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Abbreviations

BOD	Bio-Chemical Oxygen Demand
CPCB	Central Pollution Control Board, New Delhi
DO	Dissolved Oxygen Content
DMA	Directorate of Municipal Administration, Panjim Goa
GSPCB	Goa State Pollution Control Board, Panjim Goa
FC	Faecal Coliform
MBGL	Meters below ground levels
MLD	Million liters per Day
NEERI	National Environmental Engineering Research Institute Nagpur
NGT	National Green Tribunal
PWD	Public Work Department of Goa State
SEAC	State Level Environment Expert Appraisal Committee
SEIAA	State level Environment Impact Assessment Authority.
SIDCGL	Sewerage Infrastructure Development Corporation of Goa Limited, Panjim Goa.
TC	Total Coliform
ULB	Urban Local Body
WRD	Water Resources Department of Goa

References

- Salinity report by GSPCB, Panjim Goa.
- Annual parameters monitoring by GSPCB (from 2015 till 2018).
- Integrated Coastal Zone Management of Coastal Zone in Goa – Council of Scientific & Industrial Research July 2013.
- Master Plan for Mandovi River by the Panel of Experts, WRD Goa.

Executive Summary:

Mandovi River is also known as the Mhadel River, is one of the major river of the state of Goa situated along the western coast of India. With its cerulean waters, Dudhsagar falls and Varapoha falls, it is also known as Gomati River in some part of the state. The river originates from the cluster of 30 springs at Bhimgad in the Sahyadri Hillock ranges in Belgaum District of Karnataka state. The river enters in Goa from the north side via Sattari Taluka of the state and empties into the Arabian Sea near Panjim. The Khandepar, Valvanti, Bicholim, Assonora, Sinquerim and Mapusa are the major tributaries of the Mandovi River.

The Mandovi and Zuari (two major rivers of the state) are joined / interlinked by a canal, called Cumbarjua canal. The river Zuari & Mandovi meets at a common point at Cabo Aguada near Mormugao Harbour. The Mandovi River travels total length of 77 Kms out of which 29 Kms stretch is in Karnataka State and the balance 52 Kms in Goa State.

The Goa State Pollution Control Board (GSPCB) monitors the water quality of River Mandovi at 5 location (i.e. Tonca Marcel, IFFI Jetty Hotel Marriott Amona Bridge & Mandovi Bridge) under the National Water Monitoring Program (NWMP) of CPCB. The polluted stretch identified for the Mandovi River is 9.00 Kms i.e. from Marcel to Volvoi, whereas the stretch from Panjim to Marcel is 20 Kms (action plan as per Hon. NGT order in original application No. 486 / 2018 in Feb. 2019)

The said monitoring by GSPCB is carried out on a monthly basis throughout the year under the Central Pollution Control Board Programme National Water Quality Monitoring Programme (NWMP). This Stretch of the River Mandovi between Volvoi to Marcel is classified as SW-II (for bathing, contact water sports and commercial fishing). On the basis of GSPCB reports, Central Pollution Control Board (CPCB) has classified **Mandovi River (Volvoi to Marcel)** under **Priority IV**, is having BOD level **range between 3.3 to 6.2 mg/lit.**



Image 1 Floating Casino on Mandovi River

The Report of Monitoring for the period April 2015 to November, 2018 at two locations (i.e. Tonca Marcel, Amona Bridge) for the parameters of DO, BOD and Faecal Coliform have been taken into consideration for the preparation of Action Plan. The observed DO levels in the polluted river stretch between Volvoi to Marcel as can be seen from the GSPCB monitoring reports are well above the desired level of 4 mg/l required for bathing water quality (SW-II). The observed BOD levels in the polluted river stretch from Volvoi to Marcel as can be seen from the GSPCB monitoring reports are well within the desired level of 3 mg/l required for bathing water quality. The observed FC levels in the polluted river stretch from Volvoi to Marcel as can be seen from the GSPCB monitoring reports are above the desired levels of 500 MPN/100ML for bathing water quality (for bathing, contact water sports and commercial fishing).

The Hon. NGT in O. A. 486/2018 in Feb. 2019, directed that the complete stretch shall be considered for preparation of Action Plan for river Mandovi. The said monitoring by GSPCB is carried out on a monthly basis throughout the year under the Central Pollution Control Board Programme National Water Quality Monitoring Programme (NWMP). This Stretch of the River Mandovi between Marcel to Panjim is classified as SW-II (for bathing, contact water sports and commercial fishing).

The Report of Monitoring for the period April 2015 to November, 2018 at three locations (i.e. IFFI Jetty, Hotel Marriott, and Mandovi Bridge) for the parameters of DO, BOD and Faecal Coliform have been taken into consideration for the preparation of Action Plan. The observed DO levels in the polluted river stretch between Marcel to Panjim as can be seen from the GSPCB monitoring reports are well above the desired level of 4 mg/l required for bathing water quality (SW-II). The observed BOD levels in the polluted river stretch from Marcel to Panjim

as can be seen from the GSPCB monitoring reports are within the desired level of 3 mg/l required for bathing water quality. The observed FC levels in the polluted river stretch from Marcel to Panjim as can be seen from the GSPCB monitoring reports are above the desired levels of 500 MPN/ 100ML for bathing water quality (for bathing, contact water sports and commercial fishing).



Image 2 Mandovi River

The National Institute of Oceanography has conducted a study of Integrated Coastal Zone Management for Goa (2013), to detect various parameters (including DO, BOD and Faecal coliform) of 4 rivers including Mandovi. The summary of the reports of the study is attached with this report as **Annexure -2**. It is observed that, the values of DO, BOD in all seasons are within the prescribed limit for SW(II)/ bathing water quality, however, Faecal coliform count are observed to be beyond the prescribed limit during low tide in the monsoon season.

The GSPCB had carried out River Water Quality Monitoring of Mandovi River along the stretch of operations of Casino's and the report of the Monitoring for the period January 2014 to Oct 2018 (with frequency of once in four months) were submitted to the Hon'ble NGT in Application No. 228/2013. The reports of monitoring carried out on 1st March 2019 & 19th March 2019 are enclosed herewith as **Annexure- 3 & Annexure- 4**. The report indicates that the parameter of BOD, DO and Faecal Coliform are well within the SW II / bathing water quality standards.

In addition, the GSPCB has also carried out Mandovi River Water Quality Monitoring pursuant to the order of the Hon. NGT in original application no. 486/2018. On 1st March 2019 & 19th March 2019 at the same locations where monitoring is carried out under NWMP program i. e. at Marriot Hotel, IFFI Jetty, Mandovi Bridge, Tonca Marcel Raibandar and Amona Bridge. The

results of monitoring of water quality on 1st March and 19th March 2019 indicates that values of DO, BOD and Faecal Coliform are within the prescribed limits of SW II / bathing water quality.

The proposed action plan for Mandovi River comprises of the following key issues and action necessary to be implemented:

A. Source Control: The source control includes the industrial pollution control and treatment and disposal of domestic sewage, as detailed below;

a) Industrial Pollution Control:

The source identification studies were conducted during the month of January and February 2019. The Corlim Industrial Estate is located in the Corlim area. The industries like Atlas Fisheries Pvt. Ltd. Old Goa, Rahul Foods Goa, Darya Deger Multi Cuisine Restaurant, Dempo Ship Building & Engineering Pvt. Ltd., Mandovi Marine Engineering Works Mandovi Ice Plant & Thomas Ice plant are some of the industries located along the polluted stretch¹. During the survey conducted in Jan. & Feb. 2019, it was observed that there is no discharge of Industrial effluents or domestic sewage from the industries in the river Mandovi. M/s Deccan Fine Chemicals (earlier M/s Syngenta India Ltd) is discharging their treated effluent into the Cumbarjua Canal through diffusers as per the conditions stipulated in the Environmental Clearance and the Consent of the GSPCB. Similarly barge repair yards are observed along the stretch between to Tonca Marcel to Volvoi however there is no discharge from these units in to the River Mandovi.

Pursuant to the order of the Hon. NGT in original application no. 486/2018, the GSPCB has carried out inspection along both the banks of the river Mandovi from Panjim to Marcel and discharges from commercial establishment as well as households were observed. The GSPCB is initiating action against this establishment under the provisions of water act and also levying fines based on the pollutant pay principle. However the reports of the inspection are enclosed as **Annexure-3 & Annexure- 4.**

b) Channelization, treatment, utilisation and disposal of treated domestic sewage:

The physical survey was carried out during Jan & Feb. 2019. During the survey conducted for identification of pollution sources, carried out in January- February, it has been observed that the untreated domestic sewage outfalls mainly from Betqui-Candola, Marcem -Tivrem- Orgao, Amona, Navelim, Candola, Volvoi discharge to River

¹ Inspection Report by GSPCB vide order no. 1/5/18-PCB / Vol XXIV/Admin/20191

Mandovi. Mangrove cover is observed along both the banks of Mandovi and Coconut, Cashew & other indigenous flora observed in the stretch between to Marcel to Volvoi.

The GSPCB has carried out survey and inspection in compliance to the order of the Hon NGT in Application Number O.A No 486/2018 (earlier O. A. No 83/2014 WZ, Kashinath Shetye and Others V/s Srinet Kotwale and Others) from 1st March, 2019 to 6th March, 2019. The copy of the Report of the Inspection and Survey is annexed as **Annexure- 6**. Direct Discharges / outfall from houses and commercial establishment were observed by the GSPCB during their inspection and survey carried out from March 1st to 6th, 2019 and GSPCB is in the process of initiating action against such establishments.

The GSPCB is monitoring the discharge of wastewater from the Casino Vessels along the river stretch with the help of Captain of Ports on regular basis. The sewage from the casino, is being transferred in presence of the Captain of Port & GSPCB officials through barges and night soil tankers to the PWD STP at Tonca, Panjim for treatment. The GSCPb has also carried out Performance Evaluation of the Sewage Treatment Plant of PWD at Tonca on 6 number of occasions from 2015 to 2019. The reports are enclosed as **Annexure-5**. The reports indicate that the Sewage Treatment Plant is working efficiently and the parameters are well within the prescribed limits.

The Hon. NGT has directed constitution of a Monitoring Committee in Application No 228/2013 comprising of members from Department of Environment, National Institute of Oceanography, National Institute of Technology, Captain of Ports and GSPCB with Collector North to coordinate the functioning of the Committee. The Monitoring Committee was directed to monitor the operations of the Casino Vessels every four months. The Monitoring Committee is conducting the monitoring thrice a year in compliance to the direction of the Hon'ble NGT and the summarised statement of the observations (from 2013 to 2018) of the Monitoring Committee, is enclosed as **Annexure- 1**. The non-biodegradable solid waste is being disposed to Corporation of city of Panjim.

The up gradation of existing of the STP at Patto Panjim is also under progress and expected to be completed and commissioned in next 12 months. Presently the domestic sewage has been diverted to the existing sewage treatment facility at Tonca.

Discharges from individual house directly into the River and also into storm water drains / Nallahs leading to the River were observed on both the Banks during the physical survey. The Directorate of Panchayat and Directorate of health services will initiate the

following action through village Panchayat and the health officers after carrying out details survey.

1. Disconnection of the direct discharge into the river / storm water drain / Nallah.
2. Construction of septic tank and soak pits by residential houses and monitoring the frequent cleaning the septic tanks in order to avoid untreated domestic sewage discharge in to the natural drains.
3. It is proposed to have a 20-seater toilet block (on Malim Jetty) in addition to the existing 8 toilet, 7 bathroom, 7 urinals (Near to Malim Jetty) with a Waste Water Treatment Plant of 40 KLD which is expected to be completed by December, 2019.

B. River Catchment / Basin Management: Controlled ground water extraction and periodic quality assessment.

- i. **Periodic monitoring of ground water resources and regulation of ground water extraction by industries particularly over exploited and critical zones:**

The Central Ground Water Board has carried out survey of Aquifer System in the State of Goa in Sept. 2013. After studying the aquifer report, it is observed that the ground water table along the Mandovi river stretch is 2 m to 5 m below the ground level during Post monsoon season. The water table lowers down in summer by 2 to 5 M. As the ground water table is high within the Mandovi river basin, there are no such actions proposed for improvement of the ground water table².

The polluted stretch of the river Mandovi i. e. from Volvoi to Marcel (9 Kms), is in saline zone and not being used for irrigation purpose. The stretch from Panjim to Volvoi (20 Kms) is also in Saline Zone and is not being used for irrigation purpose.

C. Flood Plain Zone:

- i. **Regulating activity in flood plain zone:**

During the physical survey, domestic untreated sewage disposal in the storm water drains / Nallahs were observed near Betqui- Candola, Marcem -Tivrem- Orgao, Amona, Navelim, Candola, Volvoi on either bank including other surrounding areas. Also the inspection report of the GSPCB conducted from March, 1st to March 6st, 2019 indicate Direct Discharges / outfall from houses, restaurants and commercial establishment into Mandovi River. The Directorate of Panchayat and Directorate of health services will

² Aquifer System of Goa, Central Ground Water Board Sept. 2013

initiate action through the Village Panchayat and Health Officer Concern to ensure that the domestic sewage is diverted to septic tank and soak pit.

ii. Management of Municipal, Plastic Hazardous Bio-Medical & Electrical and Electronic Waste:

The Local bodies are collecting segregated non bio degradable waste which is sent to the Goa Waste Management Corporation (GWMC) and subsequently transported to the baling station at Saligao. The baled non-biodegradable waste is thereafter transported to cement plants in Karnataka for co incineration.

The Corporation of City of Panjim is having its own composting facilities, however the same requires improvement and hence, the State Government is in process of establishing a bio digester facility of 100 tons / day at Bainguinim for treatment of bio degradable waste. The said bio-digester facility is expected to be completed in a period of one year. The non-biodegradable waste is baled in the sorting centre at St Inez and sent for co-incineration to cement plants at Karnataka.

Improvement in the house to house collection of segregated waste is required and necessary installation of transfer station for non-biodegradable waste would be completed within period of 6 months. Necessary direction for the same will be issued by the Directorate of Panchayat/ Directorate of Municipal Administration.

iii. Greenery Development – Plantation Plan:

Mangrove cover is observed in 900 hectares along both the banks of the River (2001) as per the NIO study³. It was also observed during the Physical survey that there are extensive Mangroves, coconut, orchards, and other local species along both the bank of the River and surrounding areas in the polluted stretch between Volvoi to Marcel and also along the stretch between Panjim to Marcel.

³ NIO studies ICZM July 2013. P. No. 33 & P. N. 44.



Image 3 Greenery along the Bank of the River Mandovi

D. Ecological / Environmental Flow (E-Flow):

- i. Issues relating to E- Flow:** The saline stretch of the river is 36 Kms from the mouth of the sea near Panjim till Sanquelim- Usgaon Bridge. The Polluted stretch of 9 Kms from Volvoi to Marcel & Marcel to Panjim stretch of 20 Kms of the Mandovi, is under the influence of tides and there is no issue of E-flow.

The Mhadei Water Dispute tribunal has passed an award on 14th August 2018 in which the State of Karnataka have been directed to ensure sufficient flows in order to maintain the E-flow in the Mhadei River basin.

- ii. Irrigation practices:** The entire polluted stretch of the river Mandovi is in saline zone / tidal affected and water from River not used for irrigation purpose.

Action Plan Strategies:

The action plan strategies based on the sampling analysis of the GSPCB, site survey and observations are listed below. These strategies are classified on the basis of the existing proposal in place, recommended up gradation in order to achieve the desired objective on short term and long term basis.

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
1.	<p>Disconnection of direct discharges of domestic sewage into the Mandovi. River/storm water drains/ nallah.</p> <ul style="list-style-type: none"> ➤ Disconnection of the direct discharge into the river or through storm water drain/ Nallah. ➤ Construction of septic tank and soak pits by residential houses and monitoring the frequent cleaning the septic tanks in order to avoid untreated domestic sewage discharge in to the natural drains. ➤ Initiating action under the Water act including levying of fines for commercial establishment under Pollutant pay principal. (within 1 month) 	<p>Panjim to Volvoi</p> <ul style="list-style-type: none"> a) Betqui-Candola b) Marcem - Tivrem- Orgao c) Amona d) Navelim e) Candola, Volvoi f) Panchayat St. Estevam g) Se-old Goa. h) Salvador-Do -Mundo i) Penha de France j) Reis Magos k) Panchayat Nerul 	<p>Directorate of Panchayat, Directorate of Health Services;</p>	<p>6 months</p> <p>1 month</p>
2.	<ul style="list-style-type: none"> a) Improvement to collection system, and ensuring collection of segregated waste. b) Installation of Bio-digester having capacity 100 TPD at Bainguinim by 	<ul style="list-style-type: none"> a) Betqui-Candola b) Marcem - Tivrem- Orgao c) Amona 	<p>Respective Village Panchayat and Directorate of Panchayat</p>	<p>6 months</p>

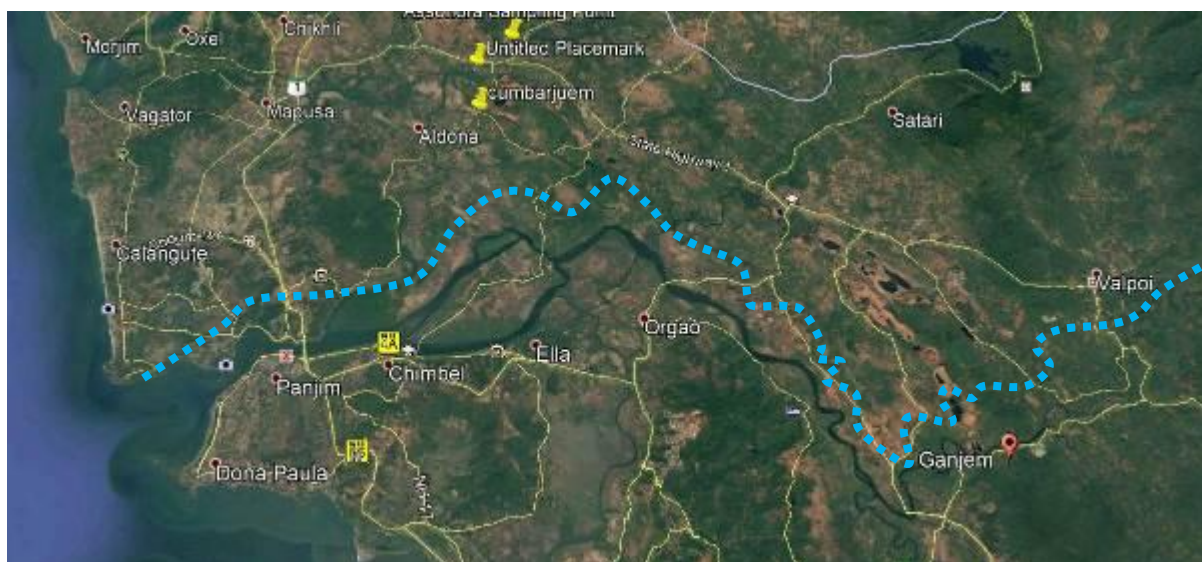
Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
	the Goa Waste Management Corporation.	d) Navelim e) Candola, Volvoi f) Panchayat St. Estevam g) Se-old Goa. h) Salvador-Do- Mundo i) Penha- De-France j) Reis Magos k) Panchayat Nerul		
3.	Providing toilet facility and sanitation facility for fishing Jetty at IFFI, Volvoi & Marcem	a) IFFI b) Volvoi c) Marcel	Captain of Port & SIDCGL	12 months
4.	Existing 8 toilets, 7 Bath rooms, 7 urinals at the fisheries complex Malim Betim, Goa managed by Sulabh International Social Service Organization Porvorim Goa. The 20 seated toilet block is proposed along the waste water treatment plant of 40 KLD. The work is been carried out through Goa State Infrastructure Development Corporation.	a) Fishing Jetty at Malim	Dept. of Fisheries	12 months
5.	The up gradation of Sewage Treatment Plant at Patto Plaza at Panjim is under progress by PWD, Goa and expected to be completed in one year.	STP at Patto, Panjim.	PWD, Goa	18 months
6.	The State of Goa has identified site for construction of Common Biomedical waste at Kundaim Industrial Estate. The National Environmental Engineering	The Common Bio-medical waste treatment	Goa Waste Management Corporation	18 months

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
	<p>Research Institute (NEERI, Nagpur) has conducted the EIA study. The study report has been submitted to the SEIAA /SEAC seeking Environmental Clearance for the facility. The facility expected to be commissioned and operation within next 18 months. In the meanwhile the Healthcare facilities have their own treatment facilities such as Autoclave, Deep burial pit and encapsulation pit, needle burners etc.</p>	<p>facility at Kundaim will treat all the Bio-medical waste generated in the State of Goa.</p>		
7.	<p>The Goa Waste Management Corporation and Producer Responsibility organization are collecting the E-waste generated throughout the State and the E waste is there after transported to authorized recyclers in other states.</p>	<p>The complete State of Goa</p>	<p>Goa Waste Management Corporation</p>	<p>Ongoing</p>

Introduction:

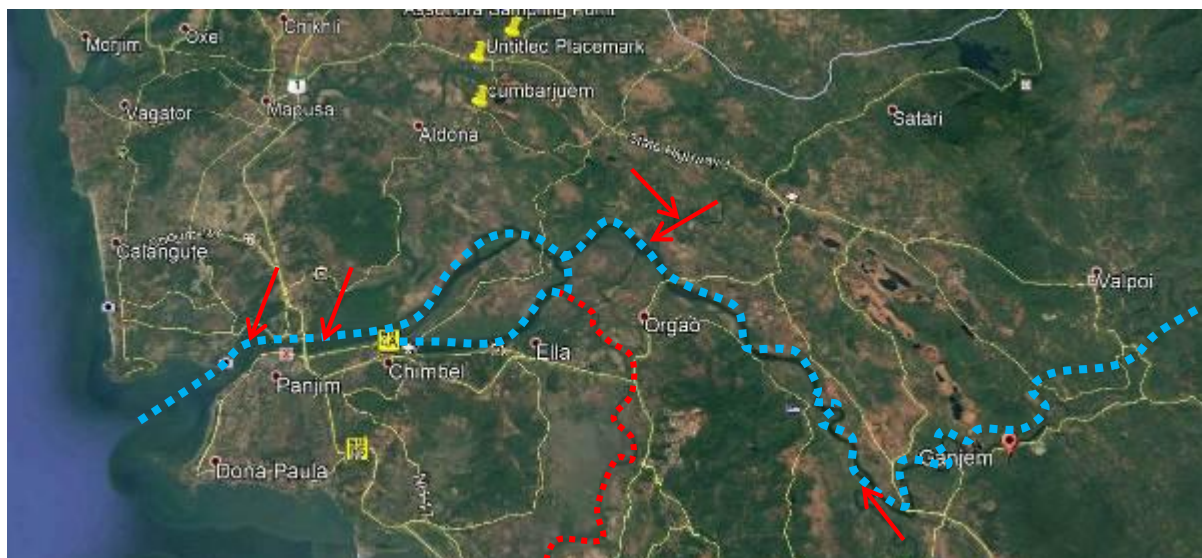
Mandovi River is also known as the Mhadel River, is one of the major river of the state of Goa situated along the western coast of India. With its cerulean waters, Dudhsagar falls and Varapoha falls, it is also known as Gomati River in some part of the state. The river originates from the cluster of 30 springs at Bhimgad in the Sahyadri Hillock ranges in Belgaum District of Karnataka state. The river enters in Goa from the north side via Sattari Taluka of the state and empties into the Arabian Sea near Panjim. The Khandepar, Valvanti, Bicholim, Assonora, Sinquerim and Mapusa are the major tributaries of the Mandovi River.

The Mandovi and Zuari (two major rivers of the state) are joined / interlinked by a canal, called Cumbarjua canal. The river Zuari & Mandovi meets at a common point at Cabo Aguada near Mormugao Harbour. The Mandovi River travels total length of 77 Kms out of which 29 Kms stretch is in Karnataka State and the balance 52 Kms in Goa State.






Map 1 Map showing the Mandovi River Stretch in Goa State.

The Goa State Pollution Control Board (GSPCB) monitors the water quality of River Mandovi at 5 location (i.e. Tonca Marcel, IFFI Jetty Hotel Marriott Amona Bridge & Mandovi Bridge) under the National Water Monitoring Program (NWMP) of CPCB. The polluted stretch identified for the Mandovi River is 9.00 Kms i.e. from Marcel to Volvoi, whereas the stretch from Panjim to Marcel is 20 Kms (action plan as per Hon. NGT order in original application No. 486 / 2018 in Feb. 2019)



Map 2 Mandovi –tributaries of Mandovi

Nomenclature	Description
	Mandovi River
	Tributaries of Mandovi River (from Left Bank to Right Bank from upstream side) Khandepar, Sinquerim, Assonora, Valvanti, Bicholim.
	Cumbarjua Canal connecting (Mandovi & Zuari river)

During the Physical Survey it has been observed that there are indigenous / endemic flora, Coconut plantations and Mangrove cover along the bank of the River. Direct discharge of untreated domestic sewage into the River and storm water drains / nallah leading to the river were observed during the Physical Survey during January and February 2019. Also the inspection report of the GSPCB conducted from March, 01 to March 06, 2019 indicate Direct Discharges / outfall from houses, restaurants and commercial establishment into Mandovi River.

a) Objectives:

The Hon’ble National Green Tribunal in the Original Application No 673 of 2018, vide its Order dated 20th September, 2018 directed the State Governments to prepare an Action Plan within two months for bringing all the polluted river stretches to be fit at least for Bathing, Contact water Sports water sports and commercial fishing (i. e. BOD < 3 mg/l and FC < 500 MPN/100

ml for SW-II rivers as per Environment Protection act 1986) within 6 months from the date of finalisation of the action plans.

In the said order the Hon'ble National Green Tribunal has directed that the Action Plan should cover aspects pertaining to Source control, Industrial Pollution Control, Channelization treatment, utilisation and disposal of treated domestic sewage, river catchment/ basin management /control, ground water extraction and periodic quality assessment, flood plain zone , ecological / environmental flow (e-flow) and such other issues may be found relevant for restoring water quality to the prescribed standards. The Hon'ble National Green Tribunal in their order has further directed to take into account the Model Action Plan for Hindon River, already prepared by CPCB while preparing the Action plans for other polluted river stretches.

Vide the said order the Hon'ble NGT directed that the four member committee comprising of Director Environment, Director Urban Development, Director Industries and Member Secretary, State Pollution Control Board shall be the Monitoring Committee for the execution of the Action Plan. The Committee shall be called "River rejuvenation Committee (RRC)" and will function under the overall supervision & co-ordination of the Principal Secretary of the concern state. The action plan shall include components like identification of polluting sources including functioning / status of STP's, ETP's CETP, and solid wastes management processing facilities, quantification and characterisation of solid waste, trade & sewage generated in the catchment areas of polluted river stretch. The action plan should address issues related to, ground water extraction, adopting good irrigation practices, protection and management of flood plain zones, rain water harvesting, ground water charging, maintaining minimum environmental flow of rivers & plantation on both sides of the river.

The Hon. NGT has directed that setting of bio-diversity Park on flood plains by removing encroachments shall be considered as an important component of river rejuvenation. The action plan is expected to focus on proper interception and diversion of sewage carrying drains to the sewage treatment plant and emphasis should be on utilisation of treated sewage so as to minimise extraction of ground or surface water.

The Hon'ble NGT has directed to ensure that the action plan should have definite or specific timelines for execution steps. The State Government is required to set up a special environment surveillance task force in terms of this order. The said task force has to ensure that no illegal mining takes place in river bed of such polluted stretches. The river rejuvenation committee is directed to have web site inviting public participation from educational, religious institutions and commercial establishment. The achievement and failure may also be published on such website. The Committee may consider suitably rewarding those contributing significantly to the success of the project.

The RRC's will have the authority to recover the cost rejuvenation in Polluter pays Principal from those whose may be responsible for the pollution, to the extent found necessary. In this case principal laid down by this tribunal in the said order. Voluntary donations, CSR contribution voluntary services and private participation may be considered in consultation with the RRC.

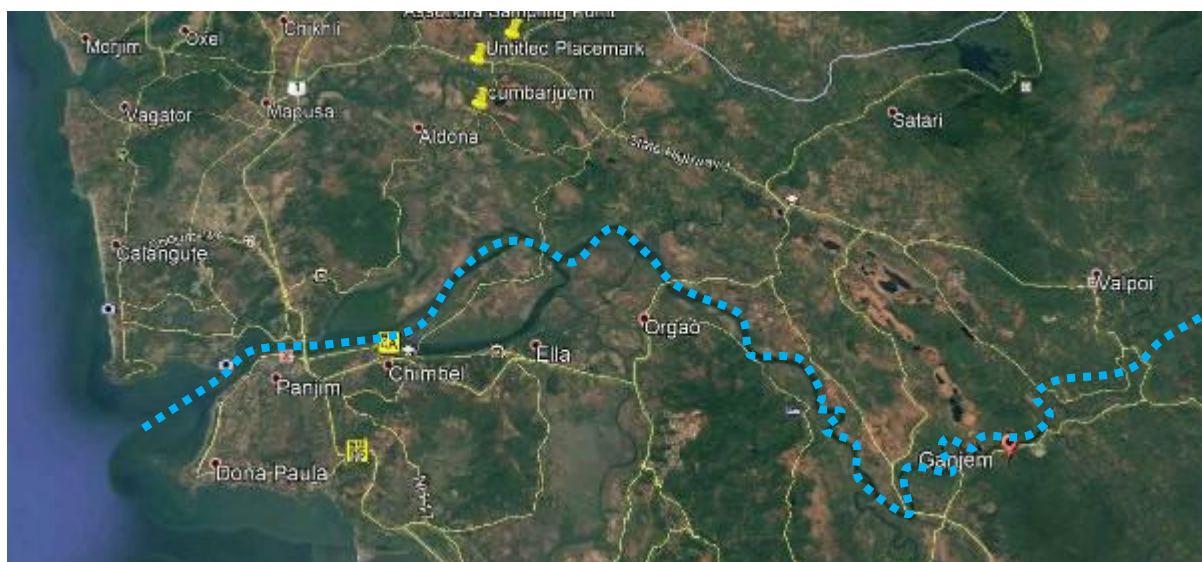
The Hon'ble NGT in Application No 486/2018 (earlier 83/2014) dated 20.02.2019 had directed the River Rejuvenation Committee shall prepare Action Plan for the entire stretch of the River and not limited to any selected area. Therefore, the present river action plan includes action plan for stretch from Panjim to Volvoi.

1. Brief about Mandovi River:


1.1. River Mandovi:

Mandovi River is also known as the Mhadel River, is one of the major river of the state of Goa situated along the western coast of India. With its cerulean waters, Dudhsagar falls and Varapoha falls, it is also known as Gomati River in some part of the state. The river originates from the cluster of 30 springs at Bhimgad in the Sahyadri Hillock ranges in Belgaum District of Karnataka state. The river enters in Goa from the north side via Sattari Taluka of the state and empties into the Arabian Sea near Panjim. The Khandepar, Valvanti, Bicholim, Assonora, Siquerim and Mapusa are the major tributaries of the Mandovi River.

The Mandovi and Zuari (two major rivers of the state) are joined / interlinked by a canal, called Cumbarjua canal. The river Zuari & Mandovi meets at a common point at Cabo Aguada near Mormugao Harbour. The Mandovi River travels total length of 77 Kms out of which 29 Kms stretch is in Karnataka State and the balance 52 Kms in Goa State.



Map 3 Map showing stretch of Mandovi River

Nomenclature	Description
	Mandovi river stretch

The water sampling was carried out by GSPCB under NWMP, the CPCB has declared the stretch between from Panjim to Volvoi having app. length of 29 Kms out of the total stretch of 52 Kms before it discharges into the Arabian Sea near Panjim. The saline stretch of the river is about 36 Kms (till Sanquelim- Usgaon Bridge).

1.2. Water Quality of River Mandovi:

For the purpose of conceptualising the plan of action for the polluted river stretch of Mandovi River the data of water quality monitoring carried out by GSPCB for three seasons was considered from year 2015 to 2018 as under

- a) Pre monsoon (January - May)
- b) Monsoon (June – September)
- c) Post Monsoon (October - December)

Table 1 NWMP Sampling locations of Mandovi River

Location	Co-ordinates	
	Latitude	Longitude
Tonca Marcel	15 ⁰ 32' 6.94" N	73 ⁰ 57' 27.83" E
IFFI Jetty	15 ⁰ 29' 39.49" N	73 ⁰ 48' 58.54" E
Hotel Marriott	15 ⁰ 29' 17.21" N	73 ⁰ 48' 35.09" E
Amona Bridge	15 ⁰ 31' 40.77" N	73 ⁰ 58' 10.81" E
Mandovi Bridge	15 ⁰ 29' 59.92" N	73 ⁰ 50' 16.22" E

The map showing the locations of the sampling is referred in map below.



Map 4 Map showing the Sampling location on Mandovi River

Nomenclature

Identification



NWMP Sampling point location on Mandovi river

The salinity in the river Mandovi was carried out by the GSPCB. The table below indicates the salinity points and the salinity recorded along the river Mandovi and its tributaries.

Table 2 Salinity locations of Mandovi River⁴

Sr. No.	Name of the Location	Latitude	Longitude	Salinity in Ppt.
1.	Mira Bridge (Tributaries)	15° 35' 41.4" N	73° 49' 55.9" E	8.75
2.	Khurjuvem Bridge (Tributaries)	15° 35' 45.1" N	73° 53' 43.3" E	13.78
3.	Gaonkar Waddo Shirgao (Tributaries)	15° 36' 55.3" N	73° 53' 37.3" E	7.66
4.	Band- 20 m from above location (Tributaries)	15° 36' 49.8" N	73° 52' 23.3" E	8.80
5.	Sirsai Dharer Manshi (Tributaries)	15° 36' 52.6" N	73° 52' 22.9" E	8.10
6.	Mapusa river near Green Park Hotel (Tributaries)	15° 34' 23.3" N	73° 48' 24.7" E	7.64
7.	Nerul River near Marna-Pilerna Panchayat (Tributaries)	15° 31' 14.8" N	73° 48' 26.6" E	31.40
8.	Khandepar river below old Khandepar Bridge (Tributaries)	15° 25' 23.8" N	74° 03' 01.3" E	9.20
9.	Khandepar river below new Khandepar Bridge (Tributaries)	15° 25' 20.4" N	74° 02' 55.9" E	8.06

⁴ Salinity Report by GSPCB

Sr. No.	Name of the Location	Latitude	Longitude	Salinity in Ppt.
10.	Khandepar river Pebble excavation at Oppa. (Tributaries)	15° 24' 55.2" N	74° 03' 04.9" E	4.54
11.	Khandepar river, Downstream of Oppa pumping station- 500 m away. (Tributaries)	15° 24' 46.6" N	74° 03' 08.6" E	2.29
12.	Ganjem below Ambeagal Bridge (Tributaries)	15° 28' 00.3" N	74° 05' 00.1" E	6.73
13.	Ganjem bridge upstream (Tributaries)	15° 28' 01.4" N	74° 05' 01.8" E	5.11
14.	Shrikant house Ganjem (Tributaries)	15° 28' 03.6" N	74° 05' 22" E	1.03



Map 5 Map showing the Salinity Sampling location on Mandovi River & Tributaries

1.3. Water Sampling Results:

The sampling results of the GSPCB for the period 2015 to 2018 was analysed to decide the Action plan strategies. The recent monitoring results for the month of the March 2019 are also

considered for analysis. The NWMP results from March 2019 are enclosed herewith as Annexure-3.

Table 3 Mandovi River parameters at near Tonca, Marcel ⁵

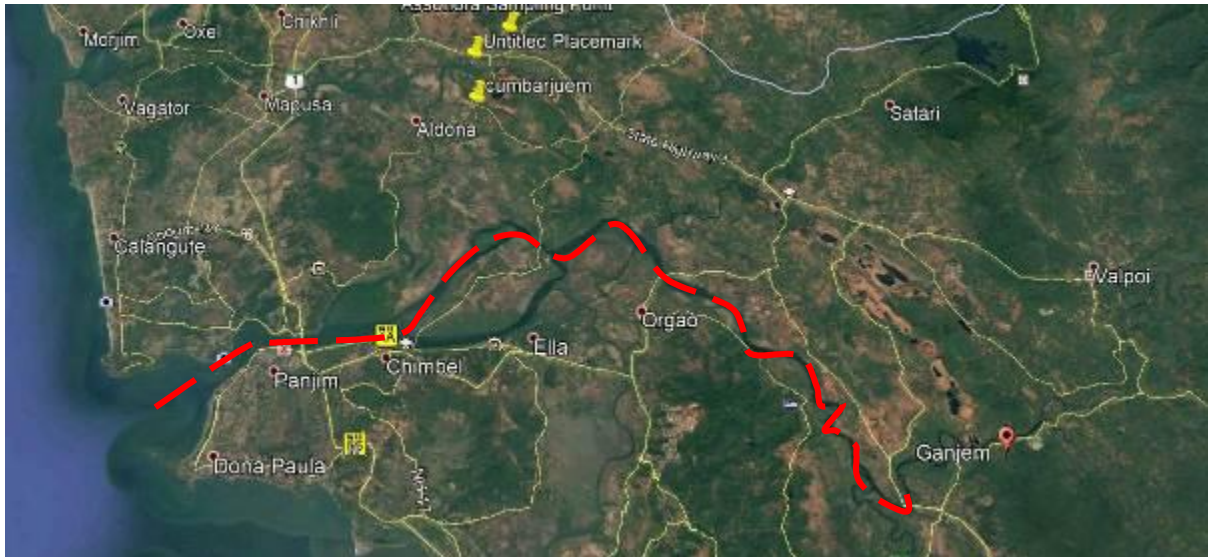
Sr. No.	Year Parameters	2015	2016	2017	2018	Range
Pre - Monsoon (January to May)						
1.	DO (mg/l)	4.6 – 4.9	4.8 – 7.0	4.3 – 5.9	5.2 – 5.7	4.3 – 7.0
2.	BOD (mg/l)	2.0 – 2.9	1.0 – 3.0	1.0 – 2.3	1.4 – 2.7	1.0 – 2.7
3.	Faecal Coliform (MPN/100ml)	780 - 790	490 - 3500	330 - 5400	13 - 2300	13 – 5400
Monsoon (June to September)						
1.	DO (mg/l)	4.2 – 7.8	4.4 – 7.2	5.2 – 7.5	4.7 – 7.7	4.2 – 7.8
2.	BOD (mg/l)	1.0 – 2.9	0.4 – 1.9	0.4 – 2.2	0.02 – 0.14	0.02 – 2.9
3.	Faecal Coliform (MPN/100ml)	1100 - 2900	1300 - 5400	230 - 3500	1300 - 4900	230 – 5400
Post - Monsoon (October to December)						
1.	DO (mg/l)	5.4 – 6.4	4.9 – 7.6	5.5 – 7.8	5.4 – 6.8	4.9 – 7.8
2.	BOD (mg/l)	1.6 – 2.1	1.2 – 1.9	1.2 – 2.3	0.5 – 2.7	0.5 – 2.7
3.	Faecal Coliform (MPN/100ml)	1300 - 4600	1300 - 4900	2300 - 7900	1300 - 2300	1300 - 7900

The DO at Mandovi River at Tonca Marcel during pre-monsoon season varies from 4.3 mg/l to 7.0 mg/l and 4.2 mg/l to 7.8 mg/l during monsoon and 4.9 mg/l to 7.8 mg/l in post monsoon.

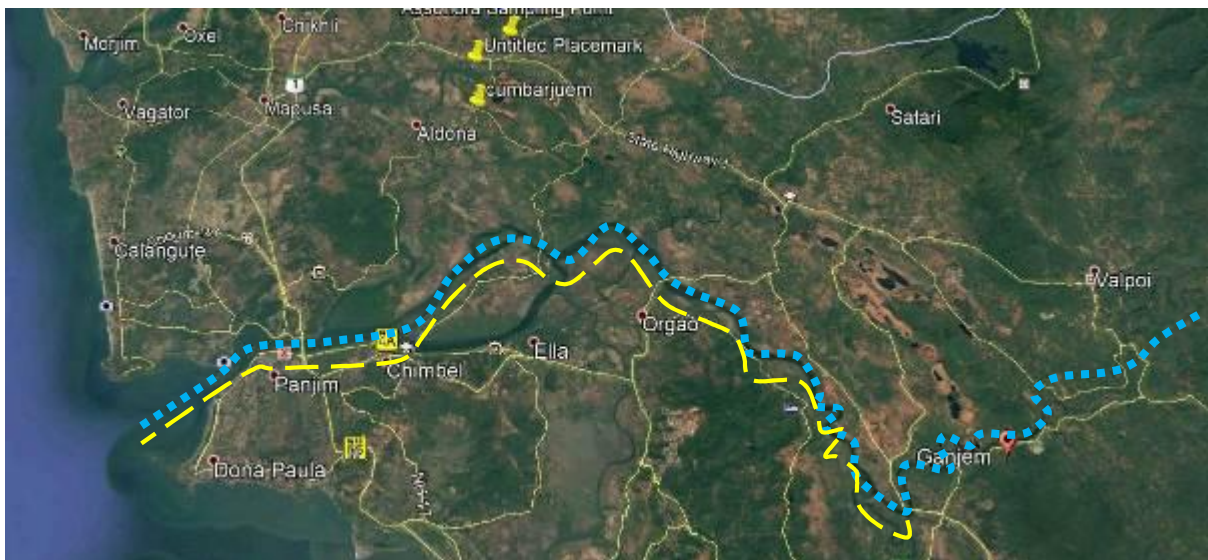
The BOD at Mandovi River at Tonca Marcel during pre-monsoon season varies from 1.0 mg/l to 2.7 mg/l and 0.02 mg/l to 2.9 mg/l during monsoon and 0.5 mg/l to 2.7 mg/l in post monsoon.

The FC at Mandovi River at Tonca Marcel during pre-monsoon season varies from 13 MPN/ 100ml to 5400 MPN/ 100ml and 230 MPN/ 100ml to 5400 MPN/ 100ml during monsoon and 1300 MPN/ 100ml to 7900 MPN/ 100ml in post monsoon.

⁵ GSPCB Sampling under NWMP



Map 6 Map showing the polluted stretch of Mandovi River



Map 7 Map showing the Saline & Polluted Stretch of Mandovi River

Table 4 Mandovi River parameters near Amona Bridge⁶

Sr. No.	Year Parameters	2015	2016	2017	2018	Range
Pre - Monsoon (January to May)						
1.	DO (mg/l)	4.5 – 5.3	4.8 – 6.1	4.5 – 6	5.6 - 6.6	4.5 – 6.6
2.	BOD (mg/l)	1.2 – 1.8	0.9 – 1.6	1 – 2	1.1 – 2.8	0.9 – 2.8
3.	Faecal Coliform (MPN/100ml)	490 - 1300	230 - 790	170 - 3500	450 - 2200	170 - 3500
Monsoon (June to September)						
1.	DO (mg/l)	4.6 – 7.3	4.8 – 7.6	5.3 – 7.5	-	4.6 – 7.6
2.	BOD (mg/l)	0.4 – 2.3	0.6 – 1.7	0.2 – 2.1	-	0.2 – 2.3
3.	Faecal Coliform (MPN/100ml)	330 - 2300	1300 - 5400	490 - 5400	-	330 – 5400
Post - Monsoon (October to December)						
1.	DO (mg/l)	6.1 – 6.8	5.7 – 7.9	5.8 – 9.9	-	5.7 – 9.9
2.	BOD (mg/l)	1.3 – 2.1	1.1 – 2.2	1.5 – 2.4	-	1.1 – 2.4
3.	Faecal Coliform (MPN/100ml)	780 - 3300	3300 - 7900	3300 - 7000	-	780 - 7900

The DO at Mandovi River near Amona Bridge during pre-monsoon season varies from 4.6 mg/l to 6.6 mg/l and 4.6 mg/l to 7.6 mg/l during monsoon and 5.7 mg/l to 9.9 mg/l in post monsoon.

The BOD at Mandovi River near Amona Bridge during pre-monsoon season varies from 0.9 mg/l to 2.8 mg/l and 0.2 mg/l to 2.3 mg/l during monsoon and 1.1 mg/l to 2.4 mg/l in post monsoon.

The FC at Mandovi River near Amona Bridge during pre-monsoon season varies from 170 MPN/ 100ml to 3500 MPN/ 100ml and 330 MPN/ 100ml to 5400 MPN/ 100ml during monsoon and 780 MPN/ 100ml to 7900 MPN/ 100ml in post monsoon.

⁶ GSPCB Sampling under NWMP1.7-2.1

Table 5 Mandovi River parameters near Mandovi Bridge

Sr. No.	Year Parameters	2015	2016	2017	2018	Range
Pre - Monsoon (January to May)						
1.	DO (mg/l)	5.3 – 5.5	3.6 – 6.6	5.4 – 6.5	-	3.6 – 6.6
2.	BOD (mg/l)	1.4 – 1.6	1.7 – 3.0	1.4 – 2.3	-	1.4 – 3.0
3.	Faecal Coliform (MPN/100ml)	1300 - 1300	130 -2300	45 - 1700	-	45 – 2300
Monsoon (June to September)						
1.	DO (mg/l)	3.7 – 6.0	6 – 7.6	4.5 – 7.8	-	3.7 – 7.8
2.	BOD (mg/l)	1.0 – 2.1	0.8 – 2.9	0.5 – 1.9	-	0.5 – 2.9
3.	Faecal Coliform (MPN/100ml)	1300 - 3300	130 - 5400	5400 - 7900	-	130 – 7900
Post - Monsoon (October to December)						
1.	DO (mg/l)	4.3- 6.0	4.48 – 7.2	4.7 – 5.1	-	4.3 – 7.2
2.	BOD (mg/l)	1.6 – 2.5	1.1 – 1.9	1.2 – 2.1	-	1.1 – 2.5
3.	Faecal Coliform (MPN/100ml)	1300 - 3300	230 -3300	4900 - 7900	-	230 - 7900

The DO at Mandovi River near Mandovi Bridge during pre-monsoon season varies from 3.6 mg/l to 6.6 mg/l and 3.7 mg/l to 7.8 mg/l during monsoon and 4.3 mg/l to 7.2 mg/l in post monsoon.

The BOD at Mandovi River near Mandovi Bridge during pre-monsoon season varies from 1.4 mg/l to 3.0 mg/l and 0.5 mg/l to 2.9 mg/l during monsoon and 1.1 mg/l to 2.5 mg/l in post monsoon.

The FC at Mandovi River near Mandovi Bridge during pre-monsoon season varies from 45 MPN/ 100ml to 2300 MPN/ 100ml and 130 MPN/ 100ml to 7900 MPN/ 100ml during monsoon and 230 MPN/ 100ml to 7900 MPN/ 100ml in post monsoon.

Table 6 Mandovi River parameters near IFFI Jetty

Sr. No.	Year Parameters	2015	2016	2017	2018	Range
Pre - Monsoon (January to May)						
1.	DO (mg/l)	6.2 - 6.4	5.7 - 7.2	5.5 - 6.6	6.1 - 6.7	5.5 - 7.2
2.	BOD (mg/l)	1.9 - 2.9	1.3 - 2.6	0.9 - 3.1	1.2 - 2.2	0.9 - 3.1
3.	Faecal Coliform (MPN/100ml)	1700 - 2300	230 - 2400	330 - 1700	200 - 780	200 - 2400
Monsoon (June to September)						
1.	DO (mg/l)	5.1 - 7.8	5.8 - 7.1	6.0 - 7.3	-	5.1 - 7.8
2.	BOD (mg/l)	0.1 - 2.2	1.5 - 2.2	1.1 - 2.3	-	0.1 - 2.3
3.	Faecal Coliform (MPN/100ml)	3300 - 7900	330 - 4900	1300 - 7900	-	330 - 7900
Post - Monsoon (October to December)						
1.	DO (mg/l)	6.0 - 6.7	5.9 - 6.8	5.8 - 6.6	-	5.8 - 6.8
2.	BOD (mg/l)	0.9 - 2.2	1.7 - 2.7	1.1 - 1.8	-	0.9 - 2.7
3.	Faecal Coliform (MPN/100ml)	230 - 7900	490 - 2300	230 - 1700	-	230 - 7900

The DO at Mandovi River near IFFI Jetty during pre-monsoon season varies from 5.5 mg/l to 7.2 mg/l and 5.1 mg/l to 7.8 mg/l during monsoon and 5.8 mg/l to 6.8 mg/l in post monsoon.

The BOD at Mandovi River near IFFI Jetty during pre-monsoon season varies from 0.9 mg/l to 3.1 mg/l and 0.1 mg/l to 2.3 mg/l during monsoon and 0.9 mg/l to 2.7 mg/l in post monsoon.

The FC at Mandovi River near IFFI Jetty during pre-monsoon season varies from 200 MPN/ 100ml to 2400 MPN/ 100ml and 330 MPN/ 100ml to 7900 MPN/ 100ml during monsoon and 230 MPN/ 100ml to 7900 MPN/ 100ml in post monsoon.

Table 7 Mandovi River parameters near Hotel Marriott

Sr. No.	Year Parameters	2015	2016	2017	2018	Range
Pre - Monsoon (January to May)						
1.	DO (mg/l)	6.2 - 6.2	5.7 - 6.2	5.7 - 6.8	6.1 - 6.7	5.7 - 6.8
2.	BOD (mg/l)	1.9 - 2.4	1.5 - 2.6	1.1 - 3.6	1.2 - 2.2	1.1 - 2.6
3.	Faecal Coliform (MPN/100ml)	450 - 2400	78 - 2400	330 - 3500	200 - 780	78 - 3500
Monsoon (June to September)						
1.	DO (mg/l)	5.9 - 7.0	6.0 - 7.2	6.0-7.3	-	5.9 - 7.3
2.	BOD (mg/l)	0.6 - 2.3	1.3 - 2.6	1.1 - 2.3	-	0.6 - 2.6
3.	Faecal Coliform (MPN/100ml)	780 - 3300	490 - 2400	1300 - 7900	-	490 - 7900
Post - Monsoon (October to December)						
1.	DO (mg/l)	6.3 - 6.4	5.1 - 6.6	5.8 - 6.6	-	5.1 - 6.6
2.	BOD (mg/l)	1.1 - 3.1	1.6 - 2.1	1.1 - 1.8	-	1.1 - 3.1
3.	Faecal Coliform (MPN/100ml)	130 - 1300	130 - 1300	230 - 1700	-	130 - 1700

The DO at Mandovi River near Hotel Marriott during pre-monsoon season varies from 5.7 mg/l to 6.8 mg/l and 5.9 mg/l to 7.3 mg/l during monsoon and 5.1 mg/l to 6.6 mg/l in post monsoon.

The BOD at Mandovi River near Hotel Marriott during pre-monsoon season varies from 1.1 mg/l to 2.6 mg/l and 0.6 mg/l to 2.6 mg/l during monsoon and 1.1 mg/l to 3.1 mg/l in post monsoon.

The FC at Mandovi River near Hotel Marriott during pre-monsoon season varies from 78 MPN/ 100ml to 3500 MPN/ 100ml and 490 MPN/ 100ml to 7900 MPN/ 100ml during monsoon and 130 MPN/ 100ml to 1700 MPN/ 100ml in post monsoon.

Summary of the Sampling analysis

Dissolved Oxygen (DO)

All the observed Dissolved Oxygen values are normal and indicate well oxygenated water during all the three seasons i.e. Pre-monsoon, Monsoon and Post – monsoon and good for aquatic life.

Biochemical Oxygen Demand (BOD)

The observed values of BOD are mainly below 3 mg/l and within limits of SW II water quality standards.

Faecal Coliform

The observed values of Faecal coliform indicate pollution sources in the River Mandovi.

1.4. Data Analysis and interpretation:

The results of the water sampling carried out by Goa state Pollution Control Board at Tonca Marcel, IFFI Jetty, Hotel Marriott, Amona Bridge and Mandovi Bridge on Mandovi River from April 2015 to December 2018, in respect of DO, BOD and Total coliform have been considered for preparation of action plan. The NIO report are also considered for preparation of the action plan on Mandovi River.

a) Summary of the NWMP monitoring reports by GSPCB.

- **Dissolved Oxygen (DO)**

The observed DO levels in the polluted river stretch between **Marcel to Volvoi** as can be seen from the GSPCB monitoring reports are well above the desired level of 5 mg/l required for bathing, contact water sports & commercial fishing source.

- **Biochemical Oxygen Demand (BOD)**

The observed BOD levels in the polluted river stretch between **Marcel to Volvoi** as can be seen from the GSPCB monitoring reports are well below the desired level of 3 mg/l required for bathing, contact water sports & commercial fishing source.

- **Coliforms**

The observed FC levels in the polluted river stretch between **Marcel to Volvoi** as can be seen from the GSPCB monitoring reports are above the desired levels of 500 MPN/ 100ML for bathing, contact water sports & commercial fishing source. The FC values are higher in Post monsoon season only in some exceptional cases or otherwise seems to be well within the permissible limits.

b) Summary of the ICZM study report of NIO July 2013⁷

⁷ ICZM study report of NIO July 2013 P. N. 187.

The results for the Water Quality Monitoring as a part of the ICZM study report of NIO commissioned by Department of Science Technology and Environment of Goa for the month of July 2013 in respect of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Faecal Coliform are as listed below,

- **Dissolved Oxygen (DO)**

The water is well oxygenated at most of the locations except near mouth station, which shows lower DO in their bottom. The DO shows variation from 0.81 mg/l to 8.09 mg/l with an average of 5.43 mg/l. The higher values of DO are observed in the surface layer relative to bottom layer and are more due to dissolution of atmospheric oxygen due to its direct contact with surface layer.

- **Bio Chemical Oxygen Demand (BOD)**

The BOD values range from 0.52 to 1.51 (average-0.98 mg/l) during Monsoon, whereas 0.38 to 2.97 mg/l (av. 1.13mg/l) in post monsoon and 1.48 to 5.74 mg/l (av. 2.77 mg/l) in Pre-monsoon season during high tide. The BOD levels increase during low tide showing slightly higher due to external additions. The vertical distribution shows higher values in surface relative to bottom, increasing towards upstream side. The BOD levels observed are slightly higher.

- **Salinity**

Salinity is an indicator of the influence of freshwater / precipitation or evaporation in water bodies. The salinity in the Mandovi river water varies from 0.49 to 29.76 PSU with av. of 10.82 PSU in monsoon, 0.12 to 34.04 PSU in post monsoon & 18.56 to 33.20 PSU with av. 26.52 PSU in Pre-Monsoon season. The salinity shows distinct low values in surface and high values in bottom with a decrease from estuarine mouth towards the upstream of the estuary. The higher values of the salinity indicate the influence of tidally increased coastal water during the high tide. During low tide the salinity varies with an average of 12.52 PSU to 28.16 PSU. The lower values of salinity are observed during monsoon due to the input of surface runoff from the external sources.

- **Bacterial Count (TC & FC)**

The FC during Monsoon varies from 0.00 to 310 with an average of 116 high tide and increases during low tide with an average of 774. The FC values in post monsoon season varies from 0.00 to 860 with an average of 132 during high tide and increases with an average of 138. The FC values in pre-monsoon season remains low and varies from 2.0 to 21, with an average of 10.30 during high tide. The FC values increases during low tide

with an average of 27.58. The distribution does not show a fixed trend of its vertical variation, as some stations show low values in surface while other shows a reverse, whereas the spatial variation shows higher values in the mid estuarine station and at the upstream.

c) Summary of the NWMP monitoring reports by GSPCB for March 2019.

The GSPCB has carried out water sampling during the month of March 2019 on 1st and 19th March 2019 respectively as per the NGT order in Feb. 2019. The samples were collected from the surface water and bottom of the river at all the locations. The observations on the results obtained are attached as **Annexure- 3 & Annexure- 4**.

1.5. Action Plan Strategies:

This Mandovi River (**SW-II**) stretch is polluted stretch under **Priority IV as identified by the CPCB**. The river is one of the major river in the state and attractive tourist destination. The action plan is limited to the Regulatory interventions proposed in order to restore the Water Quality to the desired bathing water quality standards notified by the CPCB. The Action Plan has been prepared to achieve Faecal coliform < 500 MPN/ 100 ml in the River Mandovi in the identified polluted stretch.as other parameters of DO and BOD are within the desired limits.

1.6. Major Concerns:

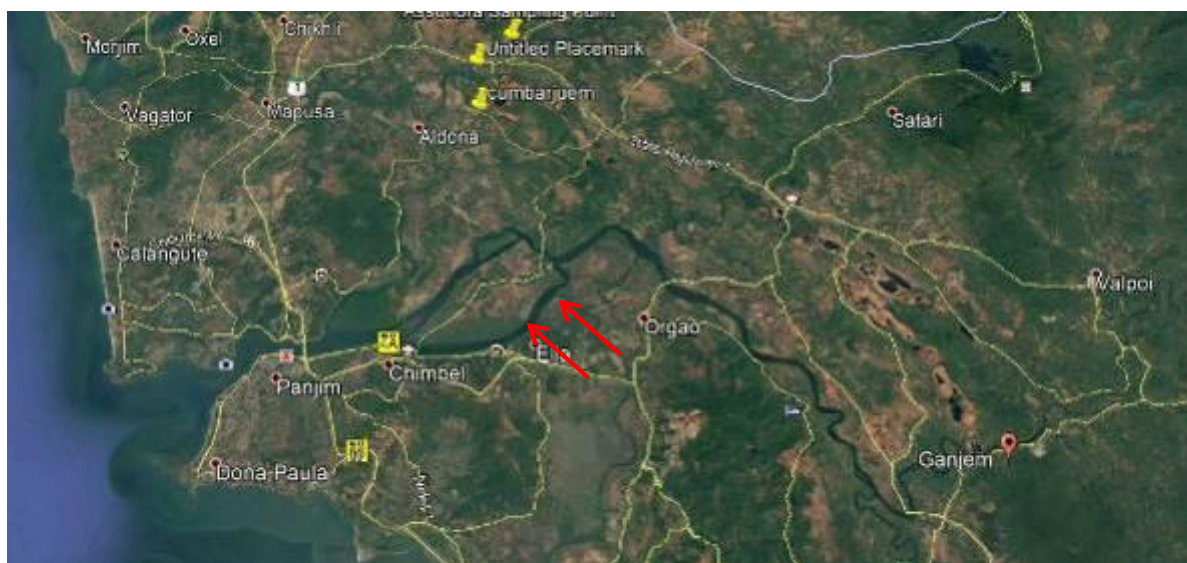
The polluted river stretches in Goa, Mandovi River **falls under priority IV**. The parameters like dissolved oxygen is meeting prescribed statutory requirement but the levels of Bio-chemical oxygen demand and Faecal Coliforms (FC) exceeds the prescribed limits.

2. Source Control:

The reconnaissance survey was conducted along with the GSPCB officials for the polluted stretch between **Marcel to Volvoi** during the month of Jan. & Feb. 2019. The objective of this study is to analyse the sources of pollutants. Also the GSPCB conducted inspections from March 01st to March 06th 2019, pursuant to the order of the Hon'ble NGT dated 20/02/2019 in Application No 486/2018 Feb. 2019

a) Industrial Pollution Control

The source identification studies were conducted during the month of January and February 2019. The Corlim Industrial Estate is located in the Corlim area. The industries like Atlas Fisheries Pvt. Ltd. Old Goa, Rahul Foods Goa, Darya Deger Multi Cuisine Restaurant, Dempo Ship Building & Engineering Pvt. Ltd., Mandovi Marine Engineering Works Mandovi Ice Plant & Thomas Ice plant are some of the industries located along the polluted stretches. Similarly barge repair yards are observed along the stretch between Tonca Marcel to Volvoi however there is no discharge from these units into the River Mandovi. The GSPCB is monitoring the discharge from these areas and there are no industrial pollutants discharging into the river. Deccan fine chemicals is having the Effluent Treatment facility and discharging the treated waste water into Cumbarjua canal let at Mirarma with valid consent to Operate.



Map 8 Outfall from Pilerne Industrial Estate

b) Channelization, treatment, utilisation and disposal of treated domestic sewage:

⁸ Inspection Report by GSPCB vide order no. 1/5/18-PCB/Vol XXIV/Admin/20191

The reconnaissance survey was carried out during the month of January, February 2019, for identification of the sources of pollution of River Mandovi.

i. Sources of Pollutants:

The polluted river stretch of Mandovi River between **Volvoi to Marcel** was physically surveyed along both the banks of river during month of January and February 2019, for identification of sources of pollution. During the physical survey the discharge of untreated domestic sewage through nallah/ storm water drains was observed mainly on the Western and Eastern bank of the river from Pilerne, Morro Candolim & Reis-Magos, and Nerul. The main challenge in this River Stretch is to control the levels of Total Coliforms.



Map 9 Map showing stretch of Mandovi River

Nomenclature



Identification

Mandovi river stretch

Outfalls polluting the river Mandovi



Image 4 Development on the Bank of River Mandovi



Image 5 Outfalls from the fisheries Market on the right Bank of River Mandovi



Image 6 Direct discharge of Domestic untreated waste (Nerul) on the Bank of River Mandovi

The GSPCB is monitoring the Casino and the commercial activity along the river stretch with the help of Captain of Ports. The GSPCB is conducting the inspection of the Casinos and the STP along the bank of the river vide Compliance to the directives of the NGT Western Zone Bench in application no. 228/2013. The summarised statement of the observations (from 2013 to 2018) of the Hon. Committee, is enclosed as Annexure-1. The sewage from the casino, is been transferred to the PWD STP at Tonca, Panjim in presence of the Captain of Port & GSPCB officials. The non-biodegradable solid waste is being disposed to Panjim Municipal Corporation.

Discharges from individual house directly into the River and also into storm water drains / Nallahs leading to the River were observed on both the Banks during the physical survey. The same the GSPCB has also carried out field inspection during March 2019 and the observations are enclosed as Annexure-6. The Directorate of Panchayat and Directorate of health services will initiate the following action through village Panchayat and the health officers after carrying out details survey.

1. Disconnection of the direct discharge into the river/storm water drain / Nallah.
2. Installation of Bio toilets along the river stretch.
3. Construction of septic tank and soak pits by residential houses and monitoring the frequent cleaning the septic tanks in order to avoid untreated domestic sewage discharge in to the natural drains.

The proposals under consideration by Captain of Port for the Marcel Jetty & IFFI Jetty are mentioned;



Image 7 Fishing Jetties at Panjim (right Bank) on Mandovi River

1. The existing facilities for fisheries along the Mandovi River stretch at Volvoi, Marcel & IFFI Jetty comprises of 13 seater toilet cum bath facility. This facility is being operated and maintained by Sulabh International Social Service Organisation Porvorim.
2. It is proposed to have a 20-seater toilet block (on Malim Jetty) in addition to the existing 8 toilet, 7 bathroom, 7 urinals (Near to Malim Jetty) with a Waste Water Treatment Plant of 40 KLD which is expected to be completed by December, 2019.
3. After implementation of these projects open defecation will get reduced along these areas.
4. The Captain of Port and the GSPCB shall monitor the outlet parameters of the proposed Sewage treatment facility.

The construction of the STP at Patto Panjim is also under progress and expected to be over in next 18 months. After completion of these schemes the pollutants in the Mandovi river will be disconnected and will help in reducing the pollution levels. The GSPCB has carried out the physical survey as per the NGT order during March 2019, the observations of the same are enclosed as **Annexure- 6**. The Village Panchayat and Director of Health will initiate the action and disconnect the direct discharge.

3. River Catchment Management:

The Mandovi River is the one of the major interstate river of the State of Goa. The total stretch of the Mandovi River is about 77 Km before it discharges into Arabian Sea and the stretch of the river in Goa state is about 52 Kms. The saline stretch of the river is about 36 Kms and the basin area is about 1580 Sq. Km with average runoff from the basin is 3580 MCM⁹ & the Mangroves covers are observed about.

i. Periodic monitoring of ground water resources and regulation of ground water extraction by industries particularly over exploited and critical zones:

The Central Ground Water Board has carried out survey of Aquifer System in the State of Goa in Sept. 2013. After studying the aquifer report, it is observed that the ground water table along the Mandovi river stretch is 2 m to 5 m below the ground level during Post monsoon season. The water table lowers down in summer by 2 to 5 M. As the ground water table is high within the Mandovi river basin, there are no such actions proposed for improvement of the ground water table¹⁰.

The polluted stretch of the river Mandovi i. e. from Volvoi to Marcel (9 Kms), is in saline zone and not being used for irrigation purpose. The stretch from Panjim to Volvoi (20 Kms) is also in Saline Zone and is not being used for irrigation purpose.

4. Flood Plain Zone:

i. Regulating activity in flood plain zone:

During the physical survey, domestic untreated sewage disposal in the storm water drains / Nallahs were observed near Betqui- Candola, Marcem -Tivrem- Orgao, Amona, Navelim, Candola, Volvoi on either bank including other surrounding areas. Also the inspection report of the GSPCB conducted from March, 1st to March 6st, 2019 indicate Direct Discharges / outfall from houses, restaurants and commercial establishment into Mandovi River. The Directorate of Panchayat and Directorate of health services will initiate action through the Village Panchayat and Health Officer Concern to ensure that the domestic sewage is diverted to septic tank and soak pit.

⁹ ICZM July 2013 P. N. 33.

¹⁰ Aquifer System of Goa, Central Ground Water Board Sept. 2013

ii. **Management of Municipal, Plastic, Hazardous, Bio-Medical & Electrical and Electronic Waste:**

The Local bodies are collecting segregated non bio degradable waste which is sent to the Goa Waste Management Corporation (GWMC) and subsequently transported to the baling station at Saligao. The baled non-biodegradable waste is thereafter transported to cement plants in Karnataka for co incineration.

The Corporation of City of Panjim is having its own composting facilities, however the same requires improvement and hence, the State Government is in process of establishing a bio digester facility of 100 tons / day at Bainguinim for treatment of bio degradable waste. The said bio-digester facility is expected to be completed in a period of one year. The non-biodegradable waste is baled in the sorting centre at St Inez and sent for co-incineration to cement plants at Karnataka.

Improvement in the house to house collection of segregated waste is required and necessary installation of transfer station for non-biodegradable waste would be completed within period of 6 months. Necessary direction for the same will be issued by the Directorate of Panchayat/ Directorate of Municipal Administration.



Image 8 Solid waste disposal along the river stretch

The State of Goa has identified site for construction of Common Biomedical waste at Kundaim Industrial Estate. The National Environmental Engineering Research Institute (NEERI, Nagpur) has conducted the EIA study. The study report has been submitted to the SEIAA /SEAC seeking Environmental Clearance for the facility. The facility expected to be commissioned and operation within next 18 months. In the meanwhile the

Healthcare facilities have their own treatment facilities such as Autoclave, Deep burial pit and encapsulation pit, needle burners etc.

There are no hospital waste observed along the stretch of the Mandovi. The Hospitals waste within the city of Panjim is managed by Panjim Corporation and Goa Waste Management Corporation, however for futuristic provision the state Govt. is taking appropriate action in order to avoid further pollution due to hospital waste management. However the Goa Waste Management has proposed to develop the Bio-Medical waste treatment facility in the State and expected to be completed in next 18 months.



Image 9 Solid waste treatment facility at Salegaon (segregation Belt)

The Goa Waste Management Corporation and Producer Responsibility organisation are collecting the E-waste generated throughout the State and the E waste is there after transported to authorised recyclers in other states.

The solid waste generation from the Casino is been collected from the respective Casino and the non-biodegradable solid waste is handed over to the Panjim Municipal Corporation and the Biodegradable waste is transferred to the treatment unit by the Casino operators only. The waste collection, conveyance and treatment is monitored by the GSPCB and Captain of Port. The observation report of the Committee is enclosed as **Annexure-1.**

5. Greenery Development- Plantation Plan:

Mangrove cover is observed in 900 hectares along both the banks of the River (2001) as per the NIO study¹¹. It was also observed during the Physical survey that there are extensive Mangroves, coconut, orchards, and other local species along both the bank of the River and surrounding areas in the polluted stretch between Volvoi to Marcel and also along the stretch between Panjim to Marcel.



Image 10 Orchard & Coconut Tree along the Bank of Mandovi River.

The flora and fauna along the Mandovi river stretch of Goa is moderately rich in biodiversity and 5 Sq. Km. of Mangroves. Most of the forests in the state are located in the interior eastern regions.

From the above statistics, it is observed that the 29% of the Forest area is located in North Goa District, where most of the Mandovi river basin is located¹². As regards with the Mandovi river basin, the Govt. Forest within in Mandovi river basin is about 279 Sq. Km. The vegetation patterns in Mandovi river basin comprises of ;

- Estuarine vegetation consisting of mangrove along the banks of the Mandovi River.
- Strand vegetation along the coastal belts
- Plateau vegetation confirmed to the low altitudes.
- Semi-evergreen and evergreen forest limited to patches along high altitudes of the Ghats in Sahyadri hillock.

¹¹ NIO studies ICZM July 2013. P. No. 33 & P. N. 44.

¹² Master Plan for Mandovi River Basin Vol. I, P. N.17 & 18.

Mangroves play an important role in the economics of the local people and constitute a reservoir for recreational fisheries and provides many other direct and indirect services. The total extent of Khanzan land in the state is 18500 Ha out of which 14500 Ha is under agriculture and pisciculture. The Mangroves are found mostly in fallow lands mostly located along the Mandovi and Zuari river Cumbarjua canal¹³.

6. Ecological / Environmental Flow (E-Flow):

i) Issues relating to E- Flow:

The saline stretch of the river is 36 Kms from the mouth of the sea near Panjim till Sanquelim- Usgaon Bridge. The Polluted stretch of 9 Kms from Volvoi to Marcel & Marcel to Panjim stretch of 20 Kms of the Mandovi, is under the influence of tides and there is no issue of E-flow. The Mhadei Water Dispute tribunal has passed an award on 14th August 2018 in which the State of Karnataka have been directed to ensure sufficient flows in order to maintain the E-flow in the Mhadei River basin.

The Mhadei Water Dispute tribunal has passed an award on 14th August 2018 in which the State of Karnataka have been directed to insure sufficient flows in order to maintain the E-flow in the River Khandepar basin in Goa State. Further the water of 50 MLD is release from Salaulim dam to Kale during the lean season to maintain the E-flow throughout the year. The state WRD is also maintaining the E-flow during summer season by pumping the water from the mining pits along the Khandepar river bank. The WRD is also pumping 40 MLD water from Ganje to Opa during summer in Khandepar River which ultimately discharges into Mandovi River at Khandepar.

¹³ Master Plan for Mandovi river by the Panel of Experts May 1999 P. N. 18 (Vol. I).



Image 11 Coconut, Cashew and Indigenous species Plantation along Mandovi River

ii) Irrigation practices:

The entire polluted stretch of the river Mandovi is in saline zone / tidal affected and water from River not used for irrigation purpose. The irrigation water demand is been fulfilled from the Barrages on the tributaries.

Action Plan Strategies:

The action plan strategies based on the sampling analysis of the GSPCB, site survey and observations are listed below. These strategies are classified on the basis of the existing proposal in place, recommended up gradation in order to achieve the desired objective on short term and long term basis.

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
1.	<p>Disconnection of direct discharges of domestic sewage into the Mandovi. River/storm water drains/ nallah.</p> <ul style="list-style-type: none"> ➤ Disconnection of the direct discharge into the river or through storm water drain/ Nallah. ➤ Construction of septic tank and soak pits by residential houses and monitoring the frequent cleaning the septic tanks in order to avoid untreated domestic sewage discharge in to the natural drains. ➤ Initiating action under the Water act including levying of fines for commercial establishment under Pollutant pay principal. (within 1 month) 	<p>Panjim to Volvoi</p> <p>a) Betqui-Candola</p> <p>b) Marcem - Tivrem- Orgao</p> <p>c) Amona</p> <p>d) Navelim</p> <p>e) Candola, Volvoi</p> <p>f) Panchayat St. Estevam</p> <p>g) Se-old Goa.</p> <p>h) Salvador- Do - Mundo</p> <p>i) Penha de France</p> <p>j) Reis Magos</p> <p>k) Panchayat Nerul</p>	<p>Directorate of Panchayat, Directorate of Health Services;</p>	<p>6 months</p> <p>1 month</p>

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
2.	<p>a) Improvement to collection system, and ensuring collection of segregated waste.</p> <p>b) Installation of Bio-digester having capacity 100 TPD at Bainguinim by the Goa Waste Management Corporation.</p>	<p>a) Betqui-Candola</p> <p>b) Marcem - Tivrem- Orgao</p> <p>c) Amona</p> <p>d) Navelim</p> <p>e) Candola, Volvoi</p> <p>f) Panchayat St. Estevam</p> <p>g) Se-old Goa.</p> <p>h) Salvador-Do-Mundo</p> <p>i) Penha-De-France</p> <p>j) Reis Magos</p> <p>k) Panchayat Nerul</p>	<p>Respective Village Panchayat and Directorate of Panchayat</p>	6 months
3.	Providing toilet facility and sanitation facility for fishing Jetty at IFFI, Volvoi & Marcem	<p>a) IFFI</p> <p>b) Volvoi</p> <p>c) Marcel</p>	<p>Captain of Port & SIDCGL</p>	12 months
4.	Existing 8 toilets, 7 Bath rooms, 7 urinals at the fisheries complex Malim Betim, Goa managed by Sulabh International Social Service Organization Porvorim Goa. The 20 seated toilet block is proposed along the waste water treatment plant of 40 KLD. The work is been carried out through Goa	<p>a) Fishing Jetty at Malim</p>	<p>Dept. of Fisheries</p>	12 months

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
	State Infrastructure Development Corporation.			
5.	The up gradation of Sewage Treatment Plant at Patto Plaza at Panjim is under progress by PWD, Goa and expected to be completed in one year.	STP at Patto, Panjim.	PWD, Goa	18 months
6.	The State of Goa has identified site for construction of Common Biomedical waste at Kundaim Industrial Estate. The National Environmental Engineering Research Institute (NEERI, Nagpur) has conducted the EIA study. The study report has been submitted to the SEIAA /SEAC seeking Environmental Clearance for the facility. The facility expected to be commissioned and operation within next 18 months. In the meanwhile the Healthcare facilities have their own treatment facilities such as Autoclave, Deep burial pit and encapsulation pit, needle burners etc.	The Common Bio-medical waste treatment facility at Kundaim will treat all the Bio-medical waste generated in the State of Goa.	Goa Waste Management Corporation	18 months
7.	The Goa Waste Management Corporation and Producer Responsibility organization are collecting the E-waste generated throughout the State and the E waste is there after transported to authorized recyclers in other states.	The complete State of Goa	Goa Waste Management Corporation	Ongoing

7.1. Conclusion & Remark:

- i) The stretch of River Mandovi from Volvoi to Marcel as **Priority IV and classified as SW-II**. The parameters such as DO and BOD are well within the CPCB prescribed standards. The only cause of concern is high levels of Fecal Coliform which is mostly due to the discharge of untreated domestic sewage through nallah, storm water drains including direct discharge from residential houses into the River. The Village Panchayat will take

appropriate action in order to stop the discharge from the houses. Action against commercial establishment as per GSPCB report will be initiated by the Village Panchayat & Director of Health.

- ii) Providing toilet facility and sanitation facility for Fishing jetty IFFI, Volvoi & Marcem Jetty. Existing 13 seated toilet cum bath managed Sulabh International Social Service Organization, Porvorim Goa at the complex. The facility is been implemented by Captain of Port and expected to be completed in next 12 months.
- iii) Existing 8 toilets, 7 Bath rooms, 7 urinals at the fisheries complex Malim Betim, Goa managed by Sulabh International Social Service Organization Porvorim Goa. The 20 seated toilet block is proposed along the waste water treatment plant of 40 KLD. The work is been carried out through Goa State Infrastructure Development Corporation.
- iv) The central Ground Water Board has carried out survey of Aquifer System in the State of Goa in Sept. 2013. After studying the aquifer report, it is observed that the ground water table along the Mandovi river stretch is 2 m to 5 m below the ground level during Post monsoon season. The water table lowers down in summer by 2 to 5 M. As the ground water table is high within the Mandovi river basin, there are no such actions proposed for improvement of the ground water table.
- v) The Polluted stretch of 9 Kms of the Mandovi River from Valvoi to Marcela, and from Marcel to Panjim of 20 Kms is under the influence of tides and hence there is no issue of E-flow.
- vi) The action plan strategies have been elaborated above and will be implemented by concerned stake holder departments/ corporations by taking necessary action for disconnection of direct discharges of domestic sewage and improvement in the collection and storage of the Solid Waste in the concerned Panchayat. The GWMC will expand their SWM facility at Saligao from 125 tons per day to 250 + 20 % (300 tons/ day) within a year.
- vii) The implementation and execution of the proposed action plan will be monitored by the River Rejuvenation Committee constituted by the order of the Hon'ble National Green Tribunal.

Annexure 1 Inspection Report on Casino in Mandovi River by GSPCB

The GSPCB has formed the Monitoring committee vide application no. 228/2013 as compliance with the directives of NGT. The Inspection report prepared by the Members of Monitoring Committee GSPCB of the Casino operating on the Mandovi River was studied for the period of Oct. 2014 till Oct. 2018. The Monitoring committee is conducting the Inspection in the month of March, July & Oct (i.e. Pre- Monsoon, Monsoon & Post Monsoon) in each year. The observations recorded and the action taken as per the report analysed for the month of Oct. 2018 are mentioned in the table below.

Sr. No.	Name of the Casino	Daily Water consumption and Waste generation	Sewage Storage Tank capacity	Treatment, End Use / Ultimate discharge	Solid waste generation	Solid Waste status	Remark
1.	Golden Peace Infrastructure Pvt. Ltd. (M.V. Boa Sorte)	9.98 KLPD 6.94 KLPD	42.77 M ³ (as per Oct. 2014 Reports)	The night soil is transferred to PWD STP at Tonca Panjim.	Wet waste- 73.99 Kg/Day Dry waste- 58.85 Kg/Day	Wet Waste- Transported to Hotel Neo Majestic Disposed to Panjim Corporation	Monitoring of the discharge of the waste water in Night Soil tankers & Solid waste disposal in presence of GSPCB & COP.
2.	Goa Coastal Resorts & Receptions Pvt.	11.92 KLPD 7.68 KLPD	85.90 M ³ (as per Oct. 2014 Reports)	The night soil is transferred to	Wet waste- 74.77 Kg/Day	Wet Waste- Transported to Hotel Neo Majestic	Monitoring of the discharge of the waste water in Night Soil

Sr. No.	Name of the Casino	Daily Water consumption and Waste generation	Sewage Storage Tank capacity	Treatment, End Use / Ultimate discharge	Solid waste generation	Solid Waste status	Remark
	Ltd. (M.V. Pride of Goa)			PWD STP at Tonca Panjim.	Dry waste- 59.40Kg/Day	Disposed to Panjim Corporation	tankers & Solid waste disposal in presence of GSPCB & COP.
3.	High Street Cruises and Entertainment Pvt. Ltd. (M.V. Casino Royale)	10.54 KLPD 5.99 KLPD	80.00 M ³ (as per Oct. 2014 Reports)	The night soil is transferred to PWD STP at Tonca Panjim.	Wet waste- 191.31 Kg/Day Dry waste- 63.06 kg/Day	Composting facility at Reis Magos, Verem Disposed to Panjim Corporation	Monitoring of the discharge of the waste water in Night Soil tankers & Solid waste disposal in presence of GSPCB & COP.
4.	Delta Corp. Limited / Victor Hotels and Motels Limited. (M. V. Horse Shoe, Deltin Royale)	24.63 KLPD 17.22 KLPD	69.40 M ³ (as per Oct. 2014 Reports)	The night soil is transferred to PWD STP at Tonca Panjim	Wet waste- 215.39 Kg/Day Dry waste- 87.38 kg/Day	Composting facility at Reis Magos, Verem Disposed to Panjim Corporation	Monitoring of the discharge of the waste water in Night Soil tankers & Solid waste disposal in presence of GSPCB & COP.
5.		2.82 KLPD	–	The night soil is transferred to	Wet waste- 232.12 Kg/Day	–	Monitoring of the discharge of the waste

Sr. No.	Name of the Casino	Daily Water consumption and Waste generation	Sewage Storage Tank capacity	Treatment, End Use / Ultimate discharge	Solid waste generation	Solid Waste status	Remark
	Creative Gaming Solutions Pvt. Ltd. (M.V. San Domino)	1.47 KLPD		PWD STP at Tonca Panjim	Dry waste- 194.96 kg/Day	Disposed to Panjim Corporation	water in Night Soil tankers & Solid waste disposal in presence of GSPCB & COP.
6.	High Street Cruises and Entertainment Pvt. Ltd. (M.V. Royal Flotel)	6.19 KLPD 3.55 KLPD	–	The night soil is transferred to PWD STP at Tonca Panjim	Wet waste- 17.08 Kg/Day Dry waste- 9.93 kg/Day	Composting facility at Reis Magos, Verem Disposed to Panjim Corporation	Monitoring of the discharge of the waste water in Night Soil tankers & Solid waste disposal in presence of GSPCB & COP.

Annexure 2 Summary of the ICZM study report of NIO July 2013

The results for the Water Quality Monitoring as a part of the ICZM study report¹⁴ of NIO commissioned by Department of Science Technology and Environment of Goa dated July 2013 in respect of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Faecal Coliform are as listed below

a) Dissolved Oxygen (DO)

- **Monsoon:** In Mandovi River, the water is well oxygenated at most of the stations except at mouth and near mouth station, which shows low DO in their bottom water layers. The DO shows a variation from 0.81 to 8.09 mg/l, with an average of 5.43 mg/l. Except for one localised low value of DO (0.81 mg / l) in the bottom layer at stn. M1, higher values of DO are observed in the surface layer relative to bottom water layer at all the stations and are due to more dissolution of atmospheric oxygen due to its direct contact with the surface layer. During low tide, DO shows a range of variation from 1.9 to 8.10 mg/l, with an average of 5.41 mg/l. Higher values of DO are observed in the surface layer relative to bottom water layer and is due to more dissolution of atmospheric oxygen due to its direct contact with the surface layer. Except for one station (M5) in the upstream which shows low DO of 1.9 mg/l in the bottom layer, all the observed DO values are normal. These DO values overall indicate well oxygenated water.
- **Post-monsoon:** The Mandovi River water shows well oxygenated water, with all the stations showing DO values above 5 mg / l during this season. During the high tide, a DO variation of 5.44 to 7.42 mg/l, is observed, with an average of 6.54 mg / l. Distinct high values of DO are observed in the surface layer relative to bottom water layer and are due to more dissolution of atmospheric oxygen due to its direct contact with the surface layer and due to low salinity in the surface water layer. Spatially, the DO shows an increase towards upstream. All the observed DO values are normal and indicate well oxygenated water. During low tide, the Mandovi River water shows well oxygenated water, with all the stations showing DO values above 5 mg/l. The observed DO variation is from 5.24 to 8.84 mg / l, with an average of 6.69 mg / l, with higher DO values in the surface layer relative to bottom water layer. Spatially, the DO shows an increase towards upstream stations. All the observed DO values are normal and indicate well oxygenated water.

¹⁴ NIO studies ICZM July 2013. P. No. 33 & P. N. 188.

- **Pre-monsoon:** The Mandovi River water shows well oxygenated water, with all the stations showing DO values above 6 mg/l during this season. During the high tide, a DO variation of 6.15 to 9.57 mg/l, is observed, with an average of 6.92 mg/l. The distribution showed low values of DO in the sub-surface layer relative to surface water layer. Spatially, the DO shows nearly consistent values from near mouth towards upstream. All the observed DO values are normal and indicate well oxygenated water. During low tide, the Mandovi River water shows well oxygenated water, with all the stations showing DO values above 4.5 mg/l. The observed DO variation is from 4.64 to 8.81 mg/l, with an average of 6.57 mg/l, with largely higher DO values in the surface layer relative to bottom water layer. Spatially, the DO shows an increase towards upstream stations. All the observed DO values are normal and indicate well oxygenated water.

b) Biochemical Oxygen Demand (BOD)

- **Monsoon:** The BOD in Mandovi River water shows low values during high and low tide. During high tide, the BOD values range from 0.52 to 1.51 mg/l, with an average of 0.98 mg/l. The vertical distribution shows distinct higher values of the range in surface layer relative to bottom water layer indicating external additions. Whereas, the spatial distribution shows increases in BOD in the estuarine and in the upstream regions. During low tide, the BOD shows slightly higher values and vary from 0.21 to 3.08 mg/l with an average of 1.59 mg/l. The vertical distribution shows alternate increase and a decrease in BOD values in surface indicating external additions. Similarly, the spatial distribution shows increases in BOD values towards upstream. The observed BOD values indicate some organic matter addition to Mandovi River mostly from upstream regions during low tide.
- **Post-monsoon:** The BOD values range from 0.38 to 2.97 mg/l, with an average of 1.13 mg/l during the high tide. The surface layer indicates high values of BOD and low values in the bottom layer, indicating external input of BOD. This input is more in the estuarine region as compared to the upstream region. During low tide, the BOD values show a slight increase and range from 0.41 to 3.31 mg / l with an average of 1.49 mg/l. The vertical distribution shows higher values in surface relative to bottom, increasing towards upstream. This indicates the localised input of BOD in the estuarine and in the upstream region. The observed BOD values are within acceptable limits.

- **Pre-monsoon:** The BOD values range from 1.48 to 5.74 mg/l, with an average of 2.77mg/l during the high tide. The surface layer indicates distinct high values of BOD and low values in the bottom layer, indicating external input of BOD. This input is more in the estuarine region as compared to the upstream region. During low tide, the BOD values show a slight increase and range from 0.76 to 5.82 mg/l with an average of 3.03 mg/l. The vertical distribution shows alternate increase and a decrease, but largely shows lower values in surface, relative to bottom, increasing towards upstream. This indicates the localised input of BOD in the estuarine and in the upstream region. The observed BOD values are slightly higher.

c) Salinity

- **Monsoon:** Salinity is an indicator of the influence of freshwater / precipitation or evaporation in water bodies. During high tide, the salinity in Mandovi River water varies from 0.49 to 29.76 PSU with an average of 10.82 PSU, with high salinity in bottom and low in the surface. The salinity shows a distinct decrease from the estuarine mouth towards the mid of the estuary and thereafter a significant decrease is observed till upstream. During coastal incursion at high tide, the sea/saline water being denser remains at the bottom and the continually out flowing riverine water being lighter remains above, giving rise to high salinity at bottom and low salinity at surface. The observed feature thus indicates the influence of tidally incursed coastal water. During low tide, the salinity in river water varies from 0.11 to 29.26 PSU with an average of 12.52 PSU, with distinct low salinity at surface and high salinity at the bottom. The salinity shows a distinct decrease from the estuarine towards the upstream of the estuary, with a significant decrease in salinity at stations in the upstream. The riverine water being lighter, remains at the surface and during its transport to the coastal sea during the low tide, it mixes with the high salinity water down below, showing higher salinity at bottom and much lower at the surface as compared to that observed during the high tide. Thus, the lower salinity observed in the surface layer is due to the increased fresh water flow from upstream. The observed variation is normal.
- **Post-monsoon:** Salinity in Mandovi River water shows wide variation and varies from 0.12 PSU in upstream station to 34.04 PSU at the mouth station, with an average of 16.68 PSU during the high tide. The salinity shows distinct low values in surface and high values in bottom with a decrease from the estuarine mouth towards the upstream of the estuary. The coastal incursed high saline waters being denser remain at the bottom. This indicates the influence of tidally incursed coastal water during the high tide.

During low tide, the salinity in Mandovi River water varies from 0.09 to 33.57 PSU, with an average of 17.29 PSU. The vertical distribution shows low values of salinity in surface and high values in bottom whereas the spatial distribution shows a decrease in salinity from mouth towards upstream. The observed salinity variation is normal and is acceptable.

- **Pre-monsoon:** Salinity in Mandovi River water shows wide variation and varies from 18.56 PSU in upstream station to 33.20 PSU at the mouth station, with an average of 26.52 PSU during the high tide. The salinity shows distinct low values in surface and high values in bottom with a decrease from the estuarine mouth towards the upstream of the estuary. The high saline waters of the incoming tide being denser remain at the bottom. This indicates the influence of tidally incursed coastal water during the high tide. During low tide, the salinity in Mandovi River water varies from 17.94 to 35.20 PSU, with an average of 28.16 PSU. The vertical distribution shows low values of salinity in surface and high values in bottom whereas the spatial distribution shows a decrease in salinity from mouth towards upstream. The observed salinity variation is normal and is acceptable.

d) Faecal Coliform

- **Monsoon:** The FC varies from 0.00 to 310, with an average of 116.67, during the high tide. The vertical distribution largely shows higher values in surface at the mouth and estuarine stations, and a reverse trend in the upstream. The spatial distribution shows as decrease in FC in upstream. During low tide, the FC increases very much and varies from 0.00 to 5560, with an average of 774.0. The spatial distribution shows higher values at surface and lower at the bottom layer at the mouth and near mouth stations and a reverse trend at rest of the stations. The increase in FC is mostly observed at the near mouth and in mid estuarine region, indicating a polluting source. The values indicate some kind of polluting source.
- **Post- Monsoon:** The FC varies from 0.00 to 860, with an average of 132.50, during the high tide. There is no fixed trend of its vertical variation, as some stations show low values in surface while others show a reverse trend. Apparently, the spatial distribution shows increasing values from mouth towards mid estuarine region decreasing further in the upstream. During low tide, the FC decreases very much and varies from 0.00 to 768, with an average of 138.17. The spatial distribution shows nearly a similar pattern as that

of the high tide, wherein the FC remains higher in the mid estuarine region with decreasing values towards the upstream.

- **Pre- Monsoon:** The FC during this season remains low and varies from 2.0 to 21, with an average of 10.30, during the high tide. There is no fixed trend of its vertical variation, as some stations show low values in surface while others show a reverse trend. Apparently, the spatial distribution shows higher values in the estuarine region and lower values at the mouth and at the upstream. During low tide, the FC shows a slight increase and varies from 2 to 128, with an average of 27.58. The spatial distribution do not show a fixed trend of its vertical variation, as some stations show low values in surface while others show a reverse, whereas the spatial variation shows higher values in the mid estuarine station and at the upstream.

Annexure 3 NWMP Monitoring reports carried out on 1st March 2019.

The GSPCB has carried out water sampling in the month of March 2019 and results of the same are enclosed in the table below.

Table 8 Summary of NWMP monitoring carried out on 1st March 2019.

Sr. No.	Parameters	Surface towards downstream side	Mid	Surface towards upstream side	CPCB Limit (for SW II river)
Tonca Marcel					
1.	DO (mg/l)	6.2	6.3	6.3	4 mg/l or less
2.	BOD (mg/l)	1.0	1.1	1.6	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	78	4.5	45	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Amona Bridge					
1.	DO (mg/l)	6.6	6.4	6.0	4 mg/l or less
2.	BOD (mg/l)	1.6	1.2	1.1	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	110	45	20	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Raibandar Jetty					
1.	DO (mg/l)	6.4	6.9	5.8	4 mg/l or less
2.	BOD (mg/l)	1.9	1.1	1.4	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	4.5	23	130	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Mandovi Bridge					
1.	DO (mg/l)	6.2	7.2	6.2	4 mg/l or less
2.	BOD (mg/l)	0.6	1.8	0.6	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	78	23	130	100 or less MPN/100 ml

Sr. No.	Parameters	Surface towards downstream side	Mid	Surface towards upstream side	CPCB Limit (for SW II river)
4.	E- Coli	Present	Present	Present	Absent
IFFI Jetty					
1.	DO (mg/l)	7.0	6.4	6.4	4 mg/l or less
2.	BOD (mg/l)	1.8	1.3	1.4	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	45	110	700	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Hotel Marriott					
1.	DO (mg/l)	6.4	6.4	6.3	4 mg/l or less
2.	BOD (mg/l)	1.0	1.8	1.4	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	20	130	330	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent

The monitoring was carried out on 1st March at 6 locations along the Mandovi River. The reports of the NWMP at all the monitoring stations in Mandovi River indicates the good DO levels at all the locations in the entire stretch. The BOD levels are also well within prescribed limit at all the locations in the entire stretch. Only the Faecal coliforms levels between IFFI Jetty and Hotel Marriott are exceeding the desire limits (above 100 MPN/100mml as per new orde), while comparing with the previous monitoring report (NWMP- Dec. 2018) it shows the values of the faecal coliform and BOD has been reduced drastically. The values of FC are well within the desired limit for the polluted stretch at Tonca Marcel, Amona Bridge, Raibandar Jetty and Mandovi Bridge.

Annexure 4 NWMP Monitoring reports carried out on 19th March 2019.

The GSPCB has carried out water sampling in the month of March 2019 and results of the same are enclosed in the table below.

Table 9 Summary of NWMP monitoring carried out on 19th March 2019.

Sr. No.	Parameters	Surface towards downstream side	Mid	Surface towards upstream side	CPCB Limit (for SW II river)
Tonca Marcel					
1.	DO (mg/l)	5.9	5.9	5.8	4 mg/l or less
2.	BOD (mg/l)	1.0	1.5	1.6	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	110	78	20	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Amona Bridge					
1.	DO (mg/l)	7.3	7.0	6.8	4 mg/l or less
2.	BOD (mg/l)	1.6	1.1	1.2	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	130	78	20	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Raibandar Jetty					
1.	DO (mg/l)	5.4	5.7	5.3	4 mg/l or less
2.	BOD (mg/l)	0.3	0.8	0.4	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	45	45	20	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Mandovi Bridge					
1.	DO (mg/l)	5.7	5.7	5.6	4 mg/l or less
2.	BOD (mg/l)	0.9	0.9	0.8	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	170	110	78	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent

Sr. No.	Parameters	Surface towards downstream side	Mid	Surface towards upstream side	CPCB Limit (for SW II river)
IFFI Jetty					
1.	DO (mg/l)	5.8	5.9	5.0	4 mg/l or less
2.	BOD (mg/l)	1.2	0.7	0.5	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	20	4.5	20	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent
Hotel Marriott					
1.	DO (mg/l)	5.7	6.3	5.8	4 mg/l or less
2.	BOD (mg/l)	1.6	1.4	1.1	3 mg/l or less
3.	Faecal Coliform (MPN/100ml)	40	45	4	100 or less MPN/100 ml
4.	E- Coli	Present	Present	Present	Absent

The monitoring was carried out on 19th March 2019 at 6 locations along the Mandovi River. The reports of the NWMP at all the monitoring stations in Mandovi River indicates the good DO levels at all the locations in the entire stretch. The BOD levels are also well within prescribed limit at all the locations in the entire stretch. Only the Faecal coliforms levels between IFFI Jetty and Hotel Marriott are exceeding the desire limits (above 100 MPN/100mml as per new order), while comparing with the previous monitoring report (NWMP- Dec. 2018) it shows the values of the faecal coliform and BOD has been reduced drastically. The values of FC are well within the desired limit for the polluted stretch at Tonca Marcel, Amona Bridge, Raibandar Jetty and Mandovi Bridge.

Annexure 5 STP Parameters at Tonca from Dec. 2015 to April 2018

The GSPCB has conducted extensive monitoring of the STP's within the State. The periodic monitoring reports are enclosed herewith for STP at Tonca. The sampling was carried out at raw effluent inlet, after screen & grit chamber, after decanting unit & treated water storage tank were considered for analysis. The parameters like pH, Suspended solids (SS), Bio-Chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Sulphate, and Ammonical were tested. The parameters like pH, SS, BOD & COD are considered for analysis.

Table 10 Sampling results – STP Tonca for Dec. 2015.

Sr. No.	Treatment Unit	pH	SS (mg/l)	COD (mg/l)	BOD (mg/l)	Faecal Coliform (MPN/100ml)
1.	Raw domestic effluent at inlet	6.32	623.00	880.00	520.00	–
2.	After grit chamber	6.41	213.00	480.00	210.00	–
3.	After Oil & Grease chamber	6.49	250.00	520.00	240.00	–
4.	After Decanting Unit	6.71	6.00	20.00	7.00	–
5.	Final treated water (after chlorination)	7.10	5.00	20.00	7.00	Nil

Table 11 Sampling results – STP Tonca for April 2017.

Sr. No.	Treatment Unit	pH	SS (mg/l)	COD (mg/l)	BOD (mg/l)	Faecal Coliform (MPN/100ml)
1.	Raw domestic effluent at inlet	6.80	1038.00	800.00	538.00	–
2.	After grit chamber	6.96	230.00	540.00	441.00	–
3.	After Oil & Grease chamber	6.69	210.00	520.00	385.40	–
4.	After Decanting Unit	7.01	13.00	50.00	10.00	–
5.	Final treated water (after chlorination)	7.74	12.00	20.00	3.2.00	79.00

Table 12 Sampling results – STP Tonca for July 2017.

Sr. No.	Treatment Unit	pH	SS (mg/l)	COD (mg/l)	BOD (mg/l)	Faecal Coliform (MPN/100ml)
1.	Raw domestic effluent at inlet	6.22	130.00	540.00	189.00	–
2.	After grit chamber	6.59	32.00	280.00	67.00	–
3.	After Oil & Grease chamber	6.51	24.00	240.00	43.00	–
4.	After Decanting Unit	7.04	12.00	20.00	3.20	–
5.	Final treated water (after chlorination)	7.05	23.00	20.00	3.20	Nil

Table 13 Sampling results – STP Tonca for Oct 2017.

Sr. No.	Treatment Unit	pH	SS (mg/l)	COD (mg/l)	BOD (mg/l)	Faecal Coliform (MPN/100ml)
1.	Raw domestic effluent at inlet	6.64	160.00	480.00	100.00	–
2.	After grit chamber	6.84	84.00	300.00	94.00	–
3.	After Oil & Grease chamber	6.80	50.00	220.00	56.50	–
4.	After Decanting Unit	7.35	7.00	120.00	10.00	–
5.	Final treated water (after chlorination)	7.43	3.00	20.00	4.80	–

Table 14 Sampling results – STP Tonca for April 2018.

Sr. No.	Treatment Unit	pH	SS (mg/l)	COD (mg/l)	BOD (mg/l)	Faecal Coliform (MPN/100ml)
1.	Raw domestic effluent at inlet	6.75	585.00	840.00	600.00	–
2.	After grit chamber	6.65	510.00	820.00	600.00	–
3.	After Oil & Grease chamber	6.64	497.00	820.00	567.00	–
4.	After Decanting Unit	7.32	12.00	30.00	9.00	–
5.	Final treated water (after chlorination)	6.93	8.00	20.00	3.20	Nil

The parameters like Dissolved Oxygen and Mixed liquor Suspended solids were also considered for analysis after Aeration tank -1 & 2, the same are not considered for analysis in this report. The faecal is also considered for testing for the final discharge of the treated water. The above table indicates that the parameters like BOD, COD, SS & pH are well within the prescribed limit in the entire monitoring period as per CPCB standards. After analysing the above test results, the BOD, SS, COD & pH and the Faecal coliforms are well within the prescribed limit as per CPCB standards.

Annexure 6 GSPCB Observations Feb. 2019.

The Hon. Member Secretary Goa State Pollution Control Board has directed to carryout inspection along the bank of the river vide Office order No. 1 / 5 / 18-PCB / Vol. XXIV / Admin. /20191 dated 28/02/2019. The inspection was carried to locate the probable open discharge in the river thereby contributing to the water pollution at river Mandovi. The stretch from village Pomburpa to Nerul was inspected in first week March 2019.

Prior to the physical survey, the information regarding probable discharge sources was gathered from the respective Village Panchayat offices. At certain locations the representative from the V P accompanied the Inspection team. The observations of the monitoring team are enclosed herewith.

Name of the Village Panchayat	Observations	Villages
Village Panchayat Pomburpa - Olaulim	Direct discharge from the many houses located along the river discharging untreated domestic sewage directly in to the river. No commercial development observed in this area.	Poriyom, Palmar, Bherotim, Bhatan Waddo, Tarbandar Waddo, Hanuman Waddo, Halarn Waddo and Chodan Waddo.
Village Panchayat Salvador – do – Mundo	Direct discharge from the many houses located along the river discharging untreated domestic sewage directly in to the river. No commercial development observed in this area.	Badem Manas, Salay and Char Manas
Village Panchayat Penha- De-France	Direct discharge from the many houses located along the river discharging untreated domestic sewage directly in to the river. The commercial establishment are also discharging the untreated sewage directly into the sewage at	Char Manas, Matov Waddo, Bhosle Waddo, Virlosa & Malim.

Name of the Village Panchayat	Observations	Villages
	<p>the same it was also observe that the consent to operate from the Pollution Control Board is not in place.</p> <p>a) M/s. Casa Britona, Near Charmanos Badem, Britona, Penha de France, Bardez, Goa- Consent to operate is not in place.</p> <p>b) M/s. Golden Heritage (Temporary floating jetty), Malim, Penha de France, Bardez, Goa. - Consent to operate is not in place.</p> <p>c) The Marine Slipway & Jetty, Captain of Ports Department, Malim, Penha- De- France, Bardez, Goa. - Consent to operate is not in place.</p> <p>d) M/s. Mandovi Fishermen Marketing Co-op Society Ltd. c/o. Directorate of Fisheries, Malim jetty, Malim, Penha de France, Bardez, Goa. – The area around the jetty is utilised for selling of fish. It was observed that no toilets are provided in the jetty area. The workers from the boats were found to be urinating along the river bank and in the river bank. The urinal located behind the fuel dispensing station was</p>	

Name of the Village Panchayat	Observations	Villages
	<p>found to be having direct discharge in the river. The food and other waste from the boat is dumped in the river by the boat workers. Further the waste water generated from floor washing of unloading area containing waste fish etc. are directly let out in the river. The waste water and the waste from the selling platforms / areas are also directly let in the river.</p> <p>e) M/s. Sai Krupa Bar & Restaurant, Malim, Penha de France, Bardez, Goa. - The discharge was observed from the residential house. The unit was found to be operating without consent to Operate.</p> <p>f) M/s. Frankie's Family Restaurant, Malim, Penha de France, Bardez, Goa. - The unit is a restaurant and was found to be operating without consent to operate.</p>	
Village Panchayat Reis Magos	<p>Direct discharge of untreated domestic sewage directly in to the river is observed.</p> <p>The commercial establishment are also discharging the untreated sewage directly into the sewage at the same it was also observe that the</p>	Kegdevelim ward, Tuant Waddo, Sonar Bhat and Betim, Malim & Betim

Name of the Village Panchayat	Observations	Villages
	<p>consent to operate from the Pollution Control Board is not in place.</p> <p>a) M/s. Thaal – Bohra Cuisine, Kegdevelim, Near Reis Magos Fort, Verem, Bardez, Goa - The unit is a restaurant and was found to be operating without consent to operate.</p> <p>b) M/s. Babazin, Kegdevelim, Near Reis Magos Fort, Verem, Bardez, Goa - The unit is a restaurant and was found to be operating without consent to operate.</p> <p>c) M/s. Mandovi River Front, Betim, Reis Magos, Bardez, Goa – The restaurant and the guest house found to be operating without consent to operate.</p> <p>d) M/s. Navdurga Garage, Near Petrol Pump, Betim, Reis Magos, Bardez, Goa – The unit is Denting, painting unit and found to be operating without consent to operate.</p> <p>e) M/s. Cabo Cabana (Cottages), Near Terry's Supermarket, Betim, Reis Magos Bardez Goa – Waste water discharge is observed and unit is operating without consent to operate.</p>	
Village Panchayat Nerul	Residential development along the bank of the river at Maina Coco	

Name of the Village Panchayat	Observations	Villages
	<p>Beach are directly discharging in to the river.</p> <p>Commercial developments are observed and in operation without having consent to operate.</p> <p>a) M/s. Rohan Bar & Restaurant, Coco Beach, Nerul, Bardez, Goa – Operating without consent to operate.</p>	

During the physical survey it was observed that, domestic untreated sewage discharge from many houses and commercial development along the bank of the physical survey. Further the concerned VPs / PHCs may take appropriate action / steps so as to stop the discharge. The GSPCB shall check the applicability of the Consent to operate for the Restaurants, Painting Shops along the bank of the river as per Water and Air act provisions. The Fisheries Department shall make provisions of the toilet facility with treatment unit near Mandovi Fishermen Marketing Co-Op Society Ltd.

Annexure 7 EIA Reports for Development of Ferry Jetties.

The Environmental and Social impact assessment studies were conducted to provide coastal jetties on 3 declared National Waterways (NW) at 9 locations in the state of Goa.

Mandovi River	Mapusa River	Zuari River
Ribandar	Aldona	Rassaim
Old Goa		Durbhat
Pilgao		Shiroda
Banastraim		Sanvordem

The jetties are proposed to cater to passenger and tourist traffic. In addition to these, additional jetties for night parking at Aldona, Raibandar, Old Goa and Sanvordem; barge jetties at Pilgao and Shiroda for parking of empty barges, mooring Dolphin at Aldona for Ro-Ro Passenger boats, and a Coastal Police Jetty at Raibandar, are also proposed. The parking is also proposed at Aldona, Pilgao and Banastraim. The ground water table is observed