Final Report

ASSESSMENT OF RIVERINE FISHERIES AND LINKING WITH WATER QUALITY RESTORATION PROGRAMME - RIVER GODAVARI IN MAHARSHATRA

2011

Maharashtra Pollution Control Board

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CONTENTS

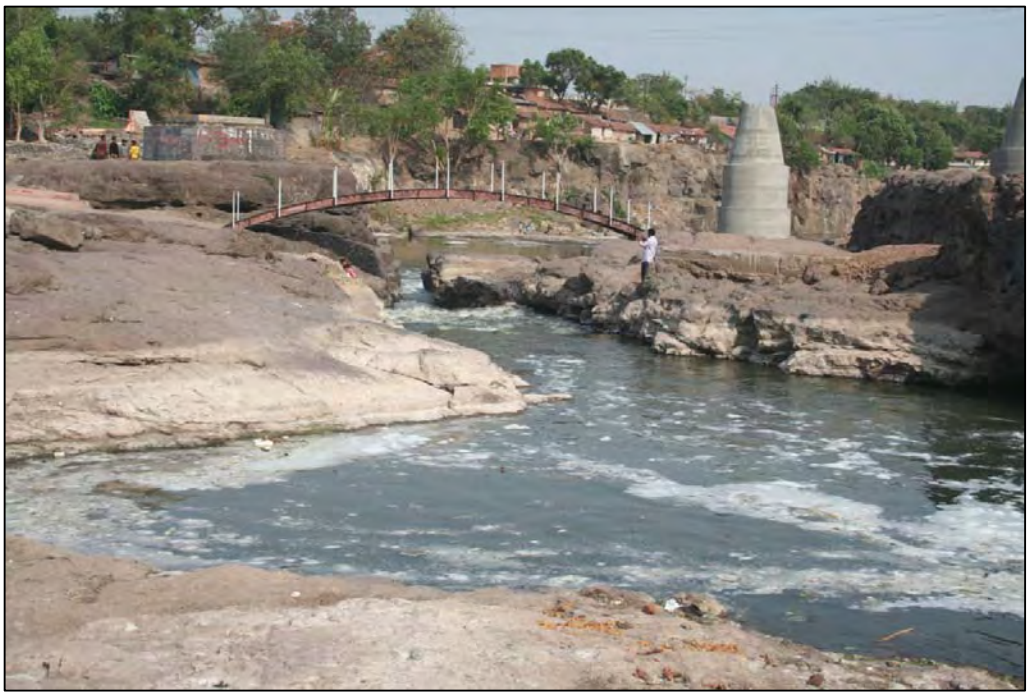
1. BACKGROUND

From time immemorial, the rivers are said to be the lifeline for living beings, as all types of developments, directly or indirectly relate to them. They have played a vital role in the development of human civilization since they provide basic necessities of life, water and food, on which depends the survival of living-beings. In a way, rivers are also the ultimate sink of all types of terrestrial and aquatic pollution. On the other hand, the rapid industrial development and demographic explosion, during the last few decades, have resulted in a galloping pace of environmental degradation and irrational exploitation of riverine resources.

India is endowed with vast expanse of open water fishery resources, noted for their variety as well as rich production potential. The 29,000 km of riverine resource of the country comprises 14 major rivers (catchment area >20,000 km²), 44 medium rivers (catchment area between 2,000 and 20,000 km²) and innumerable minor rivers (catchment area <2,000 km²). They can be grouped into five major river systems: the Ganga, the Brahmaputra and the Indus river systems in the north, and the east and west coast river systems in the Peninsular India. The East Coast River System is a composite system of rivers. Its main constituents are Mahanadi, Godavari, Krishna and Cauvery. The total combined length is about 6,437 km. This system drains the entire Peninsular India (from the east of Western Ghats in the west to the Bay of Bengal in the east) and southern parts of Central India (including Chhota Nagpur hill ranges). Our present study is related to the River Godavari in Maharashtra.

The River Godavari is the largest of the peninsular rivers and the second longest river in India next only to Ganga. River Godavari is about 1,440 km (Jhingran, 1997) long from its origin near Trimbakeswar in Deolali Hills near Nashik (Maharashtra) in Northern Western Ghats to its tidal limits below Rajahmundry (Andhra Pradesh). It flows across the Deccan Plateau from Western to Eastern Ghats through Maharashtra and Andhra Pradesh before emptying into the Bay of Bengal. The major tributaries of River Godavari are Manjira, Wainganga, Indravati, Purna, Maner and Sabri, and there is a host of rivulets and seasonally active streams serving as minor tributaries. The catchment area of River Godavari is 315,980 km^2 (Jhingran, 1997) to which Maharashtra contributes 48.6%, Andhra Pradesh (23.8%), Madhya Pradesh (20.7%), Orissa (5.5%) and Karnataka (1.4%). It includes the densely forested high rainfall zones of the Western and Eastern Ghats, and the intensely cultivated dry regions of the Deccan Plateau with low rainfall. The river is generally confined within the banks and rarely overflows in its lower course.

The river traverses 693 km in Maharashtra and is largely utilised by constructing weirs, barrages and reservoirs for irrigation and domestic purposes. Two reservoirs, one in Gangapur (2,230 ha) 15 km below its origin in Nashik District and the larger Nathsagar (Jayakwadi dam - 35,000 ha) at Paithan in Aurangabad Distinct, are situated on the main stream of River Godavari in Maharashtra. A 321-m long irrigation barrage is situated at Vishnupuri, 8 km upstream of Nanded and another old weir at Nandur-Madhyameswar, near Nashik. In addition, there are 12 weirs (Kolhapur type) in this stretch of Godavari in Maharashtra. Due to dams and weirs, the flow in the river is not continuous and water is mainly confined to these points leaving the main course almost dry in the post-monsoon and summer months. The important tributaries joining in this stretch are Pravara and Purna.



River Godavari at Tapovan

From Maharashtra, the river enters Andhra Pradesh where Manjira joins at the border. Further down, it is joined by the tributaries Kadam, Maner, Pranahita and Indravathi in succession. A large reservoir (Sriramsagar - 45,300 ha) has been created at Pochampad in Nizamabad District on the mainstream in Andhra Pradesh. The tributaries Manjira, Kadam and Maner have reservoirs constructed on them. Two large anicuts, one at Dhawaleswaram (for irrigation and navigation) and the other at Dummagudem (for navigation) near Rajahmundry, constructed a century ago, exist in this part of the river. The Dhawaleswaram anicut was replaced by a barrage in 1985.

Below Dhawaleswaram, the river splits into a northern distributary, Gautami Godavari, and a southern one, Vasista Godavari. Gautami joins the Bay of Bengal 19 km below Yanam. Below Yanam, it divides into two branches, northern and southern. Before opening into the Bay of Bengal, Vasista further divides into the Vanateyama at Vadalrevu and the main Vasista near Narsapur. Between the main distributaries, lies the extensive fertile region of Godavari delta.

The river is considered to be one of the very sacred rivers of India. It is often referred to as the 'Vridha Ganga' or 'Dakshina Ganga'. The people believe that taking a holy dip in the river relieves them from all the sins. Being the ultimate sink of anything and everything drained through surface runoff, the river has been subjected to considerable stress. As a result, the fishery has suffered both qualitatively and quantitatively. Therefore, it is quite natural to get the special attention to improve environmental conditions for eco-restoration and development of norms for management of rivers from the fishery point of view.

India is the fourth largest inland fish producer in the world (4.7 million tonnes in 2008-09). But during the last few decades, the production scenario in inland sector has indicated a mixed trend - an upward looking aquaculture with a declining fishery from riverine sector. At present, the major share of inland fish production in the country is from aquaculture and the share of rivers is very low. It is so because our open-water fishery resources, the prime means of sustenance to an estimated 0.45 million inland fishers as well as the only source of natural fish germplasm, have brutally been assaulted through various omissions and commissions on the part of the human beings. The situation needs serious thought and desired action for sustainable fish production and to attain the targeted production of nearly 8.0 million tonnes from inland sector by 2020 (Sinha, 2002).

During the post-independence phase, commissioning of a large number of river valley projects resulted in the creation of a large number of reservoirs (3,150,000 ha) and a network of canals (126,334 km), which have further enhanced the inland open-water fishery resources. The conservation and restoration of rivers are vital for harnessing the direct and indirect benefits from such an ecosystem on a sustainable basis. The water quality of the rivers in the country is being monitored by several agencies, *viz*., Central Pollution Control Board (CPCB), State Pollution Control Boards, National River Conservation Directorate, Central Water Commission, State Ground Water Agencies and Central Ground Water Board.

River Godavari at Nandur-Madhyameshwar

The riverine fisheries offer the main economic activity to our fishermen and it would be necessary to link water quality improvement with the biotic community, particularly fish diversity. It has been recognised that fishes and their presence with rich diversity in the river indicate a high level of cleanliness. There have been many reports on the massive mortalities of fishes and many river stretches have turned to be “dead pockets” where no fish exists. Riverine fisheries have also been considered to be one of the important economic activities of the nation. It could be worthwhile to link water quality improvement programmes with biotic assessments, particularly for aquatic animals, *i.e.*, fishes and invertebrates.

Thus, any strategy of fisheries development in the riverine sector needs to give equal emphasis to conservation of the bio-diversity and fish production. The CPCB, under the national programme of Monitoring of Indian National Aquatic Resources (MINARS) is monitoring water quality of ten river basins across India. To assess the impact of water quality on fisheries, the present study was carried out at selected stations of the River Godavari during 2009-10.

2. OBJECTIVES

The study was carried out in collaboration with the Maharashtra Pollution Control Board (MPCB) with the following objectives:

- To evaluate the water quality of River Godavari
- To study the fish biodiversity in the river
- To study the quality of riverine environment, particularly in the river stretches identified by MPCB in relation to fishery status
- To study the changes in fish diversity and productivity with respect to water quality changes

Construction of bridge across River Godabvari at Kopergaon in progress

2.1. Framework of the Project

Project	Problem	Constraints	Intervention	Output	Outcome
Assessment of riverine fisheries and linking with water quality restoration programme - River Godavari in Maharashtra	Likely changes in fish species in the river due to environmental stress	Lack of adequate database on ecological integrity related to fisheries for the various stretches of the river	Investigation on the status of fisheries at different stretches of the river *vis-à-vis* water quality	Comprehensive information on the ecological integrity of the river with regard to water quality status	Data for conservation and restoration of the river

3. STUDY AREA

The study was carried out seasonally during May 2009 to February 2010 by collecting fish fauna and water samples from different stations of the river. Ten sampling sites were selected, starting from Gangapur dam in Nashik District down to Raher in Nanded District, from where the river flows into the state of Andhra Pradesh. The ten sampling stations were identified and selected in consultation with MPCB and are represented in Table 1 and Fig. 1-3. The sampling stations were selected in different districts of Maharashtra such as Nashik, Ahmednagar, Aurangabad, Parbhani and Nanded. The present study covered the stretch of the river in Maharashtra State only. The River Manjira joins Godavari at the border.

Table 1. Sampling stations in River Godavari

Sr. no.	Latitude and longitude	Sampling station	District
1.	$20^0$02.945' N $73^0$40.731' E	Gangapur dam	Nashik
2.	$20^0$00.007' N $73^0$48.864' E	Tapovan	Nashik
3.	$20^0$00.481' N $74^0$07.843' E	Nandur-Madhyameshwar	Nashik
4.	$19^0$53.163' N $74^0$29.153' E	Kopergaon	Ahmednagar
5.	$19^0$37.345' N $75^0$01.277' E	Pravara Sangam	Ahmednagar
6.	$19^0$30.641' N $75^0$22.522' E	Jayakwadi dam	Aurangabad
7.	$19^0$29.083' N $75^0$22.408' E	Paithan Upstream	Aurangabad
8.	$19^0$27.966' N $75^0$23.783' E	Pathegaon	Aurangabad
9.	$19^0$13.638' N $76^0$21.782' E	Dhalegaon	Parbhani
10.	$18^0$53.808' N $77^0$40.492' E	Raher	Nanded

Dam across River Godavari at Gangapur

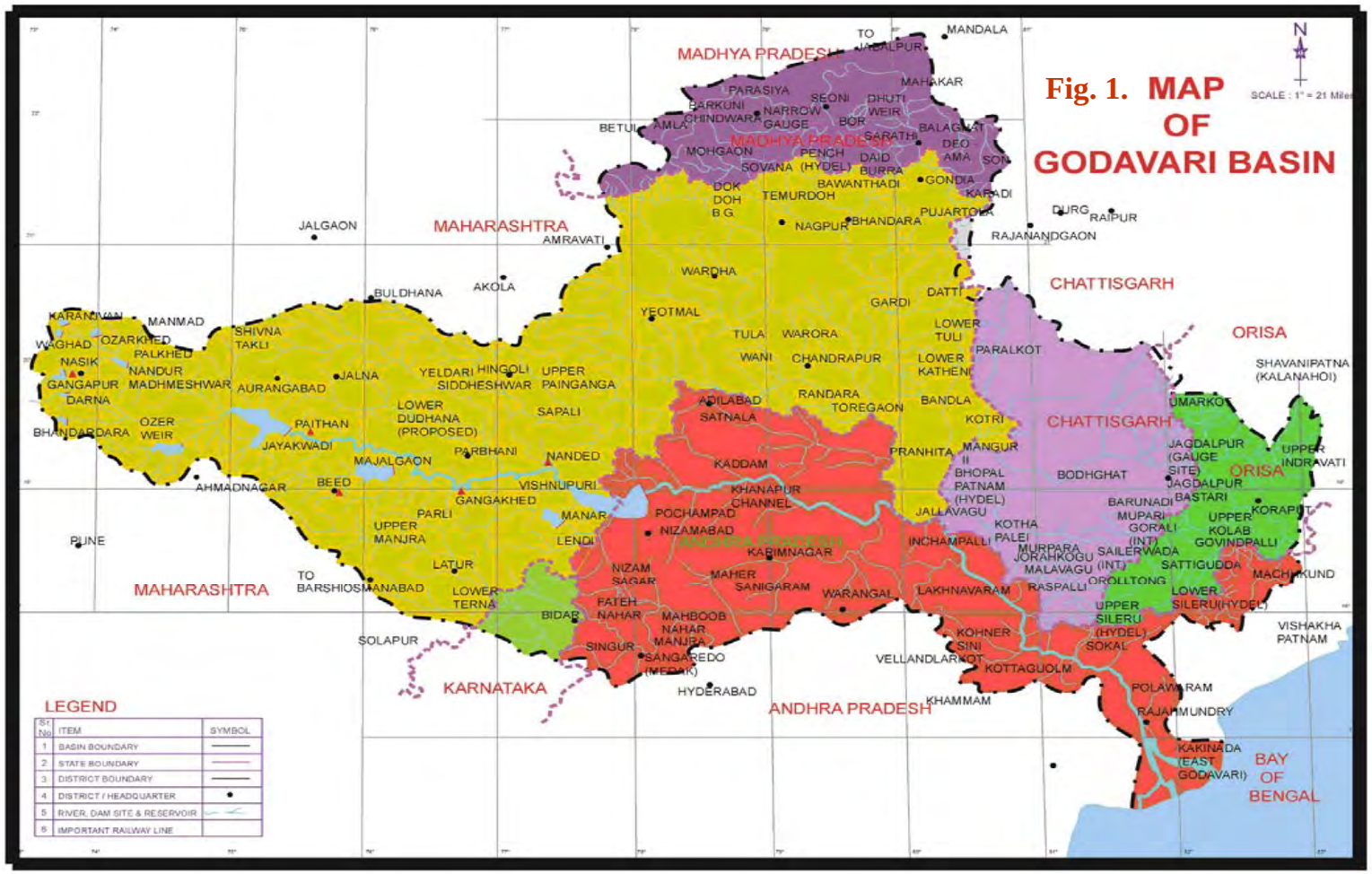
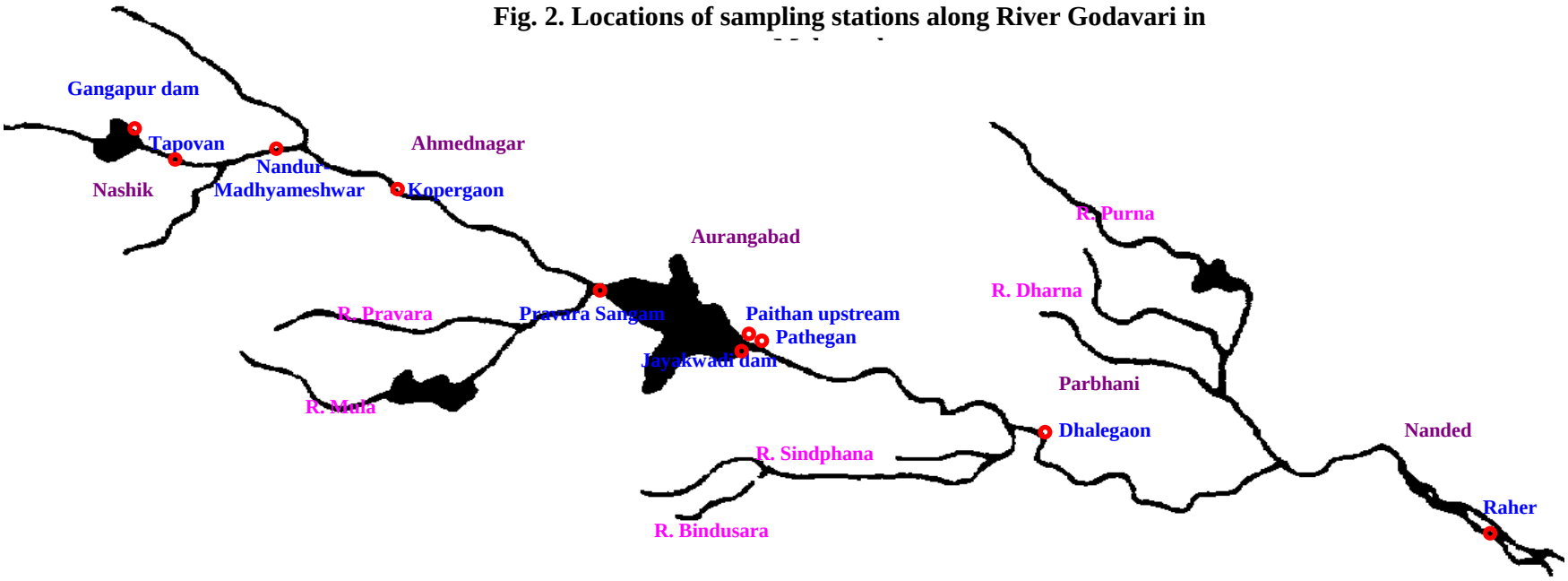
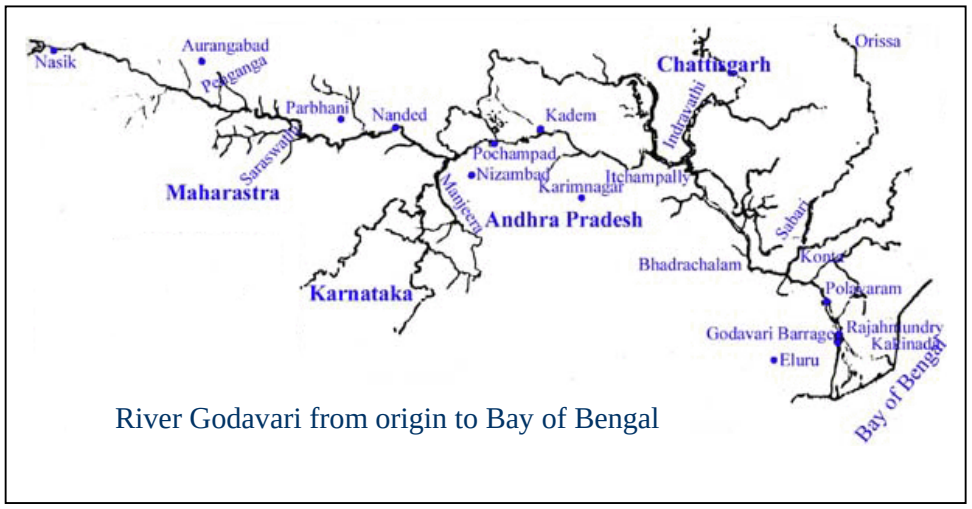


Fig. 1. MAP OF GODAVARI BASIN
SCALE : 1" = 21 Miles
N
MADHYA PRADESH
MAHARASHTRA
CHATTISGARH
ORISA
ANDHRA PRADESH
KARNATAKA
BAY OF BENGAL
MANDALA
TO NAGALPUR
MAHAKAR
PARASIYA
SEONI
DHUTI WEIR
BARKUNI
CHINDWARA
NARROW GAUGE
BOR
BALAGHAT
SARATHI
DEO
AMA
SON
BETUL
AMLA
MOHGAON
PENCH (HYDEL)
DAID BURRA
SOVANA
GONDIA
BAWANTHADI
KARADI
DOK
DOH
B.G.
TEMURDOH
NAGPUR
BHANDARA
PUJARTOLA
DURG
RAIPUR
RAJANANDGAON
JALGAON
AMRAVATI
WARDHA
BULDHANA
AKOLA
YEOTMAL
GARDI
DATTI
LOWER TULI
PARALKOT
TULA
WARORA
WANI
CHANDRAPUR
LOWER KATHENI
SHAVANIPATNA (KALANAHOI)
KARANJWAN
MANMAD
SHIVNA TAKLI
WAGHAD
OZARKHED
PALKHED
NASIK
NANDUR MADHMESHWAR
GANGAPUR
DARNA
JALNA
AURANGABAD
YELDARI SIDDHESHWAR
HINGOLI
UPPER PAINGANGA
LOWER DUDHANA (PROPOSED)
SAPALI
ADILABAD
SATNALA
RANDARA TOREGAON
BANDLA
KOTRI
UMARKOT
BHANDARDARA
OZER WEIR
PAITHAN
JAYAKWADI
PARBHANI
NANDED
MAJALGAON
KADDAM
PRANHITA
MANGUR II
BHOPAL PATNAM (HYDEL)
BODHGHAT
JAGDALPUR (GAUGE SITE)
UPPER INDRAVATI
JAGDALPUR
BASTARI
AHMADNAGAR
BEED
VISHNUPURI
GANGAKHED
KHANAPUR CHANNEL
BARUNADI
KORAPUT
PARLI
MANAR
POCHAMPAD
JALLAVAGU
MUPARI
GORALI (INT)
UPPER KOLAB
GOVINDPALLI
PUNE
UPPER MANJRA
NIZAMABAD
LENDI
KOTHA PALEI
INCHAMPALLI
MURPARA
SAILERWADA
KARIMNAGAR
JORAHKOGU (INT)
MALAVAGU (INT)
OROLLTONG
SATTIGUDDA
MACHKUND
LATUR
NIZAM SAGAR
MAHER SANIGARAM
WARANGAL
LAKHNAVARAM
RASPALLI
LOWER SILERU(HYDEL)
TO BARSHIOSMANABAD
LOWER TERNA
FATEH NAHAR
BIDAR
MAHBOOB NAHAR
MANJRA
UPPER SILERU (HYDEL)
SOKAL
KOHNER
SINI
VISHAKHA PATNAM
SOLAPUR
SINGUR
SANGAREDO (MEDAK)
VELLANDLARKOT
KOTTAGUOLM
HYDERABAD
KHAMMAM
POLAVARAM
RAJAHMUNDRY
KAKINADA (EAST GODAVARI)
LEGEND
Sr. No.
ITEM
SYMBOL
1 BASIN BOUNDARY
2 STATE BOUNDARY
3 DISTRICT BOUNDARY
4 DISTRICT / HEADQUARTER
5 RIVER, DAM SITE & RESERVOIR
6 IMPORTANT RAILWAY LINE

Fig. 2. Locations of sampling stations along River Godavari in





River Godavari from origin to Bay of Bengal

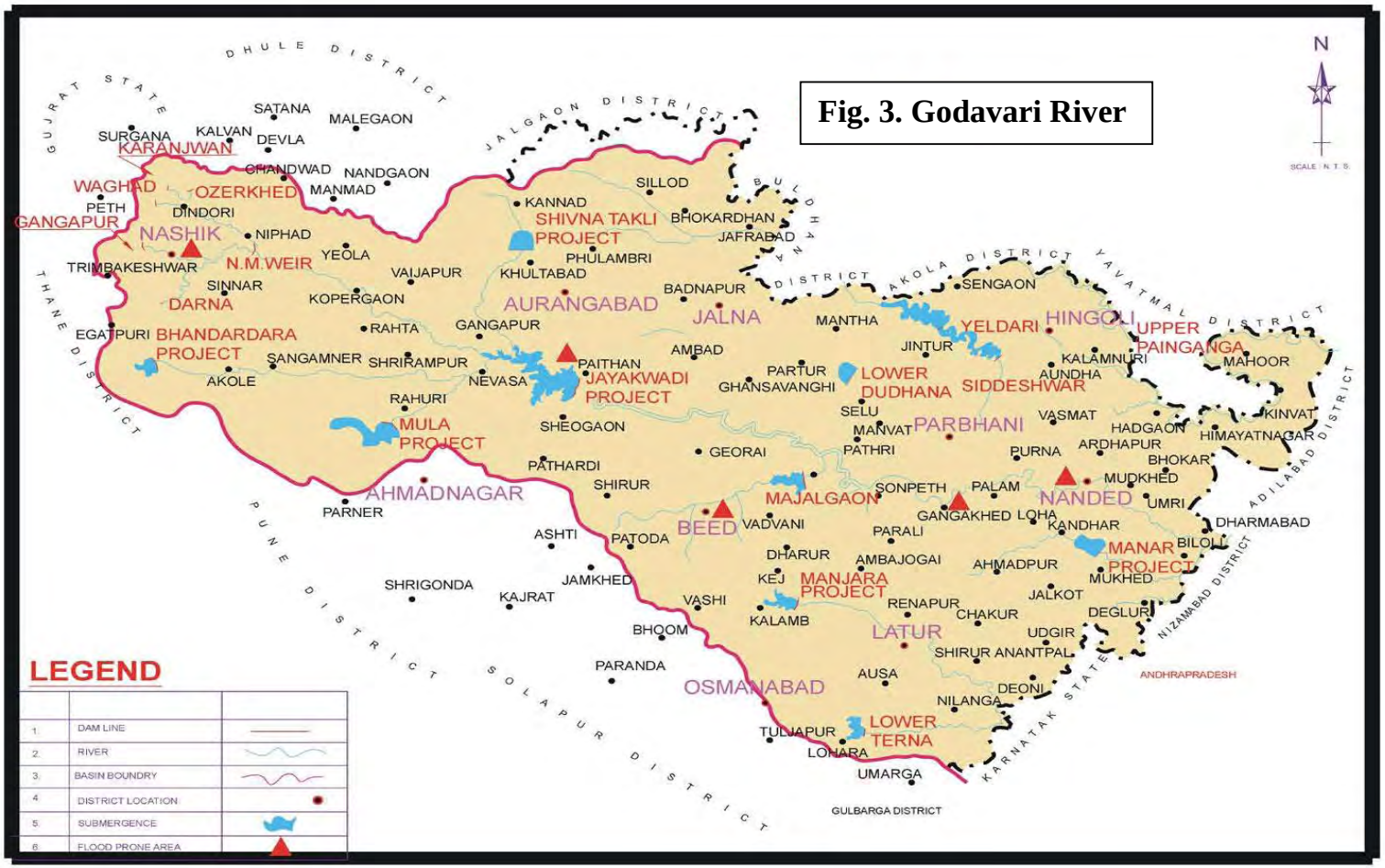


Fig. 3. Godavari River
N
SCALE : N. T. S.
DHULE DISTRICT
GUJRAT STATE
JALGAON DISTRICT
BULDHANA DISTRICT
AKOLA DISTRICT
YAVATMAL DISTRICT
THANE DISTRICT
PUNE DISTRICT
SOLAPUR DISTRICT
NIZAMABAD DISTRICT
KARNATAK STATE
ANDHRAPRADESH
GULBARGA DISTRICT
SATANA
MALEGAON
SURGANA
KALVAN
DEVLA
KARANJWAN
CHANDWAD
NANDGAON
WAGHAD
OZERKHED
MANMAD
PETH
DINDORI
GANGAPUR
NASHIK
NIPHAD
TRIMBAKESHWAR
N.M.WEIR
YEOLA
SINNAR
VAIJAPUR
DARNA
KOPERGAON
EGATPURI
BHANDARDARA PROJECT
RAHTA
SANGAMNER
AKOLE
SHRIRAMPUR
NEVASA
RAHURI
MULA PROJECT
AHMADNAGAR
PARNER
ASHTI
SHRIGONDA
JAMKHED
KAJRAT
PARANDA
BHOOM
OSMANABAD
TULJAPUR
LOHARA
UMARGA
TERNA
LOWER TERNA
LATUR
KALAMB
VASHI
KEJ
MANJARA PROJECT
DHARUR
PATODA
BEED
VADVANI
SHIRUR
PATHARDI
GEORAI
SHEOGAON
PAITHAN
JAYAKWADI PROJECT
AMBAD
GHANSAVANGHI
PARTUR
LOWER DUDHANA
SELU
MANVAT
PARBHANI
PATHRI
SIDDESHWAR
KANNAD
SHIVNA TAKLI PROJECT
SILLOD
BHOKARDHAN
JAFRABAD
PHULAMBRI
KHULTABAD
BADNAPUR
AURANGABAD
JALNA
GANGAPUR
MANTHA
JINTUR
AUNDHA
KALAMNURI
SENGAON
YELDARI
HINGOLI
UPPER PAINGANGA
MAHOOR
KINVAT
HIMAYATNAGAR
HADGAON
ARDHAPUR
PURNA
BHOKAR
MUDKHED
NANDED
UMRI
DHARMABAD
LOHA
KANDHAR
GANGAKHED
SONPETH
PALAM
MAJALGAON
PARALI
AMBAJOGAI
AHMADPUR
MANAR PROJECT
BILOLI
MUKHED
JALKOT
RENAPUR
CHAKUR
DEGLUR
UDGIR
SHIRUR ANANTPAL
AUSA
DEONI
NILANGA
VASMAT
LEGEND
1. DAM LINE
2. RIVER
3. BASIN BOUNDRY
4. DISTRICT LOCATION
5. SUBMERGENCE
6. FLOOD PRONE AREA

4. METHODOLOGY

4.1. Sampling Procedure

The study of the River Godavari was conducted during 2009-10 to assess water quality, biological productivity and status of fishery. An attempt was also made to assess the pollution levels at different stations. For this purpose, the study was carried out in the river from Gangapur dam in Nashik District down to Raher in Nanded District where the stretch of the river ends in the state of Maharashtra. The ten sampling sites selected in consultation with MPCB along the river, namely Gangapur dam, Tapovan, Nandur-Madhyameshwar, Kopergaon, Pravara Sangam, Jayakwadi dam, Paithan upstream, Pathegaon, Dhalegaon and Raher, covered a total distance of 693 km. Samples of water, sediment, fish, benthos, algae and plankton were collected at each station. Fish samples were collected through experimental fishing using a cast net and repeated attempts were made at each station. The nets of the fishermen and their catch at each station were also examined to make sure that we have collected a representative sample. In case, there was any species left out from our sample, such specimens were obtained from them. Set gill nets were also employed for collecting as many species as possible. The specimens were provisionally identified at the time of sampling and preserved in 10% formalin for confirmation and other investigations in the laboratory. Fish samples were also preserved for the analysis of heavy metals.

River Godavari at Kopergaon

4.2. Identification of Fish

The identification of the fish specimens from various stations of the river was made after Day (1889), Mishra (1962), Jayaram (1981, 1999, 2006), Fischer and Bianchi (1984), Talwar and Jhingran (1991), and Jhingran (1997).

River Godavari at Pravara Sangam

4.3. Physicochemical Parameter Analysis

Water and sediment samples were collected across the river from different sampling stations to evaluate the quality of the water and sediment. In the laboratory, soil and water samples were analysed following standard methods (APHA, 2006).

4.4. Heavy Metal Analysis

Heavy metal analysis in water, sediment and fish was carried out for the estimation of six elements, *viz*., copper, chromium, lead, cadmium, nickel and mercury. These analyses were done in an atomic absorption spectrophotometer (Aanalyst 800; Perkin Elmer).

4.5. Plankton Analysis

Plankton samples were collected at each station by filtering 50 l of water through a standard plankton net. These were preserved in neutral formaline and analysed later in the laboratory for plankter identification after Edmondson (1992).

4.6. Periodicity and Frequency of Sampling

The river at the ten stations mentioned above was sampled for three seasons, *viz*., pre-monsoon (May 2009), post-monsoon (October-November 2009) and winter (January-February 2010).

5. PHYSICOCHEMICAL PARAMETERS

River Godavari originates near Triambakeswar in Deolali hills of Western Ghats, 25 km west of Nashik at elevations ranging from 1,219 to 1,524 m above mean sea level. In its 1,465 km long course, the river flows across the Deccan Plateau through the states of Maharashtra and Andhra Pradesh before joining the Bay of Bengal. The catchment of Godavari extends to 312,812 km^2. It consists of densely forested high precipitation regions of the Western and Eastern Ghats, and intensely cultivated dry regions with moderate to low rainfall of Deccan Peninsula. More than 90% of the annual run-off in the catchment occurs between May and October under the impact of south-west monsoon. The river descends from an altitude of 1,524 m at its origin to 17 m in the deltaic stretch. It is swift flowing in its upper and middle reaches forming several riffles and pools. The river has cut deep into basaltic rock forming high banks. Though torrential during monsoon, it generally confines within the high banks and rarely overflows in its lower course. No flood plain lake is seen in Godavari or in other peninsular rivers unlike in the Ganga-Brahmaputra system.

River Godavari at Jayakwadi

The river runs about 693 km in Maharashtra and is largely utilised by constructing weirs, barrages and reservoirs for irrigation and domestic purposes. Two reservoirs are situated on the mainstream of Godavari in Maharashtra, the Gangapur

reservoir (2230 ha), 15 km below its source and the large Nathsagar (Jayakwadi dam, 35,000 ha) at Paithan in Aurangabad district. A 321-m long irrigation barrage is situated at Vishnupuri, 8 km upstream of Nanded and another old weir the Nandur-Madhyameswar, near Nashik. In addition, there are 12 weirs (Kolhapur type) in this stretch. Due to dams and weirs, the flow in the river is not continuous and water is mainly confined to these points leaving the main course almost dry in the post-monsoon and summer months. The important tributaries joining in this stretch are Pravara and Purna.

River Godavari at Paithan upstream

The different aspects of environment and fisheries of River Godavari during May 2009 to February 2010 at ten sampling stations, Gangapur dam, Tapovan, Nandur-Madhmeshwar, Kopergaon, Pravara Sangam, Jayakwadi dam, Paithan upstream, Pathegaon, Dhalegaon and Raher are elaborated in the succeeding pages.

5.1. Water and Sediment Quality

Samples for water and sediment quality analysis were collected during May 2009 to February 2010, *i.e.,* pre-monsoon (I), post-monsoon (II) and winter (III). Water and sediment samples were collected from ten sampling stations as mentioned above. Physical parameters like atmospheric and water temperature (Table 2 - 3), and topographic details were recorded. Water pH was recorded at the time of sampling

(Table 4). Water transparency (Table 5) was also recorded. For the estimation of dissolved oxygen levels (Table 6) in water, water samples were collected and fixed at the time of sampling for analysis later in the laboratory. However, the data provided by MPCB have been used for further analysis in the case of pH and dissolved oxygen. Wherever such data were absent, the data collected by the survey team have been used.

River Godavari at Pathegaon

Table 2. Atmospheric temperature (^{0}C) of River Godavari

Sr. no.	Sampling station	Sampling season			Average	Range
		I	II	III		
1	Gangapur dam	22.8	15.5	19.5	19.27	15.5-22.8
2	Tapovan	23.0	15.0	23.0	17.67	15.0-23.0
3	Nandur-Madhyameshwar	22.8	15.0	17.0	18.27	15.0-22.8
4	Kopergaon	25.0	14.0	23.0	20.67	14.0-25.0
5	Pravara Sangam	25.8	19.5	13.0	19.43	13.0-25.8
6	Jayakwadi dam	21.0	19.5	15.0	18.50	15.0-21.0
7	Paithan upstream	24.5	22.5	16.3	21.10	16.3-24.5
8	Pathegaon	27.0	22.0	12.0	20.33	12.0-27.0
9	Dhalegaon	26.2	22.0	12.5	20.23	12.5-26.2
10	Raher	29.2	23.5	12.5	21.73	12.5-29.2

The soil texture of Godavari riverbed varied from sandy to sandy-loam with certain rocky areas having very less soil content. Gangapur dam and Jayakwadi dam

have rocky beds, while the soil texture at Kopergaon and Pravara Sangam is sandy. The rest of the stations have sandy-loam.

River Godavari at Dhalegaon

Table 3. Water temperature (^{0}C) of River Godavari

Sr. no.	Sampling station	Sampling season			Average	Range
		I	II	III		
1	Gangapur dam	26.0	25.0	24.0	25.0	24.0-26.0
2	Tapovan	25.0	25.0	20.0	23.3	20.0-25.0
3	Nandur-Madhyameshwar	24.7	23.0	22.0	23.2	22.0-24.7
4	Kopergaon	25.2	22.0	20.5	22.6	20.5-25.2
5	Pravara Sangam	21.2	26.0	22.5	23.2	21.2-26.0
6	Jayakwadi dam	26.0	24.5	20.5	23.7	20.5-26.0
7	Paithan upstream	27.0	25.5	22.5	25.0	22.5-27.0
8	Pathegaon	26.5	24.5	20.5	23.8	20.5-26.5
9	Dhalegaon	28.0	25.5	21.0	24.8	21.0-28.0
10	Raher	28.0	26.5	22.0	25.5	22.0-28.0

Water is the major environmental factor influencing the distribution of fish communities in the river. Water temperature varied from 20.0 to 28.0^{0}C. However, the mean temperature fluctuated over a narrow range of 22.6 to 25.5^{0}C in the entire river course in Maharashtra in spite of the gradient, turbulence and heavy pollutant load at Tapovan, and the stagnant nature at the majority of the stations. Transparency

(Secchi disc depth) was ranging between 11 and 110 cm, while mean transparency varied from 24.67 to 92.33 cm. Higher values occurred during the post-monsoon and winter months. At Kopergaon, transparency was very low due to dense algal bloom and detritus. Water was also not flowing in this stretch as was the case with the majority of the stations. Sugar industries located in this area appear to be discharging the waste into the river. Tapovan also showed low transparency because of sewage and effluent discharge into the water and had a frothy surface throughout the study.

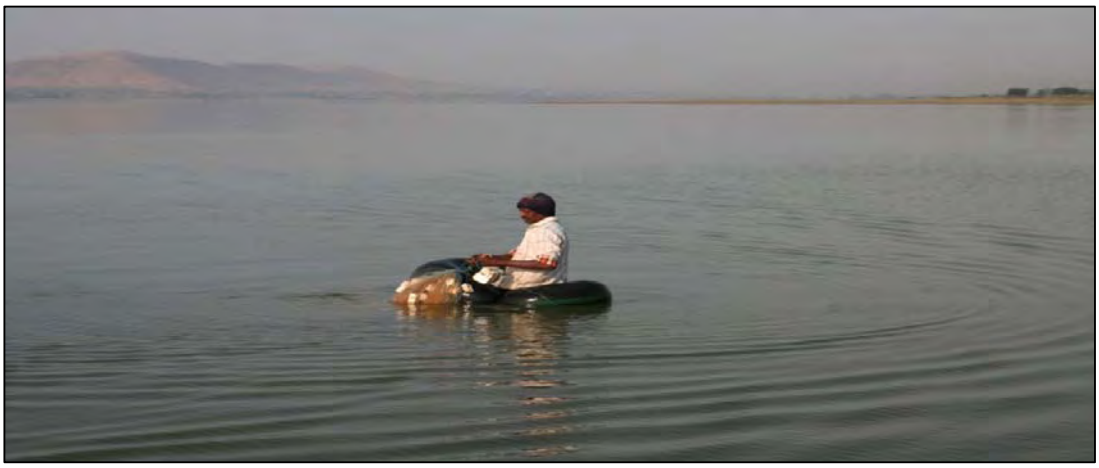
River Godavari at Raher

Table 4. Water pH of River Godavari

Sr. no.	Sampling station	Sampling season			Range
		I	II	III	
1	Gangapur dam	8.44	8.08	8.10	8.08-8.44
2	Tapovan	8.49	7.80	8.62	7.80-8.62
3	Nandur-Madhyameshwar	8.10	8.02	8.41	8.02-8.41
4	Kopergaon	7.90	7.60	7.54	7.54-7.90
5	Pravara Sangam	8.42	8.10	8.10	8.10-8.42
6	Jayakwadi dam	7.47	7.94	7.32	7.32-7.94
7	Paithan upstream	7.38	7.52	7.10	7.10-7.52
8	Pathegaon	8.25	7.70	7.22	7.22-8.25
9	Dhalegaon	7.40	7.62	7.40	7.40-7.62
10	Raher	8.21	7.82	7.48	7.48-8.21

Table 5. Water transparency (cm) of River Godavari

Sr. no.	Sampling station	Sampling season			Average	Range
		I	II	III		
1	Gangapur dam	53.0	77.0	89.0	73.00	53.0-89.0
2	Tapovan	31.5	36.0	39.0	35.50	31.5-39.0
3	Nandur-Madhyameshwar	28.0	52.0	97.0	59.00	28.0-97.0
4	Kopergaon	11.0	36.0	27.0	24.67	11.0-36.0
5	Pravara Sangam	56.0	110.0	73.0	79.67	56.0-110.0
6	Jayakwadi dam	90.0	95.0	92.0	92.33	90.0-95.0
7	Paithan upstream	36.0	72.0	102.0	70.00	36.0-102.0
8	Pathegaon	36.0	45.0	40.0	40.33	36.0-45.0
9	Dhalegaon	54.0	63.0	45.0	54.00	45.0-63.0
10	Raher	38.0	50.0	43.0	43.67	38.0-50.0



Motor tube used for fishing in River Godavari

Table 6. Dissolved oxygen concentration (mg l^{-1}) in River Godavari

Sr. no.	Sampling station	Sampling season			Average	Range
		I	II	III		
1	Gangapur dam	6.20	6.40	6.80	6.47	6.20-6.80
2	Tapovan	6.20	4.70	5.50	5.46	4.70-6.20
3	Nandur-Madhyameshwar	6.70	5.00	6.90	6.20	5.00-6.90
4	Kopergaon	3.20	2.50	2.80	2.83	2.50-3.20
5	Pravara Sangam	6.88	4.44	4.59	5.30	4.44-6.88
6	Jayakwadi dam	7.08	3.92	6.92	5.97	3.92-7.08
7	Paithan upstream	7.20	4.01	7.10	6.10	4.01-7.20
8	Pathegaon	6.82	3.77	7.32	5.97	3.77-7.32
9	Dhalegaon	5.80	4.01	7.10	5.64	4.01-7.10
10	Raher	5.83	3.68	6.88	5.46	3.68-6.88

Dissolved oxygen values fluctuated from 2.50 mg l^{-1} at Kopergaon in November 2009 to 7.32 mg l^{-1} at Pathegaon in February 2010 (Table 6). The data on biochemical oxygen demand (BOD) provided by MPCB show the lowest record as 2.0 mg l^{-1} at Pravara Sangam in November 2009, whereas the highest (32.0 mg l^{-1}) was at Kopergaon in May 2009 (Table 7).

Table 7. Biochemical oxygen demand (mg l^{-1}) in River Godavari

Sr. no.	Sampling station	Sampling season			Average	Range
		I	II	III		
1	Gangapur dam	12.0	3.2	4.0	6.4	3.2-12.0
2	Tapovan	7.0	9.0	12.0	9.3	7.0-12.0
3	Nandur-Madhyameshwar	7.0	5.0	3.0	5.0	3.0-5.0
4	Kopergaon	32.0	26.0	30.0	21.3	26.0-32.0
5	Pravara Sangam	4.0	2.0	3.2	3.1	2.0-4.0
6	Jayakwadi dam	4.8	4.2	3.2	4.1	3.2-4.8
7	Paithan upstream	3.8	5.2	3.0	4.0	3.0-5.2
8	Pathegaon	4.0	5.0	2.8	3.9	2.8-5.0
9	Dhalegaon	3.8	4.0	2.8	3.5	2.8-4.0
10	Raher	3.8	4.0	3.6	3.8	3.6-4.0

5.2. Discussion

As per the CPCB designated best use classification of inland surface water (Table 8) an analysis was made to find whether these stretches are good for fish propagation or not based on the observed values. The water quality of River Godavari was found to be fit for the propagation of fish only at Gangapur dam, Nandur-Madhyameshwar, Pravara Sangam, Paithan upstream and Dhalegaon (Table 9). The pH ranged from 7.10 to 8.62 and is suitable for fish growth.

Thermocole raft used for fishing in River Godavari

Table 8. Designated best use classification of inland surface water (Source: CPCB)

Classification	Designated best use	Criteria
A	Drinking water source without conventional treatment but after disinfection	1. Total coliform organisms (MPN 100 ml^{-1}) shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved oxygen 6 mg l^{-1} or more 4. Biological oxygen demand (5 days 20°C) 2 mg l^{-1} or less
B	Outdoor bathing (organised)	1. Total coliform organisms (MPN 100 ml^{-1}) shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved oxygen 5 mg l^{-1} or more 4. Biological oxygen demand (5 days 20°C) 3 mg l^{-1} or less
C	Drinking water source after conventional treatment and disinfection	1. Total coliform organisms (MPN 100 ml^{-1}) shall be 5000 or less 2. pH between 6 and 9 3. Dissolved oxygen 4 mg l^{-1} or more 4. Biochemical oxygen demand (5 days 20°C) 3 mg l^{-1} or less
D	Propagation of wild life and fisheries	1. pH between 6.5 and 8.5 2. Dissolved oxygen 4 mg l^{-1} or more 3. Free ammonia (as N) 1.2 mg l^{-1} or less
E	Irrigation, industrial cooling, controlled waste disposal	1. pH between 6.0 and 8.5 2. Electrical conductivity at 25°C (µmho cm^{-1}) Maximum 2250 3. Sodium absorption ratio Max. 26 4. Boron Maximum 2 mg l^{-1}

Small boat kept on the shore

Table 9. Designated best use of the stations surveyed

Station	Parameter	Designated best use					
		A	B	C	D	E	Overall
Gangapur dam	pH	F	F	F	F	F	Unfit for categories A, B and C due to high BOD; fit for propagation of fish subject to free ammonia content
	DO	F	F	F	F	-	
	BOD	U	U	U	-	-	
Tapovan	pH	U	F	F	U	U	Unfit for categories A, B, C and D due to high pH and/or low DO and high BOD
	DO	U	U	F	F	-	
	BOD	U	U	U	-	-	
Nandur - Madhyaeshwar	pH	F	F	F	F	F	Unfit for categories A, B and C due to low DO and/or high BOD; fit for propagation of fish subject to free ammonia content
	DO	U	F	F	F	-	
	BOD	U	U	U	-	-	
Kopergaon	pH	F	F	F	F	F	Unfit for categories A, B, C and D due to low DO and high BOD
	DO	U	U	U	U	-	
	BOD	U	U	U	-	-	
Pravara Sangam	pH	F	F	F	F	F	Unfit for categories A, B and C due to low DO and/or high BOD; fit for propagation of fish subject to free ammonia content
	DO	U	U	F	F	-	
	BOD	U	U	U	-	-	
Jayakwadi dam	pH	F	F	F	F	F	Unfit for categories A, B, C and D due to low DO and high BOD
	DO	U	U	U	U	-	
	BOD	U	U	U	-	-	
Paithan upstream	pH	F	F	F	F	F	Unfit for categories A, B and C due to low DO and/or high BOD; fit for propagation of fish subject to free ammonia content
	DO	U	U	F	F	-	
	BOD	U	U	U	-	-	
Pathegaon	pH	F	F	F	F	F	Unfit for categories A, B, C and D due to low DO and high BOD
	DO	U	U	U	U	-	
	BOD	U	U	U	-	-	
Dhalegaon	pH	F	F	F	F	F	Unfit for categories A, B and C due to low DO and/or high BOD; fit for fish propagation subject to free ammonia content
	DO	U	U	F	F	-	
	BOD	U	U	U	-	-	
Raher	pH	F	F	F	F	F	Unfit for categories A, B, C and D due to low DO and high BOD
	DO	U	U	U	U	-	
	BOD	U	U	U	-	-	

Cast netting in River Godavari

The only station with waterflow was Tapovan and at all the other stations, at all the sampling occasions, the water was stagnant. In spite of the flowing water, Tapovan physically appeared to be heavily polluted with foam on the surface of water, discoloured water, obnoxious smell and black sediment. Lots of discarded organic matter after performing puja and other rites were also observed.

Small fishes being collected from cast net

6. FISH AND FISHERIES

6.1. Fishing Craft and Tackle

In the stretch of Godavari in Maharashtra, fishing is free except in certain specified areas like Nandur-Madhyameswar weir, which have been declared as sanctuaries for crocodiles and birds. The effort for fishing is generally low in the Maharashtra stretch due to poor catches. Fishing activity is highly concentrated in estuaries and around barrages of Rajahmundry and Dummagudem in Andhra Pradesh.

6.1.1. Craft:

The craft and gear used in Godavari vary as per the local conditions of the river.

6.1.1.1. Raft: Thermocole rafts are common in River Godavari in Maharashtra. It is made of 2 to 3 thermocole pieces tied together and useful only for laying and hauling gillnets, casting castnets and angling.

6.1.1.2. Motor vehicle tubes: Inflated tubes of motor vehicles are also used in Godavari in Maharashtra for fishing purposes.

6.1.1.3. Boat: The boat, locally called *hodi*, is mainly owned by full-time fishermen. It is mostly used by those fishermen who do most of the fishing inside the river for large fishes. Besides, it is also used for the transport of nets and family belongings when the fishermen migrate to the other areas of the river. Now, in the Maharashtra stretch, it is rarely used because of the shallow nature of the river.

6.1.2. Gear:

Gill nets, seines, cast nets, drag nets and several miscellaneous types of gear are employed in River Godavari. The type of gear operated is mainly determined by the target species and the conditions prevailing in the river.

6.1.2.1. Set gillnet: It is usually the multifilament gillnet that is observed throughout the river course in Maharashtra. It is used all around the year, except the monsoon months. Mesh size varies from 12 to 50 mm.

6.1.2.2. Large seine: It is a large shore seine operated by 10 to 12 persons. In the earlier years, carps, catfishes and miscellaneous species formed the dominant catch, while in recent years, miscellaneous fishes and prawns account for the major portion of the catch. It was a popular gear, but its operation has come down significantly in recent years. In the present study, at Gangapur dam, we observed giant prawns, while at Raher, we could see large specimens of catla weighing 8 to 10 kg.

6.1.2.3. Small seine: It is operated by 2 to 3 persons for exploiting prawns.

6.1.2.4. Cast net: It is the most common net found throughout the river course. Almost every fisherman owns a cast net to exploit prawns and small fishes. Few units with bigger mesh (15-20 cm) exploit large carps.

Netting in Gangapur dam using large seine

6.2. Fishery Status

6.2.1. Fish diversity

The estimation of catch and catch composition in riverine fisheries poses considerable problems due to the absence of specific landing and marketing centres. An organised sampling programme spread over a reasonably long time is needed to get a true picture of the catch and composition. The present study, being a rapid survey, gives only a broad picture of the fishery that could be obtained through cast netting and making observations on the catch by the fishermen.

Fishing activity in River Godavari is mainly centred on weirs, barrages and reservoirs. Fishery is very poor in the stretch in Maharashtra and consists mainly of miscellaneous fishes. Cast nets and gillnets (12-50 mm mesh) are employed to exploit carps, catfishes and miscellaneous species. Fishermen are part-time operators and the catches are normally at subsistence level.

We could record a total of 64 fish species belonging to 15 different families and 38 genera from Gangapur dam to Raher in the river (Table 10). The abundance of fish at each site is presented in Table 11.

Drag net used for netting in River Godavari

Fish species belonging to different genera under respective families and orders that have been found in the present investigation during the study are given below:

6.2.2. Fish species

The list of species collected through experimental neeting and identified during the study is given below:

Order: Osteoglossiformes

Family: Notopteridae

1) *Chitala chitala*

2) *Notopterus notopterus*

Order: Cypriniformes

Family: Cyprinidae

Sub-family: Cyprininae

3) *Catla catla*

4) *Cirrhinus reba*

5) *Cyprinus carpio carpio*

Set drag net

Indigenous scoop net

Giant freshwater prawn at Gangapur dam

Some fishes caught at Gangapur dam

Gill-net with fishes at Nandur-Madhyameshwar

Miscellaneous fish catch at Nandur-Madhyameshwar

More fish caught at Nandur-Madhyameshwar

Represenative species from fishermen's catch at Nandur-Madhyameshwar

A collection of fish at Kopergaon

Some specimens from fisherman's catch at Kopergaon

Some of the specimens collected at Kopergaon

Some fish collected from the fishermen's catch at Pravara Sangam

Miscellaneous fish catch at Jayakwadi dam

Collection of prawns and fishes at Paithan upstream

Fish catch at Paithan upstream

Murrels of Pathegaon

Murrels, spiny eels and other fishes at Dhalegaon

Assorted fishes at Dhalegaon

Tortoise at Dhalegaon

Assorted collection of fish at Dhalegaon

A large catla at Raher

Large catla specimens at Raher

Assorted fish catch at Raher

6) *Hypselobarbus kolus*

7) *Labeo angra*

8) *Labeo bata*

9) *Labeo calbasu*

10) *Labeo dyocheilus*

11) *Labeo porcellus*

12) *Labeo rohita*

Table 10. List of fish species identified at various stations of River Godavari

Sr. no.	Species	Gangapur dam	Tapovan	Nandur-Madhyame-shwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan Upstream	Pathegaon	Dhalegaon	Raher
1	*Amblypharyngodon mola*	-	-	+	-	+	+	-	-	-	+
2	*Barilius bendelisis*	-	-	-	-	-	-	-	+	-	-
3	*Barilius gatensis*	-	-	-	-	-	-	-	-	+	-
4	*Catla catla*	-	-	-	-	-	-	-	-	-	-
5	*Chanda nama*	+	-	+	+	+	+	+	+	+	+
6	*Channa marulius*	-	-	+	+	-	+	-	-	-	-
7	*Channa punctatus*	-	-	+	+	+	-	-	+	+	-
8	*Chela fasciata*	+	-	-	-	+	+	+	+	+	+
9	*Chitala chitala*	-	-	+	-	-	-	-	-	-	+
10	*Cirrhinus reba*	-	-	+	-	-	-	-	-	-	-
11	*Cyprinus carpio carpio*	+	-	-	-	-	-	-	-	-	-
12	*Danio aequipinnatus*	+	-	-	-	+	-	-	-	-	-
13	*Etroplus maculatus*	-	-	-	-	-	-	-	-	-	+
14	*Etroplus suratensis*	-	-	-	-	-	-	-	-	+	+
15	*Garra mullya*	-	-	+	-	-	-	-	-	-	+
16	*Glossogobius giuris*	+	-	+	+	+	+	+	+	+	+
17	*Heteropneustes fossilis*	-	-	+	-	+	-	-	-	-	-
18	*Hypselobarbus kolus*	-	-	-	-	+	-	-	-	+	+
19	*Labeo angra*	-	-	-	-	-	-	-	-	-	+
20	*Labeo bata*	+	-	-	-	-	-	-	-	-	-
21	*Labeo calbasu*	-	-	-	-	-	-	-	-	-	+
22	*Labeo dyocheilus*	-	-	-	-	-	-	-	-	-	+
23	*Labeo porcellus*	-	-	-	-	-	-	-	-	-	+
24	*Labeo rohita*	-	-	-	-	-	-	-	-	-	+
25	*Macrognathus aral*	-	-	+	-	-	+	-	-	-	-
26	*Macrognathus pancalus*	+	-	+	-	+	+	-	+	+	+
27	*Mastacembelus armatus*	-	-	-	-	-	+	+	-	+	+

Table 10 (contd). List of fish species identified at various stations of River Godavari

Sr. no.	Species	Gangapur dam	Tapovan	Nandur-Madhyame-shwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan Upstream	Pathegaon	Dhalegaon	Raher
28	*Mystus bleekeri*	+	-	-	-	-	-	-	-	+	+
29	*Mystus cavasius*	+	-	+	+	+	+	-	-	+	+
30	*Mystus vittatus*	-	-	-	-	-	-	-	-	+	-
31	*Nemacheilus botia*	-	-	-	-	-	+	+	+	+	-
32	*Notopterus notopterus*	-	-	+	-	+	-	-	-	+	+
33	*Ompok malabaricus*	-	-	+	+	+	+	-	-	-	+
34	*Oreochromis niloticus*	+	-	-	+	-	-	-	-	-	
35	*Oreochromis mossambicus*	+	-	-	+	-	-	-	-	-	+
36	*Osteobrama cotio peninsularis*	-	-	-	-	+	+	-	-	+	-
37	*Osteochilus godavariensis*	+	-	-	-	-	-	-	-	-	-
38	*Parambassis ranga*	+	-	+	-	+	+	+	+	+	-
39	*Parapsilorhynchus prateri*	+	-	+	-	-	-	-	-	-	-
40	*Parluciosoma labiosa*	-	-	+	-	+	-	-	-	-	
41	*Poecilia reticulata*	-	-	-	+	-	-	-	-	-	-
42	*Proeutropiichthys taakree taakree*	-	-	-	-	-	-	-	-	-	+
43	*Puntius chola*	-	-	-	-	+	-	-	-	+	-
44	*Puntius guganio*	-	-	-	-	+	-	-	-	-	-
45	*Puntius jerdoni*	-	-	-	-	-	+	-	-	-	-
46	*Puntius phutunio*	+	-	+	-	+	+	+	+	-	+
47	*Puntius shalynius*	-	-	+	-	+	+	+	+	+	-
48	*Puntius singhala*	-	-	-	-	+	+	-	-	+	-
49	*Puntius sophore*	+	-	+	+	+	-	+	+	+	+

Table 10 (contd). List of fish species identified at various stations of River Godavari

Sr. no.	Species	Gangapur dam	Tapovan	Nandur-Madhyame-shwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan Upstream	Pathegaon	Dhalegaon	Raher
50	*Puntius terio*	-	-	-	-	+	+	+	+	-	-
51	*Puntius ticto*	+	-	+	+	+	+	+	+	+	+
52	*Puntius vittatus*	-	-	-	-	+	-	-	-	-	-
53	*Rohtee ogilbii*	+	-	-	-	-	-	-	-	-	-
54	*Salmostoma bacaila*	+	-	+	+	+	+	-	-	+	+
55	*Salmostoma novacula*	+	-	+	-	+	+	+	-	-	+
56	*Salmostoma phulo*	-	-	-	-	-	-	-	-	-	+
57	*Salmostoma sardinella*	+	-	-	-	+	+	-	-	-	-
58	*Schismatorynchus nukta*	-	-	-	-	-	-	-	-	-	+
59	*Securicula gora*	+	-	-	-	-	-	-	-	-	-
60	*Strongylura leiura*	-	-	-	-	-	-	+	-	-	-
61	*Strongylura strongylura*	-	-	+	-	+	+	+	-	+	+
62	*Tor khudree*	+	-	-	-	-	-	-	-	-	-
63	*Tor mussullah*	-	-	-	-	-	-	-	-	+	-
64	*Wallago attu*	-	-	-	-	-	-	-	-	+	-

Table 11. Fish abundance at various sites of River Godavari

Sampling station	Fish species	Sampling seasons		
		I	II	III
Gangapur dam	*Chanda nama*	14	29	48
	Chela fasciata	18	-	-
	Cyprinus carpio carpio	1	-	-
	Danio aequipinnatus	-	1	-
	Glossogobius giuris	7	3	10
	Labeo bata	5	-	-
	Macrognathus pancalus	-	-	1
	Mystus bleekeri	-	-	2
	Mystus cavasius	2	10	-
	Oreochromis mossambicus	-	8	-
	Oreochromis niloticus	-	1	-
	Osteochilus godavariensis	-	2	1
	Parambassis ranga	-	-	1
	Parapsilorhynchus prateri	1	2	1
	Puntius phutunio	-	4	8
	Puntius sophore	-	5	2
	Puntius ticto	18	-	3
	Rohtee ogilbii	-	1	-
	Salmostoma bacaila	-	-	6
	Salmostoma novacula	12	26	12
	Salmostoma sardinella	-	28	26
	Securicula gora	-	-	14
	Tor khudree	3	-	-
Tapovan	No fish			
Nandur-Madhyameshwar	*Amblypharyngodon mola*	-	26	19
	Chanda nama	-	-	6
	Channa marulius	5	1	-
	Channa punctatus	6	2	-
	Cirrhinus reba	-	1	1
	Garra mullya	2	2	-
	Glossogobius giuris	4	3	22
	Heteropneustes fossilis	7	4	-
	Macrognathus aral	-	3	-
	Macrognathus pancalus	-	20	1
	Mystus cavasius	-	1	-
	Chitala chitala	-	1	-
	Notopterus notopterus	-	2	-
	Ompok malabaricus	8	1	-
	Parambassis ranga	-	-	42
	Parapsilorhynchus prateri	-	2	-
	Parluciosoma labiosa	-	5	-
	Puntius phutunio	-	5	-
	Puntius shalynius	-	5	-
	Puntius sophore	8	54	26
	Puntius ticto	12	3	4
	Salmostoma bacaila	9	8	-
	Salmostoma novacula	-	3	-
	Strongylura strongylura	-	1	-
	Chanda nama	16	1	-
	Channa marulius	-	1	-
	Channa punctatus	-	1	11
Kopergaon	*Glossogobius giuris*	4	3	3
	Mystus cavasius	-	1	4
	Ompok malabaricus	-	-	3
	Oreochromis niloticus	-	3	3
	Oreochromis mossambicus	1	6	3
	Poecilia reticulata	1	-	-
	Puntius sophore	9	2	23
	Puntius ticto	27	-	-
	Salmostoma bacaila	13	-	-

Table 11 (contd). Fish abundance at various sites of River Godavari

Sampling station	Fish species	Sampling seasons		
		I	II	III
Pravara Sangam	*Amblypharyngodon mola*	-	14	1
	Chanda nama	45	7	1
	Chela fasciata	10	-	-
	Channa punctatus	-	2	-
	Danio aequipinnatus	-	1	-
	Glossogobius giuris	6	-	3
	Heteropneustes fossilis	2	-	-
	Hypselobarbus kolus	2	1	1
	Macrognathus pancalus	3	23	2
	Mystus cavasius	-	2	-
	Notopterus notopterus	3	-	-
	Ompok malabaricus	4	-	-
	Osteobrama cotio peninsularis	-	5	-
	Parambassis ranga	-	11	2
	Parluciosoma labiosa	-	-	13
	Puntius chola	-	9	-
	Puntius guganio	-	-	5
	Puntius phutunio	9	28	24
	Puntius shalynius	-	10	44
	Puntius singhala	-	-	19
	Puntius sophore	36	11	1
	Puntius terio	-	7	21
	Puntius ticto	27	6	86
	Puntius vittatus	-	-	1
	Salmostoma bacaila	-	22	-
	Salmostoma novacula	9	41	-
	Salmostoma sardinella	-	10	-
	Strongylura strongylura	-	4	2
Jayakwadi dam	*Amblypharyngodon mola*	-	27	45
	Chanda nama	-	36	35
	Channa marulius	2	-	-
	Chela fasciata	-	-	28
	Glossogobius giuris	-	-	3
	Macrognathus aral	-	-	2
	Macrognathus pancalus	-	19	18
	Mastacembelus armatus	-	1	1
	Mystus cavasius	2	1	-
	Nemacheilus botia	-	5	-
	Ompok malabaricus	2	2	-
	Osteobrama cotio peninsularis	2	1	-
	Parambassis ranga	-	86	44
	Puntius jerdoni	3	-	-
	Puntius phutunio	-	27	-
	Puntius terio	-	1	17
	Puntius ticto	18	22	23
	Puntius shalynius	-	-	10
	Puntius singhala	-	39	-
	Salmostoma bacaila	-	-	22
	Salmostoma novacula	-	98	30
	Salmostoma sardinella	-	20	-
	Strongylura strongylura	-	1	2

Table 11 (contd). Fish abundance at various sites of River Godavari

Sampling station	Fish species	Sampling seasons		
		I	II	III
Paithan upstream	*Chanda nama*	57	26	-
	Chela fasciata	23	-	-
	Glossogobius giuris	4	-	4
	Mastacembelus armatus	1	-	-
	Nemacheilus botia	-	1	2
	Parambassis ranga	-	39	-
	Puntius phutunio	-	59	-
	Puntius terio	-	-	24
	Puntius ticto	9	52	25
	Puntius shalynius	9	34	33
	Puntius sophore	7	-	-
	Salmostoma novacula	-	1	-
	Stongylura leiura	3	-	-
Pathegaon	*Strongylura strongylura*	-	1	1
	Barilius bendelisis	-	-	2
	Chanda nama	3	-	-
	Channa punctatus	-	5	-
	Chela fasciata	7	-	-
	Glossogobius giuris	3	-	-
	Macrognathus pancalus	-	1	-
	Nemacheilus botia	6	-	-
	Parambassis ranga	-	1	-
	Puntius phutunio	-	27	32
	Puntius shalynius	-	-	10
	Puntius sophore	-	4	-
	Puntius terio	2	-	-
	Puntius ticto	46	96	50
	Barilius gatensis	2	-	-
	Chanda nama	-	1	4
	Channa punctatus	10	-	1
	Chela fasciata	-	-	1
	Etroplus suratensis	-	2	1
	Garra mullya	-	2	3
	Glossogobius giuris	-	4	6
	Hypselobarbus kolus	2	2	16
	Macrognathus pancalus	2	1	-
	Mastacembelus armatus	10	1	4
	Mystus bleekeri	-	1	2
Dhalegaon	*Mystus cavasius*	3	1	3
	Mystus vittatus	-	-	1
	Nemacheilus botia	-	1	4
	Notopterus notopterus	3	5	4
	Puntius chola	-	-	2
	Osteobrama cotio peninsularis	4	-	-
	Parambassis ranga	-	2	4
	Puntius shalynius	-	-	3
	Puntius singhala	-	-	6
	Puntius sophore	6	-	12
	Puntius ticto	5	7	10
	Salmostoma bacaila	-	1	-
	Strongylura strongylura	-	-	1
	Tor mussullah	1	1	2
	Wallago attu	-	3	-

Table 11 (contd). Fish abundance at various sites of River Godavari

Sampling station	Fish species	Sampling seasons		
		I	II	III
Raher	*Amblypharyngodon mola*	-	10	-
	Chanda nama	34	21	-
	Catla catla	-	3	-
	Chela fasciata	6	-	-
	Chitala chitala	-	-	5
	Etroplus maculatus	-	-	2
	Etroplus suratensis	-	-	2
	Garra mullya	-	2	2
	Glossogobius giuris	-	16	-
	Hypselobarbus kolus	-	2	2
	Labeo angra	13	-	-
	Labeo calbasu	-	-	3
	Labeo dyocheilus	4	11	3
	Labeo porcellus	-	-	9
	Labeo rohita	-	-	1
	Macrognathus pancalus	-	2	-
	Mastacembelus armatus	1	-	1
	Mystus bleekeri	2	-	1
	Mystus cavasius	14	-	2
	Notopterus notopterus	-	-	9
	Ompok malabaricus	3	-	-
	Oreochromis mossambicus	-	1	1
	Proeutropiichthys taakree taakree	-	5	-
	Puntius phutunio	2	2	-
	Puntius sophore	-	2	-
	Puntius ticto	10	-	-
	Salmostoma bacaila	-	2	-
	Salmostoma novacula	-	9	-
	Salmostoma phulo	-	169	-
	Schismatorynchus nukta	-	1	2
	Strongylura strongylura	-	1	-

13) *Osteobrama cotio peninsularis*

14) *Osteochilus godavariensis*

15) *Puntius chola*

16) *Puntius guganio*

17) *Puntius jerdoni*

18) *Puntius phutunio*

19) *Puntius shalynius*

20) *Puntius singhala*

21) *Puntius sophore*

22) *Puntius terio*

23) *Puntius ticto*

24) *Puntius vittatus*

25) *Rohtee ogilbii*

26) *Schismatorhynchos nukta*

27) *Tor khudree*

28) *Tor mussullah*

Sub-family: Cultrinae

29) *Amblypharyngodon mola*

30) *Barilius bendelisis*

31) *Barilius gatensis*

32) *Chela fasciata*

33) *Danio aequipinnatus*

34) *Salmostoma bacaila*

35) *Salmostoma novacula*

36) *Salmostoma phulo*

37) *Salmostoma sardinella*

38) *Securicula gora*

Sub-family: Rasborinae

39) *Parluciosoma labiosa*

Sub-family: Garrinae

40) *Garra mullya*

Family: Parapsilorhynchidae

41) *Parapsilorhynchus prateri*

Family: Balitoridae

Sub-family: Nemacheilinae

42) *Nemacheilus botia*

Order: Siluriformes

Family: Bagridae

43) *Mystus bleekeri*

44) *Mystus cavasius*

45) *Mystus vittatus*

Family: Siluridae

46) *Ompok malabaricus*

47) *Wallago attu*

Family: Schilbeidae

Sub-family: Schilbeinae

48) *Proeutropiichthys taakree taakree*

Family: Heteropneustidae

49) *Heteropneustes fossilis*

Order: Cyprinodontiformes

Sub-order: Exocoetoidei

Family: Belonidae

50) *Strongylura leiura*

51) *Strongylura strongylura*

Sub-order: Cyprinodontoidei

Family: Poeciliidae

52) *Poecilia reticulata*

Order: Perciformes

Sub-order: Percoidei

Family: Ambassidae

53) *Chanda nama*

54) *Parambassis ranga*

Family: Cichlidae

55) *Etroplus maculatus*

56) *Etroplus suratensis*

57) *Oreochromis mossambicus*

58) *Oreochromis niloticus*

Sub-order: Gobioidei

Family: Gobiidae

59) *Glossogobius giuris*

Sub-order: Channoidei

Family: Channidae

60) *Channa marulius*

61) *Channa punctatus*

Sub-order: Mastacembeloidei

Family: Mastacembelidae

62) *Macrognathus aral*

63) *Macrognathus pancalus*

64) *Mastacembelus armatus*

6.2.2. Salient identifying characters of finfishes of River Godavari

A comprehensive knowledge on proper identification of fish stock is essential for studying fish taxonomy as well as biodiversity of a particular water body. In the present study, fish samples were collected from River Godavari to assess the fish biodiversity. The fishes were collected through different types of gear and were preserved in 10% formalin. Small fishes were preserved in absolute alcohol. These fishes were identified according to Day (1889), Mishra (1962), Jayaram (1981, 1999, 2006), Fischer and Bianchi (1984), Talwar and Jhingran (1991), and Jhingran (1997).

Order: **Osteoglossiformes**

1. Dorsal fin small
2. Anal fin very long and tapering, more than 100 rays, confluent with small caudal fin
3. Pelvic fin rudimentary
4. Bony tongue with curved teeth

Family: Notopteridae

1. Body deep and strongly compressed
2. Abdomen serrated before pelvic fins
3. Barbels absent
4. Dorsal fin small and slender, with eight to ten rays
5. Anal fin long based (100 to 135 rays)
6. Scales very small
7. Lateral line complete, with about 180 scales

- **Species: *Chitala chitala*** (chital, mohi, moya)

  D 9-10; A+C 110-135; V 6

1. Maxilla extends considerably beyond posterior edge of eye
2. Scales small on opercles, of equal size as on body
3. Pre-orbital smooth
4. Pelvic fin rudimentary
5. Anal fin very long, confluent with reduced caudal fin
6. Five to nine black, rounded spots near caudal region
7. Lateral line curved and complete
8. Body coppery-brown on narrow back with about 15 transverse silvery bars
9. Maximum size: 122 cm

- **Species: *Notopterus notopterus*** (chalat, patre, phulo, pholui, pholi, golhi)

  D 7-9; A+C 100-110; V 5-6

  1. Maxilla extends to midorbit
  2. Pre-orbital serrated
  3. Larger scales on opercles than those on the body
  4. No transverse bars on back
  5. No rounded spots near caudal origin
  6. Pectoral fin moderate, extends beyond anal fin origin
  7. Lateral line straight and complete
  8. Body silvery-white with numerous fine grey spots
  9. Maximum size: 61 cm

Order: Cypriniformes

1. Mouth usually protractile and always toothless
2. Body covered with cycloid scales; head scaleless
3. Pectoral fin devoid of an osseous spine
4. Lateral line almost always present and complete

Family: Cyprinidae

1. Barbels present or absent; if present, one or two pairs
2. Paired fins laterally inserted
3. Abdomen rounded or with a sharp edge

Sub-family: Cyprininae

1. Abdomen not compressed and no keel is formed
2. Barbels present or absent
3. No tiled row of scales on anal sheath
4. Scales small to large, always less than 100 along lateral line
5. Upper lip separated from skin of snout by a groove
6. Mouth terminal, sub-inferior or distinctly inferior
7. Lower lip without a suctorial disc
8. Lower jaw without any symphysial process
9. Dorsal fin inserted before or opposite to origin of pelvic fins, generally with a spine
10. Lateral line running along median line of caudal peduncle

- **Species: *Catla catla*** (catla, katla, chepi)

  D iii-iv 14-16; A iii 5; P i 20; V i 8; LL 40-43

1. Body deep, head enormously large
2. Mouth wide and upturned, with a prominent protruding lower jaw; upper lip absent
3. Scales conspicuously large
4. Barbels absent
5. Maximum size: 270 cm

- **Species: *Cirrhinus reba*** (reba, rewah, kharge-bata, raicheng, dumra, poorali)

  D ii-iii 8; A iii 5; P i 15; V i 8; LL 34-38

1. Body fairly elongate; its depth much more than head length
2. Mouth broad; upper lip entire, often fringed in juveniles; a thin cartilaginous covering inside lower jaw
3. One pair of short rostral barbels generally present
4. Scales hexagonal and moderate
5. Colour dark grey dorsally, silvery on flanks and belly
6. Maximum size: 30 cm

- **Species: *Cyprinus carpio carpio*** (common carp, bilati rohu)

  D iii-iv 18-20; A iii 5; P i 15; V i 8; LL 30-40

1. Body robust, more or less compressed, abdomen rounded
2. Mouth small, terminal and protrusible; lips thick and fleshy
3. Barbels two pairs; one pair each rostral and maxillary; maxillary pair longer
4. Dorsal fin very long; dorsal spine stout and serrated
5. Caudal fin deeply emarginated
6. Lateral line straight
7. Sides of the body golden-yellow; fins with reddish or golden tinge
8. Maximum size: 110 cm

- **Species: *Hypselobarbus kolus*** (kholus, rahoos, tahrak, nilusa)

  D iv 9; A iii 5; P i 14; V i 8; LL 40-43

1. Body relatively deep and compressed with considerable rise in the profile from occiput to dorsal fin
2. Mouth slightly subterminal
3. Barbels one pair, extend beyond mid-orbit
4. Scales relatively small
5. Dorsal fin inserted anterior to pelvic fins
6. Maximum size: 30 cm

- **Species: *Labeo angra*** (kharsa, riwa, buttar)

  D ii-iii 10; A ii 5; P i 15; V i 8; LL 42

  1. Dorsal profile of the body more convex than ventral
  2. Snout overhanging mouth, with a distinct lateral lobe on each side
  3. Mouth rather small, lips fimbriated and continuous
  4. Barbels one short maxillary pair
  5. Body with a black stripe along flanks from eye to caudal fin base
  6. Maximum size: 22 cm

- **Species: *Labeo bata*** (rajadi, tambti, bata, dommarcibatta, bhangan)

  D ii-iv 9-10; A ii-iii 5; P i 15-17; V i 8; LL 37-40

  1. Mouth inferior, lips thin, lower lip slightly fringed, a small tubercle above mandibular symphysis
  2. Barbels a pair of minute maxillary only, not easily perceptible
  3. Golden-yellow above and on dorsal half of flanks; silvery on lower half of flanks and belly
  4. Maximum size: 61 cm

- **Species: *Labeo calbasu*** (kanas, kalbasu, kalbose, karnaunehar)

  D iii-iv 13-16; A ii-iii 5; P i 16-18; V i 8; LL 40-44

  1. Mouth inferior, lips thick and conspicuously fringed
  2. Barbels two pairs (rostral and maxillary)
  3. Dorsal fin with a fairly long base
  4. Body blackish-green, lighter below
  5. Maximum size: 90 cm

- **Species: *Labeo dyocheilus*** (boalla, konti)

  D ii-iii 10-11; A ii 5; P i 16; V i 8; LL 43

  1. Snout conical, with a distinct lateral lobe, tubercles on snout prominent
  2. Mouth wide and inferior; lips thick, not fringed
  3. Barbels one short maxillary pair
  4. Body dull-green, darker above
  5. Maximum size: 90 cm

- **Species: *Labeo porcellus*** (tambcki, khanoos)

  D ii 13-14; A ii 5; P i 16; V i 8; LL 39

  1. Snout slightly projecting over mouth, devoid of lateral lobe
  2. Mouth sub-inferior, lips thick, with a distinct inner fold to both jaws

3. Barbels two pairs, maxillary pair slightly longer than rostral one
4. Body greyish on back, silvery-white on flanks and abdomen
5. Maximum size: 30 cm

- **Species: *Labeo rohita*** (tambada-masa, rohu, rahu, kennadi-kendai)

  D iii-iv 12-14; A ii-iii 5; P i 16-18; V i 8; LL 40-44

1. Snout fairly depressed, projects beyond mouth, devoid of lateral lobe
2. Mouth small and inferior; lips thick and fringed with a distinct inner fold to each lip
3. Barbels one pair of small maxillary, concealed in lateral groove
4. Scales moderate
5. Body bluish along back, becoming silvery on the flanks and beneath, with reddish mark on each scale during breeding season
6. Maximum size: 100 cm

- **Species: *Osteobrama cotio peninsularis*** (bhongi)

  D iii-iv 8-9; A iii 28-31; P i 12-14; V i 9; LL 55-60

1. Body trapezoid and considerably compressed
2. Abdominal edge trenchant from base of pelvic fins to anal fin, but rounded in front of pelvic fins
3. Mouth small
4. Barbels absent
5. Dorsal spine weak and serrated
6. Scales small
7. Body bright silvery with scattered pigment spots on back; a dark blotch on nap
8. Maximum size: 15 cm

- **Species: *Osteochilus godavariensis*** (Chandkas barb)

  D iii 14-15; A iii 6; P i 14; V i 8; LL 39

1. Body oblong and laterally compressed
2. Snout overhanging the mouth, covered with papillae
3. Mouth inferior, lower jaw with a cartilaginous covering internally, lips fringed
4. Barbels two pairs, rostral barbel short, maxillary pair slightly longer
5. Last unbranched dorsal fin ray non-osseous
6. Scales moderate in size, lateral line complete

7. Body dorsally dark becoming dusky on sides and white on belly; one or two dusky blotches on lateral line below insertion of dorsal fin; a dark spot at base of caudal fin
8. Maximum size: 15 cm

- **Species: *Puntius chola*** (kerrundi, katcha-karawa, siddahari)

  D iii 8; A ii 5; P i 14; V i 8; LL 26-28

1. Body fairly deep and compressed
2. Barbels one short maxillary pair
3. Last unbranched ray of dorsal fin osseous, fairly strong and smooth
4. Lateral line complete
5. Rosy spot/blotch on operculum and a deep black blotch near base of caudal fin
6. Maximum size: 12 cm

- **Species: *Puntius guganio*** (putti, gujani)

  D iii 8; A ii 5; P i 10; V i 8; LL 36

1. Mouth terminal
2. Barbels absent
3. Last unbranched dorsal fin ray osseous, strong and serrated on its posterior edge
4. Lateral line incomplete
5. One small black spot at base of anterior dorsal fin rays and a black blotch at side of caudal fin
6. Maximum size: 8 cm

- **Species: *Puntius jerdoni*** (potil, parag, chameen, saymeen)

  D iii-iv 9; A iii 5(6); P i 13-14; V i 8; LL 36

1. Body fairly deep
2. Mouth narrow
3. Barbels two pairs, maxillary pair equal to orbit, rostral slightly shorter
4. Last unbranched dorsal fin ray non-osseous, weak and articulated
5. Scales medium, lateral line complete
6. Maximum size: 46 cm

- **Species: *Puntius phutunio*** (phutuni-pungti, kudji-kerundi)

  D ii-iii 8; A iii 5; P i 14; V i 8; LL 20-23

1. Body somewhat deep
2. Mouth small
3. Barbels absent

4. Last unbranched dorsal fin ray osseous, strong and serrated (indistinct in adults)
5. Scales large, lateral line incomplete
6. Body colour usually fades into three black blotches, one behind gill cover, second above anal fin and third as a spot on caudal peduncle; dorsal fin often with an oblique dark bar
7. Maximum size: 3.5 cm

- **Species: *Puntius shalynius*** (shalyni, phabounga)

  D iii 7; A ii 5; P i 12-13; V i 7; LL 20-23

1. Body fairly deep
2. Mouth small
3. Barbels absent
4. Last unbranched dorsal fin ray osseous, strong and serrated
5. Scales medium, lateral line incomplete
6. Two distinctive dark blotches on sides of caudal peduncle
7. Maximum size: 6 cm

- **Species: *Puntius singhala*** (black-banded barb)

  D iii 8; A iii 5; P i 14-16; V i 6; LL 20-22

1. Body elongate with a convex dorsal profile
2. Mouth sub-terminal and small
3. Barbels absent
4. Last unbranched dorsal fin ray non-osseous, weak and smooth
5. Scales large; lateral line complete
6. Dorsal and caudal fins reddish with black tips
7. Maximum size: 15 cm

- **Species: *Puntius sophore*** (katcha-karawa, potthiah, pothi)

  D iii-iv 8-9; A iii 5; P i 14-16; V i 8; LL 22-27

1. Body relatively deep
2. Mouth terminal
3. Barbels absent
4. Last unbranched dorsal fin ray osseous and smooth
5. Scales medium; lateral line complete
6. A deep black round blotch at base of caudal fin, a similar black blotch on central part of dorsal fin
7. Maximum size: 13 cm

- **Species: *Puntius terio*** (teri-pungti, kakachia-kerundi)

  D iii 8; A ii 5; P i 14; V i 8; LL 22-23

  1. Body fairly deep and compressed
  2. Mouth moderate
  3. Barbels absent
  4. Last unbranched dorsal fin ray osseous, moderate to very strong and smooth
  5. Scales medium; lateral line incomplete, very short
  6. Dorsal side metallic green, flanks silvery and belly whitish; a round golden-edged black blotch over anal fin, often with a transverse oval black spot at base of caudal fin
  7. Maximum size: 9 cm

- **Species: *Puntius ticto*** (kotree, kaoli, pothia)

  D iii-iv 8; A ii-iii 5; P i 12-14; V i 8; LL 23-25

  1. Body elongated
  2. Mouth terminal and small
  3. Barbels absent
  4. Dorsal fin inserted slightly posterior to pelvic fin origin
  5. Last unbranched dorsal fin ray osseous, fairly strong and serrated at its posterior edge
  6. Scales medium; lateral line usually complete, often ceases after 6-8 scales
  7. Body often with two lateral spots; first one extending over third and fourth scales, and second one over 18^{th} and 19^{th} scales of lateral line; dorsal fin in male with red border
  8. Maximum size: 10 cm

- **Species: *Puntius vittatus*** (poothi, kooli)

  D ii 8; A ii 5; P i 11; V i 8; LL 20-22

  1. Body elongate
  2. Mouth small and terminal
  3. Barbels absent
  4. Last unbranched dorsal fin ray weak and entire
  5. Scales moderate; lateral line incomplete
  6. One dark blotch at base of caudal fin; anal and pelvic fins pale-yellow to brownish-yellow
  7. Maximum length: 5 cm

- **Species: *Rohtee ogilbii*** (vatani)

  D iii 8; A iii 13-14; P i 14; V i 9; LL 55

  1. Body deep and strongly compressed, dorsal profile more convex than abdomen
  2. Mouth small; lower jaw shorter
  3. Barbels absent
  4. Dorsal spine strong and coarsely serrated; a pre-dorsal spine present, somewhat concealed by scales
  5. Scales small
  6. Body purplish-silvery along back, fading to silvery-white on belly
  7. Maximum size: 15 cm

- **Species: *Schismatorhynchos nukta*** (nakta, nakta-shendra, nukta)

  D ii-iii 8-9; A ii 5; P i 14; V i 8; LL 37-38

  1. Body elongate and compressed
  2. Head compressed; snout projecting over mouth
  3. Mouth moderate
  4. Barbels small, flap-like; crenulated maxillary pair, embedded in labial groove
  5. Dorsal fin inserted nearer to snout-tip than to base of caudal fin; anterior three rays markedly elevated and higher than body
  6. Scales large
  7. Body silvery with some reddish marks on scales
  8. Maximum size: 30 cm

- **Species: *Tor khudree*** (khadashi, arrayam, khudchee)

  D iv 9; A ii 7; P i 14; V i 8; LL 25-27

  1. Body elongate
  2. Mouth moderate; lips fleshy, lower lip produced into a median lobe of varying length
  3. Barbels two equal pairs, slightly shorter than orbit in adults while equal to it in juveniles
  4. Scales large
  5. Snout covered with a patch of small indistinct tubercles
  6. Body above the lateral line dark bluish; flanks below the lateral line pale golden-yellow
  7. Maximum size: 46 cm

- **Species: *Tor mussullah*** (mahsiya masundi-mahseer, mussulah, masundi)

  D iv 9; A iii 5; P i 15; V i 8; LL 26 or 27

  1. Body fairly deep
  2. Mouth moderate; lips fleshy
  3. Barbels two pairs; maxillary barbels equal to eye diameter, rostral pair shorter
  4. Scales large
  5. Snout and cheeks with a patch of indistinct tubercles
  6. Body dark with bronzy reflections, belly reddish creamy
  7. Maximum size: 150 cm

Sub-family: Cultrinae

1. Abdomen or part of abdomen compressed into a sharp, keel-like edge
2. Barbels absent
3. Eyes moderate to large, not visible from underside of head
4. No particular modifications of gill-arches
5. Anal fin with at least nine branched rays

- **Species: *Amblypharyngodon mola*** (maurala, mowka, dhawai, tallamaya)

  D ii-iii 7; A ii-iii 5-6; P i 13-15; V i 8; LL 65-91

  1. Body elongate
  2. Mouth large
  3. Barbels absent
  4. Abdomen more or less rounded
  5. Upper lip absent
  6. Dorsal fin inserted slightly behind pelvic fin base
  7. Scales small, lateral line incomplete
  8. A broad silvery lateral band on body
  9. Maximum size: 20 cm

- **Species: *Barilius bendelisis*** (jodhia jhorya, jhor, khoksa, korang)

  D ii 7; A ii-iii 7-8; P i 14; V i 8; LL 40-45

  1. Mouth moderate; jaws long, maxilla extends to below anterior-third of orbit
  2. Barbels two short pairs (rostral and maxillary), rostral pair reduced or often absent
  3. Dorsal fin inserted entirely in advance of anal fin, nearer to base of caudal fin than to snout tip
  4. Scales of moderate size with many radii
  5. Tubercles small and poorly developed on snout and lower jaw

6. Body silvery with greyish back, 8 to 12 dark bands descending towards the lateral line which become indistinct in adults
7. Maximum size: 15.5 cm

- **Species: *Barilius gatensis*** (jodhie, jhorya, artcandee)

  D ii-iii 8-9; A iii 12-14; P i 14; V i 8; LL 39-40

1. Body deep
2. Mouth moderate; jaws short, maxilla extends to below the middle of orbit
3. Barbels one minute rostral pair, often wanting
4. Dorsal fin inserted in advance of anal fin, extending to above the third anal finray
5. Scales moderate, with few radii
6. Tubercles large and well developed on snout and lower jaw
7. Body silvery-grey with 13-15 vertical bars
8. Maximum size: 15 cm

- **Species: *Chela fasciata*** (Malabar hatchet chela)

  D ii 7; A iii 14-15; P i 8-9; V i 5-6; LL 33-34

1. Body greatly compressed
2. Head slightly turned upwards
3. Mouth small, obliquely directed upwards, cleft not extending to below front edge of eye
4. Pectoral fins long; outer ray of pelvic fin greatly elongated; both fins extend much beyond origin of anal fin
5. Lateral line complete
6. Upper half of body greyish while lower half and belly lighter in colour, a dark broad lateral stripe on sides commencing just behind eye and running along middle of body to about base of caudal fin

- **Species: *Danio aequipinnatus*** (balooki, chebli, vannathipodi)

  D ii-iii 9-12; A ii-iii 14-16; P i 11-12; V i 6; LL 35-37

1. Body elongate and compressed
2. A pre-orbital spine backwardly directed, from lachrymal bone
3. Mouth small, directed upwards
4. Barbels two short pairs; rostral pair about half eye-diameter, maxillary barbels minute
5. Dorsal fin inserted well in advance of origin of anal fin, extending to over anterior anal finrays

6. Scales moderate, lateral line complete
7. A well-marked lateral dark-blue band along sides, both above and below it thinner golden bands, blue band runs along the entire length from caudal fin to head
8. Maximum size: 15 cm

- **Species: *Salmostoma bacaila*** (dental, gangchela, chela, chelliah)

  D ii-iii 7; A iii 10-13; P i 11-12; V i 8; LL 86-110

1. Body elongate and strongly compressed, abdominal keel not hardened
2. Mouth oblique, lower jaw with a well-developed symphysial knob
3. Dorsal fin inserted well behind pelvic fins and in advance of anal fin
4. Scales very small, lateral line slightly decurved
5. Upper side greyish-green, often silvery; a broad, gleaming white-green band along flank
6. Maximum size: 18 cm

- **Species: *Salmostoma novacula*** (alkut)

  D iii 7; A iii 14-17; P i 12; V i 8; LL 76-94

1. Body elongate and compressed
2. Mouth oblique, lower jaw with a distinct symphysial process
3. Dorsal fin inserted opposite to anal fin
4. Scales small; lateral line gently curved downwards
5. Body silvery with a bright silvery lateral band
6. Maximum size: 12.5 cm

- **Species: *Salmostoma phulo*** (bungkachari, phul-chela, dunnahree)

  D iii 7; A iii 17-19; P i 12; V i 7; LL 99-112

1. Body elongate and greatly compressed
2. Abdominal keel not hardened
3. Mouth oblique, lower jaw with a distinct symphysial process
4. Dorsal fin inserted opposite to origin of anal fin
5. Scales small; lateral line curves gently downwards
6. Body silvery with a bright silvery lateral band
7. Maximum size: 12 cm

- **Species: *Salmostoma sardinella* (**razorbelly minnow)

  D ii-iii 7; A iii 16-19; P i 12; V i 7; LL 47-53

1. Body elongate and compressed
2. Mouth oblique, lower jaw with a rather rudimentary symphysial process

3. Dorsal fin inserted above or slightly behind origin of anal fin
4. Scales medium
5. Body silvery
6. Maximum size: 15 cm

- **Species: *Securicula gora*** (ghora-chela, chehul, chelua)

  D iii 7; A ii-iii 13-15; P i 12-13; V i 7; LL 120-160

1. Body fairly elongate and compressed
2. Mouth oblique, its cleft extending to front edge of eye
3. Abdomen with a sharp keel, extends from below operculum to anal fin
4. Dorsal fin short, inserted slightly in advance of origin of anal fin
5. Scales very small
6. Body bright silvery
7. Maximum size: 23 cm

Sub-family: Rasborinae

1. Abdomen not compressed and no keel is formed
2. Barbels present or absent
3. No tiled row of scales on anal sheath
4. Scales small to large, always less than 100 along lateral line
5. Upper lip separated from skin of snout by a groove
6. Mouth terminal, sub-inferior or distinctly inferior
7. Lower lip without a suctorial disc
8. Lower jaw generally with a symphysial process, fitting in a notch of emargination of upper jaw
9. Dorsal fin inserted behind base of pelvic fins, devoid of a spine
10. Lateral line, if present, abruptly bent downwards and, if complete, running along lower half of caudal peduncle

- **Species: *Parluciosoma labiosa*** (dandai, gayroonjee)

  D ii 7; A ii 5; P i 11; V i 8; LL 30-32

1. Body elongate and compressed
2. Mouth small; lower lip hypertrophied, more fleshy and flabby than upper lip and projects beyond jaw, with three distinct lobe-like structures
3. Pectoral fins shorter than head length
4. Lateral line incomplete, extends as far as posterior end of anal fin

5. A broad black lateral band on side; along dorsum, a narrow black median line from occiput to base of caudal fin
6. Maximum size: 8.5 cm

Sub-family: Garrinae

1. Abdomen not compressed and no keel formed
2. Barbels present or absent
3. No tiled row of scales on anal sheath
4. Scales small to large, always less than 100 along lateral line
5. Upper lip in continuation with skin of snout, crenulated
6. Mouth conspicuously inferior
7. Lower lip often modified into an adhesive suctorial disc

- **Species: *Garra mullya*** (mally, mottu, kallu-koravai, kamau, pondipakka)

  D iii 7-8; A i-ii 5; P i 12-15; V i 7-8; LL 32-34

1. Body slightly flattened
2. Head somewhat flattened on under-surface, snout rounded and smooth
3. Mouth small, suctorial disc small but well-marked
4. Barbels two pairs; rostral pair as long as or slightly shorter than eye diameter, maxillary pair shorter than rostral one
5. Dorsal fin inserted nearer to tip of snout than to caudal fin base
6. Pectoral fins shorter than head length
7. Scales of moderate size
8. Upper surface of head and body, and flanks darkish; a broad lateral band on side, bordered above and below by incomplete dark narrow lateral stripes
9. Maximum size: 17 cm

Family: Parapsilorhynchidae

1. Body spindle-shaped, ventral surface flattened
2. Head short and narrow
3. Mouth very small, inferior; lower jaw sharp edged, lip prominent with callous thickening behind it
4. Barbels a singal rostral pair, short and stumpy
5. Paired fins horizontally placed
6. Scales small

- **Species: *Parapsilorhynchus prateri*** (Deolali minnow)

  D ii 8; A ii 5; P ii 13; V i 8; LL 43-47

1. Body almost as broad as deep
2. Head and body considerably depressed, ventral surface flattened
3. Mouth small, inferior and horizontal; upper lip with a prominent rostral fold which is fringed and covered with minute tubercles; lower lip finely papillated, slightly emarginated, a callous pad behind it
4. Barbels a singal rostral pair
5. Paired fins horizontally placed
6. Scales very small
7. Maximum size: 11 cm

Family: Balitoridae

1. Head and body depressed, flattened below
2. Jaws and palate edentate
3. Three or more pairs of barbels present
4. Pectoral and pelvic fins often horizontally inserted
5. Pectoral fin with at least two undivided rays

Sub-family: Nemacheilinae

1. Pectoral and pelvic fins not inserted horizontally
2. Only outermost ray of pectoral fin simple
3. Airbladder reduced to two connected lateral parts and a small posterior part

- **Species: *Nemacheilus botia*** (balichata)

  D iii 9-11; A iii 5; P i 11; V i 7; LL 28-30

1. Body slender, almost cylindrical
2. Nostrils close to each other, anterior, not tubular
3. Mouth semicircular; lips moderately fleshy, upper lip uninterrupted with a few papillae, lower lip interrupted in middle with a broad papillose disc on each side
4. Barbels well-developed, nasal barbels short
5. Dorsal fin inserted nearer to snout-tip than base of caudal fin
6. Caudal fin slightly emarginate
7. Scales conspicuous and imbricate, considerably reduced on breast; lateral line usually complete
8. 12-16 blackish vertical cross bands of turns and twists, descending below the level of lateral line, broken up into patches and scattered irregularly on flanks; a black ocellus on upper base of caudal fin; caudal fin with 5-7 V-shaped dark bands
9. Maximum size: 7 cm

Order: Siluriformes

1. Body elongate and compressed, either naked or covered with bony plates
2. Jaws with teeth
3. One to four pairs of barbels present
4. Spines often present at the front of the dorsal and pectoral fins
5. A single spine often present in dorsal fin
6. Adipose dorsal fin usually present
7. Weberian apparatus present

Family: Bagridae

1. Body naked, rather elongate and compressed posteriorly
2. Mouth usually somewhat terminal
3. Barbels generally four well-developed pairs
4. Dorsal fin base short, preceded by a spine, usually 6-8 soft rays
5. Adipose fin present
6. Anal fin base usually short, with 8-16 soft rays
7. Pectoral fin with a strong serrated spine
8. Caudal fin forked and deeply emarginate

- **Species: *Mystus bleekeri*** (singhala, golsha-tengra, palwa, tengara)

  D I 7-8; A iii 6-7; P I 9-10; V i 5

1. Body elongate and compressed
2. Mouth terminal
3. Barbels four pairs, maxillary barbels extend posteriorly to anal fin
4. Dorsal spine smooth, rarely finely serrated; adipose fin large, inserted just behind rayed dorsal fin
5. Body with two light longitudinal bands, one above and the other below lateral line
6. Maximum size: 13.5 cm

- **Species: *Mystus cavasius*** (khirkirya, katirna, kabasi-tengra, palwa)

  D I 7; A iv 7-9; P I 8; V i 5

1. Body elongate and compressed
2. Mouth terminal
3. Barbels four pairs, maxillary barbels extend posteriorly to beyond caudal fin base
4. Dorsal spine weak, often feebly serrated; adipose fin large, inserted close behind with base of rayed dorsal fin
5. Caudal fin deeply forked, upper lobe much longer than lower lobe

6. A dark spot at base of dorsal spine
7. Maximum size: 40 cm

- **Species: *Mystus vittatus*** (tengra, kuggur, palwa)

  D I 7; A ii-iii 7-9; P I 9; V i 5

1. Body elongate and somewhat compressed
2. Mouth terminal
3. Barbels four pairs, maxillary pair extends posteriorly to beyond pelvic fins, often to the end of anal fin
4. Dorsal spine weak, finely serrated on its inner edge; adipose fin small, inserted much behind rayed dorsal fin but in advance of anal fin
5. Body with several pale blue or dark brown to deep black longitudinal bands on flank; a narrow dusky shoulder spot often present
6. Maximum size: 21 cm

Family: Siluridae

1. Body elongate and compressed
2. Barbels 1-3 pairs, nasal barbels invariably absent
3. Rayed dorsal fin usually one, devoid of a spine, with fewer than seven soft rays; adipose fin absent
4. Anal fin very long (up to 93 rays), ends shortly before anal fin
5. Pectoral fin with a spine; pelvic fin small to inconspicuous, often absent

- **Species: *Ompok malabaricus*** (goongwaree, moone, manjavhlay)

  D 4; A iii 63-69; P I 11-12; V i 7

1. Mouth somewhat oblique, gape wide
2. Barbels two pairs; maxillary barbels rather heavy and long, extend to slightly beyond pelvic fin origin; mandibular barbels slender and short extending posteriorly no farther than the hind border of eye
3. Pectoral spine strong, serrated on its inner edge
4. Maximum size: 51 cm

- **Species: *Wallago attu*** (shivada, pattan, walagh, boyari, attu-vahlay)

  D 5; A iii 74-93; P I 13-15; V i 7-9

1. Mouth wide, gape extends posteriorly to beyond eyes
2. Barbels two pairs; maxillary pair long, extends posteriorly to well beyond origin of anal fin; mandibular pair much shorter, about as long as snout
3. Dorsal fin short, inserted usually slightly in advance of pelvic fins

4. Pectoral spine weak, often poorly serrated on its inner edge
5. Upper lobe of caudal fin longer
6. Maximum size: 200 cm

Family: Schilbeidae

1. Head tapering, conical to slightly compressed
2. Eyes large, laterally or ventrolateraly directed
3. Barbels 2-4 pairs; nasal barbels generally present
4. Dorsal fin (with a short base and a spine) present or absent; adipose fin small and hyaline, vestigial or absent
5. Anal fin very long, not confluent with caudal fin
6. Pectoral fin usually with a thin stiff spine

- **Species: *Proeutropiichthys taakree taakree*** (moonia, munvi, vyadi)

  D I 6-8; A iii-iv 40-50; P I 8-10; V i 5

1. Mouth terminal; teeth villiform in bands on jaws
2. Barbels four pairs; nasal barbels extend beyond middle of eye, maxillary ones to pelvic fins, mandibular pairs to beyond pectoral fin base
3. Dorsal spine denticulated on its posterior edge and finely serrated on its anterior edge
4. Pectoral spine serrated on its inner edge
5. Body silvery in colour
6. Maximum size: 40 cm

Family: Heteropneustidae

1. Head flat and greatly depressed, dorsal and lateral parts covered with osseous plates
2. Mouth small, terminal and transverse
3. Barbels four well developed pairs (nasal, maxillary and two mandibular pairs)
4. Dorsal fin short without a spine
5. Adipose dorsal fin absent
6. Anal fin extremely long, just reaching to or confluent with caudal fin
7. Pectoral fin with a strong osseous spine
8. Skin quite naked

- **Species: *Heteropneustes fossilis*** (bitchuka-machi, singhi, talia, kari)

  D 6-7; A 60-70; P I 7; V i 5

1. Body elongate, subcylindrical to pelvic fin base, compressed behind

2. Head depressed, covered with osseous plates
3. Mouth small and terminal
4. Barbels four well developed pairs
5. Dorsal fin short, inserted usually above the tip of pectoral fins
6. Pectoral fin with a strong spine, serrated along its inner edge and with a few serrations at its anterior end externally
7. Anal fin long based, separated by a distinct notch from a rounded caudal fin
8. Body dark purplish-brown above and lighter below
9. Maximum size: 30.5 cm

Order: Cyprinodontiformes

1. Body with scales
2. No spines in fins
3. Single dorsal fin
4. Dorsal and anal fins short to moderate based
5. Lateral line may be absent

Sub-order: Exocoetoidei

1. Body elongate
2. Narial opening single
3. Dorsal and anal fins on rear half of body
4. Pelvic fins abdominal, with six soft rays
5. Fin spines absent
6. Caudal fin with 13 branched rays
7. Scales thin, cycloid
8. Lateral line running along ventral edge of body
9. Branchiostegal rays 9-15

Family: Belonidae

1. Body elongate, subcylindrical or laterally compressed
2. Both jaws extend into long beaks armed with sharp teeth to their tip
3. No spines in fins
4. Dorsal and anal fins posterior in position, bases opposite
5. Pectoral fins short, pelvic fins abdominal with six soft rays
6. Scales small, cycloid; lateral line running along ventral margin of body with a branch to pectoral fin origin

- **Species: *Strongylura leiura*** (banded needlefish)

  D 17-21; A 23-25; P 10-11; V 6

  1. Body elongate, laterally compressed, almost rectangular in cross section
  2. Both jaws greatly elongated, studded with sharp teeth
  3. Anterior parts of dorsal and anal fins forming distinct lobes
  4. Dorsal fin inserted slightly posterior to anal fin
  5. Pectoral fins not falcate
  6. Caudal fin emarginate
  7. Body with silvery stripe along sides, widening posteriorly
  8. Maximum size: 73 cm

- **Species: *Strongylura strongylura*** (spottail needlefish)

  D 12-15; A 15-18; P 10-12; V 6

  1. Body elongate, rounded in cross section
  2. Both jaws greatly elongated, studded with sharp teeth
  3. Dorsal fin inserted slightly posterior to anal fin
  4. Anterior parts of dorsal and anal fins form moderate lobes
  5. Pectoral fins not falcate
  6. Caudal fin rounded or truncate
  7. Body with silvery lateral band on flank, widening posteriorly; a prominent black spot at base of caudal fin
  8. Maximum size: 40 cm

Sub-order: Cyprinodontoidei

1. Body typically fusiform, rarely laterally compressed
2. Fins soft-rayed
3. Narial opening paired
4. Upper jaw bordered by premaxilla only, protrusible
5. Vomer and supraleithum present
6. Scales usually cycloid
7. Body generally fully scaled
8. Lateral line chiefly on head, not on body
9. Branchiostegal rays 4-7
10. Vertebrae 24-25

Family: Poeciliidae

1. Body cylindrical and compressed posteriorly

2. Dorsal fin short, without any spine
3. Anal fin of female usually rounded while in male, modified to serve as external genitalium (gonopodium, primarily formed from the third, fourth and fifth finrays); gonopodium usually with spines, hooks and serrae on or near tips of one or more rays
4. First few pectoral finrays in some cases and pelvic fins sexually modified in male

- **Species: *Poecilia reticulata*** (guppy)

  D ii 5; A ii 7; P ii 11; V i 5; LL 27-32

1. Body cylindrical
2. Mouth moderate, lower jaw projecting
3. Dorsal fin short, inserted in front of anal fin
4. Males having beautiful orange, red and black dots all over the body and fins while females are olivaceous
5. Maximum size: 3 cm (male) and 6 cm (female)

Order: Perciformes

1. Two dorsal fins, first spinous and second soft rayed
2. A small gap, notch or wide gap between two dorsal fins
3. Spines present in dorsal, pelvic and anal fins

Sub-order: Percoidei

1. Head not depressed
2. Pelvic fins thoracic
3. Each pelvic fin with a spine and 5 soft rays

Family: Ambassidae

1. Body oblong and compressed
2. Mouth moderate to large, slightly protrusible
3. Dorsal fin deeply divided before last spine, with 7-8 spines and 8-12 soft rays; anal fin with three spines and 8-17 soft rays; pelvic fin with one spine and five soft rays
4. Scales thin and cycloid, lateral line complete or interrupted
5. Body glassy or semitransparent, with the vertebral column and swimbladder easily visible in the living fish

- **Species: *Chanda nama*** (gaude-chiri, kackki-chembardi, chanda, sirsa)

  D VII + I 15-17; A III 15-17; P ii 11-12; V I 5; LL 100-107

1. Body ovate and strongly compressed; dorsal and abdominal profile convex

2. Mouth large, with a prominent lower jaw
3. Scales minute, often irregularly arranged; lateral line complete
4. Maximum size: 11 cm

- **Species: *Parambassis ranga*** (kachki, ranga-chanda)

  D VII + I 11-14; A III 13-15; P i 11-12; V I 5; LL 47-63

1. Body stout, deep and compressed
2. Preopercular hind edge smooth, at most with 1-2 serrations at angle
3. Mouth oblique, lower jaw more or less equal to upper jaw
4. Scales small
5. Body transparent with a greenish-yellow tinge and a silvery broad lateral stripe
6. Maximum size: 7 cm

Family: Cichlidae

1. Body moderately deep and compressed
2. Single nostril on each side of snout
3. Dorsal fin with 12-22 spines and 8-23 soft rays
4. Anal fin with 3-16 spines and 6-24 soft rays
5. Lateral line interrupted or abruptly ceasing, usually with 30-40 scales

- **Species: *Etroplus maculatus*** (thikree, paradi, pallattay, orange chromide)

  D XVII-XX 8-10; A XII-XV 8-9; P i 15-16; V I 5; LL 35

1. Body disc-shaped, very deep and strongly compressed
2. Eyes large
3. Mouth small
4. Caudal fin lunate
5. Scales weakly ctenoid; lateral line interrupted
6. Three large, round black blotches on flanks, middle blotch largest and darkest
7. Maximum size: 8 cm

- **Species: *Etroplus suratensis*** (cashimara,uduppati, karimeen, pearlspot)

  D XVIII-XIX 14-15; A XII-XIII 11-12; P i 16; V I 5; LL 35-40

1. Body very deep, short, oval and strongly compressed
2. Eyes large
3. Mouth small
4. Caudal fin slightly emarginate
5. Scales weakly ctenoid; lateral line interrupted at 16^{th} or 18^{th} scale

6. Body light green with 6-8 not very prominent vertical bands; most scales above lateral line with a central white pearly spot

- **Species: *Oreochromis mossambicus*** (Mossambique tilapia)

  D XV-XVI 10-12; A III 10-11; P 14-15; V I 5; LL 30-32

1. Body elongate, fairly deep and compressed; upper profile of body more convex than lower
2. Mouth large
3. Longest soft dorsal ray extending to above proximal part of caudal fin in females and immature males, but in breeding males to half or three-quarter length of caudal fin
4. Caudal fin truncate, often with rounded corners
5. Scales cycloid
6. Females and non-breeding males watery-grey to yellowish, with 3-4 dark blotches often apparent along flanks; body of males in breeding season deep black

- **Species: *Oreochromis niloticus*** (nilontika, Nile tilapia)

  D XVI-XVII 12-13; A III 9-11; P 14-15; V I 5; LL 32-33

1. Dorsal fin with 15-18 spines and 11-13 soft rays
2. Anal fin with three spines and 9-11 soft rays
3. Presence of regular vertical stripes throughout depth of caudal fin most distinguishing characteristic
4. Caudal peduncle depth equals length
5. Sides of body with 6-9 rather indistinct cross bars
6. Maximum size: 60 cm

Sub-order: Gobiodei

1. Pelvic fins placed below pectoral fins, each with one spine and 4-5 soft rays
2. Pelvic fins often united to form sucking or adhesive disc

Family: Gobiidae

1. Pelvic fins united, usually forming an adhesive or sucking disc
2. Usually two dorsal fins, but often one; spinous dorsal fin when present separate from soft dorsal fin and with 2-17 flexible spines
3. Body scales ctenoid or cycloid, often partly or totally absent
4. Teeth generally small and conical in one to several rows on both jaws

- **Species: *Glossogobius giuris*** (bele, bailla)

  D VI+I 8-9; A I 7-8; P i 16-21; LL 41-45

1. Body elongate and somewhat compressed
2. Eyes small; iris without process in pupil
3. Branchiostegal membranes attached to sides of isthmus
4. Body yellowish-brown with five dark blotches on flank
5. Maximum size: 30 cm

Sub-order: Channoidei

1. Dorsal and anal fins very long
2. Fin spines absent
3. Accessory branchial organ present
4. Caudal fin rounded
5. Scales small, but scales on head larger than on body

Family: Channidae

1. Body elongate and cylindrical
2. Shape of the head resembles that of snake
3. Dorsal and anal fins very long and entirely soft rayed
4. Mouth large with toothed jaws and palate
5. Supra-branchial organ well developed
6. Pelvic fins usually present with six rays
7. Caudal fin rounded
8. Scales small, cycloid or ctenoid
9. Colour usually in shades of grey, brown and black, often with distinctive markings

- **Species: *Channa marulius*** (gajal, bhor, saal, madinji)

  D 45-55; A 28-36; P 16-18; V 6; LL 60-70

1. Body elongate and fairly rounded in cross section
2. Eyes moderate
3. Mouth large, deeply cleft, maxilla extends behind orbit
4. Caudal fin rounded
5. Body above lateral line greyish-green, with 5-6 dark oval blotches on flank; dorsal and anal fins with white spots; a distinct pale-edged ocellus at base of caudal fin towards upper side; juveniles with an orange band running from eye to middle of caudal fin
6. Maximum size: 180 cm

- **Species: *Channa punctatus*** (lata, taki, phool-dhok, kuchi)

  D 28-33; A 20-23; P 15-18; V 6; LL 37-40

1. Body elongate and fairly rounded in cross section
2. Eyes moderate
3. Mouth large, lower jaw longer, maxilla reaching below the hind border of eye
4. Pectoral fins extend to anal fin, pelvic fin about 75% of pectoral fin length, caudal fin rounded
5. Scales on summit of head, large
6. Body black to light green on dorsal side and flanks while ventral side white to pale yellow, several dark blotches on flanks; some specimens with numerous black spots on body; also on dorsal, anal and caudal fins
7. Maximum size: 31 cm

Sub-order: Masatacembeloidei

1. Body eel like, compressed and elongated with minute scales, head long and pointed
2. Dorsal and anal fins long
3. Anterior part of dorsal fin composed of isolated spinous rays
4. Caudal fin short; either confluent with dorsal and anal or narrowly separated
5. Pelvic fins absent

Family: Mastacembelidae

1. Body eel-like and compressed, with a characteristic elongated shape
2. Snout pointed with a fleshy rostral appendage
3. Dorsal fin long, preceded by a series of isolated stout spines (usually 14-35); anal fin usually with 2-3 spines and 30-90 soft rays; no pelvic fins; caudal fin distinct, often connected to posterior ray of dorsal or anal fin
4. Scales small and cycloid

- **Species: *Macrognathus aral*** (vam, golchi, tora, patgaincha, gainchi)
  D XVI-XXIII 44-45; A III 44-52; P 19-24; C 15; LL 40-50

1. Body elongate
2. Long fleshy snout with trilobed tip
3. No spines on preorbital or preoperculum bones
4. Mouth very small
5. Dorsal fin inserted far behind tip of pectoral fin, last dorsal spine small
6. Caudal fin rounded and distinctly separated from dorsal and anal fins
7. Lateral line well developed

8. Body brownish or greenish, marbled above and yellowish below; body with two broad pale longitudinal bands extending its entire length; dorsal fin often with 3-11 ocelli at its base; dorsal and caudal fins with numerous fine streaks
9. Maximum size: 38 cm

- **Species: *Macrognathus pancalus*** (pangkal, gaincha, patya, malga)

  D XXIV-XXVI 30-42; A III 31-46; P 17-19; C 12; LL 85-87

1. Body eel-like and slightly compressed
2. Rostrum rounded in cross-section, devoid of toothplates
3. Preopercle with 2-5 spines; preorbital spine strong and pierces skin
4. Mouth small
5. Dorsal fin inserted above middle of pectoral fins; dorsal and anal fins separate from caudal fin
6. Body greenish-olive along back, yellowish on belly, with many yellowish-white spots on flanks and often with dark brown vertical stripes
7. Maximum size: 18 cm

- **Species: *Mastacembelus armatus*** (vam, vat, bam, bami, aaraah)

  D XXXII-XL 64-92; A III 64-90; P 21-27; C 14-17; LL 95-97

1. Body relatively slender
2. Preopercle with 2-3 usually conspicuous spines
3. Preorbital spine strong and usually piercing skin
4. Mouth small
5. Spinous dorsal fin inserted above middle or posterior third of pectoral fin, last dorsal spine small and hidden beneath skin
6. Dorsal and anal fins broadly joined to caudal fin
7. Body rich brown and usually with zig-zag lines; often a black band through eye continueing in an undulating course along upper half of side; often a row of black spots along base of soft dorsal fin, and short black bands over back under dorsal spines
8. Maximum size: 61 cm

6.3. Discussion

The fishes collected during the study belonged to five different orders (Osteoglossiformes, Cypriniformes, Siluriformes, Cyprinidontiformes and Perciformes). There were 15 families (Notopteridae, Cyprinidae, Parapsilorhynchidae, Balitoridae, Bagridae, Siluridae, Schilbeidae, Heteropneustidae, Belonidae, Poeceliidae, Ambassidae,

Cichlidae, Gobiidae, Channidae and Mastacembelidae). The 64 species recorded were distributed in 40 genera, out of which, 27 had only one species each representing them.

The numerically richest order was Cypriniformes with three families. Family Cyprinidae had 19 genera with the genus *Puntius* dominating the distribution with ten species. *Chanda nama, Glossogobius giuris* and *Puntius ticto* were the dominat species with distribution at all the nine stations, wherever fish could be found.

More than 150 species of freshwater fishes have been reported by various authors in River Godavari of which Fishbase.org lists 69 species including two exotics, *Cyprinus carpio carpio* and *Oreochromis mossambicus,* though the latter is erroneously stated as of native status (Table 12). Out of these, during the present investigation, only 34 species could be obtained (Table 13), though we could come across 30 species, which have not been included in the database of Fishbase.org (Table 14). It could be concluded from the present investigation that there is no appreciable depletion in species diversity when compared to the database available. However, the commercially important species have very limited presence in the samples collected as well as the fishermen's catches. This shows that contribution to the commercial fisheries is limited as has been concluded by the earlier workers.

The studies on the fisheries in River Godavari have been restricted mostly to the river stretch in Andhra Pradesh. The principal freshwater fish species that support the fishery of the river are *Labeo fimbriatus, Labeo calbasu, Cirrhinus mrigala* and *Catla catla* among carps; and *Mystus seenghala, Mystus aor, Silonia childreni, Wallago attu, Pangasius pangasius* and *Bagarius bagarius* among catfishes (Jhingran, 1997). Among these, *Labeo fimbriatus, Mystus seenghala, Mystus aor, Silonia childreni, Pangasius pangasius* and *Bagarius bagarius* were not observed during the present study indicating adverse impacts on the riverine fishery.

One of the notable factors in the study is the presence of *Cyprinus carpio carpio* (common carp) at Gangapur, very near the origin of the river. As this exotic fish is a prolific breeder, it can compete and replace the native fishes, over the entire stretch of the river within a limited period of time as has happened in the major river systems of the country like the Ganga. The presence of this fish as also *Oreochromis mossambicus* (Mossambique tilapia) has already been reported in the database available, and could also be detrimental to the native species. The two exotic species that have been reported for the first time in this study are *Oreochromis niloticus* (Nile tilapia) and *Poecilia reticulata* (guppy). The presence of *Oreochromis niloticus* could again be detrimental to the native

population as is the case with *Oreochromis mossambicus,* though that of *Poecilia reticulata* may not have a serious impact. Moreover, the latter is considered to be a larvivorous fish and may be of limited help in the control mosquito menace.

Table 12. List of fish species reported in River Godavari (Source: Fishbase.org)

Species	Family	Habitat	Total length (cm)	Trophic level	Status
Amblypharyngodon mola	Cyprinidae	Benthopelagic	20	3.0	Native
Barbodes sarana	Cyprinidae	Benthopelagic	42	3.4	Native
Barilius bendelisis	Cyprinidae	Benthopelagic	23	3.0	Native
Catla catla	Cyprinidae	Benthopelagic	180	2.8	Native
Chanda nama	Ambassidae	Benthopelagic	11	3.1	Native
Channa marulius	Channidae	Benthopelagic	183	3.0	Native
Channa striata	Channidae	Benthopelagic	122	3.7	Native
Cirrhinus cirrhosus	Cyprinidae	Benthopelagic	122	2.4	Native
Cirrhinus macrops	Cyprinidae	Benthopelagic	38	2.8	Endemic
Clarias dussumieri	Clariidae	Benthopelagic	25	3.2	Native
Cyprinus carpio carpio	Cyprinidae	Benthopelagic	147	3.0	Introduced
Danio aequipinnatus	Cyprinidae	Pelagic	15	3.2	Native
Devario devario	Cyprinidae	Benthopelagic	10	3.3	Native
Devario fraseri	Cyprinidae	Benthopelagic	10	3.3	Native
Esomus danricus	Cyprinidae	Benthopelagic	13	3.0	Native
Esomus thermoicos	Cyprinidae	Benthopelagic	12	3.3	Native
Garra gotyla stenorhynchus	Cyprinidae	Benthopelagic	15	2.7	Native
Garra mullya	Cyprinidae	Benthopelagic	17	2.6	Native
Glossogobius giuris	Gobiidae	Demersal	61	4.3	Native
Glyptothorax lonah	Sisoridae	Benthopelagic	15	3.1	Native
Gudusia chapra	Clupeidae	Pelagic	20	3.4	Native
Heteropneustes fossilis	Heteropneustidae	Demersal	30	3.9	Native
Hypselobarbus curmuca	Cyprinidae	Benthopelagic	120	2.6	Native
Hypselobarbus kolus	Cyprinidae	Benthopelagic	30	3.0	Native
Indoreonectes evezardi	Balitoridae	Demersal	5	2.6	Native
Labeo ariza	Cyprinidae	Benthopelagic	37	2.5	Native
Labeo bata	Cyprinidae	Benthopelagic	61	2.7	Native
Labeo boga	Cyprinidae	Benthopelagic	30	2.7	Native
Labeo calbasu	Cyprinidae	Demersal	90	2.0	Native
Labeo fimbriatus	Cyprinidae	Benthopelagic	91	2.5	Native
Labeo porcellus	Cyprinidae	Benthopelagic	35	2.8	Native
Labeo potail	Cyprinidae	Benthopelagic	30	2.7	Native
Labeo rohita	Cyprinidae	Benthopelagic	200	2.0	Native
Mastacembelus armatus	Mastacembelidae	Demersal	68	2.8	Native
Mystus cavasius	Bagridae	Demersal	49	3.7	Native

Table 12 (contd). List of fish species reported in River Godavari (Source: Fishbase.org)

Notopterus notopterus	Notopteridae	Demersal	74	3.5	Native
Ompok bimaculatus	Siluridae	Demersal	55	3.9	Native
Oreochromis mossambicus	Cichlidae	Benthopelagic	48	2.0	Native*
Osteobrama belangeri	Cyprinidae	Benthopelagic	38	2.8	Native
Osteobrama cotio cunma	Cyprinidae	Benthopelagic	15	3.0	Native
Osteobrama cotio peninsularis	Cyprinidae	Benthopelagic	20	3.0	Native
Osteobrama dayi	Cyprinidae	Benthopelagic	30	3.0	Native
Osteobrama vigorsii	Cyprinidae	Benthopelagic	23	3.0	Native
Osteochilus godavariensis	Cyprinidae	Benthopelagic	15	2.0	Native
Osteochilus nashii	Cyprinidae	Benthopelagic	18	2.0	Native
Parambassis ranga	Ambassidae	Demersal	8	3.3	Native
Parapsilorhynchus prateri	Cyprinidae	Benthopelagic	24	3.0	Native
Parluciosoma labiosa	Cyprinidae	Benthopelagic	11	3.0	Native
Proeutropiichthys taakree taakree	Schilbeidae	Demersal	49	3.2	Native
Pseudogobius javanicus	Gobiidae	Benthopelagic	8	4.5	Native
Puntius chola	Cyprinidae	Benthopelagic	15	3.0	Native
Puntius dorsalis	Cyprinidae	Benthopelagic	25	2.0	Native
Puntius sophore	Cyprinidae	Benthopelagic	13	3.0	Native
Puntius ticto	Cyprinidae	Benthopelagic	10	2.5	Native
Rasbora daniconius	Cyprinidae	Benthopelagic	15	3.4	Native
Rita gogra	Bagridae	Demersal	26	3.1	Native
Rita kuturnee	Bagridae	Demersal	30	3.6	Native
Rohtee ogilbii	Cyprinidae	Benthopelagic	15	3.0	Native
Salmostoma balookee	Cyprinidae	Benthopelagic	15	3.0	Native
Salmostoma novacula	Cyprinidae	Benthopelagic	13	3.0	Native
Salmostoma phulo	Cyprinidae	Benthopelagic	12	3.0	Native
Silonia childreni	Schilbeidae	Demersal	48	4.5	Native
Sperata aor	Bagridae	Demersal	180	3.8	Native
Sperata seenghala	Bagridae	Demersal	150	3.4	Native
Tenualosa ilisha	Clupeidae	Pelagic	74	2.0	Native
Thynnichthys sandkhol	Cyprinidae	Benthopelagic	46	3.0	Native
Tor khudree	Cyprinidae	Benthopelagic	50	3.1	Native
Tor mussullah	Cyprinidae	Benthopelagic	150	3.0	Native
Wallago attu	Siluridae	Demersal	240	4.5	Native

*Introduced species

A commercially important fish, *Etroplus suratensis* (pearlspot), has been found to be established at Dhalegaon and Raher. Though the natural habitat of this species is

brackish water, it grows, breeds and establishes in freshwater habitats. Another surprise was the presence of *Macrobrachium rosenbergii* at Gangapur far away from the breeding grounds as this species needs brackish water for breeding and larval development.

Parts of fishermen's catch at Raher

The presence of these species indicates the intervention of man not only by altering the habitat, but also by introducing exotic species and others which are not native to the specific part of the river. The limited flow and the discontinuous nature of the water and the dead stretches like Tapovan do prevent the migration and spread of these species to some extent. However, during monsoon, when the river floods and overflows, the undesired species could establish throughout the river and the adjoining water bodies.

The dam at Gangapur

Table 13. List of fish species common to the present study and Fishbase.org database

Species	Family	Status
Amblypharyngodon mola	Cyprinidae	Native
Barilius bendelisis	Cyprinidae	Native
Catla catla	Cyprinidae	Native
Chanda nama	Ambassidae	Native
Channa marulius	Channidae	Native
Cyprinus carpio	Cyprinidae	Introduced
Danio aequipinnatus	Cyprinidae	Native
Garra mullya	Cyprinidae	Native
Glossogobius giuris	Gobiidae	Native
Heteropneustes fossilis	Heteropneustidae	Native
Hypselobarbus kolus	Cyprinidae	Benthopelagic
Labeo bata	Cyprinidae	Native
Labeo calbasu	Cyprinidae	Native
Labeo porcellus	Cyprinidae	Native
Labeo rohita	Cyprinidae	Native
Mastacembelus armatus	Mastacembelidae	Native
Mystus cavasius	Bagridae	Native
Notopterus notopterus	Notopteridae	Native
Oreochromis mossambicus	Cichlidae	Introduced
Osteobrama cotio peninsularis	Cyprinidae	Native
Osteochilus godavariensis	Cyprinidae	Native
Parambassis ranga	Ambassidae	Native
Parapsilorhynchus prateri	Cyprinidae	Native
Parluciosoma labiosa	Cyprinidae	Native
Proeutropiichthys taakree taakree	Schilbeidae	Native
Puntius chola	Cyprinidae	Native
Puntius sophore	Cyprinidae	Native
Puntius ticto	Cyprinidae	Native
Rohtee ogilbii	Cyprinidae	Native
Salmostoma novacula	Cyprinidae	Native
Salmostoma phulo	Cyprinidae	Native
Tor khudree	Cyprinidae	Native
Tor musullah	Cyprinidae	Native
Wallago attu	Siluridae	Native

Table 14. List of fish species found in the present study, which are not included in the Fishbase.org database

Species	Family	Status
Barilius gatensis	Cyprinidae	Native
Channa punctatus	Channidae	Native
Chela fasciata	Cyprinidae	Native
Chitala chitala	Notopteridae	Native
Cirrhinus reba	Cyprinidae	Native
Etroplus maculatus	Cichlidae	Native
Etroplus suratensis	Cichlidae	Native
Labeo angra	Cyprinidae	Native
Labeo dyocheilus	Cyprinidae	Native
Macrognathus aral	Mastacembelidae	Native
Macrognathus pancalus	Mastacembelidae	Native
Mystus bleekeri	Bagridae	Native
Mystus vittatus	Bagridae	Native
Nemacheilus botia	Balitoridae	Native
Ompok malabaricus	Siluridae	Native
Oreochromis niloticus	Cichlidae	Introduced
Poecilia reticulata	Poeceliidae	Introduced
Puntius guganio	Cyprinidae	Native
Puntius jerdoni	Cyprinidae	Native
Puntius phutunio	Cyprinidae	Native
Puntius shalynius	Cyprinidae	Native
Puntius singhala	Cyprinidae	Native
Puntius terio	Cyprinidae	Native
Puntius vittatus	Cyprinidae	Native
Salmostoma bacaila	Cyprinidae	Native
Salmostoma sardinella	Cyprinidae	Native
Schismatorynchus nukta	Cyprinidae	Native
Securicula gora	Cyprinidae	Native
Strongylura leiura	Belonidae	Native
Strongylura strongylura	Belonidae	Native

7. PLANKTON

7.1. Distribution

The plankton samples were collected and analysed during each of the samplings. The details are presented in tables 15-17. Planktonic organisms could be observed even at Tapovan, where no fish could be seen. However, the abundance and the groups of plankton varied widely at the different stations. Kopergaon had either plankton bloom or floating macrophyte *(Lemna minor)* during all the three sampling periods indicating very high level of decomposing organic matter.

Sampling for plankton at Nandur-Madhyameshwar

7.2. Discussion

The values of Nygaard (Nygard, 1949) Index for post-monsoon and winter seasons ranged between 3 and 6 indicating that these stations are oligotrophic in nature except for Gangapur dam and Raher where the values were 6 and 8, respectively, showing moderately eutrophic conditions at these sites (Table 18). The values of Palmer Index (Palmer, 1969) ranged between 1 and 10 for the above sites indicating less organic pollution. The highest value (10) was recorded at Gangapur dam.

The occurrence of indicator genera of the phytoplankton at the sites studied has also been analysed as per Palmer (1969) and the results are presented in Table 19. All the stations have been found to be polluted with one to five indicator genera present. Nandur-Madhyameshwar was found to be the least polluted with only one indicator genus, whereas the highest level of pollution was found at Gangapur dam.The analysis of plankton clearly indicates that all the stations are organically polluted, different locations showing different levels as per the different indices used and the indicator genera.

Table 15. Planktonic organisms (no. l^{-1}) observed: Pre-monsoon

Organism	Gangapur dam	Tapovan	Nandur-Madhyameshwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan upstream	Pathegaon	Dhalegaon	Raher
Anabaena	14	-	22	-	28	42	56	102	180	-
Asterionella	18	12	18	20	24	28	44	32	12	20
Brachionus	12	-	4	8	6	12	8	18	6	-
Chlorella	10	-	12	6	-	20	34	18	28	12
Closterium	8	-	-	6	8	16	22	28	18	-
Copepods	104	521	86	48	92	124	84	132	62	-
Daphnia	6	4	14	-	-	12	16	22	-	-
Fragilaria	16	-	-	20	-	-	22	-	38	-
Keratella	4	-	-	6	2	8	12	18	18	-
Micractinium	-	8	-	-	-	16	28	22	-	2
Microcystis	8	-	41	8	18	10	4	8	-	-
Moina	-	-	-	-	-	16	32	44	-	-
Nauplii	-	12	18	-	-	22	18	28	-	-
Navicula	12	-	61	-	22	12	38	-	2	6
Pediastrum	14	16	8	18	28	38	42	36	6	4
Planktosphaera	-	-	-	-	36	28	32	42	12	8
Rhizosolenia	-	-	8	-	18	16	24	-	-	-
Scenedesmus	-	-	-	18	-	-	-	12	8	-
Spirulina	-	-	-	-	64	80	-	92	142	-
Synedra	422	316	440	24	450	318	266	844	812	36
Thalassionema	10	-	22	-	28	42	20	32	12	-
Volvox	6	4	-	-	-	4	6	2	-	-
Zygnema	26	-	-	-	-	22	38	68	34	-

Table 16. Planktonic organisms (no. l^{-1}) observed: Post-monsoon

Organism	Gangapur dam	Tapovan	Nandur-Madhyameshwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan upstream	Pathegaon	Dhalegaon	Raher
Anabaena	-	-	-	-	-	-	-	-	-	16
Asterionella	28	22	28	44	-	35	64	43	36	30
Brachionus	22	-	28	-	18	26	24	4	4	4
Ceretinum	4	-	-	-	-	-	-	-	-	4
Chlorella	22	-	-	8	-	30	-	-	-	-

Table 16 (contd). Planktonic organisms (no. l^{-1}) observed: Post-monsoon

Organism	Gangapur dam	Tapovan	Nandur-Madhyameshwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan upstream	Pathegaon	Dhalegaon	Raher
Closterium	18	4	-	-	-	-	8	-	-	-
Coelastrum	4	-	8	-	-	-	8	2	-	-
Copepods	218	200	128	160	102	184	92	98	280	106
Daphnia	8	-	22	20	12	32/	40	10	-	-
Fish eggs	4	-	-	6	-	-	-	-	-	-
Fragilaria	-	-	-	40	-	-	-	4	36	-
Hydrodictyon	-	-	-	-	4	-	-	-	-	-
Keratella	12	20	-	-	-	-	-	4	4	22
Lepadella	8	-	12	-	-	-	-	4	8	4
Micractininm	-	22	-	-	-	-	-	-	-	6
Microcystis	20	-	16	40	232	56	44	8	20	160
Nauplii	28	18	-	82	60	22	24	6	8	70
Navicula	16	6	-	-	38	-	-	6	20	42
Nodularia	-	-	4	-	-	-	-	-	-	8
Notholca	12	8	-	-	-	-	-	-	-	8
Pediastrum	20	26	-	36	44	16	82	12	12	12
Planktosphaera	-	-	-	-	-	-	36	16	18	4
Rizosolenia	-	-	16	-	-	20	-	-	-	-
Scenedesmus	-	-	-	-	-	-	-	-	16	22
Spirulina	-	-	-	-	-	40	62	6	-	-
Synedra	20	240	16	-	82	32	-	-	-	-
Thalassionema	22	-	-	-	-	-	-	-	-	-
Volvox	18	8	4	20	32	8	-	-	-	-
Zygnema	36	-	-	10	18	-	-	-	-	-

Table 17. Planktonic organisms (no. l^{-1}) observed: Winter

Organism	Gangapur dam	Tapovan	Nandur-Madhyameshwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan upstream	Pathegaon	Dhalegaon	Raher
Anabaena	-	-	-	-	-	-	-	-	-	8
Asterionella	20	66	24	-	-	-	-	-	22	12
Brachionus	18	-	20	-	-	-	-	4	6	-
Ceretinum	4	-	-	-		6	2	8	-	-
Chlorella	-	-	12	8	-	-	-	-	22	-
Closterium	-	6	-	-	-	-	4	-	8	-
Coelastrum	2	2	6	-	-	-	-	-	8	-
Copepods	72	52	84	78	64/l	102	-	-	4	-
Daphnia	12	-	8	4		-	2	-	4	-
Fish eggs	6	-	-	-		-	-	2	-	-
Fragilaria	-	-	8	-	4	-	-	-	4	-
Hydrodictyon	-	-	-	-	-	-	-	-	-	4
Keratella	8	12	24	-	-	-	-	4	-	-
Lepadella	2	-	10	-	-	-	-	-	-	-
Micractinium	6	-	-	-	-	-	-	-	-	-
Microcystis	18	12	10	20	118	4	4	10	12	-
Nauplii	6	4	-	6	8/l	10	4	-	4	-
Navicula	-	-	8	-	-	-	6	-	-	-
Nodularia	-	-	2	-	-	-	-	-	-	6
Notholca	6	-	-	-		-	-	6	4	-
Pediastrum	8	42	26	-	-	-	-	-	-	8
Planktosphaera	-	-	2	-	-	-	-	-	-	-
Rizosolenia	-	-	8	4	-	-	92	40	-	-
Scenedesmus	-	-	-	-	-	-	-	-	4	-
Spirulina	-	-	-	-	-	32	-	22	-	-
Synedra	-	340	202	-	62	64	-	-	-	-

Table 17 (contd). Planktonic organisms (no. l^{-1}) observed: Winter

Organism	Gangapur dam	Tapovan	Nandur-Madhyameshwar	Kopergaon	Pravara Sangam	Jayakwadi dam	Paithan upstream	Pathegaon	Dhalegaon	Raher
Thallisionema	-	-	4	-	-	12	-	-	-	-
Volvox	12	-	4	12	-	6	-	-	-	-
Zygnema	24	-	-	-	-	4	-	-	-	2

Table 18. Values of Palmer and Nygaard indices showing the status of water quality at selected sites: Pre-monsoon

Sl. no.	Name of the site	Palmer Index value (Status)	Nygaard Compound Quotient value (Status)
1.	Gangapur dam	9.0 (MOP)	7.5 (Eut)
2.	Tapovan	3.0 (LOP)	5.0 (Weakly Eut)
3.	Nandur-Madhyameshwar	8.0 (MOP)	7.0 (Moderately Eut)
4.	Kopergaon	10.0 (MOP)	7.0 (Moderately Eut)
5.	Pravara Sangam	5.0 (LOP)	9.0 (Eut)
6.	Jayakwadi Dam	9.0 (MOP)	11.0 (Eut)
7.	Paithan upstream	9.0 (MOP)	11.0 (Eut)
8.	Pathegaon	11.0 (MOP)	9.0 (Eut)
9.	Dhalegaon	13.0 (MOP)	11.0 (Eut)
10.	Raher	8.0 (MOP)	7.0 (Moderately Eut)

Abbreviations: **MOP** - Moderate Organic Pollution
LOP - Low Organic Pollution
Eut - Eutrophic

Scales:

Palmer Index: Value of 20 or above: High Organic Pollution
15-19: Probable Organic Pollution
Less than 15: Low Organic Pollution

Nygaard Index: Less than 2: Oligotrophic
2-6: Weakly Eutrophic
More than 6: Eutrophic

Table 19. Number and names of indicator genera showing the probable status of water quality at various sites: Pre-monsoon

Sl. no.	Name of the site	Number of genera	Names of genera
1.	Gangapur Dam	5	*Synedra, Chlorella, Navicula, Closterium, Scenedesmus*
2.	Tapovan	3	*Synedra, Navicula, Chlorella*
3.	Nandur-Madhyameshwar	1	*Scenedesmus*
4.	Kopergaon	4	*Synedra, Chlorella, Closterium, Scenedesmus*
5.	Pravara Sangam	2	*Navicula, Synedra*
6.	Jayakwadi Dam	4	*Synedra, Navicula, Closterium, Chlorella*
7.	Paithan upstream	4	*Synedra, Navicula, Closterium, Chlorella*
8.	Pathegaon	4	*Synedra, Chlorella, Closterium, Scenedesmus*
9.	Dhalegaon	4	*Synedra, Navicula, Chlorella, Scenedesmus*
10.	Raher	3	*Synedra, Navicula, Chlorella*

8. HEAVY METALS

Rapid urbanisation as well as industrialisation has generated organic and inorganic pollutants which finally get discharged into the open-water systems causing environmental degradation. To some extent, River Godavari is also facing the same problem. The main sources of pollutants are effluents from mills and factories which release the waste directly into the river without proper treatment. The sewage and municipal waste are also being discharged at several parts of the river like Tapovan and Kopergaon. It was observed that the river in Maharashtra has very low water level at most of the places; it is even dry in many stetches. Most of the time, the river depends upon rain. It is seen that water is regularly pumped out from the river for irrigation of crops and other purposes. During the present study, some water pumps were observed at Pathegaon, Raher, etc. If the water level is low or nil, it becomes very dangerous for aquatic organisms.

The common determinants of pollution are biological oxygen demand (BOD), chemical oxygen demand (COD) and concentration of heavy metals in different strata such as water, sediment and living organisms.

Heavy metal analysis was carried out for the estimation of six elements, *viz*., copper, chromium, lead, cadmium, nickel and mercury, in the samples of water, sediments and fish. These analyses were carried out using an atomic absorption spectrometer (Perkin Elmer Aanalyst 800) after the preaparation of the samples using a multi-wave digestion system (Anton Parr Multiwave 3000).

8.1. Water

Heavy metal concentrations in water are presented in Table 20. Copper in water was recorded from non-detectable levels to 0.020 ppm. Chromium was varying between 0.002 and 0.009 ppm. Lead concentration fluctuated between 0.005 and 0.258 ppm. Cadmium occurred in the range of 0.002 to 0.009 ppm. Nickel was in the range of 0.008 to 0.034 ppm. Mercury was recorded from non-detectable levels to 0.008 ppm. Out of the 18 observations for metals in water, with nine lowest values, Gangapur dam had the best water quality, whereas with eight highest values, Tapovan had the worst level of metals. Generally, the lowest levels of metals in water were observed during the post-monsoon season with the exception of mercury which was found at the lowest levels during the pre-monsoon season. The highest concentrations of metals other than nickel and mercury were during pre-monsoon in water, whereas those of nickel and mercury were during winter and post-monsoon, respectively.

8.2. Sediment

Heavy metal concentrations in sediments are shown in Table 21. Copper in sediment was recorded in the range of 50.23 to 2416 ppm. During winter, copper showed higher values. Chromium was fluctuating between 92.32 and 5119 ppm. High chromium content was observed during pre-monsoon (1259-5119 ppm). Lead varied between 16.34 and 618.6 ppm, with the higher values during pre-monsoon (86.19-618.6 ppm) as compared to the other seasons. Cadmium occurred in the range of 1.335 to 7.790 ppm. Nickel was varying from 64.54 to 1106 ppm, and like chromium and lead, the pre-monsoon values were high (441.9-1106 ppm). Mercury fluctuated between 0.159 and 7.410 ppm. Again, the mercury content in the pre-monsoon season showed higher values, *i.e.,* 1.099 to 7.410 ppm. From the point of view of metals in sediment, with eight lowest values, Paithan upstream had the least level of pollution and Gangapur dam had the worst level with seven highest values. The lowest levels where observed during winter with the exception of copper for which these were during pre-monsoon. All the metals were at their highest during the pre-monsoon season and the lower levels after the rains indicate that the sediment along with the metals is carried downstream during the floods.

Tapovan during first sampling

8.3. Fish

The heavy metal concentrations in fish, which were analysed, are presented in tables 22, 23 and 24, for the pre-monsoon, post-monsoon and winter seasons, respectively. Copper was found to range from 1.162 ppm in *Channa punctatus* at Nandur-Madhyameshwar during post-monsoon to 38.690 ppm in a specimen of prawn at Kopergaon during pre-monsoon. Chromium was not detected in many fishes, though it appeared at its highest level (17.85 ppm) in *Glossogobius giuris* at Gangapur dam during

pre-monsoon. The lowest level of lead was in *Labeo dyocheilus* at 0.816 ppm during post-monsoon, whereas the highest (36.81 ppm) was in another species of the same genus *Puntius sophore* during pre-monsoon. In the case of cadmium, the lowest concentration (0.126 ppm) was in *Glossogobius giuris* at Jayakwadi dam during winter making it, among the ones studied, the one that accumulates the least quantity of metals; the highest (3.913 ppm) was in one of the important foodfishes, *Notopterus notopterus* at Pravara Sangam during pre-monsoon, though the differences were marginal. Wide variation in the distribution of nickel could be observed with *Osteobrama cotio peninsularis* at Pravara Sangam during post-monsoon having the least content (0.384 ppm) and *Mastacembelus armatus* in winter at Jayakwadi dam having the highest level at 9.589 ppm. Mercury was found to be the least (0.016 ppm) in *Heteropneustes fossilis* at Pravara Sangam during pre-monsoon and the highest (0.980 ppm) in *Puntius ticto* during winter.

Tapovan during second sampling

8.4. Discussion

The Pearson correlation analysis using SPSS 16.0 showed a complex relationship between the 22 parameters studied (Table 25). The copper content in fish has significant negative correlation with copper, cadmium and nickel in water. Chromium in fish has significant positive correlation with copper and cadmium in water, and chromium, cadmium and nickel in sediment; and with all the metals analysed in fish except copper. Chromium in fish has significant negative correlation with lead in water. Lead in fish is negatively correlated with lead and mercury in water, positively with copper and cadmium in water, and positively with all the metals analysed except copper in sediment. Lead in fish also positively correlates with chromium, cadmium and nickel in fish. Cadmium in fish is significantly correlated with the metals in sediment except copper,

and with chromium, lead and nickel in fish. The other correlations are not significant. Nickel and mercury in fish are not having much significant relationship with other parameters except a few. Chromium, cadmium and lead behaved more or less in a similar way.

The principal component analysis of the 22 parameters with Varimax rotation (Table 26-27) yielded seven components explaining 85.17% variation in the samples. Component 1 explained 38.5% of the total variation. The components 2, 3 and 4 explained about 9% each of the variation. Copper, lead and cadmium in water, all the metals in sediment except copper, and lead and cadmium in fish contributed to Component 1. Transparency, dissolved oxygen and biochemical oxygen demand of the water samples contributed to Component 2. Water pH and nickel in fish contributed to Component 3, and nickel in water and copper in fish to Component 4.

The score values of the principal components were plotted with respect to sampling season and stations (Fig. 4). The plots did not show a proper distinction among the sampling stations except Kopergaon. However, there is a noticeable variation among the sampling seasons. The characteristics of pre-monsoon samples are clearly distinct from the samples of post-monsoon and winter in all the stations. Post-monsoon and winter samples do not show clear difference from each other.

Tapovan during third sampling

Out of the metals studied, lead was found to exceed the permitted levels (BIS, 1978, 1999; MoA) in 255 samples of fish out of 256 analysed; in the case of copper, it was 25. Cadmium exceeded the levels in all the 63 samples collected during the pre-monsoon season, whereas it was within limits during the rest of the study. Mercury was found to exceed the limits only in eight cases.

Table 20. Heavy metals (ppm) in water samples

Sampling station	Cu			Cr			Pb			Cd			Ni			Hg		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Gangapur dam	0.013	ND	0.015	0.007	0.002	0.003	0.021	0.224	0.238	0.007	0.002	0.003	0.017	0.008	0.019	ND	0. 006	0.008
Tapovan	0.011	0.003	0.008	0.007	0.004	0.004	0.022	0.238	0.244	0.007	0.004	0.004	0.018	0.026	0.029	ND	0. 005	0. 006
Nandur-Madhyameshwar	0.014	ND	0.002	0.007	0.002	0.003	0.014	0.229	0.244	0.007	0.002	0.003	0.023	0.016	0.017	ND	0. 006	0. 005
Kopergaon	0.020	ND	0.001	0.007	0.003	0.003	0.019	0.235	0.246	0.007	0.003	0.003	0.021	0.022	0.026	0. 003	0. 004	0. 006
Pravara Sangam	0.011	0.002	0.013	0.008	0.003	0.004	0.007	0.233	0.244	0.008	0.003	0.004	0.022	0.019	0.029	0. 005	0. 007	ND
Jayakwadi dam	0.010	0.001	0.002	0.008	0.003	0.002	0.007	0.236	0.237	0.008	0.003	0.002	0.021	0.019	0.023	0. 002	0. 003	0. 001
Paithan upstream	0.010	0.001	0.003	0.009	0.003	0.003	0.011	0.233	0.241	0.009	0.003	0.003	0.022	0.017	0.026	ND	0. 001	0.002
Pathegaon	0.018	0.002	0.005	0.008	0.004	0.003	0.012	0.244	0.242	0.008	0.004	0.003	0.023	0.023	0.026	0. 002	0. 002	0. 002
Dhalegaon	0.015	0.003	0.006	0.007	0.002	0.003	0.005	0.237	0.241	0.007	0.002	0.003	0.022	0.020	0.031	0. 002	0. 006	0. 005
Raher	0.017	ND	0.017	0.007	0.004	0.004	0.013	0.237	0.258	0.007	0.004	0.004	0.022	0.022	0.034	ND	0. 004	0. 001

ND – Not detected

Table 21. Heavy metals (ppm) in sediment

Sampling station	Cu			Cr			Pb			Cd			Ni			Hg		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Gangapur dam	87.49	67.80	500.30	1668	92.32	124.2	397.20	16.34	27.78	7.790	2.790	3.098	1106.0	122.60	140.00	1.127	0.598	0.245
Tapovan	147.30	135.30	185.90	2626	273.40	227.2	618.60	42.51	61.32	6.850	3.580	2.782	756.1	124.00	121.70	3.991	0.567	1.240
Nandur-Madhyameshwar	91.10	98.40	132.30	2807	238.90	110.1	334.10	17.83	26.25	6.273	2.937	2.326	1106.0	132.70	115.40	2.029	0.431	0.159
Kopergaon	92.89	63.90	132.60	3189	443.20	372.4	304.20	29.74	92.81	6.621	2.324	2.524	948.5	111.00	123.50	7.410	0.469	0.244
Pravara Sangam	106.90	98.88	83.38	3065	240.60	529.6	271.40	35.26	25.27	6.839	3.056	1.576	441.9	124.70	167.60	1.465	0.195	0.381
Jayakwadi dam	137.30	138.50	2416.00	1259	112.40	255.6	194.20	27.67	29.58	7.223	3.219	2.035	595.9	114.70	96.81	2.495	0.304	0.226
Paithan upstream	125.70	383.50	83.67	5119	414.10	233.7	165.30	29.76	26.08	5.854	2.273	1.335	814.3	116.20	116.90	1.200	0.481	0.286
Pathegaon	58.56	94.77	89.38	1581	418.30	159.7	86.19	34.20	21.75	6.352	2.590	1.551	664.3	118.80	109.10	4.619	0.234	0.304
Dhalegaon	115.50	167.10	778.10	4883	170.70	168.1	112.70	29.99	25.34	7.091	3.533	2.097	857.2	99.17	82.17	1.222	0.993	0.188
Raher	71.40	50.23	66.20	2014	151.90	183.4	96.30	24.65	24.32	6.482	2.947	1.998	577.6	64.54	72.33	1.099	0.306	0.400

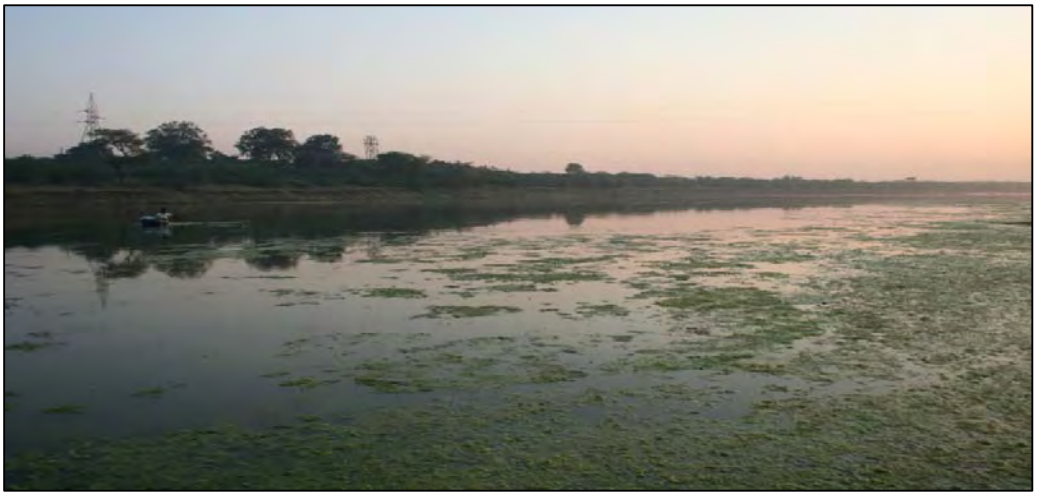
Table 22. Heavy metals (ppm) in fish samples: Pre-monsoon

Sampling station	Fish Species	Cu	Cr	Pb	Cd	Ni	Hg
Gangapur dam	*Chanda nama*	7.732	13.560	18.760	3.510	3.123	0.077
	Chela fasciata	5.612	8.460	20.210	3.079	2.375	0.746
	Glossogobius giuris	5.337	17.850	19.500	3.542	2.155	0.109
	Labeo bata	8.847	13.950	21.080	3.045	1.483	0.069
	Mystus cavasius	4.241	8.282	18.380	2.479	0.587	0.297
	Parapsilorhynchus prateri	7.122	2.945	24.020	2.988	5.109	0.187
	Puntius ticto	9.193	11.270	3.923	3.681	6.828	0.247
	Salmostoma novacula	8.065	8.959	20.250	3.267	2.831	0.206
Nandur-Madhymeshwar	*Tor khudree*	6.151	15.920	17.190	3.311	0.919	0.076
	Channa marulius	6.647	16.000	20.160	3.764	3.216	0.218
	Channa punctatus	4.772	5.682	22.070	3.120	2.870	0.214
	Garra mullya	6.416	17.030	22.770	3.280	3.226	0.049
	Glossogobius giuris	6.587	11.770	21.120	3.357	2.641	0.111
	Heteropneustes fossillis	3.530	1.348	22.410	3.012	1.379	0.212
	Ompok malabaricus	3.443	ND	23.600	2.379	5.753	0.257
	Puntius sophore	5.090	6.101	21.350	3.011	1.255	0.185
	Chanda nama	14.290	11.430	17.250	3.386	5.425	0.235
Kopergaon	*Glossogobius giuris*	14.070	12.700	22.320	3.770	5.799	0.179
	Oreochromis mossambicus	12.770	11.590	22.360	3.884	7.574	0.271
	Prawn	38.690	12.560	19.110	3.119	6.665	0.100
	Puntius sophore	19.990	13.730	20.200	3.557	8.789	0.228
	Puntius ticto	13.110	10.410	18.850	3.467	5.293	0.323
	Salmostoma bacaila	15.400	11.000	16.960	3.461	6.658	0.095
	Chanda nama	8.392	9.607	16.220	3.189	6.718	0.144
Pravara Sangam	*Chela fasciata*	7.205	8.300	12.800	3.163	8.128	0.102
	Glossogobius giuris	10.360	10.840	19.180	3.519	6.217	0.066
	Heteropneustes fossillis	7.902	9.203	16.120	2.782	6.554	0.016
	Hypselobarbus kolus	10.100	9.548	13.690	3.308	6.292	0.134
	Macrognathus pancalus	10.63	8.759	16.290	3.563	7.309	0.321
	Mystus cavasius	10.010	10.570	15.670	3.059	6.139	0.174
	Notopterus notopterus	8.553	10.590	19.500	3.913	5.711	0.076
	Ompok malabaricus	7.414	7.508	16.560	3.195	5.953	0.233
	Puntius phutunio	8.193	10.660	17.370	3.421	7.401	0.251
Jayakwadi dam	*Puntius sophore*	18.290	12.660	17.940	3.303	7.296	0.040
	Puntius ticto	8.514	8.687	16.070	2.551	6.131	0.385
	Salmostoma novacula	8.768	7.977	12.400	3.069	5.546	0.206
	Channa marulius	6.126	16.990	26.230	3.586	7.536	0.212
	Mystus cavasius	6.925	9.855	10.830	2.879	5.936	0.324
	Ompok malabaricus	2.553	13.530	15.510	3.461	4.843	0.230
Paithan Upstream	*Chanda nama*	4.622	5.760	10.160	3.135	5.107	0.255
	Chela fasciata	4.489	3.601	8.005	3.209	1.393	0.293
	Glossogobius giuris	6.195	7.531	13.270	3.307	5.267	0.155
	Puntius shalynius	5.287	5.172	12.750	2.831	5.207	0.028
	Puntius sophore	10.250	6.721	36.810	3.183	6.799	0.087
	Puntius ticto	3.510	2.428	14.900	2.996	2.829	0.126
Pathegaon	*Strongylura leiura*	6.496	6.288	7.872	2.629	4.549	0.286
	Chanda nama	7.130	9.162	15.890	3.843	8.134	0.178
	Glossogobius giuris	10.510	8.641	14.600	3.547	7.265	0.215
	Nemacheilus botia	5.977	8.173	16.030	3.902	6.677	0.236
	Puntius terio	6.167	7.273	14.600	3.601	7.070	0.265
	Puntius ticto	8.350	7.243	10.030	3.419	6.979	0.040

ND – Not detected

Table 22 (contd). Heavy metals (ppm) in fish samples: Pre-monsoon

Sampling station	Fish Species	Cu	Cr	Pb	Cd	Ni	Hg
Dhalegaon	*Channa punctatus*	8.695	17.090	23.530	3.723	7.104	0.330
	Macrognathus pancalus	18.99	15.890	26.510	3.611	5.449	0.042
	Mastacembelus armatus	7.143	17.510	27.100	3.448	7.491	0.058
	Mystus cavasius	6.072	15.460	19.340	3.307	6.211	0.238
	Notopterus notopterus	6.284	17.460	28.520	3.424	6.297	0.120
	Chanda nama	7.672	9.359	18.120	2.873	6.096	0.464
Raher	*Labeo angra*	7.634	14.510	23.210	3.825	5.501	0.022
	Labeo dyocheilus	5.865	14.960	24.820	3.647	7.833	0.198
	Mystus bleekeri	4.496	13.140	24.390	3.634	6.793	0.243
	Mystus cavasius	4.345	13.910	21.100	2.998	6.329	0.147
	Puntius phutunio	10.220	9.891	17.660	3.421	9.549	0.342
	Puntius ticto	8.895	12.120	15.250	3.146	8.397	0.242



Kopergaon during first sampling

Kopergaon during second sampling

Table 23. Heavy metals (ppm) in fish samples: Post-monsoon

Sampling station	Fish Species	Cu	Cr	Pb	Cd	Ni	Hg
Gangapur dam	*Chanda nama*	9.806	8.924	2.983	0.537	3.002	0.254
	Glossogobius giuris	4.701	7.160	4.966	0.730	2.689	0.138
	Mystus cavasius	7.765	5.055	2.990	0.233	1.459	0.145
	Oreochromis mossambicus	4.253	4.995	4.029	0.284	1.962	0.113
	Oreochromis niloticus	2.508	6.434	5.554	0.601	3.392	0.124
	Osteochilus godavariensis	2.802	6.456	5.235	0.490	2.139	0.085
	Puntius phutunio	2.604	8.228	2.597	0.596	4.562	0.156
	Puntius sophore	3.355	3.737	4.330	0.550	2.206	0.135
	Salmostoma novacula	6.686	5.452	3.918	0.161	2.677	0.177
	Salmostoma sardinella	3.872	7.836	4.378	0.376	2.231	0.226
Nandur-Madhyameshwar	*Amblypharyngodon mola*	8.470	5.918	2.370	0.838	1.615	0.138
	Channa punctatus	1.162	5.504	2.287	0.737	1.819	0.287
	Chitala chitala	7.753	7.211	2.558	0.594	3.184	0.121
	Glossogobius giuris	9.789	5.690	4.709	0.665	2.881	0.121
	Heteropneustes fossilis	4.349	4.318	3.051	0.814	1.371	0.128
	Macrognathus aral	9.500	6.400	5.115	0.816	2.094	0.095
	Macrognathus pancalus	10.110	5.582	4.422	0.545	1.943	0.153
	Mystus cavasius	2.106	3.685	1.774	0.820	1.926	0.141
	Notopterus notopterus	6.238	5.077	6.007	1.042	3.678	0.146
	Ompok malabaricus	4.140	4.831	1.942	0.130	0.615	0.265
	Parluciosoma labiosa	4.227	7.818	4.611	1.000	2.597	0.711
	Puntius phutunio	5.230	7.526	2.398	1.170	4.005	0.279
	Puntius shalynius	17.250	6.256	1.663	1.333	3.743	0.227
	Puntius sophore	7.405	3.122	6.410	1.189	1.835	0.210
	Puntius ticto	28.470	8.529	2.731	1.319	3.805	0.162
Kopergaon	*Salmostoma bacaila*	6.318	6.314	3.602	0.915	2.186	0.303
	Salmostoma novacula	6.480	8.372	6.496	1.077	2.790	0.289
	Chanda nama	16.340	9.175	7.095	0.860	1.055	0.254
	Channa punctatus	1.851	7.285	3.605	0.594	2.401	0.258
	Glossogobius giuris	6.517	7.460	4.105	0.570	2.620	0.212
	Mystus cavasius	2.848	6.536	4.381	0.365	1.332	0.245
	Oreochromis mossambicus	8.342	7.949	5.787	0.663	1.057	0.227
	Oreochromis niloticus	4.433	7.596	7.000	0.729	2.592	0.193
	Puntius sophore	22.100	6.670	4.837	0.941	1.980	0.194
Pravara Sangam	*Amblypharyngodon mola*	7.771	2.995	5.886	0.760	3.858	0.203
	Chanda nama	32.640	9.751	9.047	0.928	2.914	0.260
	Channa punctatus	3.842	7.820	6.397	0.812	2.916	0.133
	Macrognathus pancalus	4.107	6.571	3.231	0.479	3.692	0.149
	Mystus cavasius	4.918	8.206	4.239	0.637	2.550	0.130
	Osteobrama cotio peninsularis	4.589	8.295	5.562	0.798	0.384	0.197
	Parambassis ranga	3.475	9.161	1.009	1.059	3.319	0.231
	Puntius chola	3.955	11.020	7.366	0.787	4.044	0.224
	Puntius phutunio	21.720	4.472	1.108	0.984	5.099	0.136
	Puntius shalynius	4.598	0.762	6.433	1.028	2.640	0.164
	Puntius sophore	13.190	1.972	6.183	0.453	2.899	0.140
	Puntius terio	24.540	5.886	1.008	1.006	3.293	0.173
	Puntius ticto	5.423	5.307	9.222	1.105	3.754	0.247
	Salmostoma bacaila	26.510	3.137	4.943	0.688	1.216	0.187
	Salmostoma novacula	4.912	2.426	4.156	0.547	2.716	0.234
	Salmostoma sardinella	5.292	2.047	4.940	0.789	1.957	0.230
	Stongylura strongylura	2.381	7.301	3.273	0.851	2.400	0.287

Table 23 (contd). Heavy metals (ppm) in fish samples: Post-monsoon

Sampling station	Fish Species	Cu	Cr	Pb	Cd	Ni	Hg
Jayakwadi dam	*Amblypharyngodon mola*	4.751	2.954	3.757	0.431	5.732	0.168
	Chanda nama	4.810	3.703	5.098	0.610	7.002	0.215
	Macrognathus pancalus	7.545	3.093	4.311	0.739	5.917	0.225
	Mastacembelus armatus	1.715	2.686	10.44	1.011	3.693	0.129
	Mystus cavasius	4.409	4.002	5.892	0.751	3.585	0.193
	Nemacheilus botia	24.95	3.826	4.732	0.778	6.386	0.116
	Ompok malabaricus	5.267	3.704	7.644	0.697	3.494	0.206
	Osteobrama cotio peninsularis	5.622	3.123	4.935	0.893	6.058	0.120
	Pseudambassis ranga	5.682	4.212	3.953	0.999	5.573	0.117
	Puntius phutunio	3.535	5.804	2.420	0.498	4.526	0.083
	Puntius singhala	4.804	5.365	5.371	0.728	4.296	0.087
	Puntius ticto	3.603	3.615	2.168	0.440	3.978	0.102
Paithan upstream	*Salmostoma novacula*	3.388	2.771	1.056	0.443	4.808	0.182
	Salmostoma sardinella	24.590	3.764	1.504	0.550	5.015	0.160
	Stongylura strongylura	21.150	3.895	4.080	0.461	4.875	0.222
	Chanda nama	19.360	3.720	2.915	0.734	5.232	0.406
	Nemacheilus botia	5.025	4.950	2.364	0.562	5.388	0.163
	Pseudambassis ranga	8.305	6.952	5.657	0.800	6.708	0.243
	Puntius phutunio	9.599	4.980	5.199	0.670	6.096	0.120
	Puntius shalynius	19.890	4.885	5.055	0.762	7.490	0.116
	Puntius ticto	8.902	5.535	6.818	0.924	8.214	0.125
	Salmostoma novacula	6.898	4.424	1.914	0.788	4.759	0.276
	Stongylura strongylura	29.750	4.995	1.689	0.441	4.252	0.157
Pathegaon	*Channa punctatus*	13.730	5.664	4.301	0.759	6.876	0.140
	Macrognathus pancalus	11.340	4.560	2.611	0.372	5.562	0.096
	Puntius phutunio	33.450	4.547	3.268	0.571	5.242	0.115
	Puntius sophore	5.662	5.517	5.276	0.706	7.011	0.088
	Puntius ticto	4.152	7.331	3.797	0.512	5.996	0.097
Dhalegaon	*Etroplus suratensis*	3.140	6.020	4.271	0.741	6.068	0.438
	Notopterus notopterus	32.420	4.619	4.363	0.265	3.750	0.242
	Mastacembelus armatus	5.549	6.269	5.978	0.536	5.077	0.078
	Mystus bleekeri	9.151	3.801	2.286	0.327	5.658	0.080
	Glossogobius giuris	7.525	6.816	3.132	0.736	6.577	0.100
	Wallago attu	5.156	5.416	1.499	0.492	5.326	0.125
	Nemacheilus botia	6.993	15.160	5.818	0.434	8.599	0.122
	Mystus cavasius	4.621	6.192	3.032	0.278	9.176	0.061
	Puntius ticto	5.760	9.665	5.883	0.827	5.895	0.066
	Salmostoma bacaila	5.765	7.308	2.465	0.171	5.373	0.098
Raher	*Amblypharyngodon mola*	7.485	6.874	1.070	0.627	3.788	0.043
	Chanda nama	5.930	8.214	4.448	0.627	6.400	0.287
	Glossogobius giuris	6.411	6.156	3.016	0.615	4.938	0.062
	Labeo dyocheilus	12.960	6.561	0.816	0.489	4.017	0.127
	Macrognathus pancalus	5.425	7.615	1.256	0.352	4.427	0.102
	Oreochromis mossambicus	21.550	7.535	5.618	0.307	5.289	0.104
	Proeutropiichthys taakree taakree	4.870	6.070	1.660	0.218	3.940	0.095
	Puntius phutunio	5.483	7.627	4.314	0.650	6.284	0.103
	Puntius sophore	5.131	5.909	3.250	0.787	5.784	0.043
	Salmostoma bacaila	33.670	8.521	1.762	0.389	5.359	0.179
	Salmostoma novacula	18.530	6.138	2.849	0.358	5.780	0.183
	Salmostoma phulo	21.720	6.228	2.863	0.148	4.094	0.146

Table 24. Heavy metals (ppm) in fish samples: Winter

Sampling station	Fish Species	Cu	Cr	Pb	Cd	Ni	Hg
Gangapur dam	*Chanda nama*	21.080	2.589	3.278	0.665	1.982	0.210
	Glossogobius giuris	4.951	2.047	6.414	0.829	1.810	0.120
	Macrognathus pancalus	4.019	3.464	3.722	0.949	2.169	0.570
	Mystus bleekeri	19.230	3.177	1.960	0.518	2.851	0.207
	Pseudambassis ranga	3.432	3.670	9.098	0.645	5.712	0.113
	Puntius phutunio	5.722	4.283	7.202	1.031	4.260	0.195
	Puntius sophore	1.501	4.103	3.256	0.443	1.733	0.100
	Salmostoma bacaila	3.398	3.883	3.761	0.808	1.819	0.232
	Salmostoma novacula	8.131	4.591	8.496	0.749	4.720	0.170
	Salmostoma sardinella	20.160	1.460	6.410	0.702	2.754	0.213
	Securicula gora	6.730	3.336	6.066	0.989	3.096	0.294
Nandur Madhyameshwar	*Amblypharyngodon mola*	12.040	5.254	2.296	0.469	4.425	0.465
	Chanda nama	10.580	5.744	4.667	0.573	2.842	0.661
	Glossogobius giuris	28.030	5.077	5.625	0.410	1.772	0.306
	Prawn	7.112	6.269	5.749	1.048	4.342	0.216
	Pseudambassis ranga	10.780	7.451	4.016	0.426	2.128	0.436
	Puntius sophore	11.320	4.414	9.641	0.417	2.873	0.315
	Puntius ticto	22.040	3.406	6.984	0.739	1.907	0.321
Kopergaon	*Channa punctatus*	18.340	3.012	5.613	0.765	3.152	0.213
	Glossogobius giuris	2.349	5.159	5.087	0.885	3.357	0.325
	Mystus cavasius	6.969	3.034	2.774	0.550	2.110	0.643
	Ompok malabaricus	7.954	4.502	1.033	0.476	2.512	0.261
	Oreochromis mossambicus	2.150	5.482	4.652	0.642	3.804	0.155
	Oreochromis niloticus	29.780	5.582	3.607	0.716	2.898	0.240
	Puntius sophore	14.640	5.683	3.059	0.765	2.541	0.445
Pravara Sangam	*Amblypharyngodon mola*	8.127	10.930	8.256	1.043	6.077	0.367
	Chanda nama	7.458	6.145	6.819	0.548	5.608	0.174
	Glossogobius giuris	7.389	6.906	6.216	0.126	2.758	0.192
	Macrognathus pancalus	2.090	5.931	3.532	1.032	3.862	0.178
	Parluciosoma labiosa	10.440	5.270	10.51	0.706	7.204	0.357
	Pseudambassis ranga	19.460	6.005	10.480	0.197	4.496	0.395
	Puntius guganio	13.810	7.213	9.569	0.952	9.221	0.402
	Puntius phutunio	4.571	6.262	10.910	1.157	8.379	0.371
	Puntius shalynius	9.956	6.299	7.724	0.887	7.991	0.300
	Puntius singhala	7.032	4.955	9.172	0.764	7.162	0.488
	Puntius sophore	11.300	6.519	8.184	0.449	4.126	0.113
	Puntius terio	4.971	7.928	7.750	0.527	6.063	0.290
	Puntius ticto	5.364	13.790	7.770	0.996	8.554	0.624
Jayakwadi dam	*Puntius vittatus*	5.331	6.437	7.113	1.025	7.698	0.295
	Stongylura strongylura	3.530	6.039	4.535	0.815	2.937	0.114
	Amblypharyngodon mola	6.001	5.322	2.121	0.240	2.183	0.126
	Chanda nama	6.921	3.764	3.628	0.597	7.133	0.246
	Chela fasciata	11.790	5.690	3.563	0.693	6.530	0.197
	Glossogobius giuris	22.420	3.188	6.036	0.665	8.062	0.130
	Macrognathus aral	23.680	3.815	4.263	0.634	9.337	0.101
	Macrognathus pancalus	7.397	3.545	4.995	0.493	7.369	0.849
	Mastacembelus armatus	16.390	7.717	12.120	1.325	9.589	0.256
	Prawn	26.730	6.189	8.694	1.163	7.945	0.209
	Pseudambassis ranga	7.057	4.527	6.974	0.850	8.714	0.409
	Puntius shalynius	6.443	6.715	2.633	0.444	3.368	0.131
	Puntius terio	6.301	3.782	6.714	0.757	3.594	0.103
	Puntius ticto	5.567	4.138	3.118	0.778	6.693	0.106
	Salmostoma bacaila	6.301	5.264	3.369	0.532	7.400	0.256
	Salmostoma novacula	20.660	4.431	2.795	0.302	6.806	0.134
	Stongylura strongylura	7.364	5.931	2.560	0.486	6.755	0.196
Paithan Upstream	*Nemacheilus botia*	8.361	6.601	10.230	0.653	5.477	0.231
	Puntius shalynius	6.915	7.506	9.578	0.755	4.213	0.107
	Puntius terio	8.647	8.735	10.100	1.386	4.126	0.170
	Puntius ticto	6.457	7.224	7.522	0.177	4.172	0.980
	Stongylura strongylura	6.114	4.041	2.369	0.176	3.016	0.222

Table 24 (contd). Heavy metals (ppm) in fish samples: Winter

Sampling station	Fish Species	Cu	Cr	Pb	Cd	Ni	Hg
Pathegaon	*Barilius bendelisis*	6.340	5.999	3.761	0.480	4.341	0.152
	Puntius phutunio	9.741	7.408	7.320	1.120	3.539	0.194
	Puntius shalynius	10.09	9.207	9.132	0.711	4.095	0.206
	Puntius ticto	8.591	7.589	8.833	0.816	5.711	0.254
Dhalegaon	*Chanda nama*	8.099	10.820	1.503	1.064	4.955	0.179
	Channa punctatus	12.130	8.556	6.815	0.567	6.942	0.183
	Glossogobius giuris	14.940	7.660	7.796	0.679	4.922	0.207
	Mastacembelus armatus	3.934	11.170	1.219	0.804	5.385	0.162
	Mystus bleekeri	8.981	10.140	5.203	0.471	5.458	0.240
	Mystus cavasius	6.553	7.964	8.562	0.773	7.374	0.200
	Nemacheilus botia	9.999	8.107	9.480	0.673	7.428	0.269
	Notopterus notopterus	8.664	12.320	1.282	0.968	7.489	0.186
	Osteobrama cotio peninsularis	7.801	6.779	6.022	0.605	3.513	0.204
	Prawn	7.662	10.120	7.624	0.876	6.991	0.147
	Pseudambassis ranga	10.050	11.110	1.298	1.133	7.516	0.355
	Puntius chola	9.857	9.912	1.477	0.775	5.437	0.222
	Puntius shalynius	9.241	9.303	1.626	0.602	4.667	0.235
	Puntius singhala	9.462	9.336	1.203	1.174	7.420	0.274
	Puntius sophore	11.930	7.526	4.865	0.580	3.748	0.296
	Puntius ticto	10.200	8.572	1.137	0.763	3.692	0.440
	Stongylura strongylura	8.288	8.635	5.455	0.653	5.475	0.343
Raher	*Etroplus maculatus*	8.839	11.400	8.254	0.891	7.108	0.328
	Etroplus suratensis	7.932	9.330	4.269	1.112	5.562	0.233
	Labeo calbasu	8.901	10.150	5.654	0.643	5.135	0.334
	Labeo dyocheilus	9.740	5.083	4.164	0.723	2.371	0.103
	Labeo porcellus	10.300	10.020	5.878	0.804	4.789	0.141
	Mastacembelus armatus	9.617	9.099	6.624	0.761	6.262	0.223
	Mystus bleekeri	9.672	9.691	3.395	0.560	4.809	0.220
	Mystus cavasius	8.840	9.016	1.716	0.373	5.170	0.249
	Notopterus chitala	11.790	9.753	1.227	0.942	7.693	0.202
	Notopterus notopterus	11.080	10.610	1.046	0.847	8.820	0.218
	Schismatorhynchos nukta	9.672	9.498	6.588	0.802	2.997	0.611

Kopergaon during third sampling

Table 25. Pearson correlation matrix of various parameters (n = 30)

	Water temp.	pH	Transparency	DO	BOD	WCu	WCr	WPb	WCd	WNi	WHg
pH	0.096	1									
Transparenc.	-0.032	-0.076	1								
DO	-0.088	0	0.203	1							
BOD	-0.179	0.017	-0.525**	-0.600**	1						
WCu	0.296	0.261	-0.372*	0.357	0.055	1					
WCr	-0.228	0.101	-0.043	0.018	-0.061	0.08	1				
WPb	-0.547**	-0.26	0.358	-0.306	-0.074	-0.686**	-0.134	1			
WCd	0.496**	0.243	-0.413*	0.3	0.059	0.720**	0.172	-0.941**	1		
WNi	-0.438*	-0.327	-0.306	0.084	0.062	0.262	0.136	0.179	0.035	1	
WHg	-0.277	0.156	0.227	-0.238	0.127	-0.415*	0.099	0.485**	-0.525**	-0.183	1
SediCu	-0.335	-0.276	0.271	0.222	-0.137	-0.159	-0.003	0.197	-0.285	0.085	-0.056
SediCr	0.478**	0.056	-0.407*	0.211	0.096	.0590**	0.151	-0.859**	0.841**	-0.073	-0.450*
SediPb	0.24	0.407*	-0.384*	0.164	0.237	0.472**	0.114	-0.740**	0.680**	-0.185	-0.418*
SediCd	0.605**	0.361	-0.336	0.2	0.107	0.635**	0.126	-0.961**	0.891**	-0.259	-0.35
SediNi	0.527**	0.255	-0.410*	0.234	0.185	0.687**	-0.056	-0.925**	0.856**	-0.169	-0.537**
SediHg	0.312	0.263	-0.462*	-0.019	0.410*	0.610**	0.024	-0.665**	0.618**	-0.097	-0.24
FishCu	-0.013	0.016	0.108	-0.303	0.02	-0.507**	-0.079	0.317	-0.456*	-0.549**	0.289
FishCr	0.346	-0.225	-0.089	0.16	0.015	0.476**	0.148	-0.532**	0.442*	0.03	-0.319
FishPb	0.440*	-0.012	-0.199	0.305	0.037	0.681**	0.122	-0.806**	0.735**	0.002	-0.435*
FishCd	0.492**	0.093	-0.266	0.268	0.088	0.691**	0.164	-0.883**	0.835**	-0.078	-0.408*
FishNi	0.218	-0.357	0.094	0.078	-0.223	0.307	0.312	-0.234	0.221	0.153	-0.337
FishHg	-0.241	-0.287	0.365*	0.149	0.045	0.013	-0.079	0.133	-0.168	0.079	-0.065

WCu = Average copper content of water; SediCu = Average copper content of Sediment; FishCu = Average copper content of fish

*.Correlation significant at the 0.05 level (2-tailed)

**Correlation significant at the 0.01 level (2-tailed)

Table 25 (contd). Pearson correlation matrix of various parameters (n = 30)

	SediCu	SediCr	SediPb	SediCd	SediNi	SediHg	FishCu	FishCr	FishPb	FishCd	FishNi	FishHg
SediCu	1											
SediCr	-0.169	1										
SediPb	-0.147	0.604**	1									
SediCd	-0.233	0.786**	0.759**	1								
SediNi	-0.199	0.830**	0.786**	0.899**	1							
SediHg	-0.165	0.514**	0.618**	0.643**	0.656**	1						
FishCu	-0.092	-0.297	-0.305	-0.292	-0.319	-0.214	1					
FishCr	-0.139	0.446*	0.11	0.473**	0.490**	0.235	-0.106	1				
FishPb	-0.14	0.733**	0.373*	0.727**	0.790**	0.417*	-0.314	0.852**	1			
FishCd	-0.171	0.755**	0.423*	0.822**	0.820**	0.541**	-0.269	0.755**	0.944**	1		
FishNi	0.209	0.204	-0.2	0.136	0.095	0.149	-0.166	0.642**	0.496**	0.489**	1	
FishHg	0.084	-0.165	-0.287	-0.252	-0.114	-0.212	0.034	0.406*	0.248	0.154	0.368*	1

WCu = Average copper content of water; SediCu = Average copper content of Sediment; FishCu = Average copper content of fish
*Correlation significant at the 0.05 level (2-tailed)
**Correlation significant at the 0.01 level (2-tailed)

Table 26. Principal component analysis of different water quality parameters and metals content of sediments and fish

Component	Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %
1	8.856	38.504	38.504
2	2.122	9.227	47.730
3	2.112	9.183	56.913
4	2.103	9.142	66.056
5	1.752	7.617	73.673
6	1.325	5.759	79.432
7	1.321	5.743	85.174

Table 27. Principal Component analysis - Rotated component matrix (Varimax with Kaiser normalization)

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
Water temp.	0.550	0.184	0.293	-0.389	-0.266	0.431	-0.255
pH	0.261	0.069	**-0.759**	-0.154	-0.097	0.221	0.186
Transparency	-0.367	**0.630**	0.000	-0.348	0.300	-0.149	0.002
DO	0.289	**0.717**	-0.157	0.301	0.203	-0.252	-0.043
BOD	0.109	**-0.942**	-0.147	0.011	0.152	-0.045	-0.049
WCu	**0.734**	0.041	-0.043	0.436	0.164	0.149	0.046
WCr	0.086	0.020	0.042	0.086	-0.065	-0.048	**0.945**
WPb	**-0.984**	-0.033	0.004	0.010	0.019	-0.045	-0.052
WCd	0**.919**	0.041	0.005	0.208	-0.095	0.151	0.067
WNi	-0.179	-0.121	0.216	**0.919**	0.028	0.012	0.085
WHg	-0.527	-0.115	-0.374	-0.275	0.107	0.184	0.320
SediCu	-0.154	0.154	0.189	0.015	0.014	**-0.882**	0.031
SediCr	**0.858**	-0.037	0.140	0.056	-0.123	0.036	0.042
SediPb	**0.765**	-0.141	-0.389	0.040	-0.212	-0.183	-0.033
SediCd	**0.949**	0.007	-0.092	-0.097	-0.098	0.108	0.075
SediNi	**0.962**	-0.072	-0.058	0.016	0.010	0.023	-0.162
SediHg	**0.706**	-0.383	-0.128	0.020	-0.066	-0.041	0.029
FishCu	-0.336	-0.152	0.013	**-0.729**	0.030	0.080	0.000
FishCr	0.542	0.019	0.501	-0.022	0.514	0.200	0.141
FishPb	**0.817**	0.070	0.289	0.070	0.385	0.135	0.075
FishCd	**0.877**	0.020	0.223	0.001	0.288	0.140	0.135
FishNi	0.244	0.153	**0.747**	0.043	0.276	-0.050	0.343
FishHg	-0.118	0.056	0.194	0.019	**0.905**	-0.074	-0.086

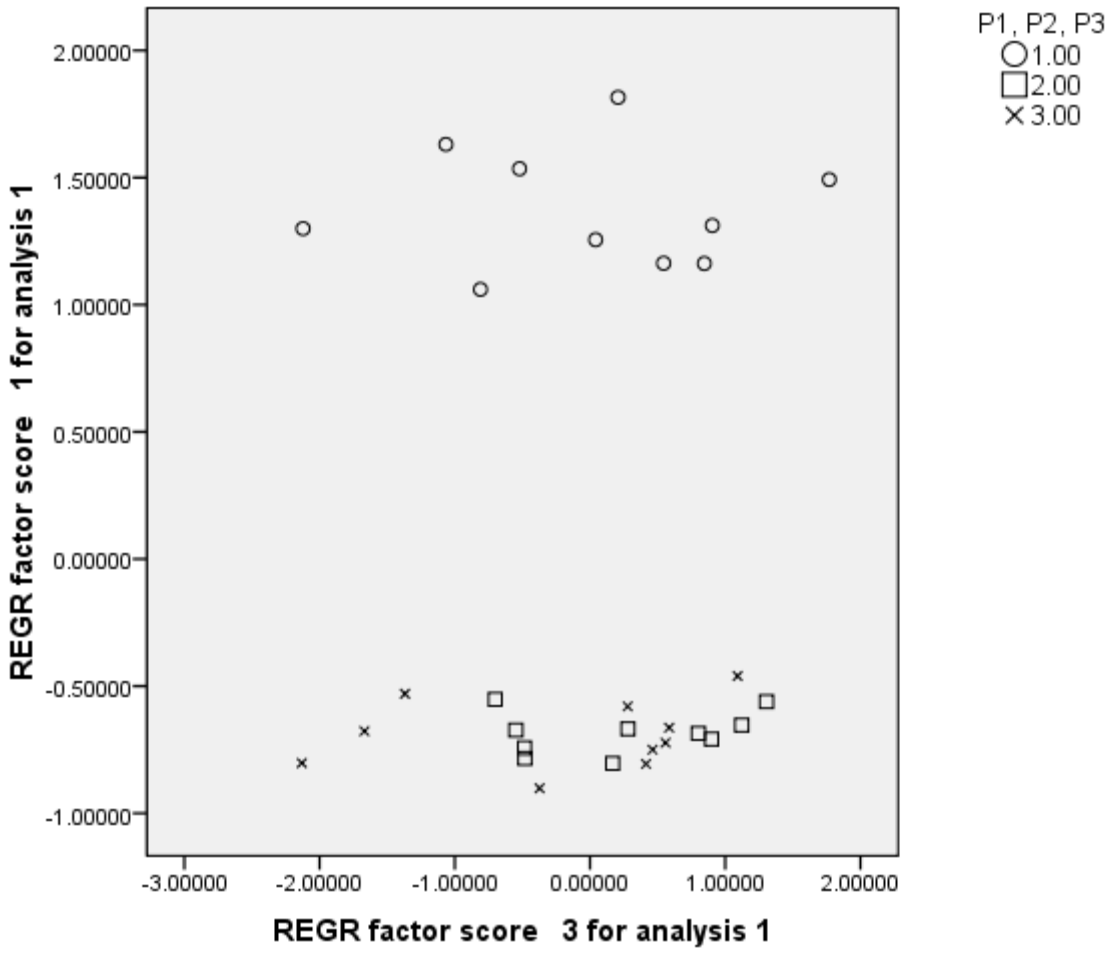


Fig. 4. Score value plots for principal components (physicochemical parameters and metals)

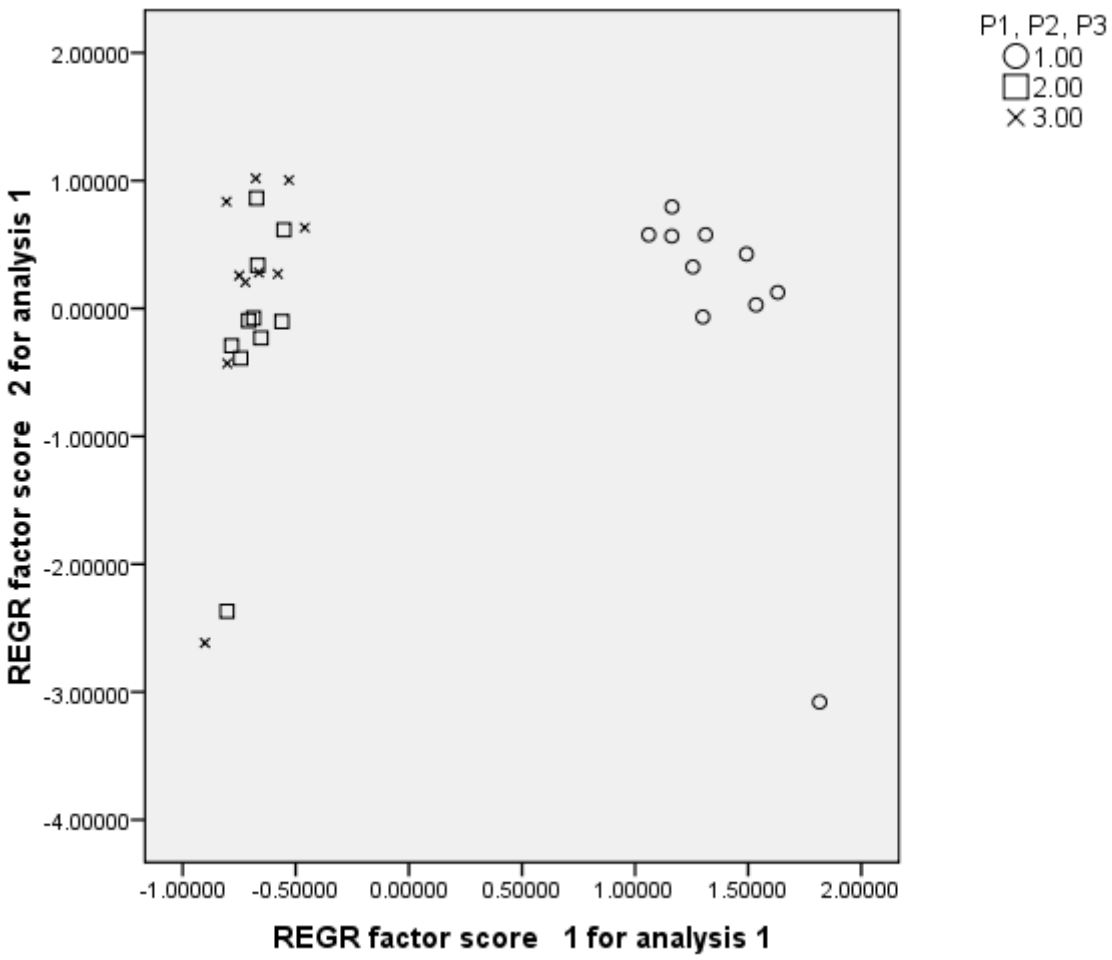


Fig. 4 (contd). Score value plots of principal components (physicochemical parameters and metals)

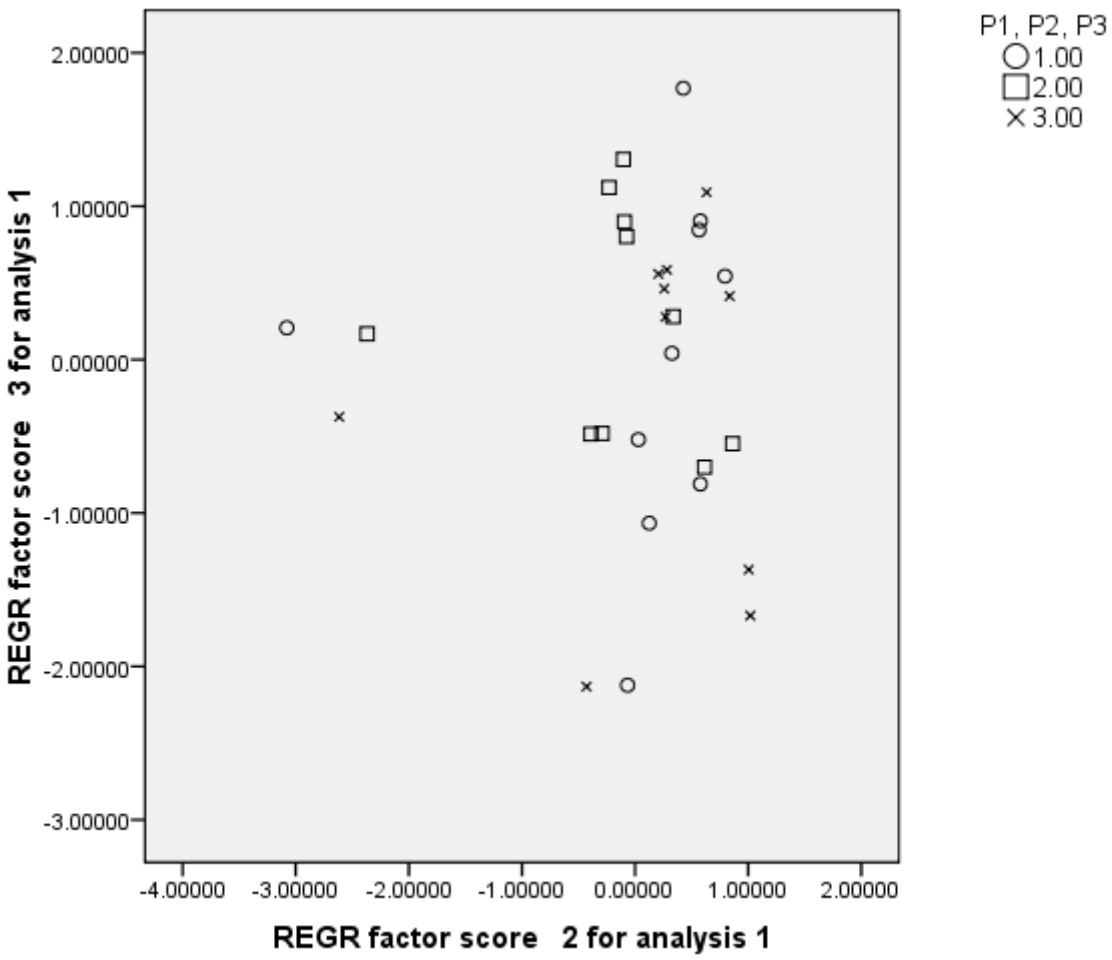


Fig. 4 (contd). Score value plots of principal components (physicochemical parameters and metals)

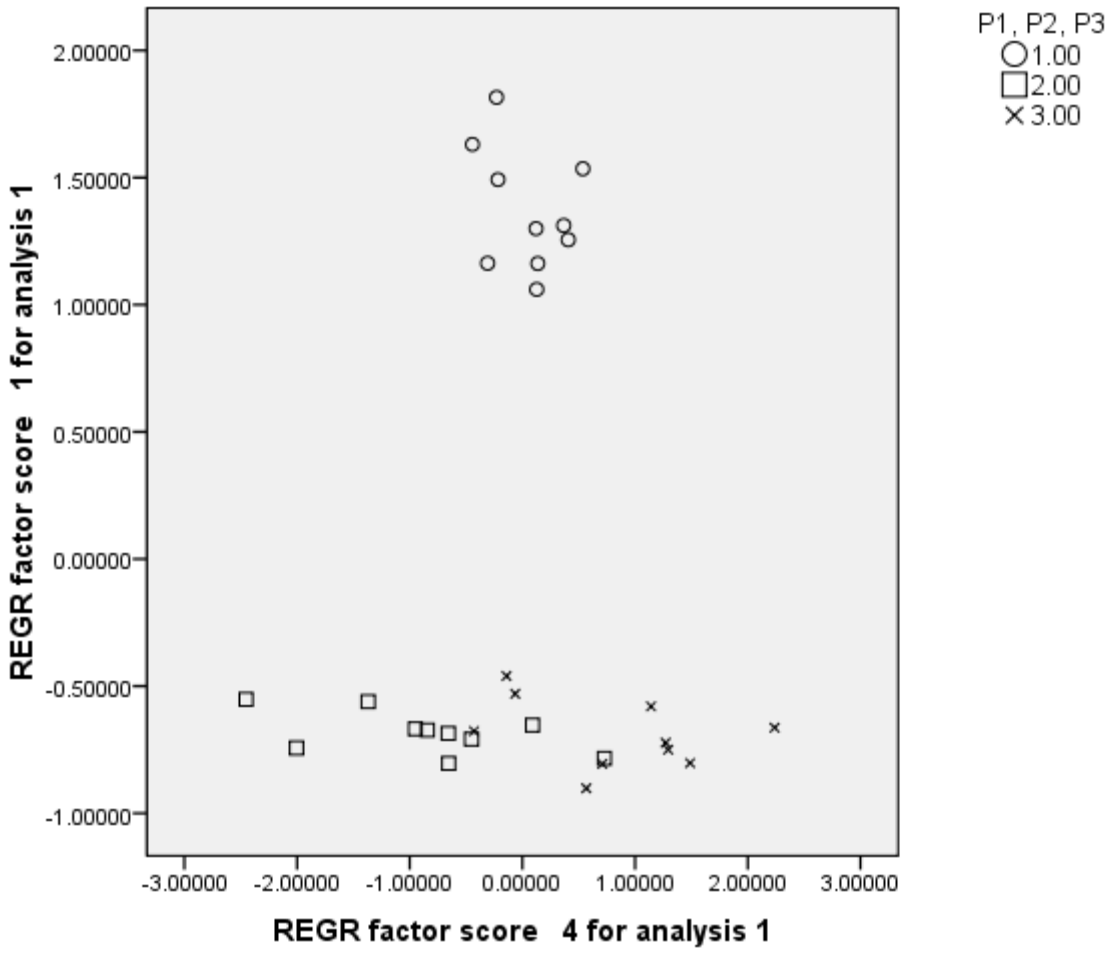


Fig. 4 (contd). Score value plots of principal components (physicochemical parameters and metals)

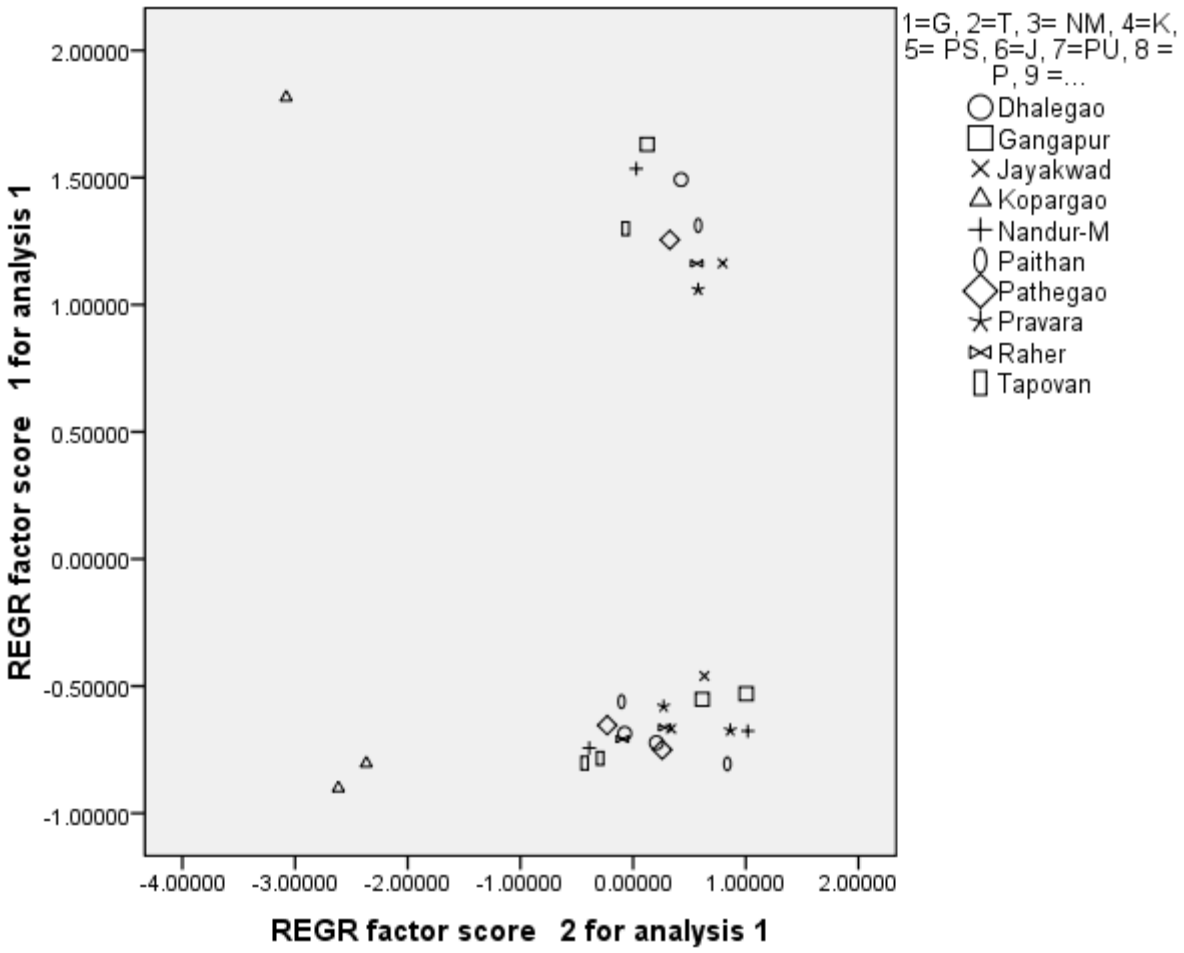


Fig. 4 (contd). Score value plots of principal components (stations)

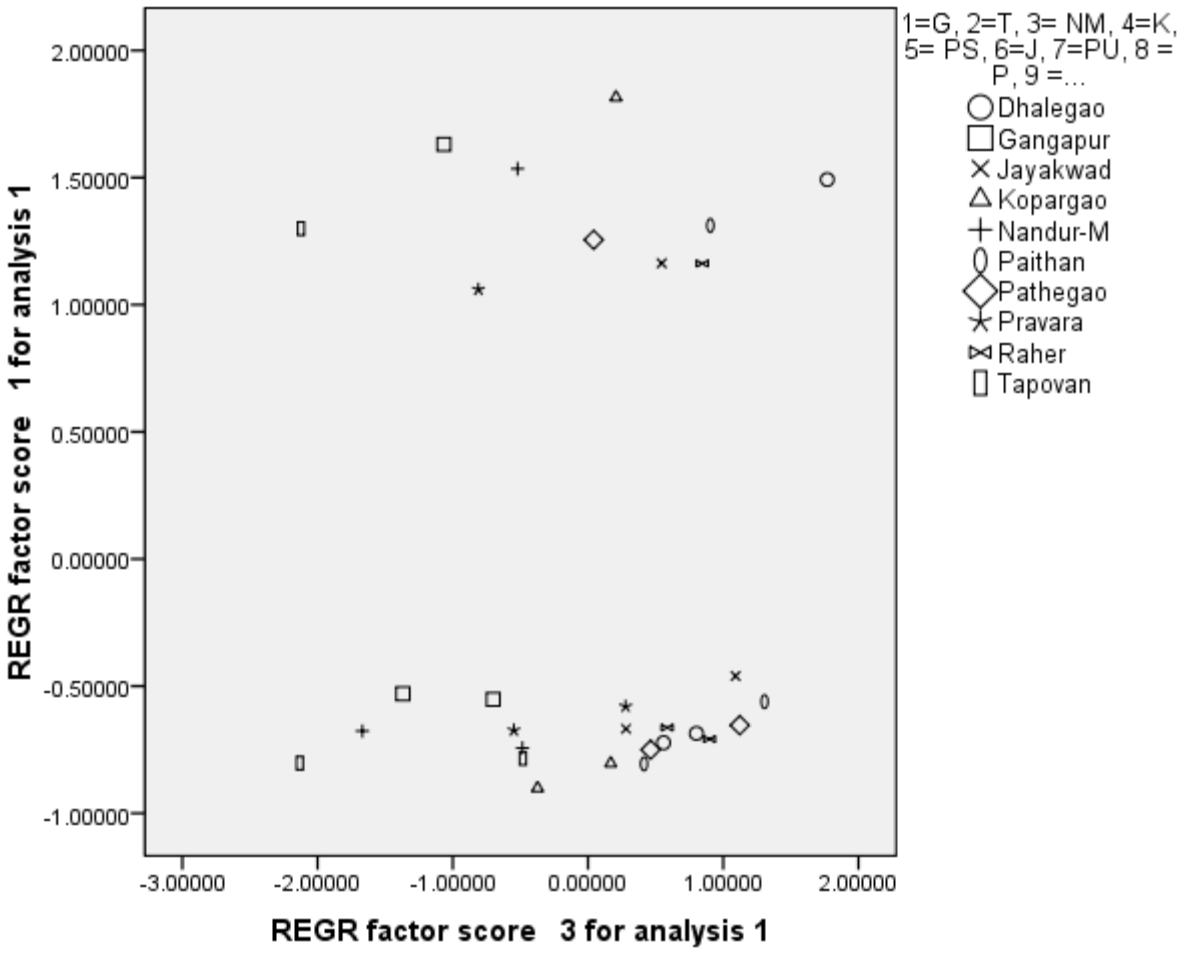


Fig. 4 (contd). Score value plots of principal components (stations)

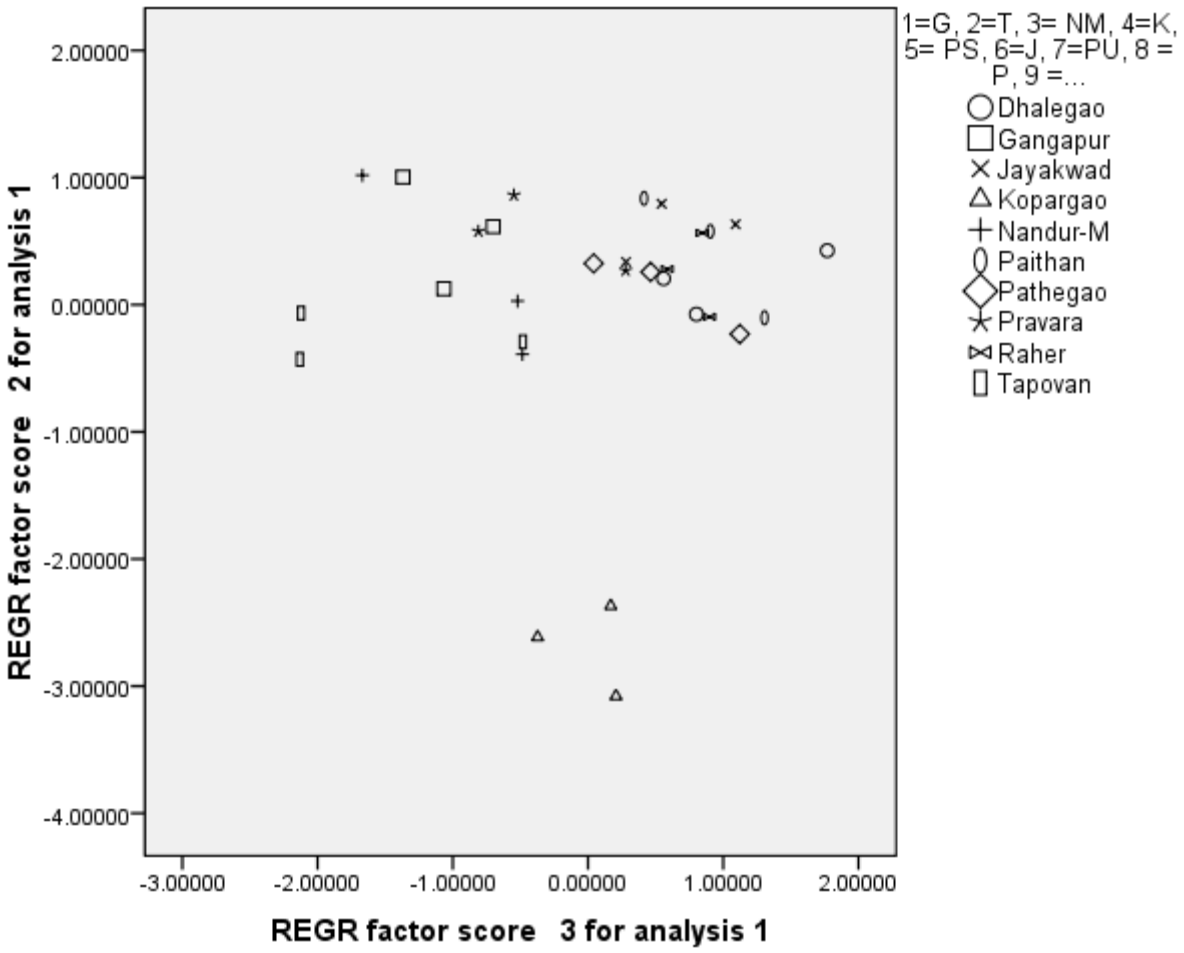


Fig. 4 (contd). Score value plots of principal components (stations)

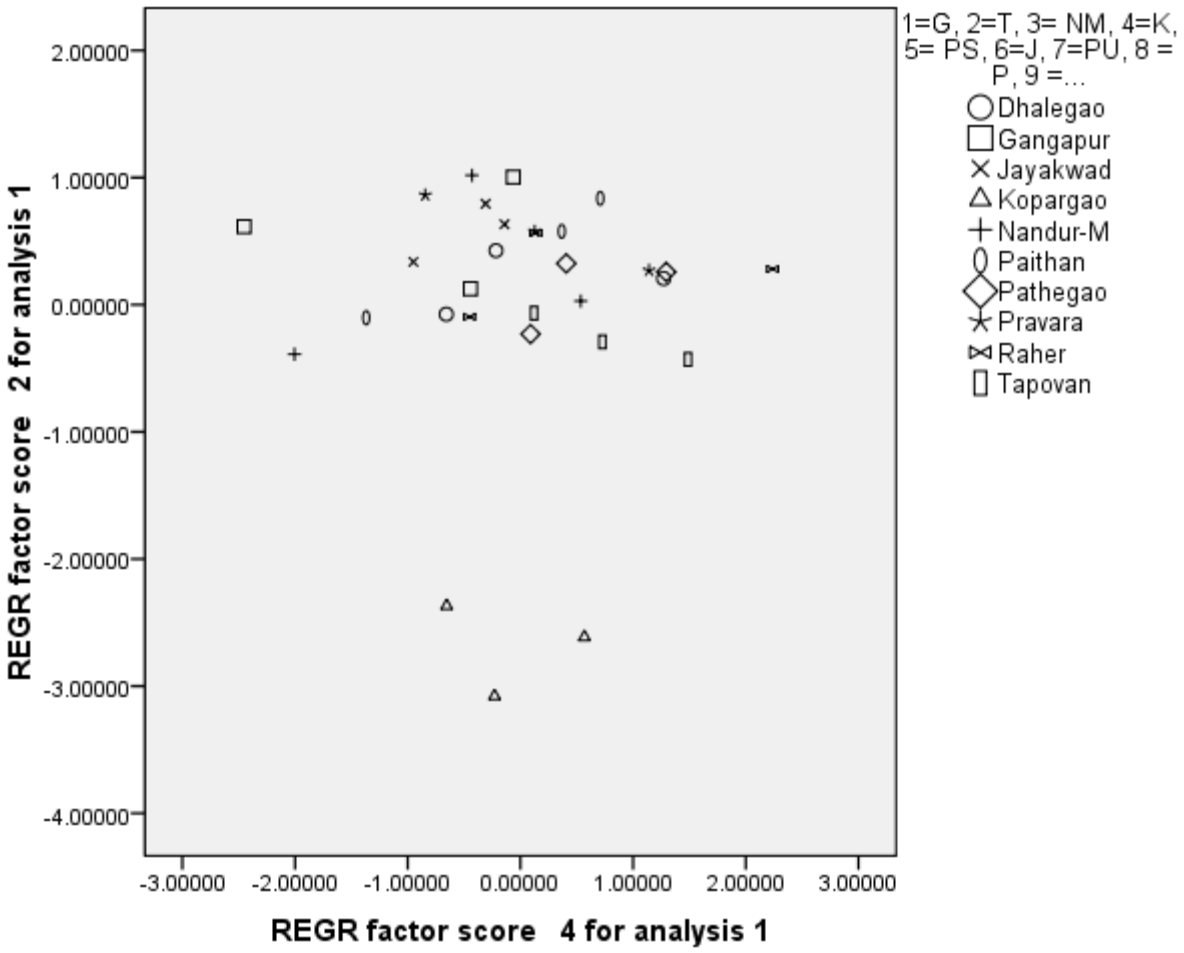


Fig. 4 (contd). Score value plots of principal components (stations)

9. CONCLUSIONS AND RECOMMENDATIONS

9.1. Conclusions

Among the stations studied, the water quality of River Godavari was found to be fit for the propagation of fish only at Gangapur dam, Nandur-Madhyameshwar, Pravara Sangam, Paithan upstream and Dhalegaon. All the other stations had lower levels of dissolved oxygen and/or higher biochemical oxygen demand than the limits prescribed by the CPCB for the purpose.

The only station with waterflow was Tapovan and at all the other stations, at all the sampling occasions, the water was stagnant. In spite of the flowing water, Tapovan physically appeared to be heavily polluted with foam on the surface of water. The water was discoloured and had obnoxious smell, and sediment was black.

Kopergaon showed high levels of decomposing organic matter with algal mats, algal blooms and/or floating macrophytes. There was no fishing activity, though the highest number of exotic species (three) could be found at this station.

Fishing activity was limited and the fish catch modest, majority of the fish caught being small, mainly minnows. No commercially important catch could be observed at any place other than at Raher, where catla weighing 8-10 kg could be observed in fishermen's catch.

The fishes collected during the study belonged to five different orders, 15 families, 40 genera and 64 species; 27 genera had only one species representing these. The numerically rich order was Cypriniformes with three families. Family Cyprinidae had 19 genera with the genus *Puntius* dominating the distribution with 10 species. *Chanda nama*, *Glossogobius giuris* and *Puntius ticto* were the dominat species with distribution at nine stations.

More than 150 species of freshwater fish have been reported by various authors in River Godavari of which the most authentic database Fishbase.org lists 69 species including two exotics, *Cyprinus carpio carpio* and *Oreochromis mossambicus*. Out of the 69, only 34 species could be obtained in the present investigation. However, there were 30 species, which have not been included in the database of Fishbase.org.

There is no considerable depletion in species diversity when compared to the data available. Moreover, the present investigation was carried out only at specific stations and

was not a holistic study of the entire stretch of the river. However, the commercially important species have very limited presence in the samples collected as well as the fishermen's catches. This shows that the river's contribution to commercial fisheries is limited.

Deliberate or accidental introduction of exotic fish species has occurred in the river as is evidenced by the presence of *Cyprinus carpio carpio, Poecilia reticulata, Oreochromis mossambicus* and *Oreochromis niloticus. Etroplus suratensis* must also be an introduction as the stretch of the river in Maharashtra cannot be the original habitat of the species. This is true for the prawn *Macrobrachium rosenbergii,* which needs brackish water for reproduction.

The Nygaard Index for plankton during post-monsoon and winter indicated Tapovan, Nandur-Madhyameshwar, Kopergaon, Pravara Sangam, Jayakwadi dam, Paithan upstream, Pathegaon and Dhalegaon to be oligotrophic, and Gangapur Dam and Raher as moderately eutrophic. Palmer Index indicated low organic pollution at all the stations with Gangapur dam showing the highest pollution level.

Nandur-Madhyameshwar was found to the least polluted station when the presence of indicator genera was analysed. The analysis of plankton clearly indicates that all the stations are organically polluted, different locations showing different levels as per the different indices and indicator genera.

9.2. Recommendations

Actions are to be initiated to maintain the minimum waterflow, otherwise known as environmental flow, to sustain the ecological functions at a healthy status. The lack of this flow adversely affects the loading of nutrients as also the distribution and recruitment of fish species. The lack of a continuous stream of water adversely affects the migration and breeding of the fishes.

Urgent action is needed for the treatment domestic sewage and industrial effluents, especially at Tapovan and Kopergaon. This would help in the restoration of these two stretches, which are the most polluted sections of the river.

Another area requiring attention is water recharge. It would be necessary to find ways and means to recharge the river with rain water and seepage from the surrounding area by channelizing the excess water into the river. In the interest of the health of the river and the

fishery resources, maintaining continuous flow almost throughout the year becomes mandatory.

At least four species of exotic fishes could be found in the river. With the introduction of more species of fishes and shellfishes officially and clandestinely, it is possible that more and more exotics would make the river their home. This has to be curbed by vigorous monitoring and control of the fish farming activities in the watershed area of the river.

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