

**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI
Original Application No. 361/2018**

IN THE MATTER OF

Narmada Pradushan Nivaran

Samiti & Ors. ...Applicant

VS

Ministry of Environment, Forest &

Climate Change & Ors. ... Respondents

**ADDITIONAL REPLY AFFIDAVIT/FURTHER PROGRESS REPORT ON
BEHALF OF RESPONDENT NO.2/NARMADA CONTROL AUTHORITY
AND RESPONDENT NO.3/MINISTRY OF JALSHAKTI, DEPARTMENT
OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA
REJUVENATION**

I, R. Vasudevan, S/o. Late Sh. P. M. Kammasamy Aged about 55 Years working as Director (Civil), Narmada Control Authority, Ministry of Jal Shakti, DoWR, RD & GR, Govt. of India do hereby solemnly affirm and declare as under:

1. That I am authorized and competent to file the present additional reply affidavit on behalf of Respondent No.2 and 3. I am well versed with the facts and circumstances of the case and filing the present affidavit on the basis of the

(R. VASUDEVAN)
Director (Civil)
Narmada Control Authority
(MoJS, DoWR, RD & GR)
INDORE (M.P.)

d.v. -
(R. VASUDEVAN)
Director (Civil)
Narmada Control Authority
(MoJS, DoWR, RD & GR)
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official records, discussions and materials provided by SSNNL, GoG on the progress made so far w.r.t E-Flow study.

2. **That**, the Respondent Nos.2 and 3 have filed reply by way of affidavit dt.30.07.2018 before this Hon'ble Tribunal, which is on record(Paper Book Page No.482 to 627).
3. **That**, the Respondent Nos. 2 and 3 have filed Additional documents by way of affidavit dated 01.02.2021 before theHon'bleSupreme Courtin Civil Appeal No.4550/2019, which is on record(Paper Book Page No.1 to 18).
4. **That**, the Respondent Nos. 2 and 3 have filed Additional documents by way of affidavit dated 18.04.2024 before theHon'ble National Green Tribunal (NGT) in OA No.361/ 2018, which is on record(Paper Book Page No.1 to 58).
5. **That**, the Respondent Nos. 2 and 3 have filed additional reply/ fresh status report by way of affidavit dated 27.07.2024 before theHon'ble National Green Tribunal (NGT) in OA No.361/ 2018, which is on record(Paper Book Page No.774-832).
6. **That**, the Respondent Nos. 2 and 3 have filed additional reply/ fresh status report by way of affidavit dated 11.03.2025 before theHon'ble National Green Tribunal (NGT) in OA No.361/ 2018, which is on record(Paper Book Page No.972 to 987).
7. **That**, the Respondent Nos. 2 and 3 have filed additional reply/ fresh status report by way of affidavit dated ~~16.10.2025~~ ^{16.10.2025} before the Hon'ble National Green

(R. VASUDEVAN)
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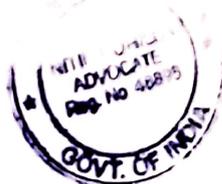


R. Vasudevan
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Tribunal (NGT) in OA No.361/ 2018, which is on record (Paper Book Page No. ~~1094 to~~ 1103)

8. That, with reference to the order of the Hon'ble National Green Tribunal, Principle Bench, New Delhi dated 17.07.2025 directing the submission of an affidavit detailing the further progress report in respect of the study, it is respectfully submitted that E-Flow Committee Meeting was convened on 12th September, 2025 at Kevadia, Gujarat where in progress of the studies were discussed with CIFRI, Kolkata and SSNNL, GoG and Technical Inputs were provided by the Expert and Committee Members of the E-Flow Committee followed by a Joint Field visit to the Downstream of Garudeshwar Weir upto Bhadbhut Barrage on 12th September, 2025 in the afternoon and on 13th September, 2025.
9. That, Draft Minutes of the Meeting was sent to the E-Flow Committee Members for providing comments/views, if any, within fifteen days from the date of issue of the same on 03.10.2025.
10. That, SSNNL, GoG, vide letter dated 29.09.2025, which is annexed as **Annexure-R/21** forwarded the First Pre-Monsoon Site Visit Report i.e. the Preliminary Report of the study conducted by CIFRI, Kolkata on "*Assessment of Environmental flows towards river habitat and ecological requirement with a focus on downstream fish species of Sardar Sarovar Dam (SSD) in Narmada River.*"
11. That, as a progress of the study it was reported that sampling was carried out for Pre-monsoon period from 23rd June to 28th June 2025 to assess the Hydrological and Ecological status during the pre-monsoon season. A total of nine representative sampling sites (*Garudeshwar, Poicha, Sisodra, Lilod,*

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Jhanor, Shuklatirth, Bharuch, Sakarpura, and Bhadbhut) have been selected from where samples were collected having a stretch of about 125 km downstream of the Sardar Sarovar Dam (SSD), extending from Garudeshwar Weir to Bhadbhut Barrage.

12. That, the present investigation assessed the water quality, hydrological, sediment, planktons & benthic parameters and aquatic habitat assessment. In water quality parameters total 21 parameters were assessed like temperature, pH, Conductivity, Salinity, Dissolved Oxygen, Free Carbon dioxide, Alkalinity, Total Hardness, Total Phosphorus, Available phosphorus, Nitrate-Nitrogen, Silicate, Chloride and Biochemical Oxygen Demand etc. The Test results are given in Table 1 to 5 of Annexure-R/21 at Page No.5,10,22, 31-32 and 34-35.

13. That, SSNNL, GoG intimated that the final report shall be prepared and scheduled to be submitted by CIFRI, Kolkata to SSNNL, GoG upon completion of the nine month study period, at the end of December, 2025.

14. That, the Respondent Nos.2 & 3 will abide by whatever direction/order passed by this Hon'ble Tribunal.

[Signature]
Deponent

(R. VASUDEVAN)
Director (Civil)
Narmada Control Authority
(MoJS, DoWR, RD & GR)
INDORE (M.P.)



10 OCT 2025

Verification

Verified at New Delhi on 10 OCT. 2025 that the contents of above affidavit are true and correct to the best of my knowledge and belief and derived from the official records.

[Signature]
Deponent

(R. VASUDEVAN)
Director (Civil)
Narmada Control Authority
(MoJS, DoWR, RD & GR)
INDORE (M.P.)

ATTESTED

NOT. PUBLIC
GOVT. OF INDIA

(R. VASUDEVAN)
Director (Civil)
Narmada Control Authority
(MoJS, DoWR, RD & GR)
INDORE (M.P.)



Sardar Sarovar Narmada Nigam Limited

(A Wholly Owned Govt. of Gujarat undertaking)

Annexure-R/21
1108

Add. Principal Chief Conservator of Forests

Environment Cell, Block-12, 9th Floor, New Sachivalay,
Gandhinagar-382010 (Gujarat)

(L) (079) 232 52812, 232 52442
E-Mail: envirementcell@gmail.com

NO. SSNNL/ENV/CIFRI/ 561

date: 29/09/2025

To
The Executive Member, NCA & Chairman of E-flow committee
Narmada Control Authority, Indore.

Sub: Submission of First Pre-Monsoon Site Visit report w.r.t study awarded to ICAR-CIFRI entitled "Assessment of Environmental Flow towards river habitat and ecological requirement with a focuses on the downstream fish species of Sardar Sarovar Dam (SSD)" – reg

Ref: 1. Director (Civil)'s letter No. NCA/ENV/443/MIII/2025/926 dated 26/09/2025.
2. Director (CIFRI)'s e-mail dated 27/09/2025.

Sir,

As decided in the 95th meeting of NCA held on 04/09/2024, SSNNL has entrusted the project to ICAR-CIFRI, Kolkata, W.B. for undertaking the study titled "**ASSESSMENT OF ENVIRONMENTAL FLOW TOWARDS RIVER HABITAT AND ECOLOGICAL REQUIREMENT WITH A FOCUS ON DOWNSTREAM FISH SPECIES OF SARDAR SAROVAR DAM (SSD) IN NARMADA RIVER**"

As per the MoU signed between SSNNL and ICAR-CIFRI, the agreement became effective from 27.03.2025, following the release of the first installment of ₹24, 37,795/- (40% of the consultancy fee).

The agreed submission schedule is as follows:

- Preliminary Report – within six months (i.e., by 27.09.2025)
- Final Report – upon completion of the nine-month study period

In this context, the Director, CIFRI has submitted the First Pre-Monsoon Site Visit report with reference to the above study vide e-mail dated 27/09/2025 (**Copy attached**). The same has also communicated to NCA by CIFRI. SSNNL is submitting this report to the Chairman of the E-flow Committee for further necessary action as deemed fit. Thanking You.

Encl : As above


(G. Ramana Murthy)
Add. Pri. Chief Conservator of Forests
SSNNL, Gandhinagar

Copy for kind information to:

- Hon'ble CMD, SSNNL, Gandhinagar.
- Executive Member, NCA & Chairman of E-flow committee, Indore.
- Director (Canals), SSNNL, Gandhinagar.
- Commissioner (Fisheries), Gandhinagar.
- CGM (T&C); SSNNL, Gandhinagar.
- Chief Engineer (Dam), Ekta Nagar.
- Director (Civil), NCA, Indore.

FIRST PRE-MONSOON SITE VISIT REPORT
ON
ASSESSMENT OF ENVIRONMENTAL FLOW TOWARDS RIVER
HABITAT AND ECOLOGICAL REQUIREMENT WITH A FOCUS ON
DOWNSTREAM FISH SPECIES OF SARDAR SAROVAR DAM (SSD) IN
NARMADA RIVER



Submitted to:

SARDAR SAROVAR NARMADA NIGAM LTD, Govt. of Gujarat



ICAR – CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
BARRACKPORE, KOLKATA-700120

PROJECT TEAM

Project Co-ordinator

Dr. Basanta Kumar Das (Director, ICAR– CIFRI)

Project Investigator

Dr. A.K. Sahoo (Sr. Scientist, ICAR-CIFRI)

Project Co-Investigators

Dr. D. K. Meena (Sr. Scientist, ICAR-CIFRI)

Dr. Ajoy Saha (Sr. Scientist, ICAR-CIFRI)

Dr. S. P. Kamble (Sr. Scientist, ICAR-CIFRI)

Young Professionals

Mr. Rajiv Ranjan (ICAR–CIFRI)

Miss. Subhasmita Behera (ICAR–CIFRI)

Skilled Technical

Mr. S. K. Paul (ICAR–CIFRI),

Mr. Dibyasingh Dev Parida (ICAR–CIFRI)

Sponsored by:

Sardar Sarovar Narmada Nigam Limited, Govt. of Gujarat

Submitted by:

ICAR – Central Inland Fisheries Research Institute

Barrackpore, Kolkata-700120



भा.कृ.अनु.प. - केंद्रीय अन्तर्स्थलीय मात्स्यिकी अनुसंधान संस्थान

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Foreword

SSNL vide letter no. SSNNL/Env/CIFRI/e-flow/119 dated 15/03/2025, requested for technical expertise from ICAR-Central Inland Fisheries Research Institute (CIFRI), Barrackpore under a consultancy project for “**Assessment of Environmental flow towards river habitat and Ecological requirement with a focus on downstream fish species of Sardar Sarovar Dam (SSD) in Narmada River**”. The expert team from CIFRI visited the sites and investigated on both biotic and abiotic factors determining the optimum environmental flows. The sites were selected based on the fish species habitat requirement, fishers villages, and hydrological gauging sites. Both biotic and abiotic samples were collected as per the standard procedures. This present report outlines the results of the study analysis highlighting the diversity of indigenous fish species, and migratory fish species, habitat of the sampling sites, fish food organisms and benthic community as river health assessment. Secondary data particularly on the river cross sections have been collected from the respective authority. The preliminary results showed important migratory fish species particularly Mahseer, *Tor pituitora* in the downstream stretch of SSD and Hilsa (*Tenualosa ilisha*) in the middle and estuarine stretches. These data help us to find out the habitat requirement and estimation of environmental flows in the selected stretches of river Narmada. I appreciate the efforts of all the Scientists, Technical Officers, Administrative and Supporting Staff for support rendered in sampling, data analysis and report preparation, and representatives from SSNL and NCA who assisted during the site visit and co-ordination.

Date: 27/09/2025

Place: ICAR-CIFRI, Barrackpore

(Basanta Kumar Das)

DIRECTOR

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1. Executive Summary

Sardar Sarovar Dam (SSD), a multipurpose dam on the mainstream of River Narmada has been comprehensively deliberated globally due to its environmental intricacies. This Dam has FRL 138.68 m, with a large network of canals and provision of sophisticated turbine system, is being commissioned 5.6 km upstream of Village Navagam under Taluka Nandod, District Narmada, Gujarat and is about 162 km from the estuarine mouth. The project assumes greater ecological concern since the downstream stretch has vast fisheries potential, which is liable to be impacted owing to prioritized use of stored water upstream, leading to freshwater crunch at downstream.

Realizing the importance of the downstream ecology and fisheries, SSNL Limited awarded the study on the “Assessment of environmental flow towards river habitat and ecological requirement with a focus on downstream fish species of Sardar Sarovar Dam (SSD) in Narmada River to ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), Barrackpore. A stretch of 162 km was taken with the available ecology and fisheries data from Garudeshwar, Poicha, Sisodra, Lilod, Jhanor, Shuklatirth, Bharuch, Sakarpura, Bhadbhut and surrounding places. Pre-monsoon sampling was carried out, and results revealed that the electrical conductivity and TDS of river water are normal; slight variations indicate tidal and estuarine influences. pH ranges from 8 to 8.5, slightly alkaline. DO is suitable for aquatic life and BOD values show minimal organic pollution. Nutrient levels (nitrates and phosphates) are within limits, but phosphate presence suggests some anthropogenic impact. Habitat profile of each sampling site of the river Narmada has been portrayed, and data were recorded. The mean depth of the studied stretches varied from 3.26 m. to 10.3 m. The substrate type was dominated by boulders, coarse sand, gravels, and sandy clay at the upper stretches of the river (Garudeshwar to Sisodra) and sandy clay and sand in all remaining sites (Lilod to Bhadbhut), which are considered to be ideal habitats for the freshwater ecosystem. Fish samples were collected and recorded that a total of 36 species belonging to 17 families, 36 genera, were recorded from the study stretch, of which the majority of the fish species were found to be of Least Concern (LC) as per the IUCN criteria. *Tenualosa ilisha* (60.18%) was the dominant species in the estuarine station Bhadbhut. A temporal fluctuation in fish catch and catch per unit effort (CPUE) was observed during the pre-monsoon survey. A significant landing of hilsa was reported from the

station Bhadbhut, which resulted in a higher value of CPUE (1.6 kg/hr/person) and a lower value of CPUE (0.55 kg/hr/person) recorded from Lilod. Six phytoplankton taxa were also recorded, and *Pediastrum simplex* was found to be the most abundant. Thirteen macro- and meiobenthic taxa were recorded. The study focused on the abundance of migratory fish species, including Mahseer and Hilsa.

The water depth and water velocity, which play a significant role in estimating environmental flows, were measured particularly during the pre-monsoon period. However, the post-monsoon habitat suitability factors along with river cross sections and hydrological discharge data at respective sites will further support in developing the environmental flows estimation, particularly towards conservation of fish species in the downstream of the SSD till Bhadbhut.

2. Introduction

The river Narmada has been India's river of faith, devotion and worship since time immemorial. The Narmada a Sanskrit word meaning 'the Giver of Pleasure' is one of the most sacred rivers in India. It is the longest west flowing river rising from a spring at a height of 1057 m. above MSL on the summit of Amarkantak hill in Shadol district of Madhya Pradesh in the Maikal hill range. The total length of the Narmada from its source to its outfall into the Gulf of Cambay in the Bharuch district of Gujarat is 1312 kms. The Narmada basin lies between east longitudes 72 degrees 32' to 81 degrees 45' and north latitude 21 degrees 20' to 23 degrees 45', lying on the northern extremity of the Deccan plateau and extending over an area of 98796 km² (38,145.3 sq. mi.). The basin covers large areas in the states in Madhya Pradesh (86%), Gujarat (14%) and a comparatively smaller area (2%) in Maharashtra. In the river course of 1,312 km (815.2 mi.), there are 41 tributaries, out of which 22 are from the Satpura range and the rest on the right bank are from the Vindhya range. The river serves as an important source of livelihood for the artisanal fishermen. However, over the years, various anthropogenic activities have altered the health of the aquatic environment, particularly in terms of ecology and biodiversity. Of late, it is assumed that the production process at different trophic levels of fish has been impeded, resulting in a decline in fish production and diversity. In addition, climate change has been a significant challenge for the water managers.

Water provided by the river supports ecological integrity, improves river health, sustenance of native fish species, and river-dependent plants and animals that rely on different flows to trigger migration and breeding. It is evident that due to the overall environmental degradation like diminishing water flow, manmade interferences in the catchment area of river basin, there has been a perceptible decline in both fish productivity and diversity. Therefore, it is necessary to give added emphasis on the water management through the environmental flows in the regulated river towards sustenance of river ecology, biodiversity and particularly on fishery in the downstream of the dam and barrages. Environmental flow defines the optimum water requirement for the sustenance of river ecology including the fisheries in the downstream of the dam towards biodiversity, livelihood improvement. The environmental flows in the river play a

pivotal role as important goods and ecological services to society, including fisheries. The downstream of Sardar Sarovar Dam (SSD) plays a critical role for biodiversity, fish species migration, livelihood of millions through capture fisheries, drinking water, navigation, agriculture, industry and is very important for mangrove sustenance. Therefore, estimation of environmental flows in the downstream of SSD is essential towards the above requirements. In the present investigation, environmental flows estimation in the downstream of the SSD was focus towards fish habitat conservation which reflects the water requirement for the biodiversity. With this backdrop, the present investigation was designed to address the following objectives

3. Objectives

- To assess the seasonal hydrological and hydraulics dynamic in the study area.
- To assess the seasonal habitat requirement (ecology) of the key stone fish species and major fish diversity
- To estimate E-flow for fish diversity employing hydraulic rating cum habitat simulation method

4. Sampling & methodology

Study area and sampling sites

The stretch from downstream of SSD to Bhadbhut places a critical stretch for indigenous fish species, including the migratory fishes. Therefore, focus was given to those sites important for the fish based environmental flows estimation. Sampling was undertaken in the rivers in regular interval to obtain information about populations density of fishes, their abundance, species wise occurrence, often in relation to the habitat they occupy and other biotic and abiotic factors. Keeping the above aspects in view, pre-monsoon sampling in river Narmada was carried out during June 23rd to 27th, 2025. In addition, identification of breeding and spawning grounds and other hydrological data from selected sites in river Narmada were carried out. Nine sampling sites were selected covering about 162 km. downstream of Sardar Sarovar Dam (SSD) of river Narmada. The sites are Garudeshwar, Poicha, Sisodra, Lilod, Jhanor, Shuklatirth, Bharuch, Sakkarpura and Bhadbhut (Table.1). The positional coordinates were ranged from N 21.807099, E 73.656058 to N 21.680952, E 72.845297 at an elevation between 60.57 to 25.47 m. of msl (Table.1 & Fig. 1). Sampling sites were selected based on fish abundance, pollution discharge

point, varying substrate and to estimate the possible impact of downstream and upstream due to environmental flow. Sampling sites selected were almost at equidistant distances. Some important habitat characteristics at the sampling sites of the River Narmada are also provided.

Table 1: Details of sampling sites

Sampling sites	River basin	District	GPS Coordinates
Garudeshwar (S1)	Narmada	Narmada	N 21.887099 E 73.656058
Poicha (S2)	Narmada	Narmada	N 21.975716 E 73.458628
Sisodra (S3)	Narmada	Navsari	N 21.913903 E 73.347048
Lilod (S4)	Narmada	Vadodara	N 21.878093 E 73.233343
Jhanor (S5)	Narmada	Bharuch	N 21.8388 E 73.134
Shuklatirth (S6)	Narmada	Bharuch	N 21.747727 E 73.123398
Bharuch (S7)	Narmada	Bharuch	N 21.690182 E 73.00644
Sakkarpura (S8)	Narmada	Bharuch	N 21.682 E 73.907
Bhadbhut (S9)	Narmada	Bharuch	N 21.680952 E 73.845297

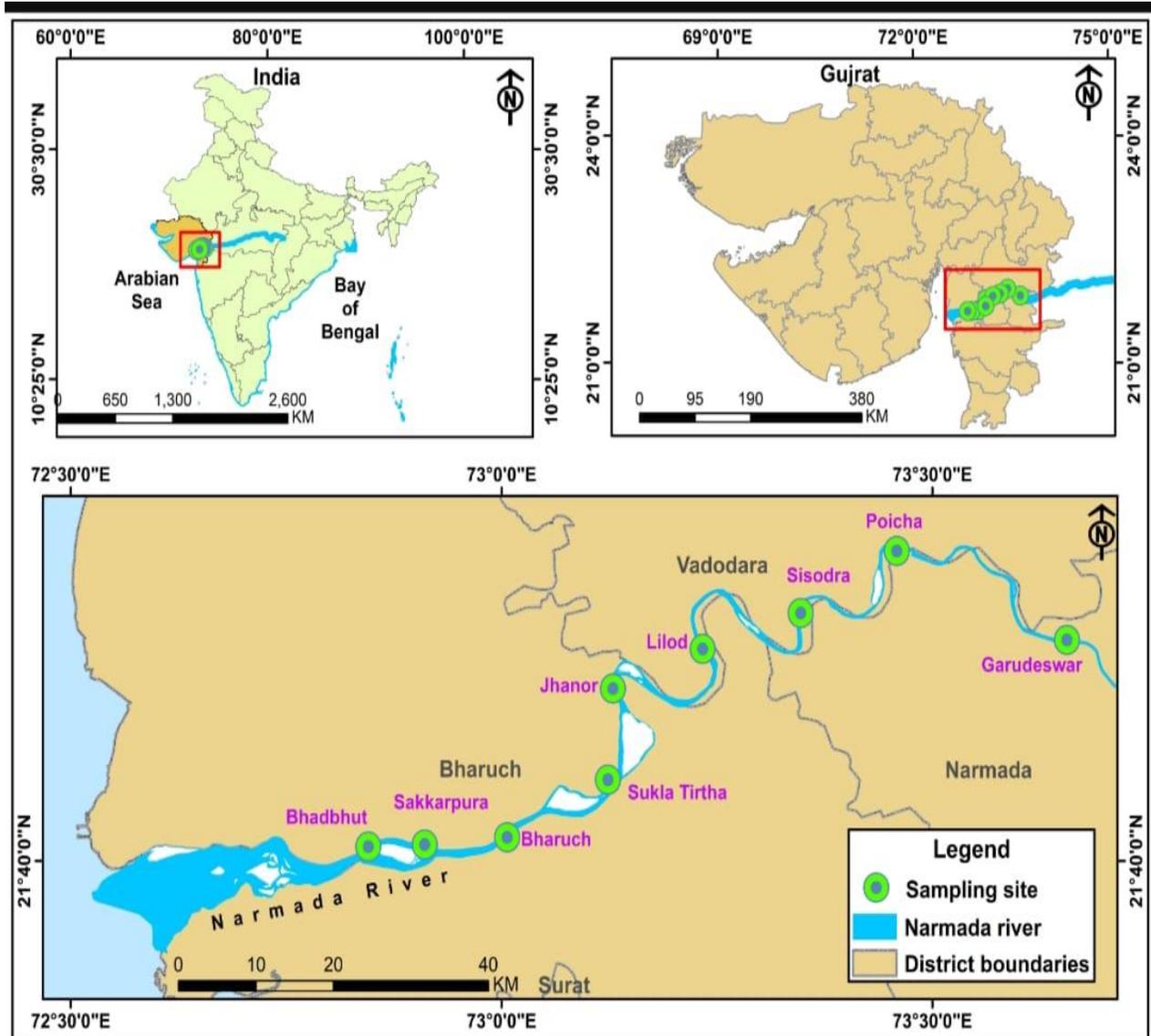


Figure 1: GIS map depicting sampling sites along the river Narmada

Methodology

Fish Sample collection and Analysis

The experimental fishing was carried out along the longitudinal gradient of the river within 5 km. up and downstream. A sampling effort of 6 hours for the gill net was carried out. Further, the abundance of species indicative in the observations is the total number of fishes of the individual species collected. Fish catch data and samples were also collected from fish landing stations from all the sampling sites. Representative specimens (n=5) of all fish species were identified and preserved in 10% formalin and brought to the laboratory for analysis.

The identification of the fish specimen from various sites of river Narmada was conducted using the keys per Francis Day (1889), Mishra (1962), Talwar and Jhingran (1991), Jayaram (1981 & 2006), Nath and Dey (2000).

Water quality parameters

The water quality characteristics, including, temperature, pH, conductivity, salinity, dissolved oxygen, free carbon dioxide, alkalinity, total hardness, total phosphorus, available phosphorus, nitrate-nitrogen, silicate, chloride, and biological oxygen demand were monitored throughout the experiment according to methods of APHA (2017).

Hydrological parameters

Shoreline depth of left and right bank, mid channel depth (Eco sounder, PS-7, LCD Digital sounder), wetted perimeter, water flow (Digital flow meter: Global water instrument: model FP 111, USA) and transparency (Secchi Disk).

Sediment parameters

The sediment characteristics, including, pH, conductivity, organic carbon, texture, free calcium carbonate (CaCO_3) and available phosphorus were monitored throughout the experiment according to methods of APHA (2017).

Planktonic status in river Narmada

To explore the planktonic communities of the Narmada River downstream of the Sardar Sarovar Dam (SSD), 100 litres of water were filtered using plankton net with a mesh size of

50 μ m. The concentrated 10 ml sample was preserved in 5% formalin. Numerical enumeration was carried out following the method described by Welch (1948). Identification of plankton was performed using standard taxonomic keys and literature, including those by Pennak (1978), Davis (1955), Ward & Whipple (1959), Cox (1966), and Needham & Needham (1972).

Benthic communities

Benthos samples were collected by using Petersen Grab having area of 19.0 x 19.5 cm² from each site. Three random hauls constituted one sample which was preserved in 10% formalin after sieving through Sieve No. 40. The qualitative and quantitative enumerations have been carried out by following Welch (1948), Subba Rao (1989), Ramakrishna & Anirudha Day (2007) and APHA (2017).

5. Observations

Aquatic habitat assessment

Aquatic habitat plays a significant role in the successful colonization of fishes and other aquatic organisms. As it is well known that water will not alone ensure the survival of fish. Along with quality water fishes need an ideal and suitable aquatic habitat for their growth, breeding, migration, etc. In general, freshwater can be categorized into lentic (standing) and lotic (flowing) water habitats. Habitat diversity can vary tremendously within these two broad categories and few fish taxa can be found in both the habitat. The habitat factors that influenced fishes to complete their lifecycle are substrate type, deep pools, scar pools, riparian vegetation, water depth, water flow, river gradient, the width of the wetted channel, flood plains, etc. Some indigenous fishes also have to move between different habitats as they mature and breed. Different fish species have different habitat requirements and these may change as they grow older.

In the present seasonal exploration of the pre-monsoon season habitat profile of each sampling sites of river Narmada have been portrayed in table 2. Some significant variations were recorded in each sampling site. The mean depth of the studied stretches varied from 3.26 m. to 10.3 m. Depth was recorded from the shoreline (L and R banks) and mid-channel. The substrate type was dominated by boulders, coarse sand, gravels, sandy clay at upper stretches of river (Garudeshwar to Sisodra) and sandy clay and sandy in all remaining sites (Lilod to Bhadbhut) which are considered to be ideal habitats for the freshwater ecosystem. In site Garudeshwar to

Sisodra, substrates were predominant with boulders, gravels, cobbles and coarse sand which are ideal habitat for cat fishes. Water velocity recorded ranged from 25 to 130 cm./sec. which is supposed to acceptable for freshwater rivers. This is common features in lean period. Deep pools were recorded from the sampling sites which are significant for aquatic fauna for their shelter and breeding ground, especially in the lean period. Significant observation was that agriculture practices were observed in catchment areas in the sampling sites which are a serious concern as the pesticides used for agriculture practice may be deposited into the river through runoff. Good riparian vegetation on the catchment area and riverbanks is considered to be an important part of the river habitat.

Riparian vegetation growing on the catchment area and river banks of the stream considered to be an important part of the stream habitat. In the present investigation fairly good bank vegetation were observed in all the sampling sites. Good diverse bank vegetation was observed in all the remaining sampling sites which as a whole act as a filter for runoff from the surrounding land partly purifying the water before enters the stream. More or less meandering nature of the stream observed in studied area.

Table 2: Habitat profile of sampling stations

	Garudeshwar	Poicha	Sisodra	Lilod	Jhanor	Shuklatirth	Bharuch	Sakkarpura	Bhadbhut
Width of channel (wetted)	300 m.	300 m.	200 m.	500 m.	450 m.	400 m.	700 m.	500 m.	900 m.
Bank to bank width	800 m.	800 m.	800 m.	700 m.	700 m.	700 m.	1000 m.	700 m.	1200 m.
Depth (Av.)	3.5 m.	3.26 m.	3.9 m.	9.6 m.	5.46 m.	4.7 m.	11.46 m.	5.2 m.	7.76 m.
Water velocity	130 cm./sec.	110 cm./sec.	75 cm./sec.	42 cm./sec.	32 cm./sec.	36 cm. / sec.	25 cm./sec.	61 cm./sec.	56 cm./sec. (Synchronized with the tidal effect)
Substrate composition	Boulders 25%, coarse sand 45%, gravels 10%, clay and others 20%.	Coarse sand 25%, gravels 15%, cobbles 10% clay and others 50%.	Small gravels 15%, sand 35%, clay and others 50%	Sandy clay and others 100%	Sandy clay	Sandy clay	Clay and organic materials	Sandy clay	Sandy clay
Deep pools	2 nos. identified with average depth of 18.5 ft.	1 no (depth 12 m.)	Not recorded	Recorded (1 no. with 30 m. depth)	Not recorded	Not recorded	Not recorded	Not recorded	Not recorded
Riparian vegetation	Trees 45%, Herbs 15%, Shrubs 25%, grass land 15%	Trees 40%, Herbs 20%, Shrubs 25%, grass land 15%	Trees 35%, shrubs 15%, herbs 15%, grass land 25%	Trees 40%, shrubs 10%, herbs 15%, grass land 35%	Trees 20%, shrubs 25%, herbs 15%, grass land 40%	Trees 15%, shrubs 25%, herbs 20%, grass land and others 40%	Trees 20%, shrubs 25%, herbs 20%, grass land and others 35%	Trees 25%, shrubs 15%, herbs 10%, grass land and others 50%	Rich riparian vegetation (Trees, shrubs, herbs, grass land and others)
Other information	Check dam constructed, ritual activities by the local people were visualized, temple exist. No pollution sources were observed.	Pollution source not recorded, bank soil erosion observed, instream cover not found.	Ritual activities visualized, sources of pollution not found.	Temple exists, no significant pollution discharge source identified.	Water lifting pump installed in the bank of the river, no pollution sources were found.	Ritual activities observed as the site considered as one of the holiest shrines.	Urban area, city sewage being discharged into the river, railway and road bridge constructed over the river.	Water lifting pump installed in the shoreline of the river, no instream cover was recorded.	Island formed in the middle of the river, Temples are located on the bank of the river, barrage under construction.

Physiochemical parameters of water

Water Temperature

During the pre-monsoon season, water temperature values across the sampling stations ranged between approximately 25°C to 28.2°C, indicating relatively stable thermal conditions along the downstream stretch of the Sardar Sarovar Dam. The maximum water temperature was recorded at Bhadbhut, while the minimum was observed at Garudeshwar.

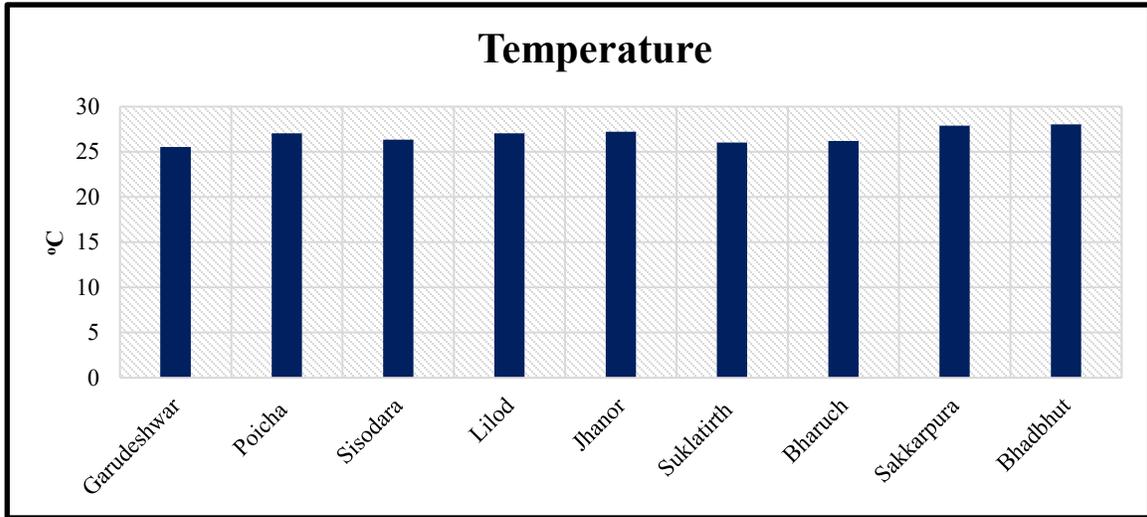


Figure 2: Variation in water temperature in the studied stretch of river Narmada

Water Velocity

The water flow across the sampling sites showed considerable variation, with the highest velocity recorded at Garudeshwar (129.6 cm/sec), followed by Poicha around 110.3 cm/sec. A moderate flow was observed at Sisodara (75.6 cm/sec), while Sakkarpura and Bhadbhut exhibited flows of roughly 61.6 cm/sec and 55 cm/sec, respectively. Lilod (42 cm/sec), Suklatirth (36.33 cm/sec), and Jhanor (32 cm/sec) recorded relatively lower water velocities, and the lowest flow was observed at Bharuch which was 24.6 cm/sec.

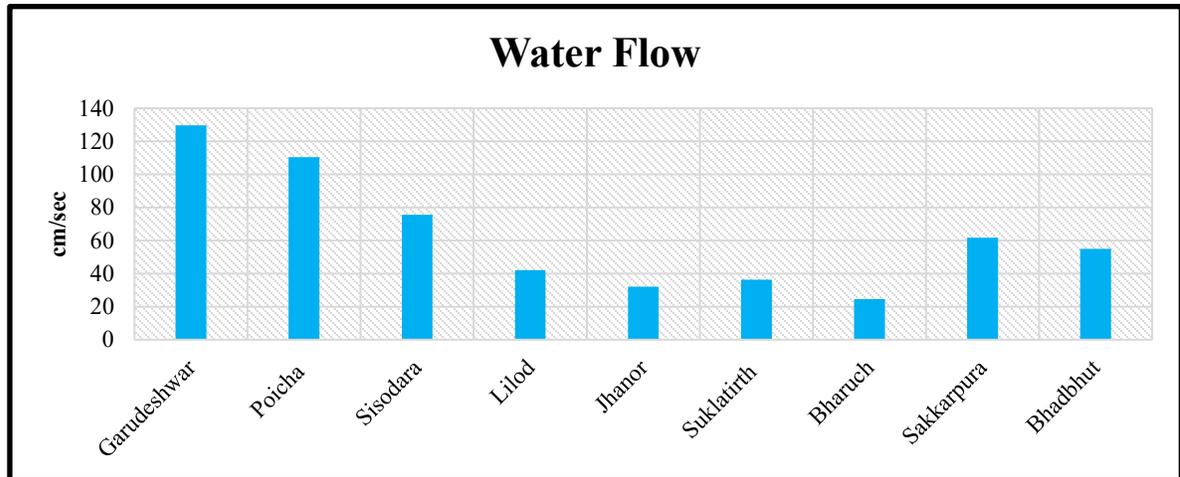


Figure 3: Fluctuation of water flow in the studied stretch of river Narmada

Transparency

Transparency across the studied sites of the river is very low due to pre-monsoon rain during sampling, and the turbidity is attributed to the presence of suspended clay particles in the river. It showed small variation among the sites. The highest transparency was recorded at Shuklatirth (11.1 cm), closely followed by Jhanor (10.3 cm) and Poicha (9.7 cm). While at Sisodra, Sakkarpura, Lilod, Bhadbhut and Bharuch it was observed 8.2, 8.1, 8.5, 7.9 and 7.6 cm, respectively. The lowest transparency was observed at Garudeshwar (6.8 cm).

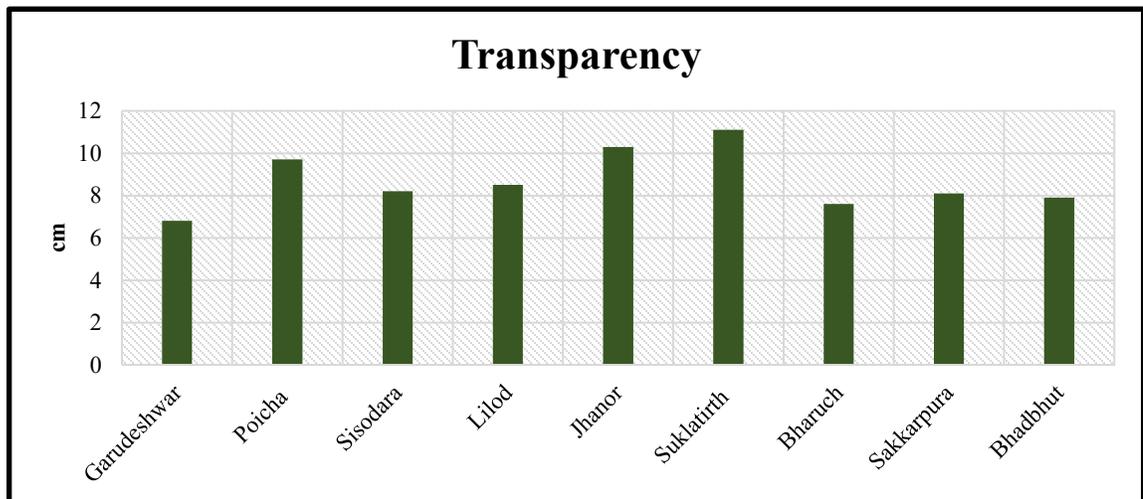


Figure 4: Variation in transparency in the studied stretch of river Narmada

Water pH

The pH generally ranges from approximately 8 to 8.5; there is no significant difference between the sampling stations. The pH is slightly alkaline in all the stations, which is suitable for fish production. Among them, the highest pH was observed at Poicha. Conversely, relatively lower pH values were recorded at Bhadbhut. The pH values across all sampling sites remained within the optimal range for aquatic life.

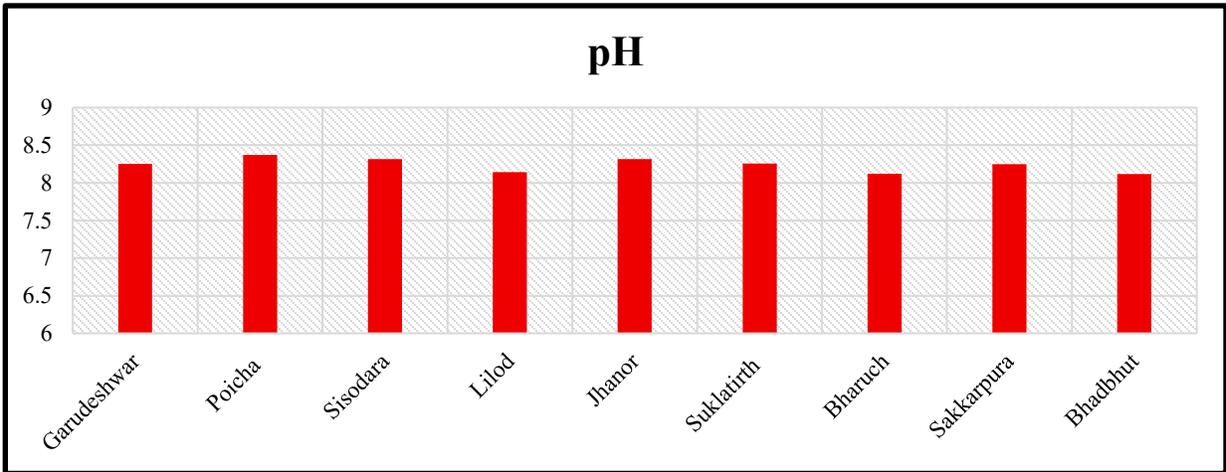


Figure 5: Variation in pH in the studied stretch of river Narmada.

Electrical Conductivity of water

The electrical conductivity (EC) of water samples collected on the Narmada River during the pre-monsoon period showed considerable spatial variation across the sampling stations. The highest EC value was recorded at Bhadbhut, followed closely by Sakkarpura and Bharuch, indicating a greater concentration of dissolved ions in these lower reaches of the river, indicating estuarine influence.

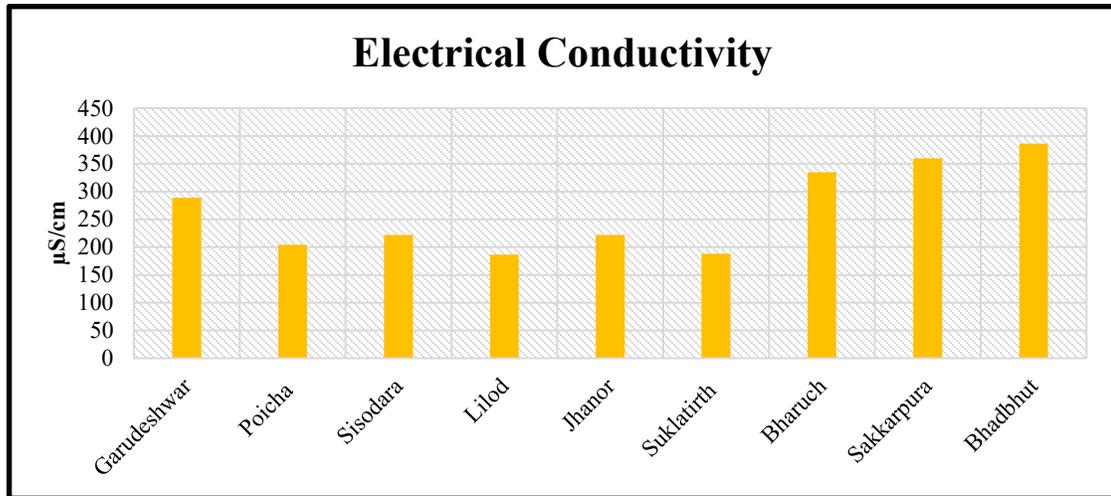


Figure 6: Variation in electrical conductivity in the studied stretch of river Narmada

Total dissolved Solid

Total dissolved Solid (TDS) values across the downstream stretch of the Sardar Sarovar Dam ranged from approximately 130 to 235 mg/L. The highest concentration was observed at Bharuch, followed by Sakarpura and Shuklatirth, indicating elevated dissolved ion levels. The lowest values were recorded at Lilod and Poicha. All observed levels remained within acceptable limits for freshwater ecosystems.

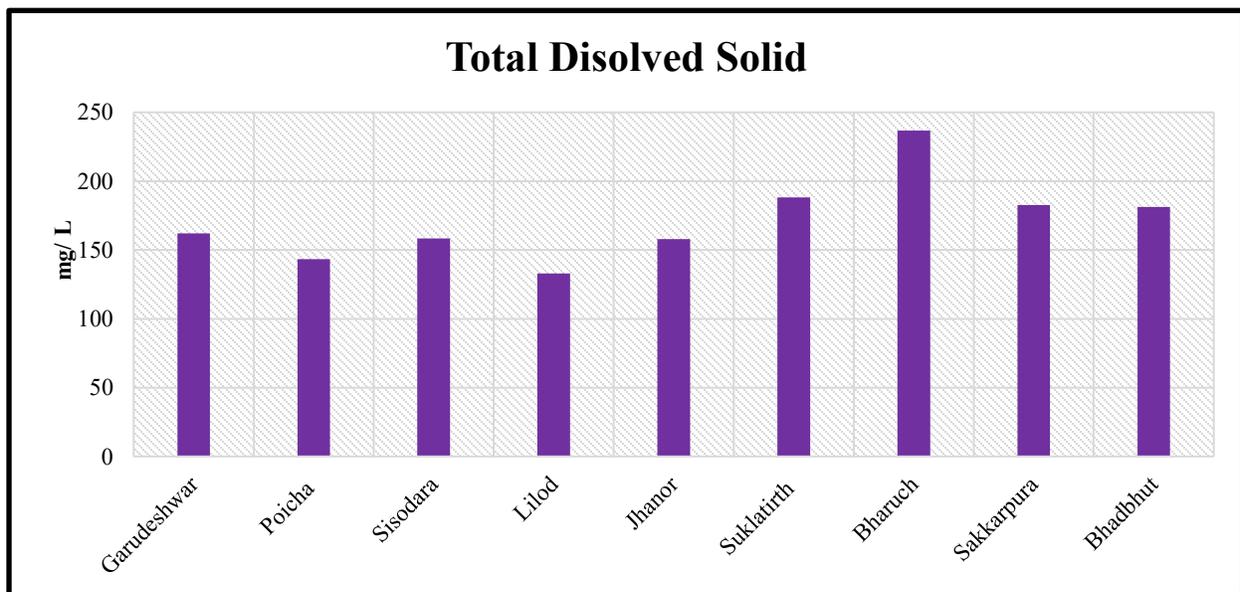


Figure 7: Variation in total dissolve slid in the studied stretch of river Narmada

Salinity

Salinity levels varied across the downstream stretch of the Sardar Sarovar Dam, ranging from approximately 0.07 to 0.27 ppt. The highest salinity was recorded at Bhadbhut, followed closely by Sakkarpara and Bharuch, indicating estuarine influence and possible tidal intrusion in the lower stretches. The salinity is observed less than that of literature due the sampling done in low tide and there was a water inflow on the river due to rain. Lower values were observed at Shuklatirth, Garudeshwar, and Poicha, reflecting relatively fresh water conditions at upstream.

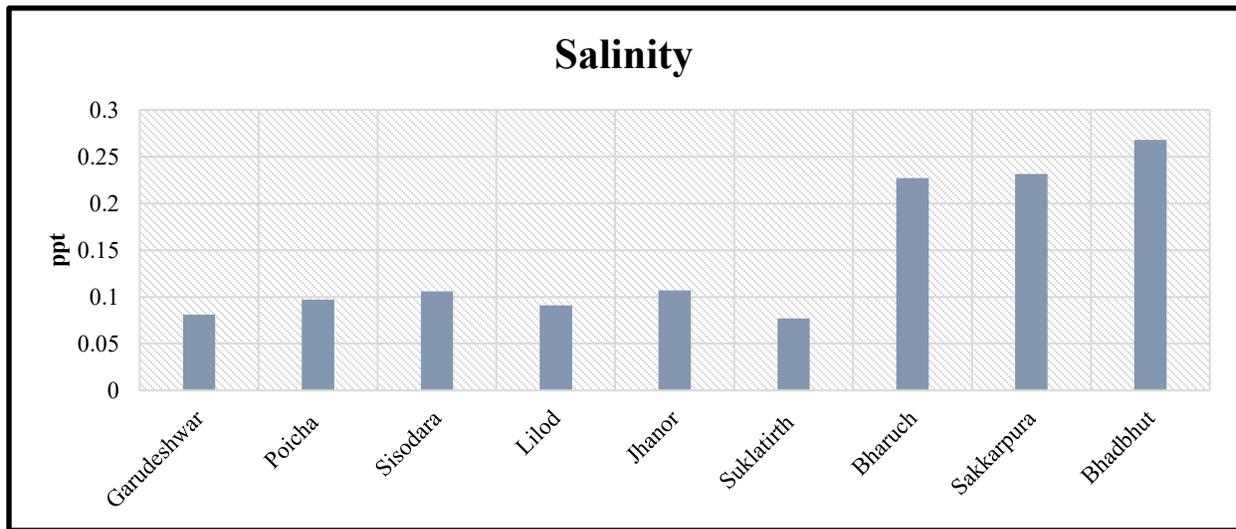


Figure 8: Variation in salinity in the studied stretch of river Narmada

Dissolved oxygen

Dissolved oxygen (DO) levels across the sampling stations varied notably, ranging from a minimum of 4.96 mg/L at Sisodara to a maximum of 7.19 mg/L at Poicha. Higher DO concentrations were recorded at Poicha (7.19 mg/L) and Garudeshwar (7.1 mg/L), indicating relatively better oxygenation conditions at these sites. In contrast, comparatively lower DO values were observed at Sisodara (4.96 mg/L), due to influences such as reduced flow and anthropogenic activities affecting oxygen availability.

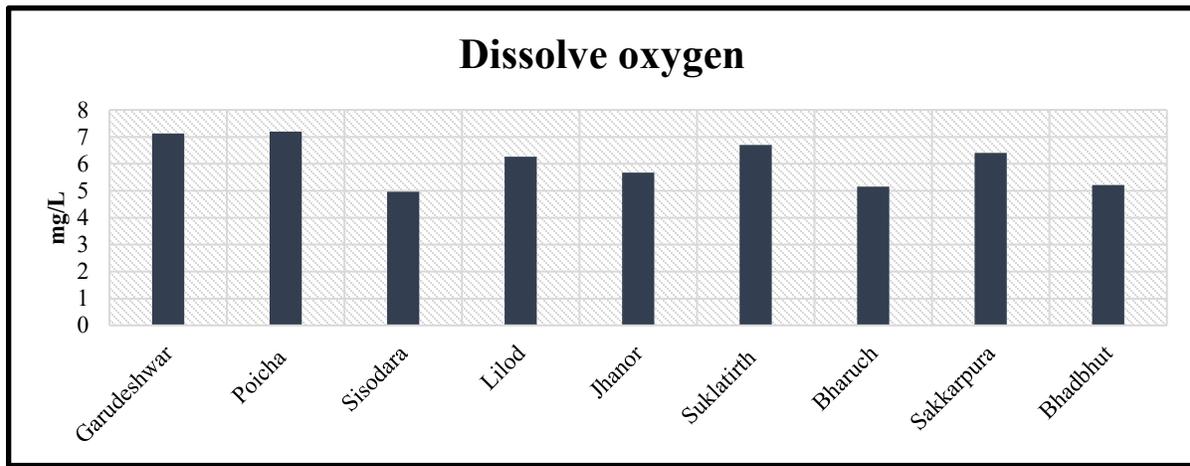


Figure 9: Variation in dissolve oxygen in the studied stretch of river Narmada

Free Carbon dioxide

There was no free carbon dioxide at all the sampling stations

Total alkalinity

Total alkalinity across the sampling stations showed considerable variation, ranging from a minimum of 77 mg/L at Sakarpura to a maximum of 117 mg/L at Garudeshwar. High alkalinity values were also recorded at Bharuch (115.33 mg/L) and Bhadbhut (107 mg/L), indicating strong buffering capacity in these zones. Moderate alkalinity levels, between 85 and 101 mg/L, were found at Poicha, Sisodra, Lilod, Jhanor, and Shuklatirth, suggesting relatively balanced carbonate and bicarbonate concentrations.

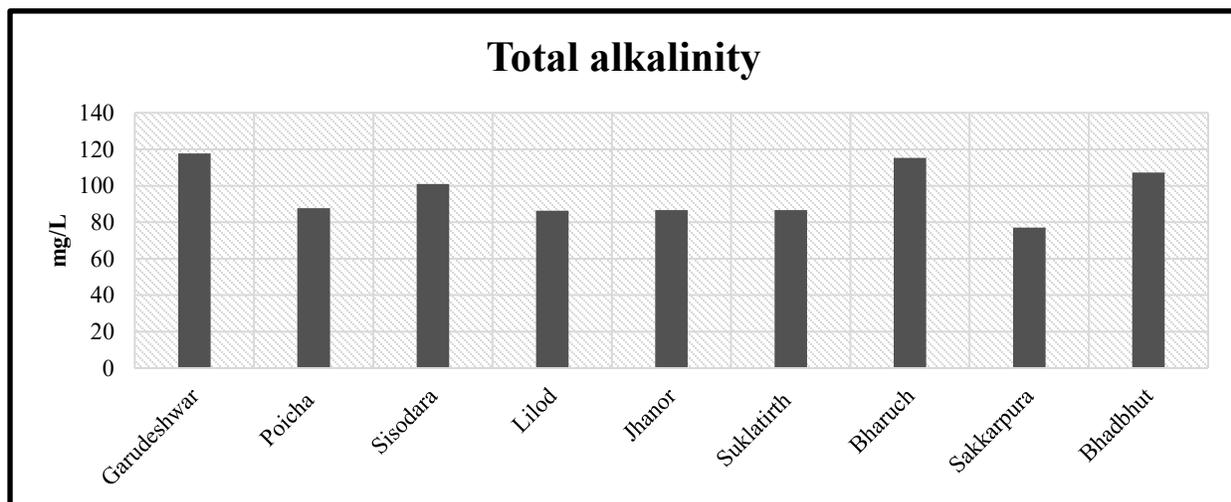


Figure 10. Variation in total alkalinity in the studied stretch of river Narmada

Total Hardness

Total hardness ranges from a minimum of 68.27mg/L at Shuklatirth to a maximum of 108 mg/L at Bhadbhut. High hardness levels were also noted at Bharuch (~103 mg/L) and Sakkarpura (~96 mg/L), indicating elevated concentrations of calcium and magnesium salts in these locations. Moderate hardness, between ~80 and 95 mg/L, was recorded at Garudeshwar, Sisodara, Lilod, and Jhanor. Despite this, the hardness level is found to be in the normal range.

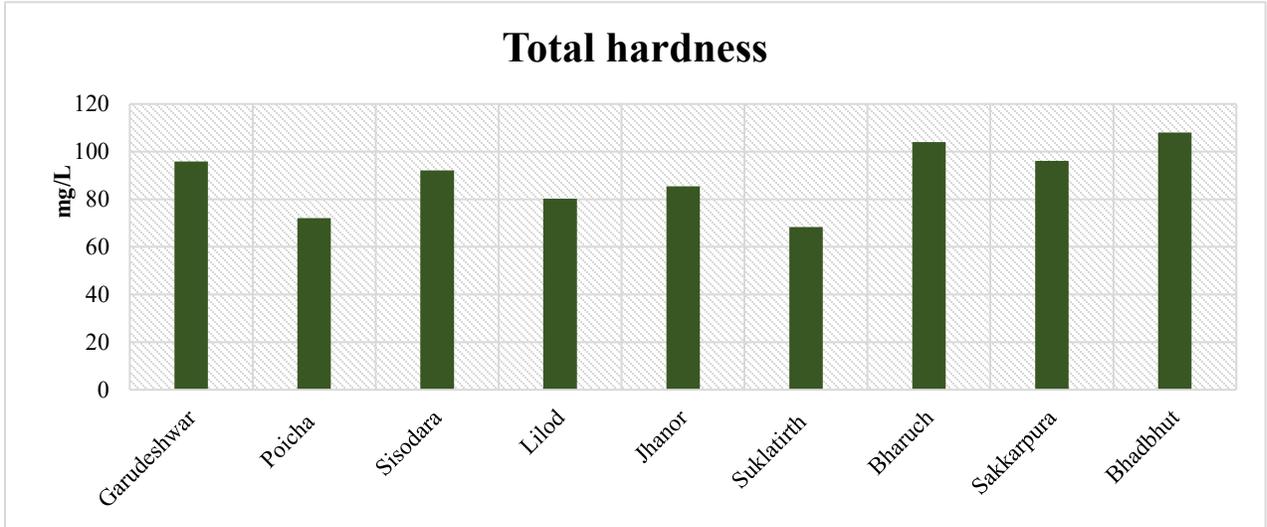


Figure 11: Variation in total hardness in the studied stretch of river Narmada

Nitrate-nitrogen

Nitrate levels ranged from 0.05 mg/L at Sisodara to 0.25 mg/L at Bhadbhut, with higher values at Poicha and Bhadbhut. All concentrations were well below the maximum permissible limit.

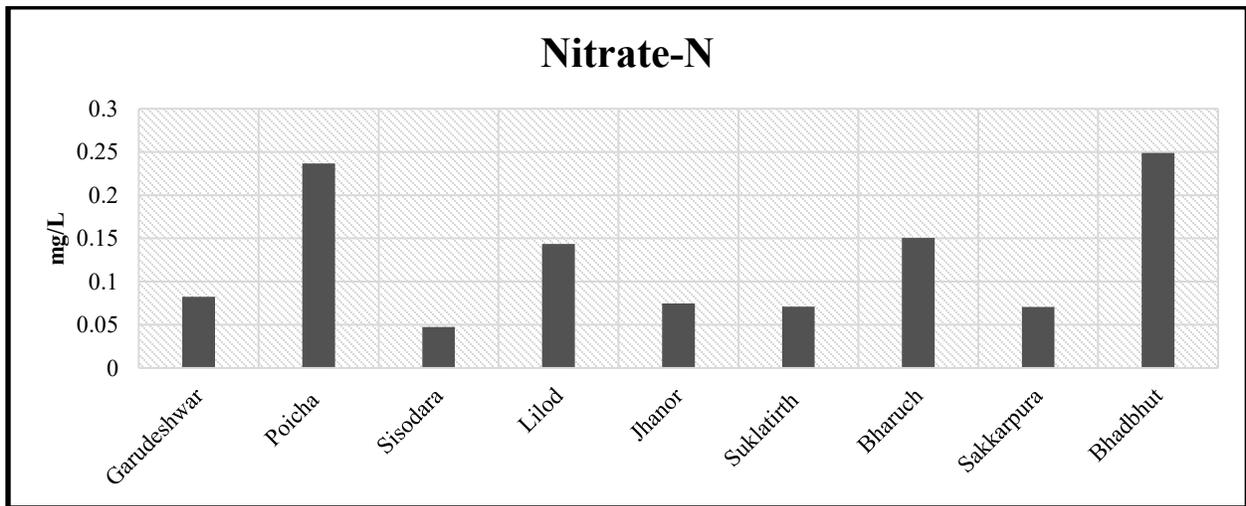


Figure 12: Variation in nitrate-N in the studied stretch of river Narmada

Silicate

Silicate concentrations varied from ~7.1 mg/L at Lilod to ~11.9 mg/L at Sisodara. Higher values were observed at Sisodara and Garudeshwar (~10.2 mg/L), while moderate levels (~8–9.5 mg/L) were recorded at Jhanor, Bharuch, and Sakarpura. Lower concentrations were found at Lilod (~7.1 mg/L), Poicha (~7.8 mg/L), and Shuklatirth (~7.8 mg/L). Overall, silicate distribution indicates site-specific variations, possibly influenced by geological weathering, runoff, and anthropogenic inputs.

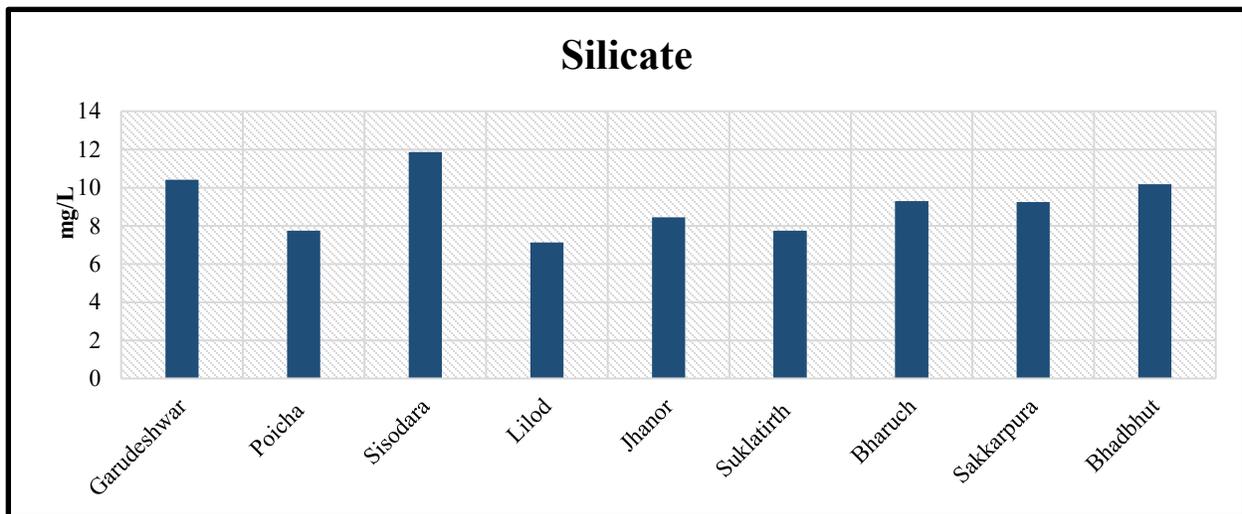


Figure 13: Variation in silicate in the studied stretch of river Narmada

Chlorinity

Among the sampling sites, Bhadbhut has the highest chloride concentration at approximately 23 mg/L, while Lilod had the lowest at around 15.99 mg/L. Other locations such as Garudeshwar, Poicha, Sisodara, and Jhanor showed moderate levels ranging between 16 and 19 mg/L. Shuklatirth, Bharuch, and Sakrapura each exhibited slightly higher concentrations, close to 18–21 mg/L. Overall, the data reveal a relatively narrow range of chloride levels, suggesting slight variation across the sampling sites.

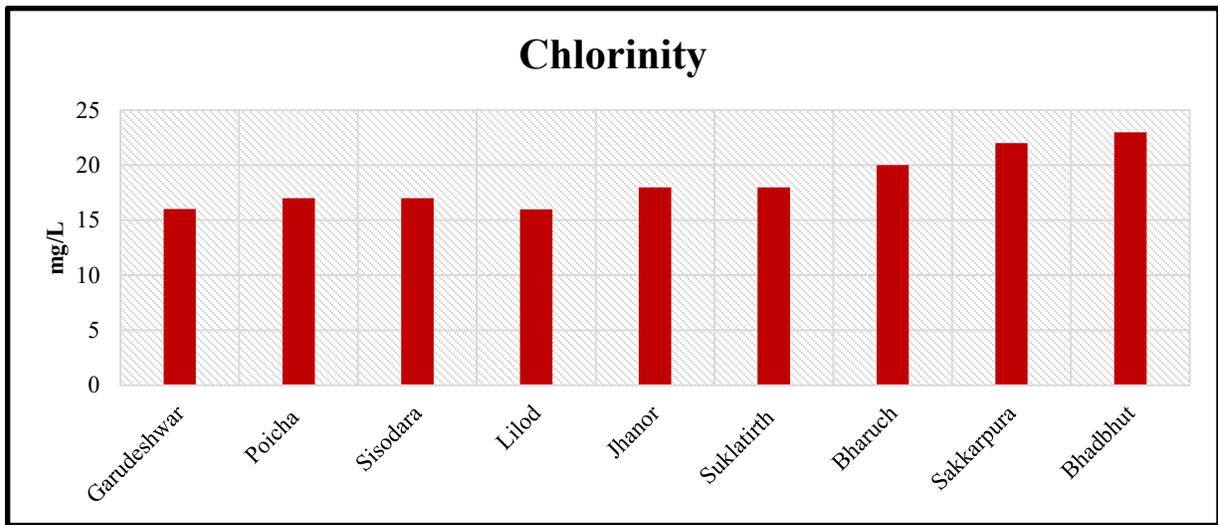


Figure 14: Variation in chlorinity in the studied stretch of river Narmada

Available and total phosphorus

Available phosphate levels ranged from 0.01 mg/L at Jhanor to 0.033 mg/L at Poicha among the sampling stations. Higher concentrations were observed at Poicha (0.033 mg/L) and Sisodara (0.03 mg/L), while moderate levels (0.025 mg/L) were recorded at Bharuch and Sakkarpura. Lower values were found at Jhanor (0.01 mg/L), Bhadbhut (0.015 mg/L), and Lilod (0.018 mg/L). However, total phosphorus (TP) ranged from 0.20-0.33 mg/l, with the maximum value at Bhadbhut, followed by Shuklatirth.

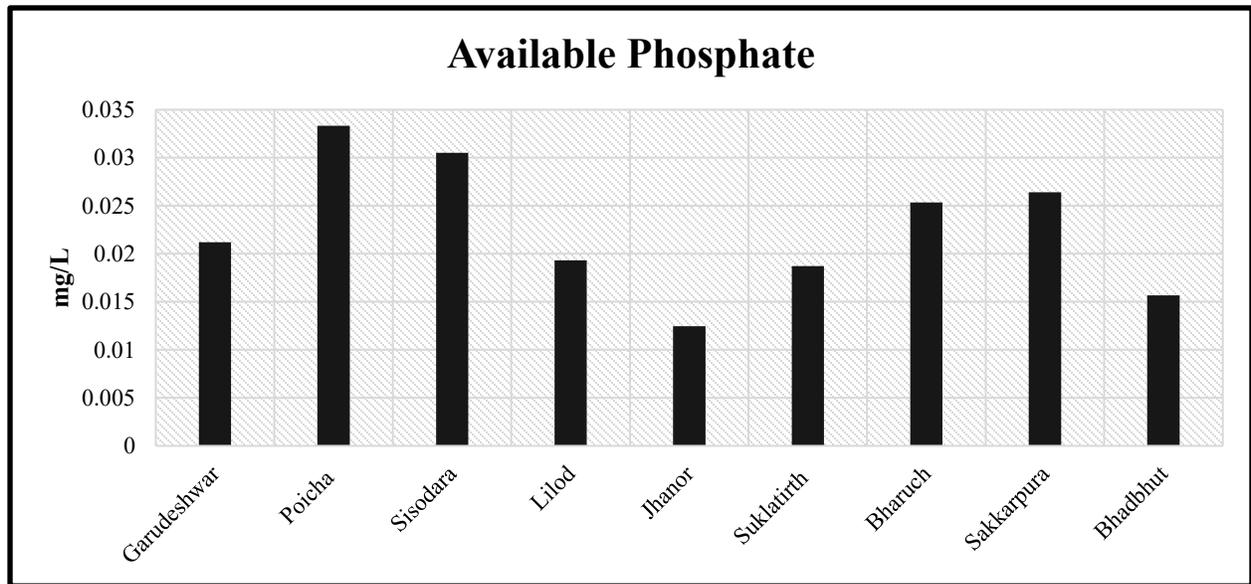


Figure 15: Variation in available phosphate in the studied stretch of river Narmada

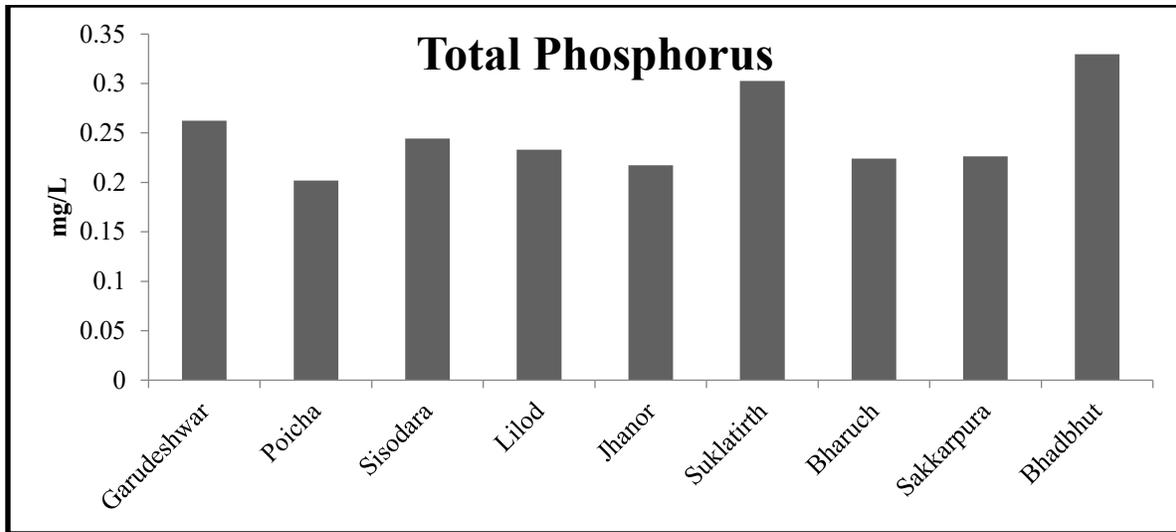


Figure 16: Variation in total phosphorus in the studied stretch of river Narmada

Biological Oxygen Demand

Among the stations Shuklatirth exhibits the highest BOD at 4.7 mg/L, due to organic matter. Bharuch had 3.5 mg/L, and Lilod had 3.4 mg/L. Poicha and Garudeshwar show moderate levels at 2.4 and 2.3 mg/L, respectively, while Sakarpura also records 2 mg/L. Lower BOD values are observed in Bhadbhut (1.6 mg/L), Jhanor (0.88 mg/L), and Sisodara, which has the lowest at just 0.5 mg/L. All BOD values are under prescribed limits.

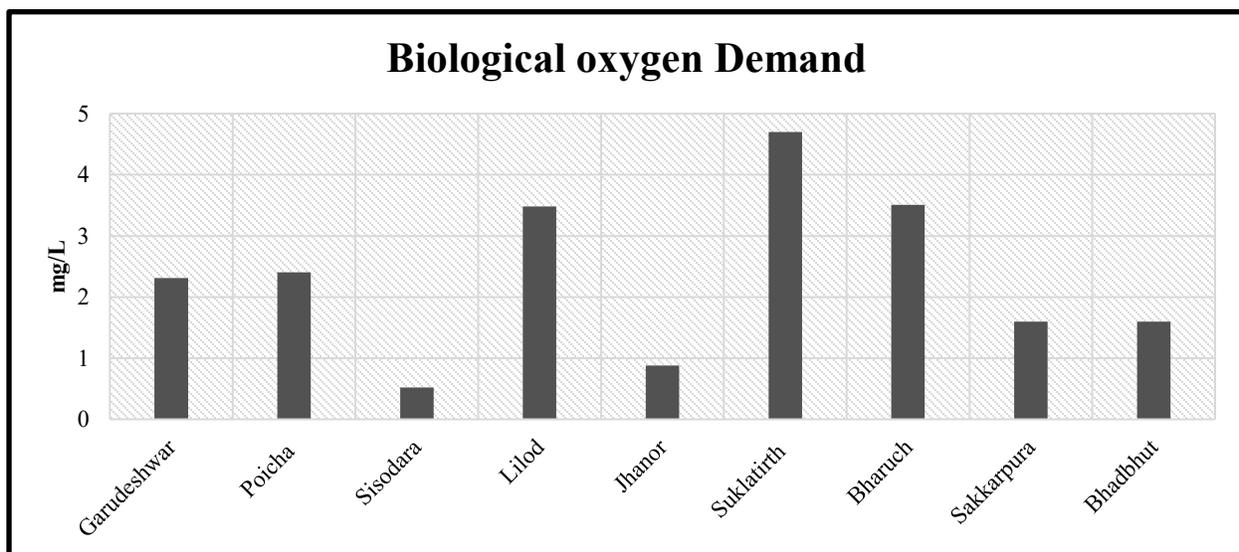


Figure 17: Variation in biological oxygen demand in the studied stretch of river Narmada

Chlorophyll content

Chlorophyll levels (chl-a, chl-b, chl-c) vary across nine locations. Chl-a is dominant, especially at Suklatirth and Bharuch. Chl-b and chl-c remain low throughout.

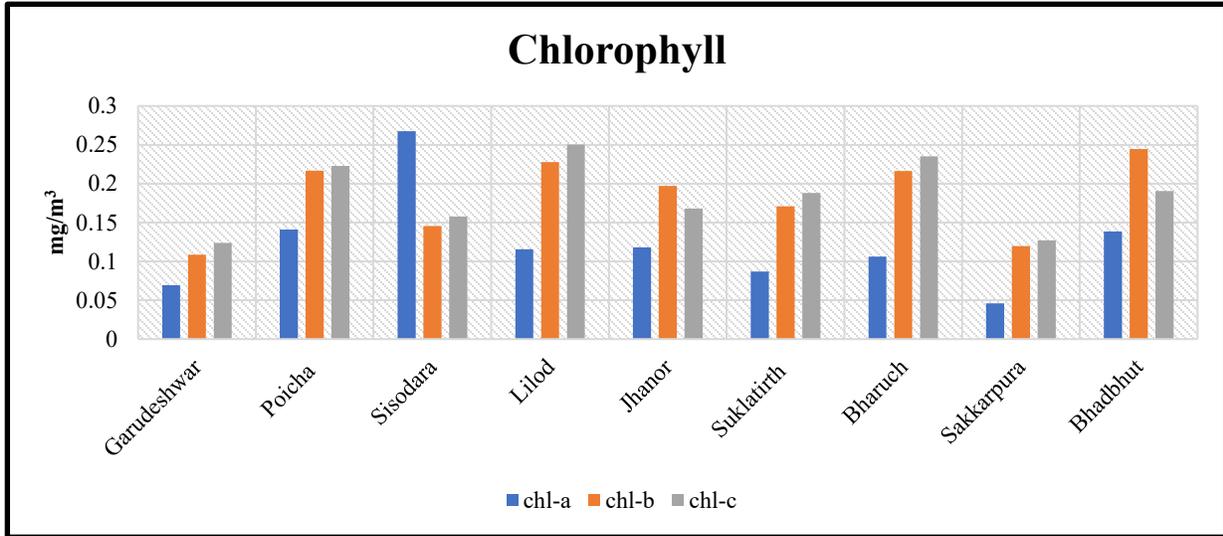


Figure 18: Variation in chlorophyll in the studied stretch of river Narmada

Table 3: Water quality parameter of pre monsoon season

S.no	Parameters	Garudesh war	Poicha	Sisodara	Lilod	Jhanor	Shuklatirth	Baruch	Sakkarpura	Bhadbuth
1.	Temperature (°C)	25.53±0.08	27.03±0.03	26.33±0.03	27.03±0.03	27.23±0.03	26.03±0.03	26.2±0.05	27.9±0.05	28.03±0.08
2.	Water flow (m/s)	129.67±0.88	110.33±0.88	75.67±0.66	42.00±0.00	32.00±0.57	36.33±0.67	24.66±0.33	61.60±0.33	55.00±0.58
4.	Transparency (cm)	6.8±0.00	9.7±0.00	8.2±0.00	8.5±0.00	10.3±0.00	11.1±0.00	7.6±0.00	8.1±0.00	7.9±0.00
5.	pH	8.25±0.00	8.37±0.00	8.31±0.00	8.14±0.01	8.31±0.00	8.25±0.01	8.12±0.00	8.24±0.00	8.11±0.00
6.	EC (µS/cm)	289.03±0.03	204.1±0.05	222.1±0.05	186.66±0.17	222.16±0.27	188.2±0.11	334.53±0.29	360.06±0.23	386.06±0.47
7.	TDS (mg/L)	162.13±0.08	143.37±0.73	158.3±0.15	133.03±0.03	158.03±0.31	188.23±0.14	236.73±0.37	182.63±0.34	181.27±0.17
8.	Salinity (ppt)	0.08±0.00	0.10±0.00	0.11±0.00	0.09±0.00	0.10±0.00	0.08±0.00	0.23±0.00	0.23±0.00	0.27±0.00
9.	Dissolved oxygen (mg/L)	7.12±0.02	7.20±0.01	4.96±0.02	6.26±0.03	5.66±0.02	6.70±0.01	5.15±0.02	6.40±0.03	5.21±0.01
10.	Free CO ₂ (mg/L)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
11.	Total alkalinity (mg/L)	117.66±0.33	87.66±1.45	101.00±0.58	86.33±1.45	86.66±1.33	86.66±1.45	115.33±0.66	77.00±1.00	107.33±1.20
12.	Total hardness (mg/L)	95.83±0.44	72.07±0.18	92.10±0.21	80.17±0.44	85.4±0.80	68.27±0.14	103.97±0.26	96.10±0.20	108±0.11
13.	Nitrate-N (mg/L)	0.08±0.00	0.24±0.00	0.05±0.00	0.14±0.00	0.07±0.00	0.07±0.00	0.15±0.00	0.07±0.00	0.25±0.00
14.	Silicate (mg/L)	10.41±0.01	7.74±0.01	11.85±0.00	7.12±0.00	8.45±0.00	7.74±0.00	9.30±0.00	9.25±0.00	10.17±0.00
15.	Chlorinity (mg/L)	16.01±0.01	17.00±0.00	17.00±0.01	16.00±0.00	18.00±0.00	18.00±0.00	20.00±0.01	22.00±0.00	23.00±0.01
16.	Phosphate (mg/L)	0.02±0.00	0.03±0.00	0.03±0.00	0.02±0.00	0.01±0.00	0.02±0.00	0.03±0.00	0.03±0.00	0.02±0.00
17.	BOD (mg/L)	2.31±0.02	2.40±0.01	0.52±0.00	3.48±0.01	0.88±0.01	4.70±0.01	3.51±0.00	1.60±0.01	1.60±0.00
18.	COD (mg/L)									
19.	Chlorophyll- <i>a</i> (mg/m ³)	0.07±0.00	0.14±0.00	0.27±0.00	0.12±0.00	0.12±0.00	0.09±0.00	0.12±0.00	0.05±0.00	0.14±0.00
20.	Chlorophyll- <i>b</i> (mg/m ³)	0.11±0.00	0.22±0.00	0.14±0.00	0.23±0.00	0.20±0.00	0.17±0.00	0.22±0.00	0.12±0.00	0.25±0.00
21.	Chlorophyll- <i>c</i> (mg/m ³)	0.12±0.00	0.22±0.00	0.16±0.00	0.25±0.00	0.17±0.00	0.19±0.00	0.24±0.00	0.13±0.00	0.19±0.00

Sediment characteristics

pH

The pH of Narmada River sediment varied among the sampling sites, ranging from slightly alkaline to alkaline conditions. The lowest pH value was recorded in Garudeshwar (7.6), while the highest values were observed in Bharuch and Bhadbhut (8.6). Intermediate pH values were found at Poicha, Sisodara, Lilod, Jhanor, Shuklatirth, and Sakkarpura, ranging between 8.0 to 8.4. Overall, the results indicate that the sediment pH in the downstream region of the Sardar Sarovar Dam is predominantly alkaline in condition.

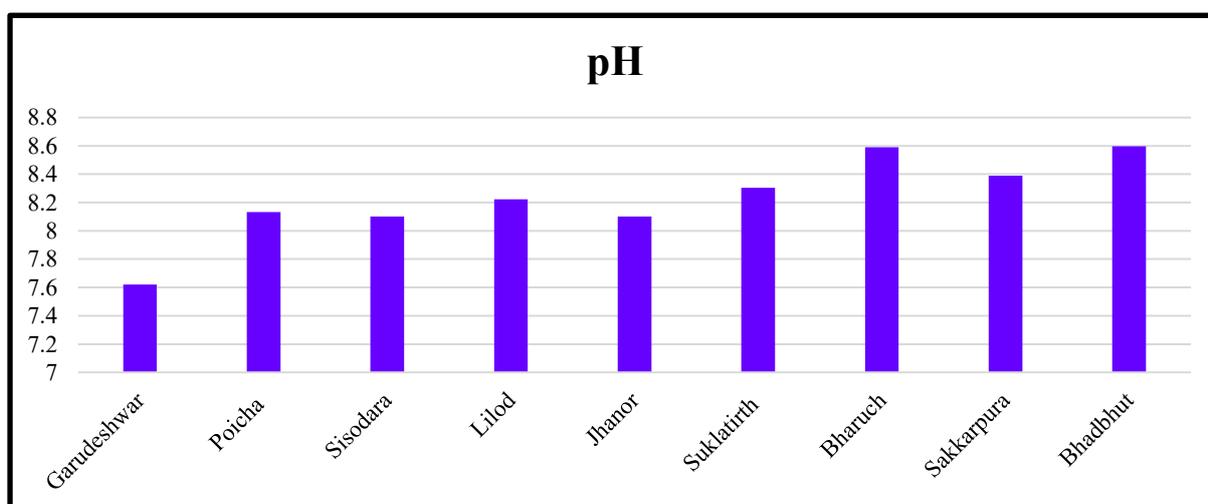


Figure 19: Sediment pH in the studied stretch of Narmada River

Electrical conductivity

Across the downstream stretch of the Narmada River, sediment electrical conductivity (EC) values significantly vary. Sisodara recorded the highest EC which is 391 $\mu\text{S}/\text{cm}$, followed by Jhanor (312 $\mu\text{S}/\text{cm}$), Lilod (297 $\mu\text{S}/\text{cm}$), and Garudeshwar (280 $\mu\text{S}/\text{cm}$). Moderate values were found at Bhadbhut (256 $\mu\text{S}/\text{cm}$), Sakkarpura (243 $\mu\text{S}/\text{cm}$), and Bharuch (245 $\mu\text{S}/\text{cm}$), while the lowest readings occurred at Shuklatirth (180 $\mu\text{S}/\text{cm}$) and Poicha (70 $\mu\text{S}/\text{cm}$).

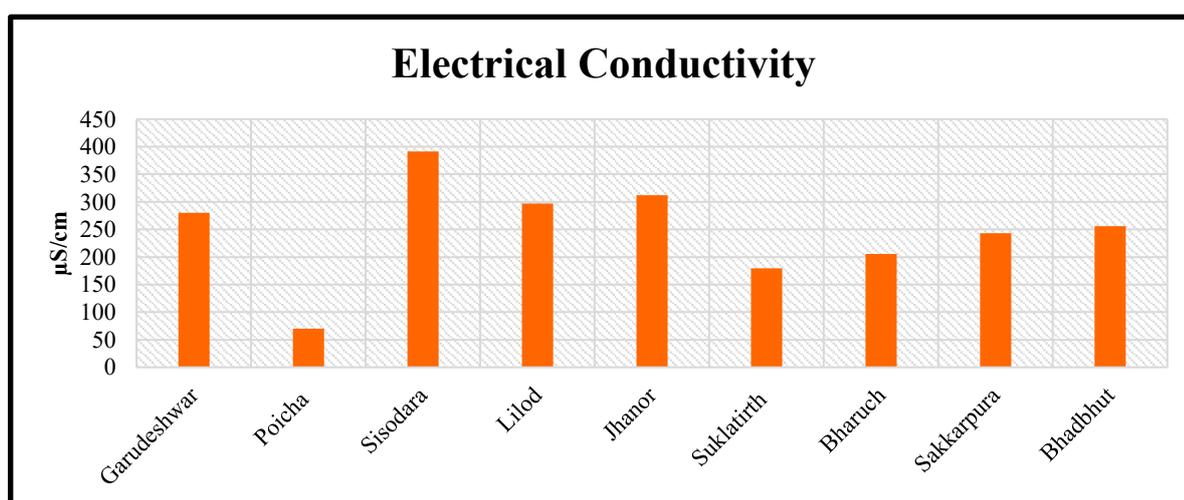
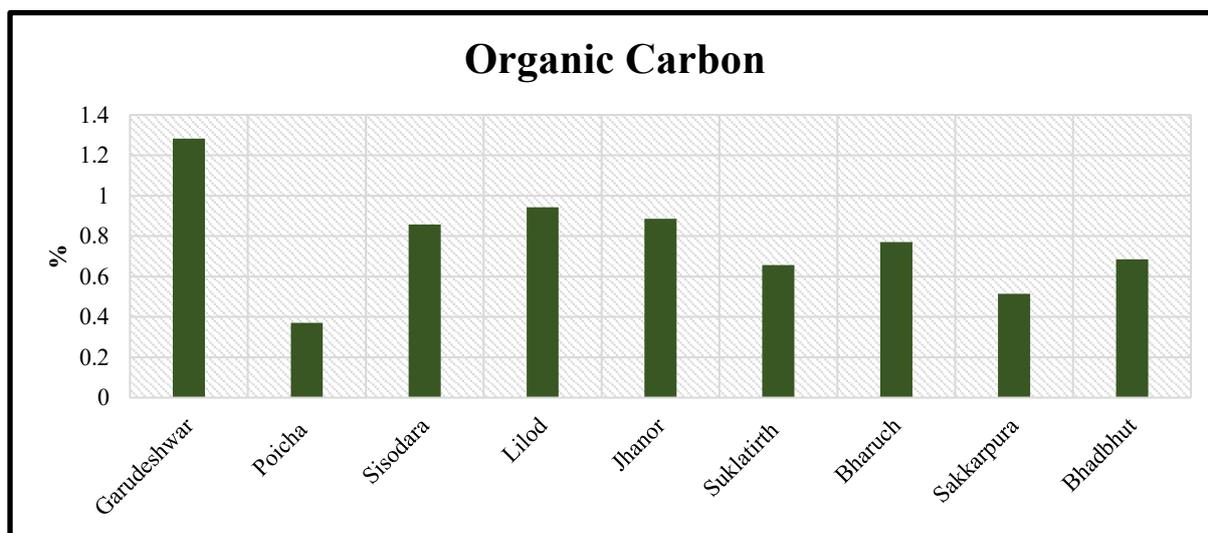


Figure 20: Sediment electrical conductivity in the studied stretch of Narmada River

Organic Carbon

Organic carbon content in the Narmada River sediment varied notably among the sampling sites. The highest value was recorded at Garudeshwar (1.28%), followed by Lilod (0.95%), Jhanor (0.89%), and Sisodara (0.86%). Moderate levels were observed at Bharuch (0.78%), Bhadbhut (0.68%), and Shuklatirth (0.65%), while lower values occurred at Sakkarpura (0.50%) and Poicha (0.36%). Overall, upstream Garudeshwar exhibited the greatest organic carbon content, whereas Poicha and Sakkarpura showed comparatively lower



concentrations.

Figure 21: Sediment organic carbon in the studied stretch of Narmada River

Free Calcium Carbonate

Free CaCO_3 in Narmada River sediment ranged from ~3.0% at Poicha to ~9.03% at Sakkarpura, with higher values at downstream sites and lower levels at upstream.

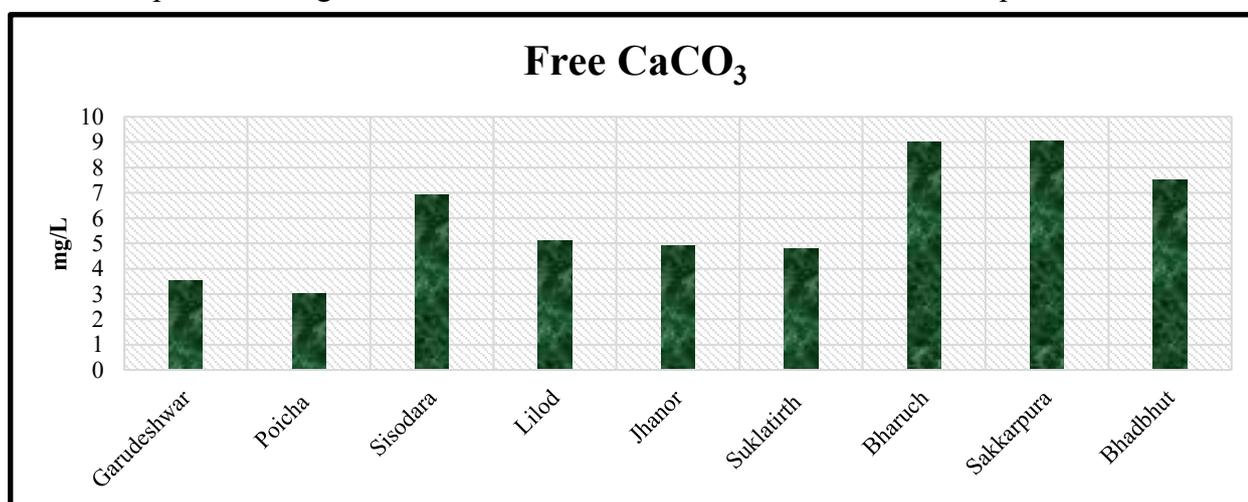


Figure 22: Free CaCO₃ in the sediment of studied stretch of Narmada River

Available Phosphorus

Available phosphorus in the Narmada River sediment showed only minor variations among sites, with values ranging from 3.6 to 4.9 mg/kg. The highest concentration was noted at Lilod (4.9 mg/kg) and the lowest at Jhanor (3.6 mg/kg), but overall differences were not significant, indicating a relatively uniform distribution across the sampling locations.

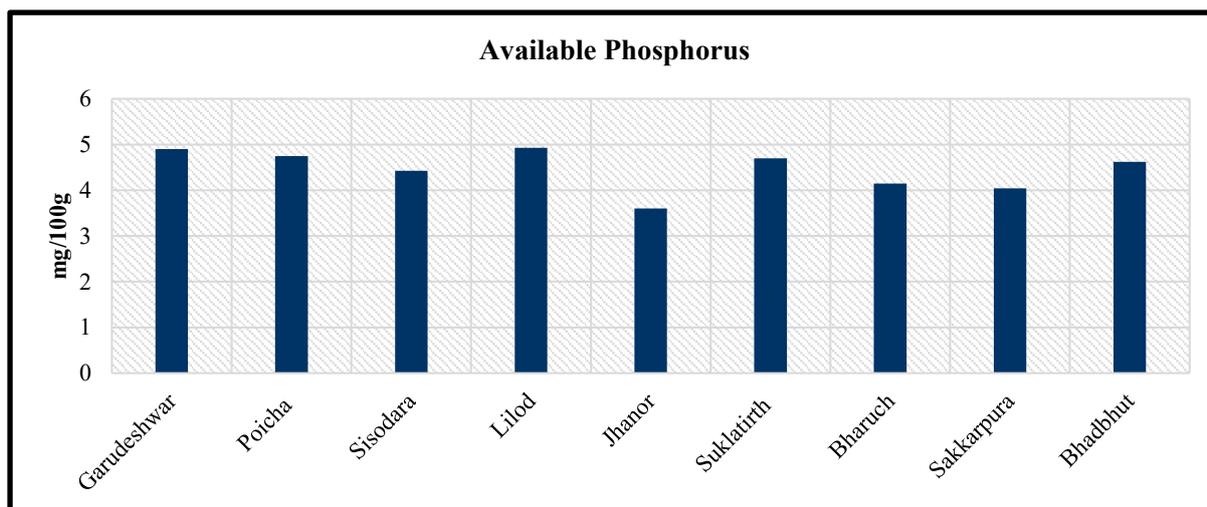


Figure 23: Available phosphorus in the sediment of studied stretch of Narmada River

Soil Texture

Soil texture analysis of the Narmada River sediment indicated that sand was the predominant component across all sampling sites, though its composition varies among sampling stations. The highest sand content was recorded at Poicha about 95%, having coarse sand, along with small pebbles are also present while the lowest was observed at Sakarpura 55%, where silt and clay contributions were relatively higher giving loamy texture. Silt content at Poicha is 5% which is lowest and highest in Sisodara about 35%. Clay content remained comparatively low across sites, varying between 0 to 20%, with the higher clay percentages observed at sites such as Bhadbhut and Sakarpura. Overall, the sediment along the downstream stretch of the Narmada River is characterized by a predominantly sandy texture, interspersed with varying amounts of silt and minimal clay.

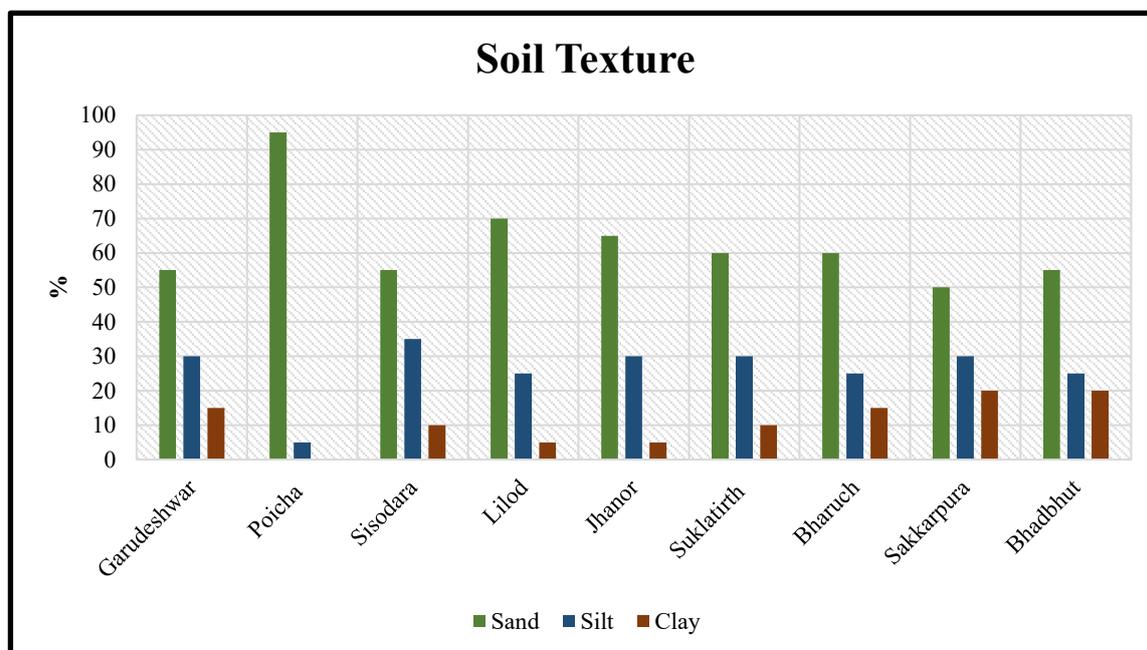


Figure 24: Contribution of sand, silt and clay in the sediment of studied stretch of Narmada River

Plankton diversity

Phytoplankton

A total of six phytoplankton taxa (Plate 3) were observed from the downstream stretch of the Sardar Sarovar Dam (SSD) on the Narmada River during the pre-monsoon study from 9 different sampling stations. Among all the recorded phytoplankton groups, *Pediastrum simplex* was found to be the most abundant, indicating its better adaptability to the prevailing environmental conditions during this period. The other species recorded included *Closterium* sp., *Coscinodiscus* sp., *Spirogyra* sp., *Ceratium* sp., and *Fragilaria* sp.

Zooplankton

Zooplankton was recorded less total 3 species of zooplankton was recorded as shown in Plate 4. Their density is also very less.

Benthic communities

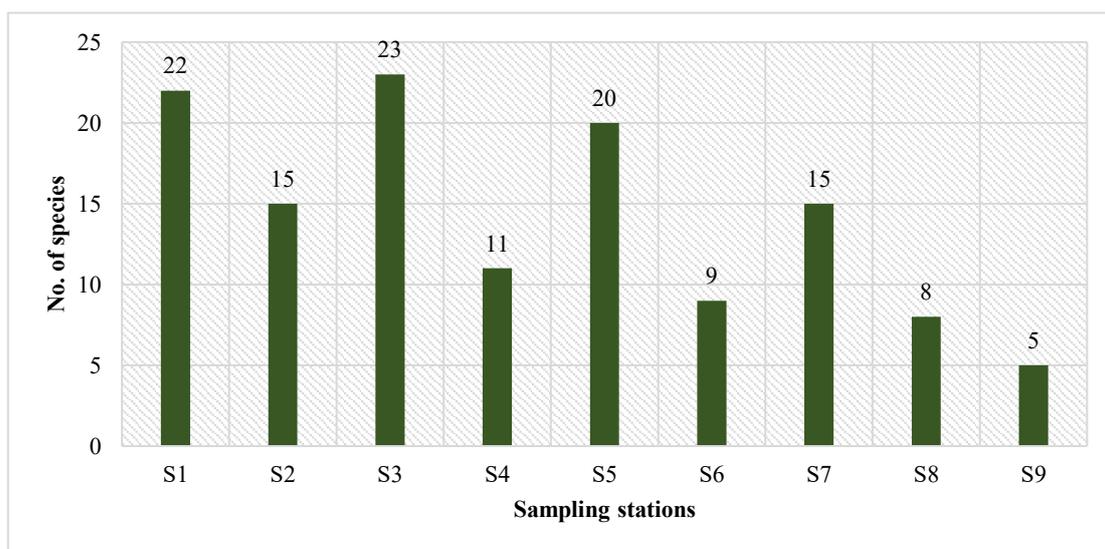
A total of 13 macro- and meiobenthic taxa (Plate 4) were recorded from the downstream stretch of the Sardar Sarovar Dam (SSD) on the Narmada River. Among these, four gastropod species—*Thiara scabra*, *Tarebilineata*, *Parreysia caerulea*, and *Indoplanorbis exustus*—were identified, with three of them being exclusively reported from the Sakkarpura sampling station. Crustacean such as prawn larvae and crab juveniles were observed at the Sisodara and Lilod sampling stations, respectively. In addition, some arthropods were also reported from various sites. Notably, polychaetes belonging to the genus *Syllidae* were recorded from the Bharuch and Bhadbhut sampling stations.

Fish Diversity and Fisheries

Fish were collected from the main channel as well as the adjacent area. Though the river was bank full due to heavy rain, fish were collected from the river using gill nets, hook and lines and cast nets of assorted mesh sizes from all possible habitat niches along the sampling sites, assuming that the existing species and their abundance would be reflected in the sample. The fish samples were collected mainly through experimental fishing and from adjoining landing centres.

A total of 36 fish species are reported from the lower stretch of the Narmada River during the pre-monsoon sampling. Highest number of species reported from station S₃ (23) while lowest was from S₉ (5) (Fig. 25). The relative abundance of fish species across different sampling stations (S₁–S₉) (Fig.26) during pre-monsoon shows that at S₁, the fish community was relatively diverse, with *Clupisoma garua* (19.83%) emerging as the dominant species, followed by *Osteobrama cotio* (15.01%) and *Salmophasia bacaila* (10.99%), while other species such as *Pethia conchonius* (8.57%) and *Systomus sarana* (9.91%) also contributed notably to the species diversity. In S₂, the composition changes, where *Pethia conchonius* (31.97%) was dominant followed by *Puntius sophore* (20.68%) forming the bulk of the catch, along with significant proportions of *Chanda nama* (14.10%) and *Salmophasia bacaila* (10.34%). In Sampling station 3 (S₃), *Amblypharyngodon mola* (24.15%) was the most abundant species, while *Pethia conchonius* (7.58%) and *Clupisoma garua* (4.19%) also maintained their presence, suggesting a moderately diverse fish assemblage. Some species were not reported such as *Salmophasia bacaila* which was found one of the dominant species in S₁ and S₂. In this site along with fin fish species *Macrobrachium rosenbergii* was also reported contributing to 9.98 % of relative abundance. The community structure at S₄ was dominated by *Salmophasia bacaila* (37.77%), followed by *Pethia conchonius* (20.74%) and *Macrobrachium rosenbergii* (20.37%). Similarly, in S₅ showed mixed relative dominance of *Clupisoma garua* (14.93%) and *Macrobrachium rosenbergii* (11.03%) constituting the highest percentage in this site, while *Pethia conchonius* and *Mystus cavasius* contribute equally (7.14%) remaining species contributed less than 4 % each. In S₆, *Salmophasia bacaila* (27.77%) again became dominant but the relative abundance was less as compared to S₄, followed by *Chanda nama* (16.66%) and *Mystus cavasius* (14.81%), showing the prominence of small-sized fishes and catfishes in this stretch.

A marked shift in dominance was observed from S₇ onwards, where *Mystus cavasius* (19.56%) became the most abundant species, reflecting the dominance of catfishes towards the downstream stretch. At S₈, *Tenualosa ilisha* was the most dominant species (39.28%), followed by *Escualosa thoracata* (19.64%) and *Otolithoides pama* (8.92%), indicating an increasing influence of clupeid fishes in the lower reaches due to estuarine zone. The trend was even more pronounced at S₉, only 5 species of fishes were reported among all *Tenualosa ilisha* majorly dominates due to migration to freshwater contributing relative abundance of 60.17%, followed by *Escualosa thoracata* (23.45%) and smaller proportions of *Otolithoides*



pama (9.29%).

Figure 25: Number of species obtained during pre-monsoon sampling seasons from different sampling stations

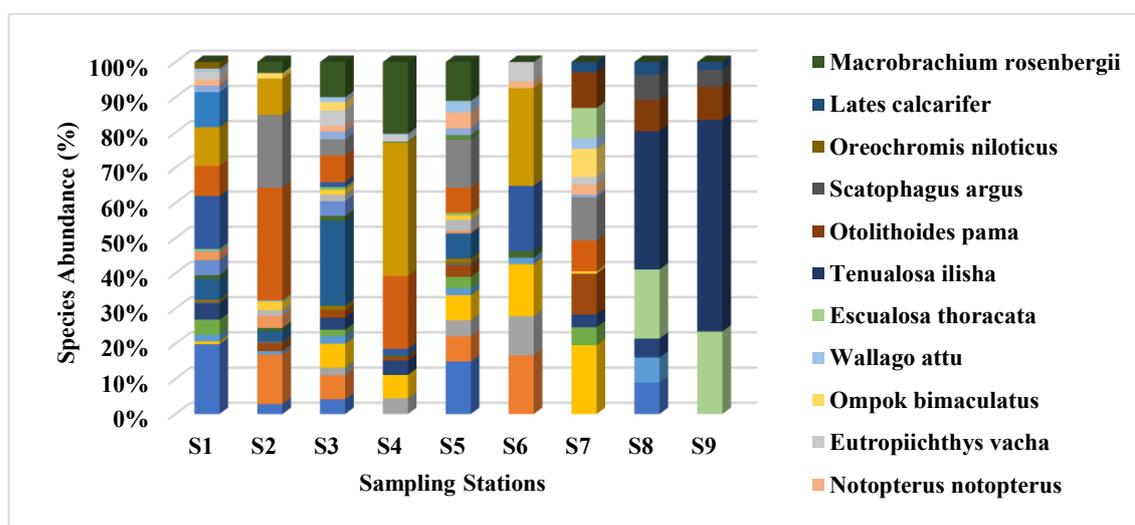


Figure 26: Species relative abundance percentage reported during pre-monsoon sampling seasons from different sampling stations

Cyprinidae is the most dominant family in the downstream of SSD, with the highest contribution recorded at S₂ (74.60%) and S₄ (61.11%). Its share, however, gradually decreases downstream, especially at S₇–S₉ due to estuarine zone. Bagridae family is consistently present across most stations and becomes highly abundant at S₇ (39.85%), while Ambassidae shows its peak at S₆ (27.77%). Palaemonidae which include *Macrobrachium rosenbergii* occurs mainly in the midstream, with high values at S₄ (20.37%) and S₅ (11.04%). In the downstream stations, a major shift in dominance is observed where Clupeidae and Sciaenidae replace Cyprinidae as the leading families. Clupeidae dominates at S₈ (39.28%) followed by Dorosomatidae (19.64 %) and 83.62% at S₉, while Sciaenidae maintains considerable abundance at S₇–S₉, with more than 9% at each station. Other families such as Channidae, Cobitidae, Mastacembelidae, Notopteridae, Schilbeidae, Siluridae, Cichlidae, and Latidae occur in low percentages (<10%) and are limited to specific sites. Overall, data showed that freshwater families like Cyprinidae dominates middle and upper stretch, whereas estuarine-associated families such as Clupeidae and Sciaenidae dominate downstream, showing a clear longitudinal shift in fish family composition.

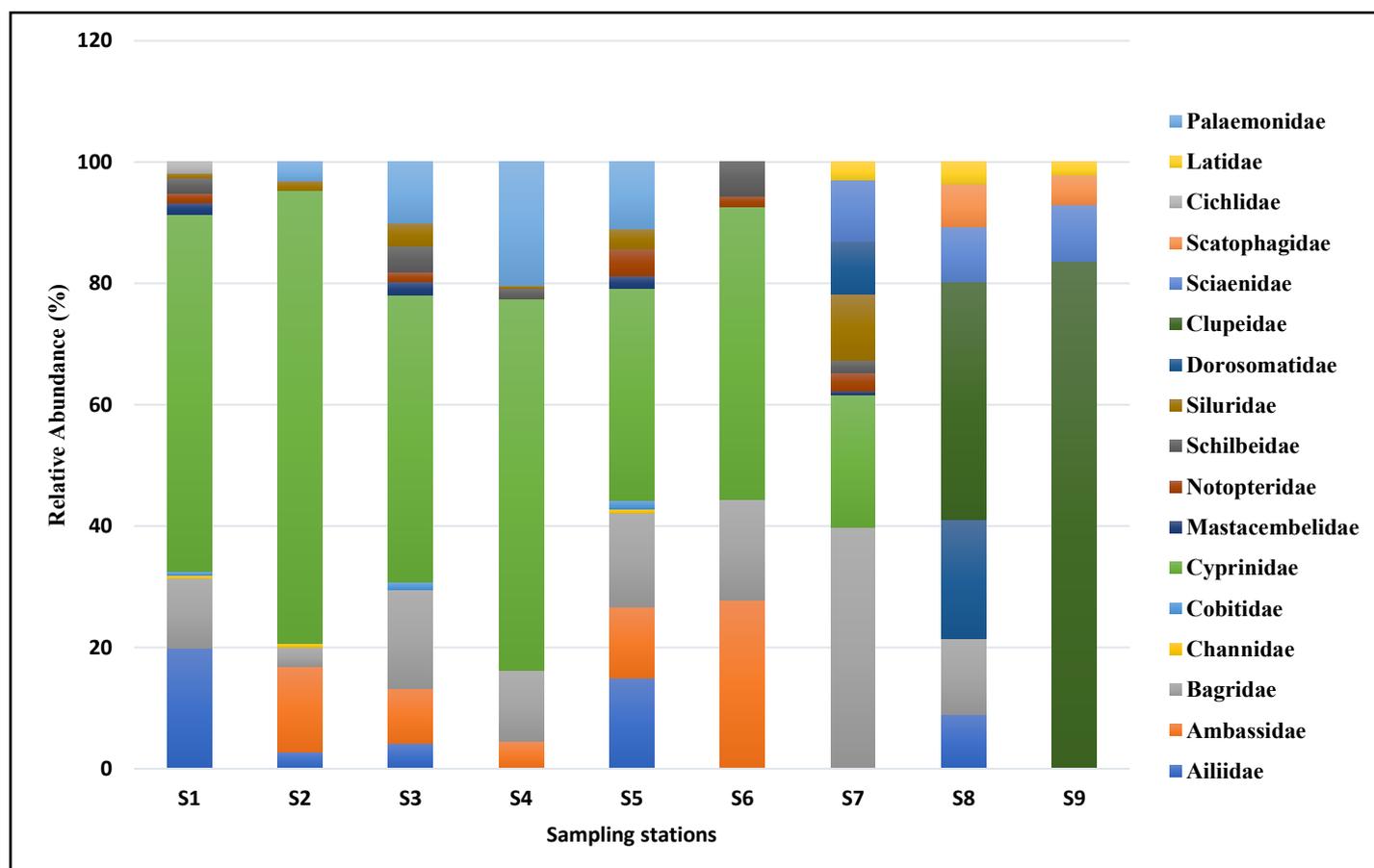


Figure 27: Relative abundance of fish species belongs to different families in the Narmada River downstream of SSD during pre- monsoon season

Table 4: Details of the fish species reported from the study area

Family	Fish species	IUCN status	Garudeshwar	Poicha	Sisodra	Lilod	Jhanor	Suklatirth	Bharuch	Sakkarpura	Bhadbhut
Ailiidae	<i>Clupisoma garua</i>	LC	+	+	+	-	-	-	-	+	-
Ambassidae	<i>Chanda nama</i>	LC	-	+	+	-	+	+	-	-	-
	<i>Parambassis ranga</i>	LC	-	-	+	+	+	+	-	-	-
Bagridae	<i>Mystus cavasius</i>	LC	+	-	+	+	+	+	+	-	-
	<i>Sperata seenghala</i>	LC	+	+	+	-	+	+	-	+	-
	<i>Spreta aor</i>	LC	+	-	+	-	+	-	+	-	-
	<i>Rita rita</i>	LC	+	-	+	+	-	-	+	+	-
	<i>Mystus bleekeri</i>	LC	-	+	+	+	+	-	+	-	-
Channidae	<i>Channa marulius</i>	LC	+	+	-	-	+	-	-	-	-
Cobitidae	<i>Lepidocephalichthys guntea</i>	LC	+	-	+	-	+	-	-	-	-
Cyprinidae	<i>Amblypharyngodon mola</i>	LC	+	+	+	-	+	-	-	-	-
	<i>Cirrhinus mrigala</i>	LC	+	+	+	+	-	+	-	-	-
	<i>Cirrhinus reba</i>	LC	+	-	+	-	-	-	-	-	-
	<i>Labeo boga</i>	LC	+	+	-	-	+	-	-	-	-
	<i>Labeo boggut</i>	LC	-	+	+	-	+	-	-	-	-
	<i>Labeo calbasu</i>	LC	-	+	+	-	+	-	+	-	-
	<i>Labeo dyocheilus</i>	LC	+	+	-	-	-	-	-	-	-
	<i>Labeo rohita</i>	LC	+	-	+	-	+	-	-	-	-
	<i>Osteobrama cotio</i>	LC	+	-	+	+	-	+	-	-	-
	<i>Pethia conchonius</i>	LC	+	+	+	+	+	-	+	-	-
	<i>Puntius sophore</i>	LC	+	+	+	-	+	-	+	-	-
	<i>Salmophasia bacaila</i>	LC	+	+	-	+	-	+	-	-	-
	<i>Systemus sarana</i>	LC	+	-	-	-	-	-	-	-	-
	<i>Tor tor</i>	DD	-	-	-	+	+	-	-	-	-
Mastacembelidae	<i>Mastacembelus</i>	LC	+	-	+	-	+	-	+	-	-

	<i>armatus</i>											
Notopteridae	<i>Notopterus notopterus</i>	LC	+	-	+	-	+	+	+	-	-	
Schilbeidae	<i>Eutropiichthys vacha</i>	LC	+	-	+	+	+	-	+	-	-	
Siluridae	<i>Ompok bimaculatus</i>	NT	-	+	+	-	-	-	+	-	-	
	<i>Wallago attu</i>	VU	+	-	+	+	+	-	+	-	-	
Dorosomatidae	<i>Escualosa thoracata</i>	LC	-	-	-	-	-	-	+	+	+	
Clupeidae	<i>Tenualosa ilisha</i>	LC	-	-	-	-	-	-	-	+	+	
Sciaenidae	<i>Otolithoides pama</i>	DD	-	-	-	-	-	-	+	+	+	
Scatophagidae	<i>Scatophagus argus</i>	LC	-	-	-	-	-	-	-	+	+	
Cichlidae	<i>Oreochromis niloticus</i>	LC	+	-	-	-	-	-	-	-	-	
Latidae	<i>Lates calcarifer</i>	LC	-	-	-	-	-	-	+	+	+	
Palaemonidae	<i>Macrobrachium rosenbergii</i>	LC	-	+	+	+	+	-	-	-	-	

IUCN Red List: NE-Not evaluated, DD-Data deficient, LC-Least concern, NT-Near threatened, VU-Vulnerable, EN-Endangered, CR-Critically endangered

Further, fish species documented during sampling are categorized into fourteen major fish groups (Table 5). Catfishes (CTF) formed the major group with 9 fish species followed by BML (Barbs, Minnows and Loaches), which mainly includes small indigenous fishes, and Minor and Peninsular Carps (MPC) (Fig. 11).

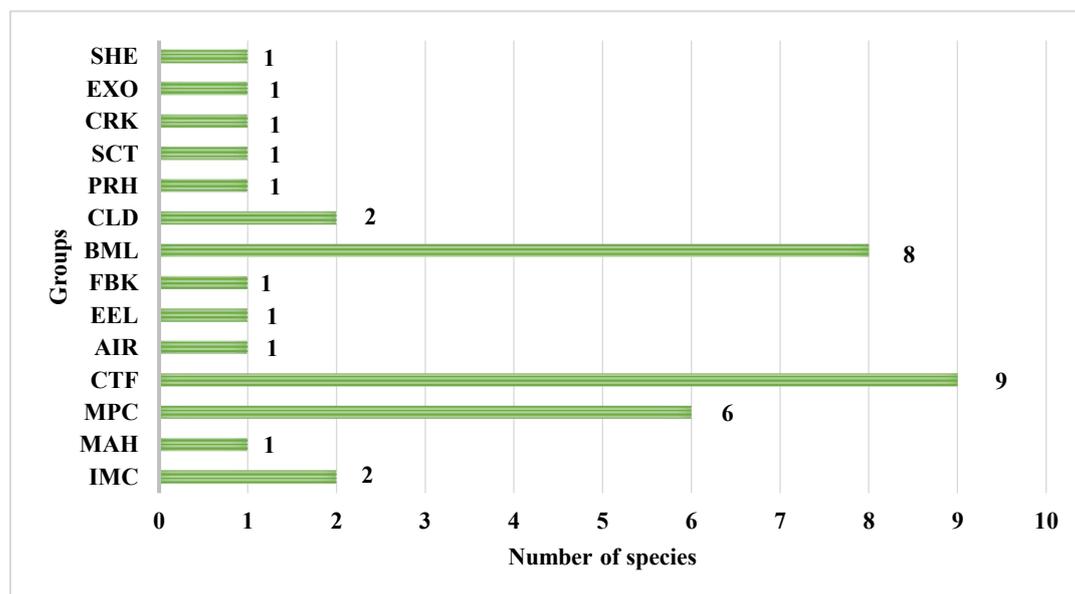


Figure 28: Group wise number of species reported during study period

Indian major carps IMC, MAH-Mahseer, MPC-Minor and peninsular carps, CTF- Catfishes, AIR-Air breathing fishes, EEL-Eels, FBK- Featherbacks, BML-Barbs, Minnows and Loaches, CLD- Clupids, PRH- Pearch SCT-Scat, CRK-Croaker, EXO-Exotics, SHE-Shell fish

Table 5: Fish groups observed during the pre-monsoon sampling at different stations

Sl. No.	Groups	Code	Species	Number
1.	Indian major carps	IMC	<i>Cirrhinus mrigala</i> , <i>Labeo rohita</i>	2
2.	Mahseer	MAH	<i>Tor tor</i>	1
3.	Minor and peninsular carps	MPC	<i>Cirrhinus reba</i> , <i>Labeo calbasu</i> , <i>Labeo dyocheilus</i> , <i>Labeo boggut</i> , <i>Systemus sarana</i> , <i>Labeo boga</i>	6
4.	Catfishes	CTF	<i>Wallago attu</i> , <i>Sperata seenghala</i> , <i>Clupisoma garua</i> , <i>Mystus cavasius</i> , <i>Mystus bleekeri</i> , <i>Ompok bimaculatus</i> , <i>Sperata aor</i> , <i>Eutropiichthys vacha</i> , <i>Rita rita</i>	9
5.	Air breathing fishes	AIR	<i>Channa marulius</i>	1
6.	Eels	EEL	<i>Mastacembelus armatus</i>	1
7.	Featherbacks	FBK	<i>Notopterus notopterus</i>	1
8.	Barbs, Minnows and Loaches	BML	<i>Parambassis ranga</i> , <i>Puntius sophore</i> , <i>Salmophasia bacaila</i> , <i>Chanda nama</i> , <i>Amblypharyngodon mola</i> , <i>Lepidocephalichthys guntea</i> , <i>Osteobrama cotio</i> , <i>Pethia conchoni</i>	8
9.	Clupids	CLD	<i>Tenualosa ilisha</i> , <i>Escualosa thoracata</i>	2

10.	Pearch	PRH	<i>Lates calcarifer</i>	1
11.	Scat	SCT	<i>Scatophagus argus</i>	1
12.	Croaker	CRK	<i>Otolithoides pama</i>	1
13.	Exotics	EXO	<i>Oreochromis niloticus</i>	1
14.	Shell fish	SHE	<i>Macrobrachium rosenbergii</i>	1

Catch Per Unit Effort (CPUE):

Catch Per Unit Effort (CPUE) is one of the important metrics widely used in fisheries to estimate the abundance of the fish in a targeted stretch of the river. It represents the quantity of fish caught relative to the amount of fishing effort. It is assumed that the decline in CPUE reflects the decrease in fish stock. CPUE is calculated by dividing the total catch (in weight) by the amount of fishing effort by a single person or unit. In the present investigation, CPUE is calculated in each sampling site (Figure 29). A higher value of CPUE (1.6 kg/hr/person) was recorded from the Bhadbhut site, and the lowest value (0.55 kg/hr/person) was recorded from Lilod. Significantly less fish diversity was recorded from Bhadbhut, but this was probably due to the huge hilsa catch, which triggered the CPUE value at the site.

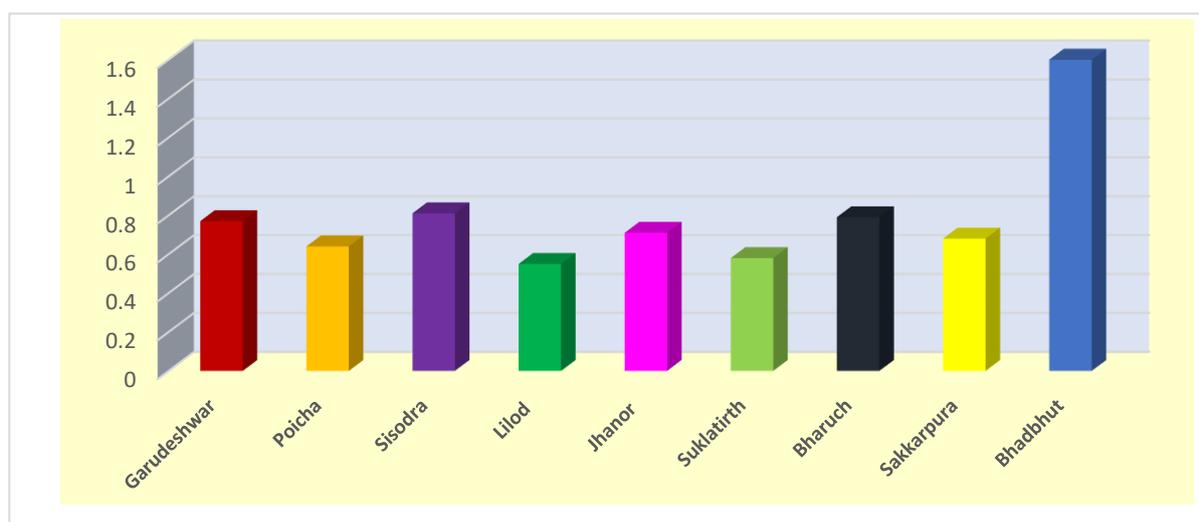


Figure 29: Diagram representing site-wise CPUE value (Kg/ hr/person)

Distribution of migratory fishes

In the present study, the migratory fish species mostly available in the stretch between Garudeshwar and Bhadbhut were *Tor tor* and *Tenualosa Ilisha*. The stretch around Sisodra to Bhadbhut has been identified as a hilsa fishing zone, and as such, there was no regular fishing activity in the upper stretches of the river Narmada. In general, the catch of *T. Ilisha* is abundant in the Bhadbhut and Bharuch areas. According to fishermen's perception, *T. Ilisha* is occasionally caught in the Sisodra area, especially during heavy rain. In the stretch between Garudeshwar and Shuklatirth, the migratory species *Tor tor* was found to be dominant during the rainy season along with other fish species.

Early life stages of fish

The early life stages of fish in the natural aquatic environment, including eggs, fry, larvae and juveniles, play a crucial role in population success and ecosystem health because they are highly vulnerable to predators and environmental changes, and their development determines the new recruitment of fish fauna diversity in the river habitats. During the sampling period, significantly fewer juveniles and fry of the fish species were found due to the heavy downpour and overcast conditions throughout the entire tour period.

Images of fish species with salient features:

Salient features	Representative images of fishes
Family: Cyprinidae	
<p><i>Amblypharyngodon mola</i> (Hamilton)</p> <ul style="list-style-type: none"> • Abdomen more or less rounded. Barbels absent. Dorsal fin inserted behind pelvic fin base. Scales small, lateral line incomplete. A broad silvery lateral band on body. • The species recorded from Garudeshwar, Poicha, Sisodara and Jhanor 	
<p><i>Cirrhinus mrigala</i> (Hamilton)</p> <ul style="list-style-type: none"> • Body streamlined. Lower lip indistinct. One pair of short rostral barbels. Dorsal fin with 15-17 rays • Fish species collected from Garudeshwar and Sisodara 	
<p><i>Cirrhinus reba</i> (Hamilton)</p> <ul style="list-style-type: none"> • Body elongate. Dorsal fin with 10-11 rays. Scales hexagonal. A short pair of rostral barbels. • Sample collected from Sisodara and Garudeshwar 	
<p><i>Labeo boga</i> (Hamilton)</p> <ul style="list-style-type: none"> • Mouth narrow, lips thick, a thin horny layer of cartilage to inner surface of lower lip. Dorsal fin with 9 to 10 branched rays. One pair of minute maxillary barbels. • Species recorded from Garudeshwar, Poicha, and 	

Jhanor	
<p><i>Labeo boggut</i> (Sykes)</p> <ul style="list-style-type: none"> • Slightly convex dorsal profile, thin lips and a short pair of maxillary barbels, scales comparatively small. • Sample recorded from Poicha, Sisodara and Jhanor 	
<p><i>Labeo calbasu</i> (Hamilton)</p> <ul style="list-style-type: none"> • Mouth inferior, lips thick and fringed, lower jaw more thickened. Two pairs of barbels. Easily distinguished from the very dark colour of its body. • Sample collected from Poicha, Sisodara and Bharuch. 	
<p><i>Labeo dyocheilus</i> (McClelland)</p> <ul style="list-style-type: none"> • Snout conical, with a distinct lateral lobe, tubercles on snout prominent. Mouth inferior, lips thick, not fringed. One pair of short maxillary barbels. • Fish species recorded from Garudeshwar and Poicha sites. 	
<p><i>Labeo rohita</i> (Hamilton)</p> <ul style="list-style-type: none"> • Snout obtuse, mouth small and inferior. Lips thick and fringed with a distinct inner fold to each lip. Branched dorsal rays 12 to 14. • Species collected from Garudeshwar, Poicha and Jhanor sites 	

<p><i>Osteobrama cotio</i> (Hamilton)</p> <ul style="list-style-type: none"> • Body deep and compressed. Snout bluntly rounded, eyes large. Abdominal edge keeled only between pelvic and anal fins. Rounded abdominal edge in front of pelvic fins. Scales small. • Recorded from Garudeshwar, Poicha, Lilod sites 	
<p><i>Pethia conchonius</i> (Hamilton)</p> <ul style="list-style-type: none"> • Body deep, barbels absent. Dorsal fin spine osseous, moderately strong and serrated. A large round black spot over posterior portion of anal fin, dorsal fin with its upper half black. • The species collected from Garudeshwar, Poicha, Sisodra, Lilod, Jhanor and Bharuch 	
<p><i>Puntius sophore</i> (Hamilton)</p> <ul style="list-style-type: none"> • Barbels absent. Last unbranched ray of dorsal fin osseous and smooth. A deep black round blotch at base of caudal fin, a similar black blotch on central part of dorsal fin. • Fish specimen collected from Poicha, Sisodra, Jhanor and Bharuch 	
<p><i>Salmophasia bacaila</i> (Hamilton)</p> <ul style="list-style-type: none"> • Body elongated and strongly compressed, abdominal keel not hardened. Dorsal fin inserted well behind pelvic fins and in advance of anal fin. Scales very small. • Fish species collected from Garudeshwar, Poicha, Lilod and 	

Shuklatirth	
<p><i>Systemus sarana</i> (Hamilton)</p> <ul style="list-style-type: none"> • 2 pairs of barbels. Last unbranched ray of dorsal fin osseous, strong and finely serrated posteriorly. A blotch on lateral line before base of caudal fin. • Fish sample recorded from Garudeshwar site 	
<p><i>Tor tor</i> (Hamilton)</p> <ul style="list-style-type: none"> • Mouth small, lips thick, fleshy with the labial fold continuous. Barbels 2 pairs (maxillary barbels equal to eye-diameter. Dorsal spine bony, smooth. Scales large, head length almost equal to body depth. • Fish species collected from Lilod and Jhanor 	
<p>Family: Ambassidae</p>	
<p><i>Chanda nama</i> (Hamilton)</p> <ul style="list-style-type: none"> • Body ovate, strongly compressed, dorsal and abdominal profile convex. Mouth large, lower jaw prominent. 1st dorsal with 7 spines and 2nd dorsal with one spine and 15 to 17 rays; 2nd spine of 1st dorsal longest. Caudal fin forked. • Fish sample recorded from Poicha, Sisodara, Jhanor and Shuklatirth sites. 	

<p><i>Parambassis ranga</i> (Hamilton)</p> <ul style="list-style-type: none"> • Body oblong, deeply compressed. 1st dorsal with 7 spines and 2nd dorsal with one spine and 11 to 14 rays. Mouth oblique, lower jaw more or less equals to upper jaw. Caudal fin forked. • Fish sample collected from Sisodara, Lilod, Jhanor and Shuklatirth sites. 	
<p>Family: Channidae</p>	
<p><i>Channa marulius</i> (Hamilton)</p> <ul style="list-style-type: none"> • Mouth large, deeply cleft, maxilla extends behind orbit. Dorsal fin with 45 to 55 soft rays. Grayish-green above and becoming lighter below, 5 or 6 dark oval blotches on flank. Dorsal and anal fins with white spots, a large black ocellus at upper part of the base of caudal fin. • Fish species collected from Garudeshwar, Poicha and Jhanor. 	
<p>Family: Schilbeidae</p>	
<p><i>Clupisoma garua</i> (Hamilton)</p> <ul style="list-style-type: none"> • Abdominal edge keeled between pelvic fins and vent. Barbels 4 pairs. Maxillary barbels extend to base of pelvic fins in adults. Adipose dorsal fin absent. • Fish species collected from Garudeshwar, Poicha, Sisodara, Jhanor and Sakkarpura sites. 	

<p><i>Eutropiichthys vacha</i> (Hamilton)</p> <ul style="list-style-type: none"> • Mouth wide, cleft of mouth extends to posterior border of orbit. Barbels 4 pairs. Maxillary barbels reaching end of preopercle or even as long as head. Nasal barbels extend to posterior margin of head. • Sample recorded from Garudeshwar, Sisodara, Lilod, Shuklatirth and Bharuch sites. 	
<p>Family: Dorosomatidae</p>	
<p><i>Escualosa thoracata</i> (Valenciennes)</p> <ul style="list-style-type: none"> • Dorsal profile nearly horizontal while ventral profile convex. Snout obtuse, lower jaw slightly the longer. Maxilla reaching the middle of eye. Dorsal origin opposite to pelvic origin. • Collected from Bhadbhut and Bharuch sites 	
<p><i>Tenulosa Ilisha</i> (Hamilton)</p> <ul style="list-style-type: none"> • Dorsal and ventral profile equally convex. Belly with 30-33 scutes. Caudal fin deeply forked as long as head. A dark blotch behind gill opening followed by a series of small spots along flanks in the immature. • Collected from Bhadbhut and Bharuch sites 	
<p>Family: Latidae</p>	

<p><i>Lates calcarifer</i> (Bloch)</p> <ul style="list-style-type: none"> • Mouth large, slightly oblique, gape extending to anterior border of eye. Lower jaw longer than upper. First dorsal (spinous) with 7 to 9 strong spines and second dorsal with one spine and 10 to 11 soft rays. Anal fin with 3 spines. Lateral line curved and continued on to caudal fin. • Fish sample recorded from Bharuch, Sakarpura and Bhadbhut sites. 	
<p>Family: Cobitidae</p>	
<p><i>Lepidocephalichthys guntea</i> (Hamilton)</p> <ul style="list-style-type: none"> • Mouth inferior. Barbels 3 pairs. Short dorsal fin inserted posterior to origin of pelvic fins, and nearer to caudal base than to snout tip. Caudal fin truncated. There are 10 to 12 black blotches along this stripe grow in size and fuse with one another to form a continuous dark band with age. • Fish species collected from Sisodara and Jhanor sites. 	
<p>Family: Mastacembelidae</p>	
<p><i>Mastacembelus armatus</i> (Lacepede)</p> <ul style="list-style-type: none"> • Tri-lobed snout tip. Pre-orbital spine strong. • Pre-opercle with 2 or 3 spines. Mouth small, sharp teeth on both jaws. Spinous dorsal fin inserted above middle of pectoral fin, last dorsal spine 	

<p>small. Dorsal fin with 37-38 spines. Dorsal and anal fins broadly joined to caudal fin.</p> <ul style="list-style-type: none"> Species explored from Garudeshwar, Sisodra, Jhanor and Bharuch sites. 	
<p>Family: Bagridae</p>	
<p><i>Mystus bleekeri</i> (Day)</p> <ul style="list-style-type: none"> Maxillary barbels extend posteriorly to anal fin. Dorsal spine smooth, rarely finely serrated. Body with two light longitudinal colour bands one above and below the lateral line. Fish sample recorded from Poicha, Sisodra, Lilod, Jhanor and Bharuch sites. 	
<p><i>Mystus cavasius</i> (Hamilton)</p> <ul style="list-style-type: none"> Maxillary barbels very long extend posteriorly to beyond caudal fin base. Upper lobe of caudal fin much longer than lower lobe. A dark spot on base of dorsal spine. Recorded from Garudeshwar, Sisodra, Lilod, Jhanor, Shuklatirth and Bharuch. 	
<p><i>Sperata aor</i> (Hamilton)</p> <ul style="list-style-type: none"> Anterior margin of snout rounded. 4 pairs of barbels. Maxillary barbels extend to the end of anal or caudal base or beyond. Pectoral spine denticulate posteriorly. Caudal fin deeply forked with pointed lobes, upper longer. Fish sample collected from Garudeshwar, Sisodra, Jhanor and Bharuch. 	

<p><i>Sperata seenghala</i> (Sykes)</p> <ul style="list-style-type: none"> • Outer margin of snout truncate. Barbels four pairs, maxillary pair extend to the base of pelvics or a little beyond. Pectoral spine stronger than dorsal. • The cat fish collected from Garudeshwar, Poicha, Sisodra, Jhanor, Shuklatirth and Bharuch sites. 	
<p>Family: Notopteridae</p>	
<p><i>Notopterus notopteus</i> (Pallas)</p> <ul style="list-style-type: none"> • Body strongly compressed. Dorsal fin inserted nearer snout-tip than to base of caudal fin. Pectoral fins moderate, extend beyond anal fin origin. Scales minute. • This featherback explored from Garudeshwar, Sisodra, Jhanor, Shuklatirth and Bharuch. 	
<p>Family: Siluridae</p>	
<p><i>Ompok bimaculatus</i> (Bloch)</p> <ul style="list-style-type: none"> • Gape of mouth not extending beyond eye. Maxillary barbels long extend slightly beyond anal fin base. Dorsal fin short with 4 rays, spine absent. One spot behind operculum. • The butter catfish collected from Garudeshwar, Poicha and Bharuch. 	
<p><i>Wallago attu</i> Bloch and Schneider</p> <ul style="list-style-type: none"> • Gape of mouth wide and very long reaching beyond eye posteriorly. Dorsal fin short with 5 rays and devoid of spine. Barbels two pairs, maxillary barbels extending beyond origin of anal fin. • The freshwater catfish collected from Sisodra, Lilod, Jhanor and 	

Bharuch	
Family: Sciaenidae	
<p><i>Otolithoides pama</i> (Hamilton)</p> <ul style="list-style-type: none"> • Snout prominent and projecting. Mouth inferior, outer row of upper jaw teeth slightly enlarged. Dorsal fin deeply notched and dorsal spines (9-10). Light brownish coloration along the back and fins are yellowish to pale orange. • The fish species collected from Bharuch, Sakarpura and Bhadbhut. 	
Family: Ritidae	
<p><i>Rita rita</i> (Hamilton)</p> <p>Head depressed with osseous plates and flattened ventral side. 3 pairs of barbels. Maxillary barbels extend to the end of head. Dorsal spine strong, serrated posteriorly in upper part only.</p>	
Family: Scatophagidae	
<p><i>Scatophagus argus</i> (Linnaeus)</p> <ul style="list-style-type: none"> • First dorsal with 11 spines and 2nd dorsal with 16 to 18 soft rays. Pectoral fins relatively small. Caudal fin truncate. Lateral line arched. Large round blackish or greenish spots on body. • The species collected from Sakarpura and Bhadbhut. 	
Family: Chichlidae	

***Oreochromis niloticus* (Linnaeus)**

- Dorsal fin with 15 to 18 spines and 11 to 13 soft rays. Anal fin with 3 spines and 9 to 11 soft rays. Most distinguishing characteristics is the presence of regular vertical stripes throughout depth of caudal fin. Caudal peduncle depth equals to length.
- The exotic species recorded from Garudeshwar site.

**6. Summary**

The presentation investigation was conducted to assess the hydrological and ecological status during the pre-monsoon season. The study showed that 36 fish species are in the stretch from SSD to Bhadbhut. The entire stretch was represented by nine sampling sites. The fish species abundance was higher in the Sisodra site, followed by the Garudeshwar sites. The study focused on the abundance of migratory fish species, including Mahseer and Hilsa. Mahseer juveniles/adults were recorded in Lilod and Jhanor sites. At the same time, Hilsa was recorded in Bharuch and Bhadbhut sites. The habitat characteristics of these two species were studied. At sites Lilod and Jhanor, the Mahseer habitat was represented by sandy substratum with rich riparian vegetation, including deep pools. In contrast, the suitable habitat for the Hilsa was recorded in the tidal stretch of the river. The water depth and water velocity, which play a significant role in estimating environmental flows, were measured particularly during the pre-monsoon period. Based on this, the preliminary habitat suitability for these two species was prepared. However, the post-monsoon habitat suitability factors, along with river cross-sections and hydrological discharge data at respective sites, will further support the development of environmental flow estimation, particularly in the conservation of fish species in the downstream areas of the SSD, extending to Bhadbhut.

The current study also highlighted six sp. of phytoplankton at different sites, and 13 macro- and meiobenthic taxa were recorded. The water quality parameters showed little anthropogenic stress. The habitat in each site is mainly represented by boulders, coarse sand, gravels, and sandy clay at the upper stretches of the river (Garudeshwar to Sisodra) and sandy

clay and sand in all remaining sites (Lilod to Bhadbhut), which are considered to be ideal habitats for the freshwater ecosystem.

Plates



Plate 1: Habitat profile of sampling stations



Plate 2: Sampling at different sampling sites.



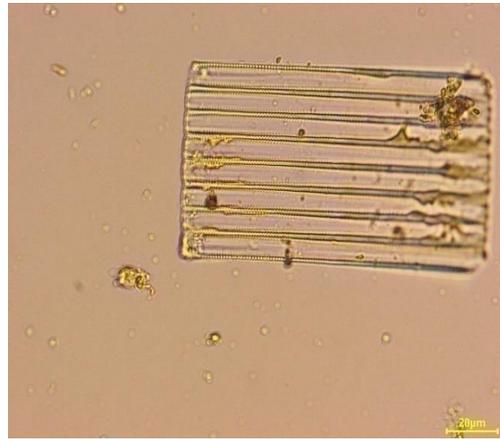
Pediatrum simplex



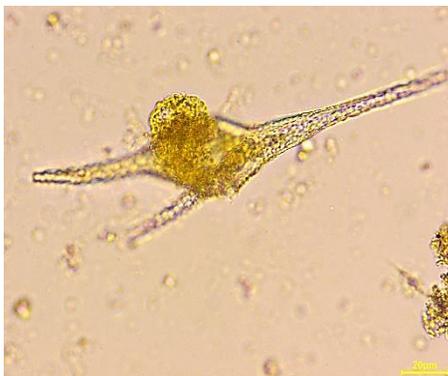
Closterium sp.



Coscinodiscus sp.



Fragilaria sp.



Ceratium sp.



Spirogyra sp.

Plate 3: Commonly recorded phytoplankton species during the premonsoon study



Copepod



Mesocyclops Sp.

Plate 4: Commonly recorded Zooplankton species during the premonsoon study



Prawn larvae



Crab juvenile



Austrolimnius montanus Larva



Aulodrilus sp.



Thiara scabra



Syllidae sp.



Fish larvae



Gnorimosphaeroma sp.



Prostoma sp.



Tarebia lineata



Parreysia caerulea



Indoplanor bisexustus



Agabus binotatus

Plate 5: Common benthic macroinvertebrates during the pre-monsoon study

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