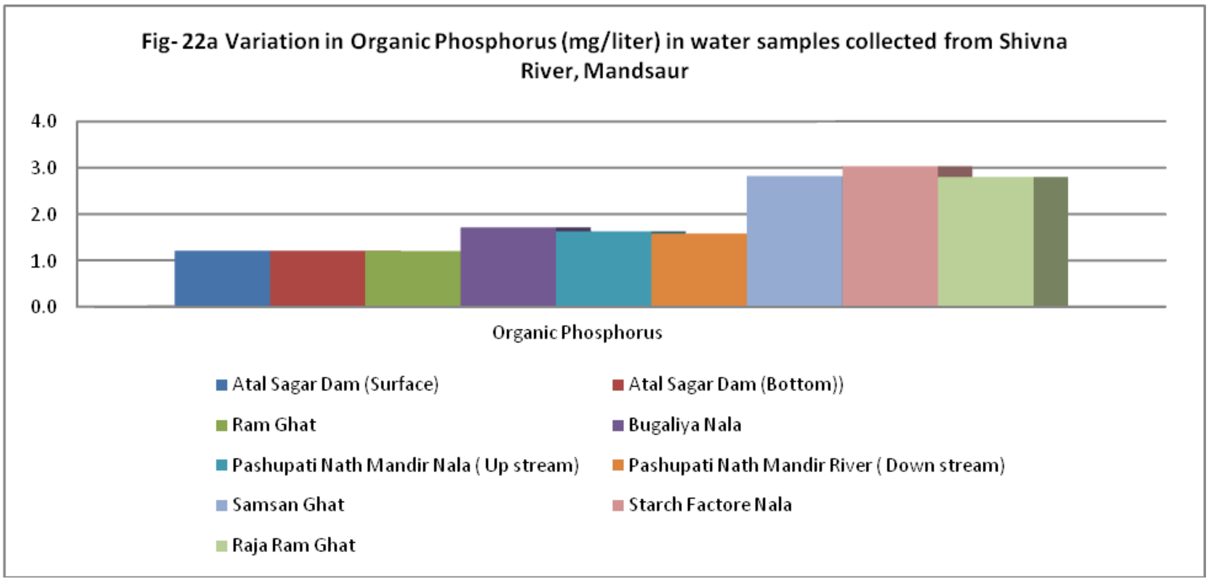
A. Pre-monsoon Period

Organic Phosphorus during the period of Pre monsoon investigation was found within the range of 1.0 mg/liter to 3.0 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-6



B. Post-monsoon Period

Organic Phosphorus during the period of post monsoon investigation was found within the range of 1.0 mg/liter to 3.0 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-6



The element phosphorus is necessary for plant and animal growth. Nearly all fertilizers contain phosphates (chemical compounds containing the element, phosphorous). When it rains, varying amounts of phosphates wash from farm soils into nearby waterways. Phosphates stimulate the growth of plankton and water plants that provide food for fish. This may increase the fish population and improve the waterway's quality of life. If too much phosphate is present, algae and water weeds grow wildly, choke the waterway, and use up large amounts of oxygen, due to which many fish and aquatic organisms may die. Phosphates may come from fertilizers, pesticides, industry, and cleaning compounds into the water. Natural sources include phosphate-containing rocks and solid or liquid wastes.

Phosphates enter waterways from human and animal wastes (the human body releases about a pound of phosphorus per year), phosphate-rich rocks, wastes from laundries, cleaning and industrial processes, and farm fertilizers. Phosphates also are used widely in power plant boilers to prevent corrosion and the formation of scale.

Phosphorous is probably the most important parameter for plankton growth. Presence of high phosphorus indicates high trophic status supporting profuse algal growth. The water quality of Shivna river is poor and pollutants of both organic and inorganic origin are entering into the river and deteriorating water quality.

Vyas, A. (2007) found similar observations with study of Upper and Lower lake Bhopal. Nirmal et. al. (2003) studied that elevated concentrations of nitrates, phosphates, pH, hardness causing ions, conductivity causes depletion in water quality. Higher values due to rains were also be observed by Vyas et. al. (2006). Similar finding was supported by Bajpai, A. (1994). Tiwari et. al., (2005) and Tamot and Sharma (2006) found higher concentration of phosphate in winter season in lake water. Vaish et. al. (2010) reported higher values of phoshate in the stations nreaby agricultural fields of Betwa River.

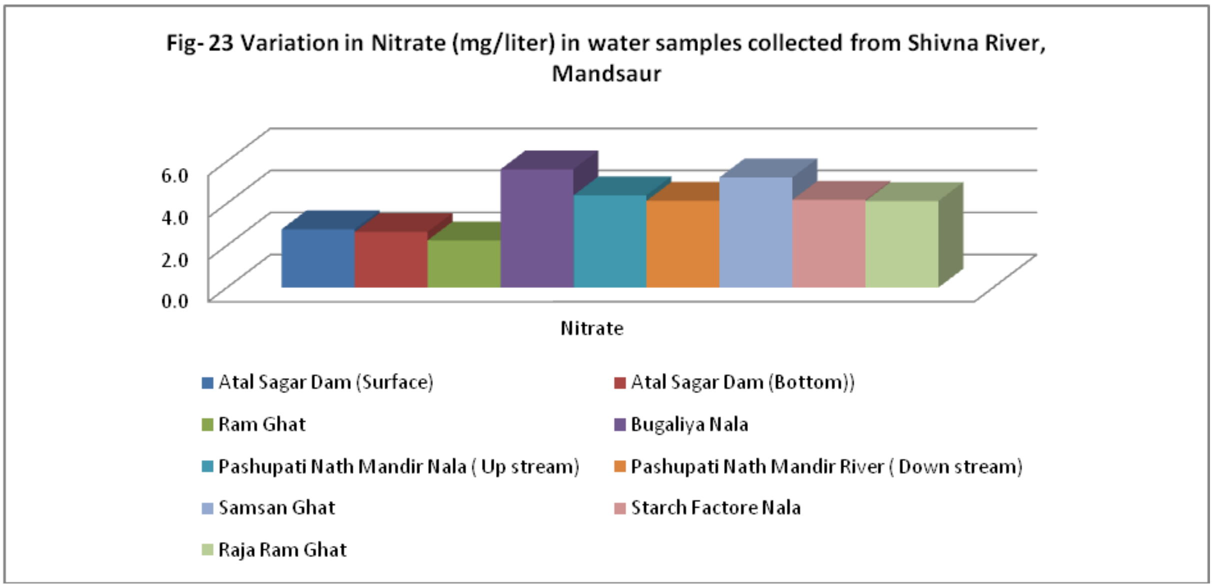
23. Nitrate:

Nitrate is a form of the element Nitrogen, which makes up about 80 percent of the air we breathe. As an essential component of life, nitrogen is recycled continually by plants and animals, and is found in the cells of all living things. Organic nitrogen (nitrogen combined with carbon) is found in proteins and other compounds. Inorganic nitrogen may exist in the Free State as a gas, as ammonia (when combined with hydrogen), or as nitrite or nitrate (when combined with oxygen). Nitrites and nitrates are produced naturally as part of the nitrogen cycle, when bacteria breaks down 'production line' toxic ammonia wastes first converts into nitrite, and then into nitrate as a sources of nitrites and nitrates.

Variation in Nitrate in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -23&23a.

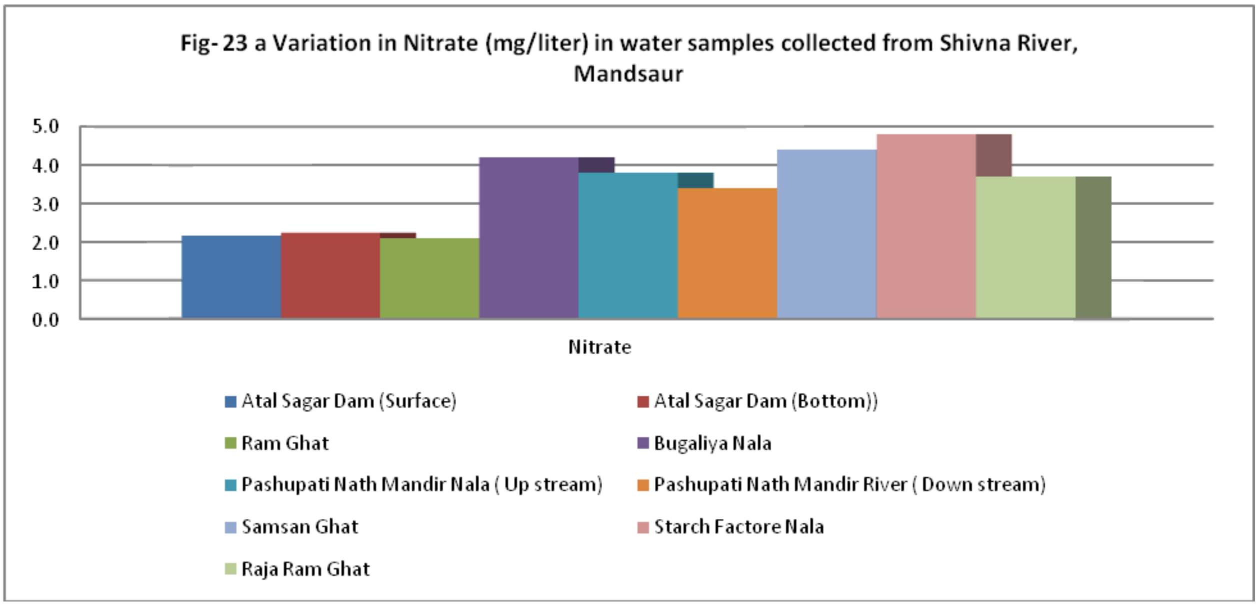
A. Pre-monsoon Period

Nitrate values during the period of Pre monsoon investigation were found within the range of 2.2 mg/liter to 5.6 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-4.



B. Post-monsoon Period

Nitrate values during the period of post monsoon investigation were found within the range of 2.2 mg/liter to 5.6 mg/liter. The minimum value was observed at station –3 while the maximum value was recorded at station-4.



Nutrients like nitrogen and phosphorus also enter our water from farms. Manure and other fertilizers are used to increase crop production. When these nutrients reach our streams and rivers, they have the same effect on aquatic plants. Aquatic plant and algae growth can reach nuisance levels. Decomposing plants also consume dissolved oxygen. When less oxygen and warmer temperatures are combined, things change.

Nitrates at some extent stimulate the growth of plankton and water weeds that provide food for fish. This may increase the fish population, Vaish et. al (2010). However, if algae grow too wildly, oxygen levels will be reduced and fish will die. The Bureau of Indian Standard (1991) has established 45mg/L of nitrate as the desirable limit for public drinking water. Nitrate-nitrogen levels below 90 mg/L and nitrite levels below 0.5 mg/L seem to have no effect on warm-water fish, but cold-water fishes are more sensitive for this.

Nitrates derived from agriculture sources. The introduction of large quantity of nutrients, mainly nitrogen and phosphorus to lake water can cause eutrophication problems (Kouimtzis et. al., 1994, Fytianos et. al., 2002). Nutrient pollution especially not only with phosphorus but also with nitrogen coming from urban runoff and sanitary sewer systems can lead to eutrophication of the receiving water bodies, Stevens, (2005). Dubey (2003) found nitrate in upper lake between 0.06mg/L to 1.15 mg/L. Increased nutrient inputs in fresh water runoff are some of the most significant and widespread casual factor, Kodarkar (2005). Amit et. al. (2010) studied that availability of nutrient is directly proportional to primary production.

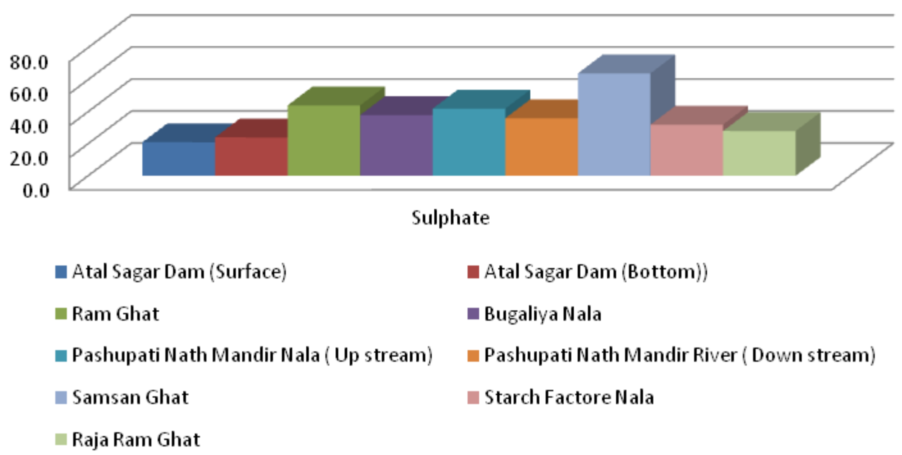
24. Sulphate:

Variation in Sulphate in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -24&24a.

A. Pre-monsoon Period

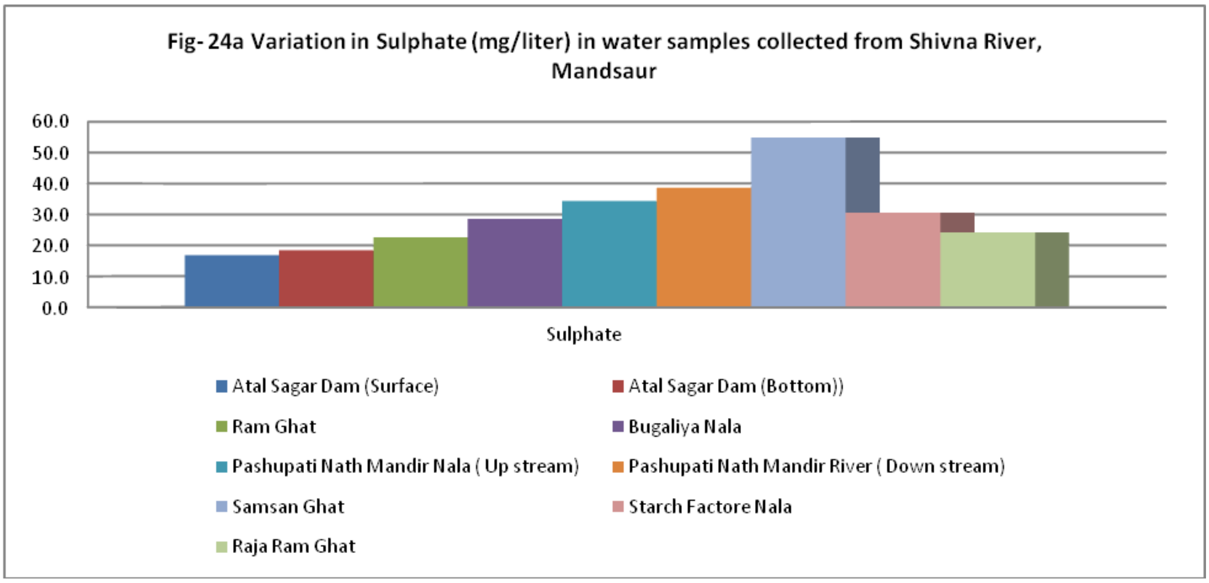
Sulphate values during the period of Pre monsoon investigation were found within the range of 21 mg/liter to 64 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-7.

Fig- 24 Variation in Sulphate (mg/liter) in water samples collected from Shivna River, Mandsaur



B. Post-monsoon Period

Sulphate values during the period of post monsoon investigation were found within the range of 21 mg/liter to 64 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-7.

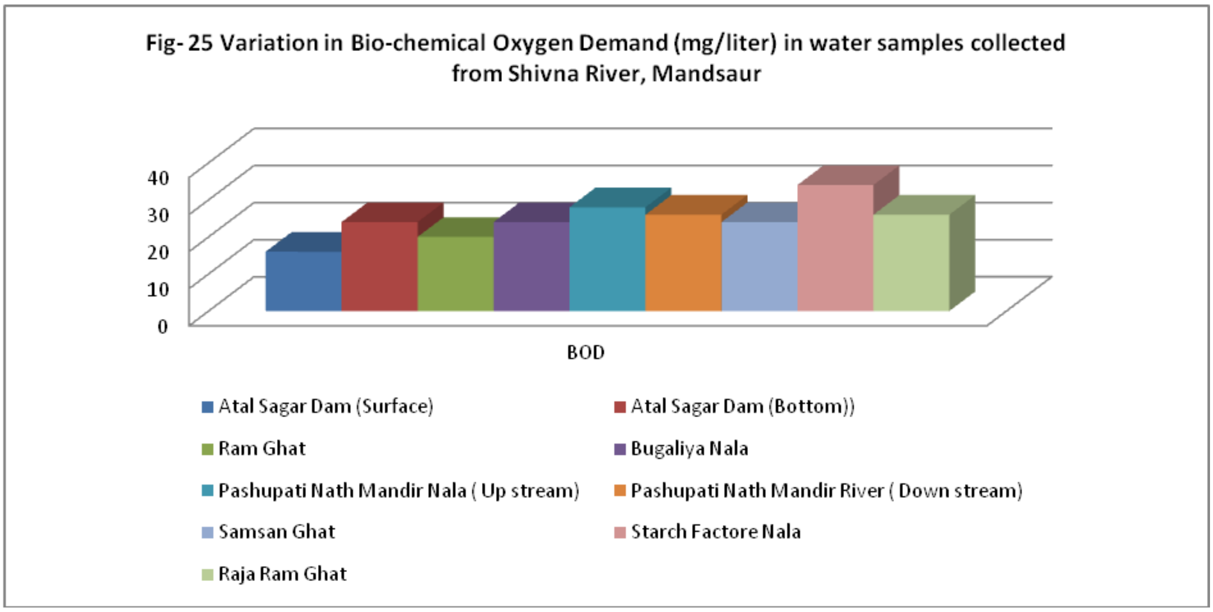


25. Bio-chemical Oxygen Demand (BOD):

Variation in BOD in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -25&25a.

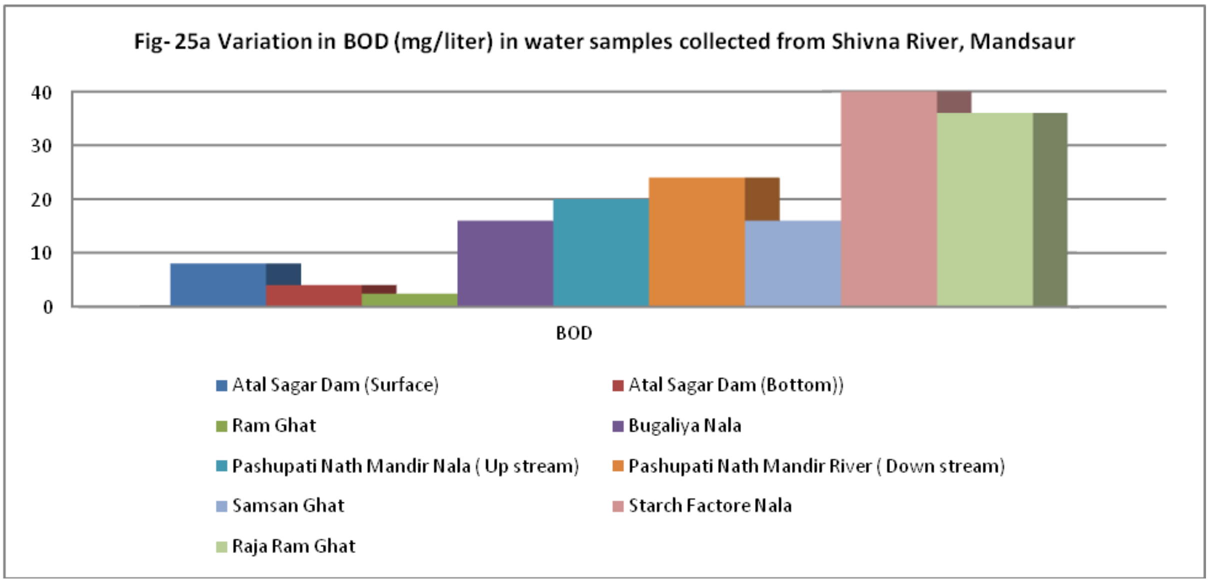
A. Pre-monsoon Period

BOD values during the period of Pre monsoon investigation were found within the range of 16 mg/liter to 34 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-8.



B. Post-monsoon Period

BOD values during the period of post monsoon investigation were found within the range of 16 mg/liter to 34 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-8.



As mentioned earlier BOD is used as a measured of biodegradable organic compounds, which from a reasonable fraction of organic matter in lakes. In recent times, with the increase of pollution by large amount of various chemically oxidizable organic substance of different nature entering in the aquatic system, BOD alone does not give a clear picture of the organic matter contents of the sample. Furthermore, the presence of various toxicants in the samples may severely affect the validity of the BOD test. Hence, COD is better estimate of the organic matter, which needs no sophistication and is time savings.

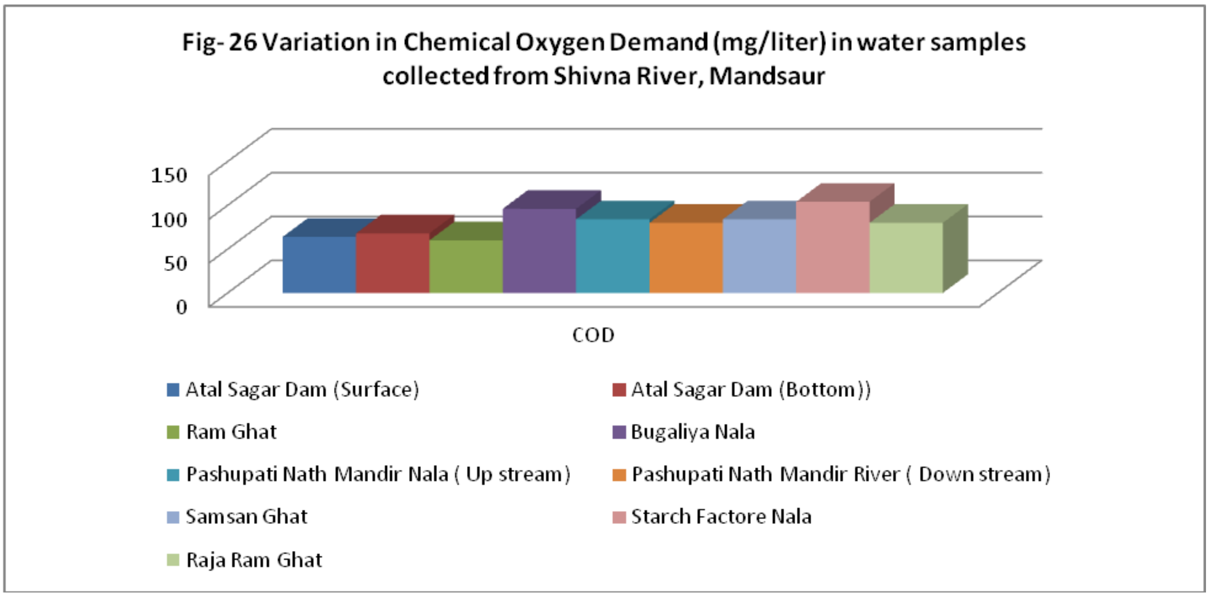
However, COD i.e., the oxygen consumed (OC) does not differentiate the stable organic matter from the unstable form. Therefore, the COD values are not directly comparable to that of BOD furthermore, some cyclic organic compounds are not oxidized; whereas, on the other hand many inorganic compounds like nitrates, sulphides and reduced metal ions get oxidized. Samples containing chlorides more than 2 g/l, the chloride ions are oxidized to chlorine giving erroneous results. Despite these limitations COD is still an important parameter for estimate the carbonaceous fraction of the organic matter much closer to the actual amounts.

26. Chemical Oxygen Demand:

Variation in COD in surface water at different stations of Shivna River during the study period is depicted in Table-A, Figure -26&26a.

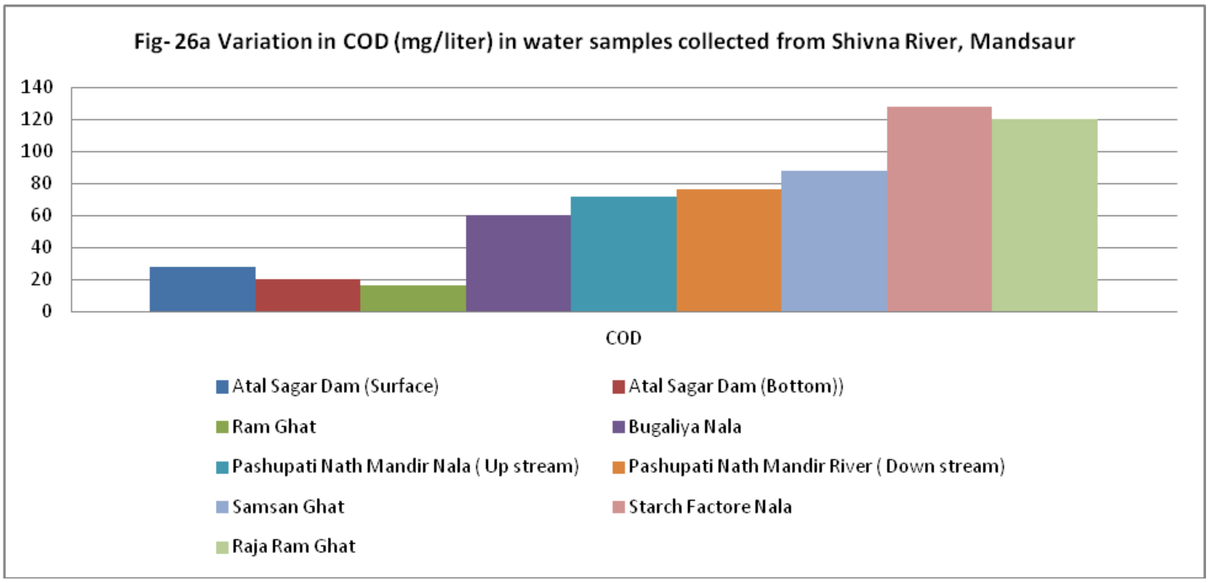
A. Pre-monsoon Period

COD values during the period of Pre monsoon investigation were found within the range of 64 mg/liter to 104 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-8



B. Post-monsoon Period

COD values during the period of post monsoon investigation were found within the range of 64 mg/liter to 104 mg/liter. The minimum value was observed at station –1 while the maximum value was recorded at station-8



Hence, COD is better estimate of the organic matter, which needs no sophistication and is time savings.

However, COD i.e., the oxygen consumed (OC) does not differentiate the stable organic matter from the unstable form. Therefore, the COD values are not directly comparable to that of BOD furthermore, some cyclic organic compounds are not oxidized; whereas, on the other hand many inorganic compounds like nitrates, sulphide and reduced metal ions get oxidized. Samples containing chlorides more than 2 g/l, the chloride ions are oxidized to chlorine giving erroneous results. Despite these limitations COD is still an important parameter for estimate the carbonaceous fraction of the organic matter much closer to the actual amounts.

Biological status

A. Phytoplankton Community:

In Shivna River qualitative analysis of phytoplankton community depicted presence of 9 species of Phytoplankton during the period of investigation. In general blue green algae were observed to be present at all the stations.

1. *Amphora sp*
2. *Epithemia sp*
3. *Melosira sp*
4. *Microcystis aeruginosa*
5. *Navicula sp*
6. *Oscillatoria sp*
7. *Pediastrum simplex*
8. *Phormidium sp*
9. *Rivularia sp*

B. Zooplankton community

Qualitative analysis of Zooplankton community in Shivna River depicted presence of 11 species of zooplankton during the period of investigation. In general class rotifera were observed to be present in most of the stations.

1. *Anuraeopsis sp*
2. *Bosmina longispina*
3. *Brachionus bidentata*
4. *Brachionus calciflorus*
5. *Brachionus quadridentata*
6. *Ceriodaphnia reticulata*
7. *Cyclops viridis*
8. *Cypris sp*
9. *Keratella cochlearis*
10. *Keratella tropica*
11. *Lepadella sp*

C. Macrophytes

Name of species	Salient Feature	Representative Photo
Trapa bispinosa	• Annual or Perennial. • Found in still or slowly flowing water, the seedlings are submerged, the adult leaves float in rosettes. • It is frequently cultivated in Asia, where it is a staple food. • The fruits are eaten raw or cooked; & they are also used for making flour. • Large populations may be very troublesome to navigation, Fisheries and recreation.	
Nymphoides nouchali:	• Mostly annual, sometimes perennial. • Deeply rooted in mud in water bodies. The roots may give rise to new shoots. • It flourishes as long as it has sufficient water. • The leaves are used in medicine for Ulcers & bites, it is also claimed to	

	be a helminthic. • Flowers and Fruit during winter season.	
Ceratophyllum demersum	• Shoot tip often with shortened internodes giving it a "Bottle brush" appearance. • Almost cosmopolitan. • Often gregarious in eutrophic water & sometime troublesome. • Flowers from January to March and fruits later.	
Myriophyllum spathulatum	• Stem submerged, floating or ascending, upper part, usually emergent. • Perennial or perhaps sometimes annual. In water in tanks, Lakes & Marshes. • Flowers and fruits in Nov. & Dec.	
Hydrilla verticillata	• Mostly annual but sometimes perennial. • Totally submerged, Growing in still or slowly flowing waters. • Grass carp readily eats it but mostly chemical control is used.	

Najas minor:	• Annual, • Submerged • Characteristically found in habitats, which show great fluctuations in water level or even dry out annually such as tanks.	
Polygonum glabrum	• Stem erect, shrubby up to + 2.5m tall • Perennial or annual • Gregarious along watercourses also found in marshes • It is often dominant along lakes, rivers where it withstands considerable flooding and swift currents • Tender branches used as vegetable in Rajasthan • It is also used for dispelling fever and colic. Flowers & fruiting from Sept. to March.	

Conclusion

Madhya Pradesh is very rich in river systems. Narmada, Betwa, Tapti, Chambal, Sone, Kshipra, Mahi, etc. are the river wealth of Madhya Pradesh. Narmada and Betwa rivers are the major river systems of Madhya Pradesh and approximate half of the area is dependent on these systems directly or indirectly. Shivna is also one of the major rivers in Mandsaur region catering various services of both rural and urban catchments.

In last few decades most of these rivers are suffering from water quality deterioration due to various anthropogenic therefore availability of adequate quantity of potable water has become a prime cause of concern necessitating the need for water quality assessment of these water sources.

Considering the above problem in mind the water quality assessment of Shivna River at Mandsaur town was analysed in two seasons (Pre monsoon and post monsoon) of 2019. Sampling was carried out from eight different locations of the River covering a stretch of about 10 Kms to assess the impact of agricultural residues, industrial effluents on the water quality and bio-diversity of the river. The study was focused to investigate the impact of such factors on the water quality of the river especially on potability as well as the biodiversity as on many occasions mortality of fishes have been reported from some locations.

The anthropogenic impact on the water quality in the downstream of the river is reflected by variations in different physico-chemical parameters conducted at two intervals during the study period. Conspicuous seasonal variations in physico-chemical parameters of the river have been observed at some stations due to variation in the catchments, structure and consequence anthropogenic, agricultural and industrial activities.

The inflow of nutrients in the form of untreated sewage from the adjacent settlements and also high accumulation of silt from the eroded banks of the river has resulted in profuse growth of submerged macrophytes especially at Station-5, Station-6 & 7. The growth of macrophytes especially *Eichhornia crassipes* further confirms nutrient enrichment of the river water especially nitrate and phosphate. The accumulation of nutrient in the river water is further accelerated by erosion of nutrient rich soil and silt from the agricultural catchment with very poor reflection of biodiversity. The death and decay of the vegetal mass in the river and its seasonal turn over further enriched the river water with nutrients. The deterioration in water quality of the river has reached to an alarming level and can leading towards eutrophication. In general the river is highly polluted due to addition of organic load.

Almost all the sampling points showed very high values in nutrient parameters especially Phosphorus, and Nitrate-Nitrogen. A significant part of the river was observed to be anoxic as oxygen was found to be present in upper stretch of the river (Sampling Stations 1, 2 &3). Rest of the stretches was influenced by discharge of sewage and solid wastes which not only deteriorated the water quality to an alarming level (conforming to Class D of CPCB Standard of designated best use) but also made survivality of the other living organisms difficult. The entire bio-diversity of the river is at stake and many species are vulnerable to extinction. The ecosystem of the river needs to be restored with necessary remedial measures.

The analysis of various parameters for pre monsoon season indicates a very poor state of river water quality. However a fair conclusion can be drawn after compilation of data of Post Monsoon season.

The quality of water at different stations of Shivna River has been observed to be highly variable with varied diversity of phytoplankton, zooplankton and macrophytes. The river water in general was observed to have very higher concentration of nutrients like Nitrate and Phosphate at Bugaliya Nalla, near Pashupati Nath Temple, Samsan Ghat stations. The quality of water observed to be deteriorated at these stations possibly due to accumulation of nutrients received in the form of sewage from the adjoining residential areas mainly through Bugaliya Nalla. In addition to this the inflow of nutrient through silts as a result of intensive agricultural practices probably another important factor in increasing the nutrient concentration in these locations of the river.

The main observations based on selected limnological parameters during the period of study can be concluded as follows:

- Total dissolved solids were recorded very high at cremation ghat due to dispose of ashes and other solid waste during both the season.
- The water quality at sampling stations at S-1 and S-2 observed to be better in comparison to rest of the stations, as higher values of dissolved oxygen were recorded in these two stations. This could be due to less exposure of the catchments to human activities.

- Lower concentration of dissolved oxygen recorded at station S -3, 4, 5 & 6 onwards may be due to inflow of domestic sewage mainly through Bugaliya Nalla as these sampling stations are situated amidst densely populated area.
- Higher values recorded for total hardness and total alkalinity at Station-3 ,4 &5 may be due to joining of hardness causing ions and salts through surface runoff especially during rainy season.
- Nutrients such as nitrate, phosphate were also recorded very high during post monsoon season especially at Station-4, 5, 6 & 7. This may be because of accumulation through surface runoff from agricultural fields in catchment areas.
- The biological characteristics of the Shivna River depicted wide variation in both flora and fauna at different stations. Significant variations in biological diversity at different stretches of the river were observed during the entire period of investigation. The highlights of the biotic community of Shivna River are as under:
    - The algal community was observed to be primarily dominated by the Chlophyceae, Bacillariophyceae group. Maximum number of phytoplankton species was observed at Station S-1 followed by S-2. However density of phytoplankton species varied at different station. The important species recorded in various stations are *Scenedesmus armatus* (St-2), Epithemia sp (St-1) and Rivularia sp (St-7).
    - The zooplankton community on the other hand was mostly represented by Rotifera group. Total 14 species of zooplankton were observed during present investigation. At Station S-1 and S-2 presence of all the zooplankton species were recorded. Maximum density of zooplankton species was observed for Cyclops (St-2) and Nauplius larva (St-1).
    - The macrophytic vegetation was observed to be poorly developed in most of the places. However they are scantly observed in almost all the stations in patches. The macrophyte community remained confined to the places where the river water becomes stagnant for some time. Maximum number of Macrophyte species was observed at Station S-7. Macrophytic vegetation included almost all the groups viz. Free Floating, Submerged and Emergent species.

During the period of investigation although most of the parameters in general were observed to be very high and may be placed in the category of: permissible limits of class – D of Central Pollution Control Board, New Delhi, under designated best uses of water for irrigation and drinking water after conventional treatment however accumulation of nutrients at few places has been witnessed. In future if the inflow of untreated industrial effluents and agricultural waste continues, the quality of river may further get deteriorated to an alarming level. But parameters, such as higher accumulation of nutrients at few places could be alarming for the ecological sustainability in the river.

The present study affirms that in last few decades the river has witnessed the adversity of the nature as well as growing anthropogenic pressure like inflow of sewage, dumping of solid wastes , establishment of industries without effective wastewater treatment facilities in the fringe area and withdrawal of excessive water for irrigation etc. These factors ultimately resulted in reducing the carrying capacity of the river with irregular flow. The water quality of the river as a result has deteriorated at many places because of the combination of these factors.

Inferences:

A close perusal of data generated while monitoring different indicative parameters reveals that Shivna River is severe victims of anthropogenic activities and water quality of the river is severely degraded when compared with the CPCB standards as very high values of BOD and COD have been observed at almost all the stations from where samples were collected.

Designated-Best-Use	**Class of water**	**Criteria**
Drinking Water Source without conventional treatment but after disinfection	**A**	• Total Coliforms Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	**B**	• Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more

		• Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	**C**	• Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	**D**	• pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	**E**	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D & E Criteria

Suggestion and recommendations

The present study was carried out in two seasons of 2019. The identification of sampling stations was done on the basis of problem or situation of the site. The general observation during the study is that the sampling stations which were situated in the upstream and comparatively far away from habitations are less polluted. On the basis of the study following suggestions and recommendations are made

- Shivna River is one of the life lines in the regions. However in last few decades the regular inflow in this river is affected due to many reasons, insufficient inflow of rain water from the catchment, illegal drawl of water by the farmers and discharge of waste water from the industries being some of the reasons. Therefore adequate measures should be taken for ensuring maximum availability of water from its catchment during monsoon by widening and deepening the river and also the inflow channel like Bugaliya joining the river. The illegal drawl of water should also be regulated.
- Periodical De-silting and De-weeding operation should be conducted to remove the excess silt and weeds.
- The bank and fringe areas of the river should be protected from erosion by afforestation and landscaping.

- Industries situated near the Shivna River are polluting the river with starch, chemicals and other pollutants, so, the discharge from these industries should be treated before their disposal.
- Entry of domestic sewage should be prevented.
- Disposal of solid wastes into the river especially from the Temple areas should be strictly prohibited.
- Idol immersion is also taking place at some places along the river; this should be diverted by providing alternative ghats.
- Organic farming should be promoted in the agricultural fields situated in the catchment area of the river.
- Animal intervention should be stopped to prevent the pollution from animal origin.
- Vehicle washing was also observed at some places which cause oil and grease pollution to the river. So, this should be stopped.
- Washing and bathing activities should also be restricted to prevent the soap and detergent pollution.
- Regular water quality monitoring and other measures should be taken care of to assess the pollution level and sources of pollution in the river.

On the basis of above suggestions and recommendations, better conservation and management plan can be formulated for the Shivna River and other similar type of water resources which will help the policy makers to develop a self sustainable long run plans for the conservation plans of aquatic resources.

Bugaliya Nalla heavily infested with Water Hyacinth (Eichhornia Crassipes)

4 माह में शिवना की स्थिति बिगड़ी देख जताई चिंता, 8 जगह से लिए सैंपल

शिवना शुद्धिकरण : भोपाल से पहुंची एप्को की टीम, नदी की जांच की

आओ मिलकर करें शिवना को शुद्ध

भास्कर संवाददाता | मंदसौर

शिवना शुद्धिकरण के लिए बुधवार सुबह भोपाल से एप्को की टीम मंदसौर पहुंची। नपा इंजीनियर के साथ शिवना के पानी का सैंपल लिया। जुलाई के बाद शिवना की खराब स्थिति देख अधिकारियों ने नाराजगी व चिंता जताई। इंजीनियर से कहा नपा क्या कर रही है। घाट पर गंदगी तक साफ नहीं हो रही। आप कम से कम घाट पर सफाई व कुछ सुधार तो कर ही सकते हैं। टीम ने देर शाम तक शिवना में करीब 8 जगह पानी के सैंपल लिए व वापस भोपाल पहुंची। जांच के बाद प्रदूषण के आधार पर डीपीआर में फिल्टर प्लांट व अन्य मानक तय किए जाएंगे।

भोपाल से आई एप्को की टीम ने मुक्तिधाम के पास इस तरह गंदगी हटाकर शिवना के पानी का लिया सैंपल।

बुधवार को भोपाल से एप्को का तीन सदस्यीय दल नपा कार्यालय पहुंचा। उपयंत्री विरल जैन के साथ उन्होंने शिवना का निरीक्षण शुरू किया। टीम सबसे पहले मुक्तिधाम के पास शिवना किनारे पहुंची। यहां अधिकारी बोले कि शिवना की हालत दयनीय हो गई। जैन ने बताया कि नपा के पास इतने संसाधन व राशि नहीं है कि इसका स्थायी समाधान कर पाए। इस पर टीम प्रमुख डॉ. सुभ्रतो पाणी ने कहा कि आप घाट की गंदगी तो उठवा सकते हैं। टीम ने अलावदाखेड़ी रोड पर राजाराम फैक्टरी के पीछे से आ रहे नाले को देखा। जैन ने सफाई दी तो डॉ. पाणी बोले- यह तो आपकी जिम्मेदारी है। आप सख्ती कर फैक्टरी संचालक से सुधार करा सकते हैं। आपसी सहयोग से शुद्धिकरण करा सकते हैं। टीम ने पशुपतिनाथ मंदिर के सामने छोटी पुलिया, रामघाट, कालाभाटा बांध तक करीब 8 जगह से शिवना के पानी के सैंपल लिए।

डीपीआर में देंगे बैक्टीरिया व प्रदूषण की जानकारी

डॉ. पाणी ने बताया कि हमने जुलाई में भी सैंपल लिए थे, अब वापस लिए जा रहे हैं। दोनों नमूनों की तुलना के बाद रिपोर्ट एप्को के इंजीनियरों को दी जाएगी। इसमें बैक्टीरिया व प्रदूषण की स्थिति की जानकारी दी जाएगी जिसका डीपीआर में विवरण होगा। उसी के आधार पर वाटर फिल्टर प्लांट व सीवरेज लाइन के मानक तय होंगे। डीपीआर की समय सीमा तय है। इसके लिए हमें एक सप्ताह में रिपोर्ट तैयार कर उच्च अधिकारियों को सौंपना है।

References

1 Water Quality of Reservoir in Mandsaur District, Madhya Pradesh, by Deepali Amb, Rachna Modi, M.S.Sharma[2], Vipul Sharma and Kuldeep Singh Gour, Current World Environment, Vol. 6(1), 173-176 (2011).

[2] Recently geological study of Shivna river basin, north western region, Madhya Pradesh, India by Shyam Lal Bamniya, 2 Pramendra Dev, 3 Vinita Kulshreshtha, National Journal of Multidisciplinary Research and Development, https://www.researchgate.net/publication/326655010

KEY POINTS

- Madhya Pradesh is blessed with many important riverine systems, Shivna being one of them.
- The main objective of the present study is to evaluate the water quality as well as biodiversity of the river as in last few decades the river has been subjected to increased anthropogenic pressure.
- The river is an important habitat for flora and fauna and is also an important resource of fish culture.
- During the study the water quality of river was also assessed and it can be concluded that nutrient loading through surface runoff and joining of domestic sewage are the prominent causes of pollution at some stations.
- The overall biological diversity of the river is affected due to accumulation of nutrients especially because of agricultural activities.
- The overall water quality of the river is very poor in terms of potability and domestic uses.
- Looking to the above facts long term conservation and management plan should be prepared and implemented for sustainable management.