The River Rejuvenation Committee
Government of Goa

Name of the work: Preparation of Action Plan for Rejuvenation of Polluted Stretches of Rivers in Goa

Action Plan Report on Zuari River

March 2019

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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 litters per Day
NEERI	National Environmental Engineering Research Institute Nagpur
NGT	National Green Tribunal
NWMP	National Water Quality Monitoring Programme.
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 – NIO, D'paula, and Council of Scientific & Industrial Research July 2013.

Executive Summary

The Zuari River is the largest river in Goa and is having total length of 145 kilometres. The 42km stretch of this river is affected by tides and is in saline zone. The port city of Vasco da Gama lies at the mouth of Zuari River. This river originates at Hemad-Barshem in the Western Ghats and was earlier known as the Aghanashani in the interior regions of Goa. It flows in the southern-west direction through, Sanguem, Quepem, Ponda, Salcete, Tiswadi and Mormugao talukas and finally opens up into the Arabian Sea around the Mormugao harbour. It merges with the Talaulim stream at the town of Sanguem. It is in this town that the river widens and accepts waters from its tributary, Kushavati. Zuari basin extending from Netravali to Panjim covers an area of about 975 km2 and constitutes about 27 % of the total area of Goa. The basin has forest area of 31.4% and hosts Netravali Wildlife Sanctuary. It has two sub-basins formed by Kushavati and the Gulolil Sanguem rivers both, which have a north-westerly flow. The average runoff is 2247.4 MCM.

The Cumbarjua Canal links Zuari River with Mandovi River enabling the ships to navigate to the interior regions of iron ore mines. The Zuari River along with Mandovi forms the backbone of Goa's agricultural economy and these along with their tributaries traverse a major portion of the state. The Zuari and the Mandovi thus act as the lifelines of Goa, with their tributaries draining 69% of its geographic area. The waters of Mandovi and Zuari both flush out into the Arabian Sea at Cabo Aguada, a common point where Zuari meets the Mandovi River.

Image 1 Mormugao Harbour on Zuari River

The Goa State Pollution Control Board (GSPCB) monitors the water quality of River Zuari at three locations i. e. Panchawadi, Borim Bridge and Marcaim Jetty, The said monitoring is carried out on a monthly basis throughout the year under the Central Pollution Control Board Programme i.e. National Water Quality Monitoring Programme. This Stretch of the River Zuari from Curchorem to Marcaim Jetty as well as the tributary at Kumbarjua canal 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 Zuari River (from Stretch Curchorem to Madkai 28 km) under Priority V, having BOD level range between 3.2 -5.1 mg/lit. The Report of Monitoring for the period April 2015 to December, 2018 of GSPCB at three locations 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 Curchorem to Madkai as can be seen from the GSPCB monitoring reports and the two NIO reports are above the desired level of 4 mg/l required for bathing water quality. The observed BOD levels in the polluted river stretch between Curchorem to Madkai as can be seen from the GSPCB monitoring reports and the NIO report are below the desired level of 3 mg/l required for bathing water quality. The observed FC levels in the polluted river stretch between Curchorem to Madkai as can be seen from the GSPCB monitoring reports are above the desired levels of 500 MPN/ 100ML for bathing water quality. The reports of NIO of 2013 and 2018 also indicate pollutions source in the polluted stretch between Curchorem to Madkai in view of the presence of Faecal Coliform levels observed during these Studies.

The proposed action plan for Zuari 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. There are no industrial outfalls from Verna Industrial units, contributing to the pollution in this stretch.

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

- During the physical survey carried out during Jan / Feb. 2019, discharge of the domestic untreated sewage is observed from the areas like Marcaim, Adpai, Kaswada, Borim, Loutolim, Zamboli and Cortalim towns on the bank of the River.
- Discharge from individual house directly into the river and also into storm water drains / Nallahs leading to the river where observed on the Northern as well as Southern bank 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 drains / Nallahs.
    2. Installation of Bio-toilet.

3. Construction of septic tank and soak pits by residential houses.

- The fisheries Department jetty at Cortalim Ferry requires a toilet facility and it is proposed to install/ construct toilets in a period of one year at estimated cost of Rs. 20 lakhs.

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 domestic / Agricultural industries particularly over exploded and critical zones:

a) The ground water table in the region is 2 to 5 MBGL in post monsoon and lower downs by 2- 4m from pre-monsoon ground water table in post monsoon. The decadal variation in the ground table is about 2 – 5 MBGL[1].

b) All portion of the river stretch is in saline zone / tidal affected and not used for irrigation purpose.

C. Flood Plane Zone:

i. Regulating activity in flood plain zone: During the physical survey, it is observed that, no measures are required to regulate activity in flood plain zone

ii. Management of Municipal, Plastic, Hazardous, Bio-Medical & Electrical and Electronic Waste: The Local bodies are collecting segregated non-biodegradable waste which is sent to the Goa Waste Management Corporation and subsequently transported to the bailing station at Verna. The bailed non-biodegradable waste is thereafter transported to cement plants in Karnataka for co incineration. The Goa Waste Management Corporation is in the process of establishing a Solid Waste Management Facility at Curchorem of 100 tons per day capacity which is expected to be completed in 18 months. The remediation of legacy waste at the proposed site for the Solid Waste Management Facility at Curchorem is in progress and is expected to be completed in next one month.

iii. Sanitation and solid waste management facility shall be improved on jetty /ferry jetty: The toilets will be installed/ constructed at Cortalim fishing jetty, to treat domestic sewage from jetty workers in next six months.

[1] Aquifer System of Goa by Central Ground Water Board Sept. 2013

iv. **Greenery Development – Plantation Plan:** Entire identified polluted stretch of 28 km of the Zuari River is under salinity zone wherein the Mangrove cover is observed in total area of 467 Ha[2].

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

i. **Issues relating to E- Flow:** The Polluted stretch of the Zuari River is having length of 28 Kms from Curchorem to Madkai and is in Saline zone from the Marcaim Jetty (i.e. till Sanguem junction point app). There is no issue of E-Flow in the 28 km saline stretch of river Zuari.

ii. **Irrigation practices:** The entire portion of the river is in saline zone / tidal affected and not used for irrigation purpose.

Action Plan Strategies:

The action plan strategies based on the sampling analysis of the GSPCB and observation made in the NIO reports of 2013 and 2018, 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.	Disconnection of direct discharges of domestic sewage into the Zuari River/storm water drains/ Nallahs. 1. Disconnection of the direct discharge into the river/storm water drains/Nallahs. 2. Installation of Bio-toilet. 3. Construction of septic tank and soak pits by residential houses.	Curchorem to Madkai	Directorate of Panchayat and Directorate of Health	6 months

[2] ICZM studies for Goa, National institute of Oceanography July 2013 P. N. 44.

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
2.	Improvement and up gradation of the existing Solid Waste Management Facility including collection system and erection of material recovery facilities / storage shed for non-biodegradable waste in the village panchayat areas along the banks of Zuari River. Establishment of toilets at Fishing Jetty at Cortalim in one year. Establishment of SWM facility at Curchorem of 100 tpd capacity within 18 months at cost of Rs 190 Cr. This will cater to Quepem, Sanguem, and Dharbandora talukas.	a) Savordem b) Panchwadi c) Shiroda d) Borim e) Wadi – talaulim f) Durbhat g) Bandora h) Marcaim i) Neura j) St. Lawrence(Agasaim) k) St. Andre (Velha) l) Siridao – pale m) Curchorem – kakora n) Macasona o) Curtorim p) Rachol Lotolium q) Cortalim – Quelosim r) Sancoal	Respective Village Panchayat and Directorate of Panchayat	12 months
3.	Toilets facility for Fishing Jetty at Cortalim		Department of Fisheries	6 months
4.	The underground sewerage scheme in progress for Ponda municipal area including Curti, Bandora, Kavelem, Undir and area close to Kapleshwari nallah which further joins the Zuari River. Three STP's are proposed at Curti, Kavelem and Bandora of capacity 8MLD, 15MLD and 15MLD respectively. At present 70% sewerage		SIDCGL	12 months

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
	network is laid and 15MLD STP at Kavelem is in progress. Sewerage scheme with 1MLD STP is commissioned for Durbhat village which is on the bank on River Zuari. This STP was commissioned in September 2017 and is running successfully. The total cost of all the projects mentioned above is 536 cr.			
5.	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.		Goa Waste Management corporation	18 months
6.	The Goa Waste Management Corporation and Producer Responsibility organisation are collecting the E-waste generated		Goa Waste Management Corporation	ongoing

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
	throughout the State and the E waste is there after transported to authorised recyclers in other states.			

Introduction:

The Zuari River is the largest river in Goa and is a tidal river with a total length of 145 kilometres of which 42 kms is in Saline Zone. The port city of Vasco da Gama lies at the mouth of Zuari River. This river originates at Hemad-Barshem in the Western Ghats and is referred to as the Aghanashani in the interior regions of Goa. It flows in the southern-west direction through Tiswadi, Ponda, Mormugao, Salcete, Sanguem and Quepem talukas and finally opens up into the Arabian Sea around the Mormugao harbour. It merges with the Talaulim stream at the town of Sanguem. It is in this town that the river widens and accepts waters from its tributary, Kushavati.

The Cumbarjua Canal links Zuari River with Mandovi River enabling the ships to navigate to the interior regions of iron ore mines. The Zuari River along with Mandovi forms the backbone of Goa's agricultural economy and these along with their tributaries traverse a major portion of the state. The Zuari and the Mandovi thus act as the lifelines of Goa, with their tributaries draining 69% of its geographic area. The waters of Mandovi and Zuari both flush out into the Arabian Sea at Cabo Aguada, a common point where Zuari meets the Mandovi River. The total basin area of River Zuari 973 Sq. km with average runoff of 2247.4 MCM[3].

Image 2 Mormugao Harbour on Zuari River

[3] ICZM studies for Goa, National institute of Oceanography July 2013 P. N. 237.

Image 3 Kumbarjua Canal on Zuari River.

Zuari River provides a good fishing area which provides the supports the fishermen of their livelihood. The banks Zuari River are covered with mangrove tree ad are a perfect destination for adventure lovers. Crocodiles inhabit the swampy and marshy area which can be easily spotted while making river cruises in Kumbarjua canal.. The lush green vegetation growing along the river bank serves as the home to many local birds and other tiny creatures.

The Goa State Pollution Control Board (GSPCB) monitors the water quality on a monthly basis throughout the year on all the rivers in the state including Zuari River under the Central Pollution control board (CPCB) programme. On the basis of GSPCB reports, Central pollution control Board has classified Zuari River (in between Curchorem to Madkai) under priority V, having the BOD level ranges between 3.2 to 5.1 mg/l.

a) Objectives:

The Hon'ble National Green Tribunal in the Original Application No 673 of 2018 in its Order dated 20th September, 2018 directed the State Governments to prepare and Action Plan within two months for bringing all the polluted river stretches to be fit at least for bathing purposes (i.e. BOD < 3 mg/L and FC < 500 MPN/100 ml) 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 EETP'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 State has constituted the River rejuvenation Committee (RRC), under the Chairmanship of The Secretary Environment, with Director, Department of Environment, The Director Urban Development, Director Industries and The Member Secretary of GSPCB. The Chief Engineer, WRD Goa, The Directorate of Health services. The Managing Director SIDCGL have been co-opted as other members of the committee. Accordingly the said report has been prepared based on the Hindan river action plan.

1. Brief about Zuari River:

1.1. River Zuari:

The Zuari River is the largest river in Goa and is a tidal river with a total length of 145 kilometres. The port city of Vasco da Gama lies at the mouth of Zuari River. This river originates at Hemad-Barshem in the Western Ghats and is referred to as the Aghanashani in the interior regions of Goa. It flows in the southern-west direction through Tiswadi, Ponda, Mormugao, Salcete, Sanguem and Quepem talukas and finally opens up into the Arabian Sea around the Mormugao harbour. It merges with the Talaulim stream at the town of Sanguem. It is in this town that the river widens and accepts waters from its tributary, Kushavati.

The Length of the River Zuari in Salinity zone is 28 km from Curchorem to Madkai.

Map 1 Map showing Polluted Stretch of Zuari River

Nomenclature	Identification
▪▪▪▪▪▪	Zuari river polluted stretch

1.2. Monitoring Locations

The GSPCB collects samples at below mention three locations under the National Water-quality Monitoring Program (NWMP) of the CPCB on monthly basis.

Map 2 Map showing Saline Stretch of Zuari River

1.3. Water Quality of Zuari River

For the purpose of conceptualising the plan of action for the polluted river stretch of Zuari 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)

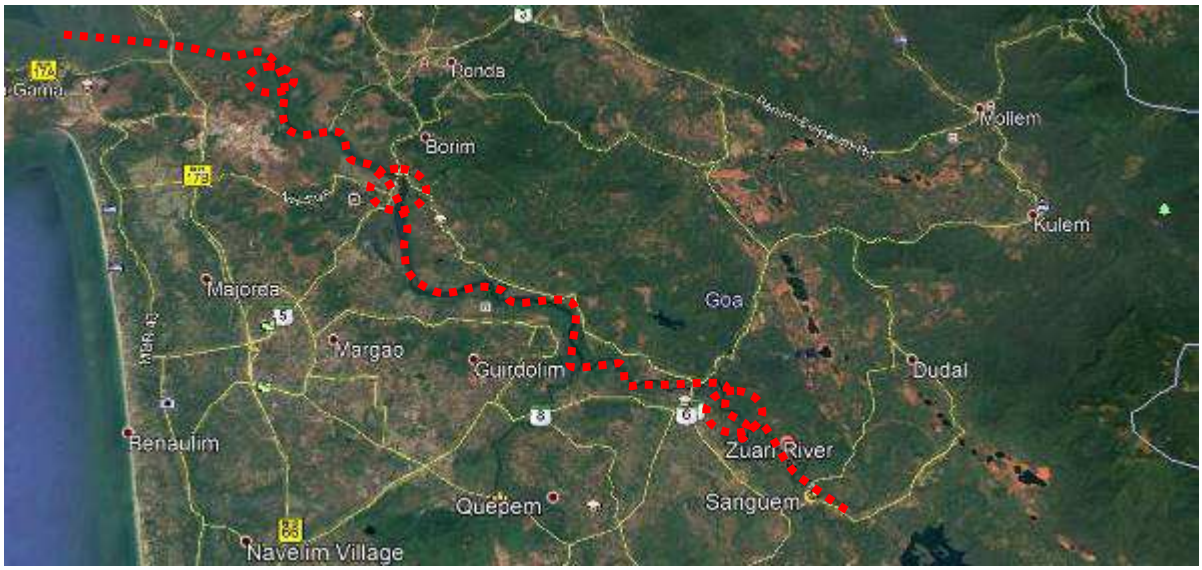
The Water Quality Monitoring Reports in the ICZMP Study of NIO, July, 2013 and the EIA Study of NIO, 2018 were also considered for conceptualisation of the Action Plan.

The sampling results of GSPCB at locations mentioned in the table below have been considered.

Table 1 Sampling Point Locations on Zuari River[4].

Location	Co-ordinates	
	Latitude	Longitude
Panchawadi	$15^0$18’ 30.32” N	$73^0$2’ 16.90” E
Borim Bridge	15^0 20’ 59.11” N	$74^0$0’16.14” E
Maraciam Jetty	15^0 25’ 14.39” N	$73^0$55’35.37” E

[4] Salinity Report GSPCB



Map 3 Map showing Water Sampling Points

1.4. Water Sampling Results:

The sampling results of the GSPCB for the period 2015 to 2018 was analysed to decide the Action plan strategies.

Table 2 Zuari River Parameter near Panchwadi[5]

Sr. No.	Year Parameters	2015	2016	2017	2018	Average
Pre - Monsoon (January to May)						
1)	DO (mg/l)	4.9 - 5.8	5.2 - 6	4.8 - 5.7	5 - 5.8	4.8 - 6
2)	BOD (mg/l)	0.2 - 3	0.5 - 1.8	0.6 - 2.1	1.6 - 2.8	0.2 - 3
3)	Faecal Coliform (MPN/100ml)	2300 - 2300	230 - 2300	490 - 3300	200 - 1300	200 - 3300
Monsoon (June to September)						
1)	DO (mg/l)	4.5 - 7.6	4.7 - 7.9	6.5 - 7.5	-	4.5 - 7.9
2)	BOD (mg/l)	0.2 - 1.4	0.6 - 2.6	0.9 - 3.2	-	0.2 - 3.2
3)	Faecal Coliform (MPN/100ml)	130 - 3300	450 - 2300	790 - 4900	-	130 - 4900
Monsoon (October to December)						
1)	DO (mg/l)	5 - 5.2	5.3 - 7.1	4.2 - 6.9	-	4.2 - 7.1
2)	BOD (mg/l)	0.8 - 1.5	1.5 - 2.8	1.5 - 2	-	0.8 - 2.8
3)	Faecal Coliform (MPN/100ml)	1300 - 2300	780 - 1300	450 - 1300	-	450 - 2300

[5] GSPCB Monitoring under NWMP

The DO in Zuari River near Panchwadi during Pre-monsoon season varies from 4.8 mg/l to 6 mg/l and 4.5 mg/l to 7.9 mg/l during monsoon and 4.2 mg/l to 7.1 mg/l in post monsoon.

The BOD in Zuari River near Panchwadi during Pre-monsoon season varies from 0.2 mg/l to 3 mg/l and 0.2 mg/l to 3.2 mg/l during monsoon and 0.8 mg/l to 2.8 mg/l in post monsoon.

The FC in Zuari River near Panchwadi during Pre-monsoon season varies from 200 MPN/100ml to 3300 MPN/100ml and 130 MPN/100ml to 4900 MPN/100ml during monsoon and 450 MPN/100ml to 2300 MPN/100ml in post monsoon.

Table 3 Zuari River Parameter near Borim Bridge

Sr. No.	Year Parameters	2015	2016	2017	2018	Average
Pre - Monsoon (January to May)						
1)	DO (mg/l)	5.1 - 5.6	5.2 - 6.3	5 - 6.5	4.5 - 6.1	1.4 - 6.5
2)	BOD (mg/l)	0.8 - 1.7	1.6 - 2.8	1.4 - 2.6	0.4 - 3.4	0.8 - 3.4
3)	Faecal Coliform (MPN/100ml)	1300 - 1300	330 - 2300	230 - 3500	450 - 2300	230 - 3500
Monsoon (June to September)						
1)	DO (mg/l)	4.9 - 7.5	4.1 - 6.8	6.6 - 7.6	4.4 - 7.9	4.1 - 7.9
2)	BOD (mg/l)	0.6 - 1.8	1 - 1.8	1.8 - 3.3	1.1 - 3.8	0.6 - 3.8
3)	Faecal Coliform (MPN/100ml)	490 - 1300	3300 - 7900	1700 - 7900	2300 - 4900	490 - 7900
Monsoon (October to December)						
1)	DO (mg/l)	5.3 - 6.4	5.9 - 6.5	4.6 - 6.9	4.7 - 5.6	4.6 - 6.9
2)	BOD (mg/l)	0.5 - 4.1	0.004 - 01	1.3 - 2.1	1.3 - 1.7	0.004 - 4.1
3)	Faecal Coliform (MPN/100ml)	1300 - 4600	780 - 3500	200 - 1300	780 - 1300	200 - 4600

The DO in Zuari River near Borim Bridge during Pre-monsoon season varies from 1.4 mg/l to 6.5 mg/l and 4.1 mg/l to 7.9 mg/l during monsoon and 4.6 mg/l to 6.9 mg/l in post monsoon.

The BOD in Zuari River near Borim Bridge during Pre-monsoon season varies from 0.8 mg/l to 3.4 mg/l and 0.6 mg/l to 3.8 mg/l during monsoon and 0.4 mg/l to 4.1 mg/l in post monsoon.

The FC in Zuari River near Borim Bridge during Pre-monsoon season varies from 230 MPN/100ml to 3500 MPN/100ml and 490 MPN/100ml to 7900 MPN/100ml during monsoon and 200 MPN/100ml to 4600 MPN/100ml in post monsoon.

Table 4 Zuari River Parameter near Madkai Jetty

Sr. No.	Year Parameters	2015	2016	2017	2018	Average
Pre - Monsoon (January to May)						
1)	DO (mg/l)	5.3 - 6	4.8 - 6.1	4.6 - 6.6	5 - 7.8	4.6 - 7.8
2)	BOD (mg/l)	2.4 - 3.5	0.9 - 3	1.2 - 2.3	1.3 - 5.8	0.9 - 5.8
3)	Faecal Coliform (MPN/100ml)	1300 - 1300	78 - 1400	130 - 790	130 -450	78 - 1400
Monsoon (June to September)						
1)	DO (mg/l)	3 - 6.8	4.8 - 6.7	5.8 - 7.8	4 - 7.7	3 - 7.8
2)	BOD (mg/l)	0.6 - 1.5	1.5 - 1.7	1.8 - 4.2	1.9 - 3.8	0.6 - 4.2
3)	Faecal Coliform (MPN/100ml)	1300 - 3300	780 - 2200	450 - 1100	2200 - 4900	450 - 4900
Monsoon (October to December)						
1)	DO (mg/l)	4.9 - 5.9	5.5 - 6.5	4.9 -6.5	4.8 - 5.8	4.8 - 6.5
2)	BOD (mg/l)	1.2 - 2.9	2.4 - 3.1	1.5 -1.9	1.2 - 2.3	1.2 - 3.1
3)	Faecal Coliform (MPN/100ml)	130 - 780	130 - 490	450 - 1300	780 - 2200	130 - 2200

The DO in Zuari River near Madkai Jetty during Pre-monsoon season varies from 4.6 mg/l to 7.8 mg/l and 3 mg/l to 7.8 mg/l during monsoon and 4.8 mg/l to 6.5 mg/l in post monsoon.

The BOD in Zuari River near Madkai Jetty during Pre-monsoon season varies from 0.9 mg/l to 5.8 mg/l and 0.6 mg/l to 4.2 mg/l during monsoon and 1.2 mg/l to 3.1 mg/l in post monsoon.

The FC in Zuari River near Madkai Jetty during Pre-monsoon season varies from 78 MPN/100ml to 1400 MPN/100ml and 450 MPN/100ml to 4900 MPN/100ml during monsoon and 130 MPN/100ml to 2200 MPN/100ml in post monsoon.

Summary of the ICZM study report of NIO July 2013

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 dated July

2013 and EIA Report of NIO of 2018 in respect of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Faecal Coliform are as listed below,

- **Dissolved Oxygen (DO)**

All the observed Dissolved Oxygen values are normal and indicate well Oxygenated water during all the three season i.e. Pre-monsoon, Monsoon and Post-monsoon.

- **Biochemical Oxygen Demand (BOD)**

All the observed values of BOD are less than 3 mg/l and indicate low organic matter addition to the Zuari River.

- **Faecal Coliforms**

The observed values of Faecal Coliform indicate pollution sources in the estuarine region.

The extract of the relevant portion of NIO report is annexed as annex. 1.

Summary of the EIA report of NIO May, 2018

The results of the Water Quality Monitoring carried out by the National Institute of Oceanography (NIO) as a part of the EIA Study for de-silting the River Chapora by Captain of Ports between Curchorem to Madkai, in respect of DO, BOD and Faecal coliform are listed below

- **Dissolved Oxygen (DO)**

All the observed Dissolved Oxygen values are normal and indicate well oxygenated water during all the three season i.e. Pre-monsoon, Monsoon and Post-monsoon.

- **Faecal Coliforms**

The observed values of Faecal Coliform indicate pollution sources in the estuarine region.
The extract of the relevant portion of NIO report is annexed as annex. 2.

1.5. Data Analysis and Interpretation

The results of the water sampling carried out by Goa state Pollution Control Board at three locations in the Zuari River i.e. At Panchwadi, Borim bridge and Madkai Jetty from April 2015 to December 2018, the summary of the analysis of water quality parameters of the ICZM study carried out by NIO for Department of Science technology and environment Government of Goa and the summary of the water quality monitoring of the EIA study carried out by NIO for

the captain of ports in 2018 in respect of DO, BOD and Faecal coliform have been considered for preparation of action plan.

The Report of Monitoring for the period April 2015 to December, 2018 of GSPCB at three locations for the parameters of DO, BOD and Faecal Coliform have been taken into consideration for the preparation of Action Plan.

- **Dissolved Oxygen (DO)**

The observed DO levels in the polluted river stretch between Curchorem to Madkai as can be seen from the GSPCB monitoring reports and the two NIO reports are above the desired level of 4 mg/l required for bathing water quality.

- **Biochemical Oxygen Demand (BOD)**

The observed BOD levels in the polluted river stretch between Curchorem to Madkai as can be seen from the GSPCB monitoring reports and the two NIO reports are below the desired level of 3 mg/l required for bathing water quality.

- **Coliforms**

The observed FC levels in the polluted river stretch between Curchorem to Madkai as can be seen from the GSPCB monitoring reports are above the desired levels of 500 MPN/ 100ML for bathing water quality. The reports of NIO of 2013 and 2018 also indicate pollutions source in the polluted stretch between Curchorem to Madkai in view of the presence of Fecal Coliform levels observed during these Studies.

1.6. Action Plan Strategies:

This Zuari river stretch is polluted stretch under **Priority V as identified by the CPCB.** 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 Chapora in the identified polluted stretch.as other parameters of DO and BOD are within the desired limits.

1.7. Major Concerns:

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

2. Source Control

The reconnaissance survey was conducted along with the GSPCB officials for the polluted stretch as well as along the upstream side (till bridge on Dharglim Road) during the month of Jan. & Feb. 2019. The objective of this study is to analyse the sources of pollutants.

a) Industrial Pollution Control

During the physical survey carried out in the month of January, February 2019. Verna Industrial Estate is located at a distance of about 2 km (areal distance), on a plateau, but there are no such industrial discharge observed in Zuari river from the Industries in this Industrial Estate. There are number of shipyards located along the bank of the River of which presently most of the shipyards are non-functional due to the stoppage of mining activities. Similarly there are barge loading jetty near Savardem and Curchorem which are operating to certain extent for transportation of e auctioned ore. However there are no Industrial or domestic discharges into the River from these activities.

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

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

Sources of the pollutants:

The entire stretch (Curchorem to Marcaim Jetty) was physically surveyed both the bank of river during month of January and February for identification of sources of pollution. The entire stretch is under tidal effect. There are several discharges through nallah, natural outflow, which is coming through habitations of Marcaim, Undir, Adpai, Kaswada, Borim, Loutolim, Zamboli and Cortalim.

Map 4 Map showing the tributaries discharging the pollutants.

Image 4 Zuari River near Cortalim Bridge

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Image 5 Mangroves at Marcaim Jetty

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Image 6 Outfall at Borim Bridge

Image 7 Zuari River at Borim Bridge

Image 8 Zuari River from Marcaim Jetty

The underground sewerage scheme in progress for Ponda municipal area including Curti, Bandora, Kavelem, Undir and these areas are close to Kapleshwari nallah which further joins the Zuari River. Three STP's are proposed at Curti, Kavelem and Bandora of capacity 8MLD, 15MLD and 15MLD respectively. At present 70% sewerage network is laid and 15MLD STP at Kavelem is in progress. Sewerage scheme with 1MLD STP is commissioned for Durbhatt village which is on the bank on River Zuari. This STP was commissioned in September 2017 and is running successfully. The total cost of all the above projects is 536 cr.

3. River Catchment / Basin Management

The river Zuari has the catchment area of 973 sq. Kms. with an average runoff of 2247.4 MCM. The polluted stretch of 28 km stretch of the river is in the saline zone from Curchorem to Marcaim Jetty. The river in this stretch has in all 8 outfalls bringing the domestic untreated sewage causing the main source of the pollutants.

i. Periodic monitoring of ground water resources and regulation of ground water extraction by domestic / Agricultural industries particularly over exploded and critical zones:

a) The ground water table in the region is 2 to 5 MBGL in post monsoon and lower downs by 2- 4m from pre-monsoon ground water table in post monsoon. The decadal variation in the ground table is about 2 – 5 MBGL[6].

b) All portion of the river stretch is in saline zone / tidal affected and not used for irrigation purpose.

4. Flood Plane Zone

i. Regulating activity in flood plain zone: During the physical survey, it is observed that, no measures are required to regulate activity in flood plain zone.

ii. Management of Municipal, Plastic, Hazardous, Bio-Medical & Electrical and Electronic Waste: The Local bodies are collecting segregated non-biodegradable waste which is sent to the Goa Waste Management Corporation and subsequently transported to the bailing station at Verna. The bailed non-biodegradable waste is thereafter transported to cement plants in Karnataka for co incineration. Improvement and up gradation of the existing Solid Waste Management Facility including collection system and erection of material recovery facilities / storage shed for non-biodegradable waste in the village Panchayat areas along the banks of Zuari River will be completed within period of one year.

The Goa Waste Management Corporation is in the process of establishing a Solid Waste Management Facility at Curchorem of 100 tons per day capacity which is expected to be completed in 18 months. The remediation of legacy waste at the proposed site for the

[6] Aquifer System of Goa by Central Ground Water Board Sept. 2013

Solid Waste Management Facility at Curchorem is in progress and is expected to be completed in 18 months.

iii. **Sanitation and solid waste management facility shall be improved on jetty / ferry jetty: T**oilets will be installed /constructed at Cortalim Fishing Jetty are expected to be completed in one year.

5. Greenery Development – Plantation Plan

Entire identified polluted stretch of 28 km of the Zuari River is under salinity zone wherein the Mangrove plantation is observed. The total area of 467 Ha has been occupied by Mangroves in Zuari Estuary[7]. There are orchards observed along both the banks of the Zuari River.

6. Ecological / Environmental Flow (E-Flow)

i. **Issues relating to E- Flow:** The Polluted stretch of the Zuari River is having length of 28 from Curchorem to Madkai Kms and is in Saline zone. There is no issue of E-Flow in the 28 km saline stretch of river Zuari.

ii. **Irrigation practices:** The entire portion of the river is in saline zone / tidal affected and not used for irrigation purpose.

[7] ICZM studies for Goa, National institute of Oceanography July 2013 P. N. 44.

7. Action Plan Strategies:

The action plan strategies based on the sampling analysis of the GSPCB and observation made in the NIO reports of 2013 and 2018, 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.	Disconnection of direct discharges of domestic sewage into the Zuari River/storm water drains/ Nallahs. 4. Disconnection of the direct discharge into the river/storm water drains/Nallahs. 5. Installation of Bio-toilet. 6. Construction of septic tank and soak pits by residential houses.	Curchorem to Madkai	Directorate of Panchayat and Directorate of Health	6 months
2.	Improvement and up gradation of the existing Solid Waste Management Facility including collection system and erection of material recovery facilities / storage shed for non-biodegradable waste in the village panchayat areas along the banks of Zuari River. Establishment of toilets at Fishing Jetty at Cortalim in	a) Savordem b) Panchwadi c) Shiroda d) Borim e) Wadi – talaulim f) Durbhat g) Bandora h) Marcaim i) Neura j) St. Lawrence(Agasaim) k) St. Andre (Velha) l) Siridao – pale	Respective Village Panchayat and Directorate of Panchayat	12 months

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
	one year. Establishment of SWM facility at Curchorem of 100 tpd capacity within 18 months at cost of Rs 190 Cr. This will cater to Quepem, Sanguem, and Dharbandora talukas.	m) Curchorem – kakora n) Macasona o) Curtorim p) Rachol Lotolium q) Cortalim – Quelosim r) Sancoal		
3.	Toilets facility for Fishing Jetty at Cortalim		Department of Fisheries	6 months
4.	The underground sewerage scheme in progress for Ponda municipal area including Curti, Bandora, Kavelem, Undir and area close to Kapleshwari nallah which further joins the Zuari River. Three STP's are proposed at Curti, Kavelem and Bandora of capacity 8MLD, 15MLD and 15MLD respectively. At present 70% sewerage network is laid and 15MLD STP at Kavelem is in progress. Sewerage scheme with 1MLD STP is commissioned for Durbhat village which is on the bank on River Zuari. This STP was commissioned in September 2017 and is running successfully. The total cost of all the projects mentioned above is 536 cr.		SIDCGL	12 months

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
5.	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.		Goa Waste Management corporation	18 months
6.	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.		Goa Waste Management Corporation	ongoing

7.1. Conclusion & Remark

The stretch of River Zuari from Curchorem to Marcaim Jetty having a length of 28 kms is categorized as Priority V by the Central Pollution Control Board. The main cause of concern is high levels of Fecal Coliform, while other parameters such as DO and BOD are well within the CPCB prescribed standards on majority of occasions. The cause of pollution is mostly due to the discharge of domestic sewage directly into the River or into the storm water drains /nallahs leading to the River.

The action plan strategies have been elaborated in chapters above and will be implemented by concerned stake holder departments/ corporations.

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

i. Dissolved Oxygen (DO)

- **Monsoon:** Zuari River shows well oxygenated water at all the stations, showing DO values above 4.5 mgl^{-1}, except the mouth and near mouth stations, which show hypoxic DO condition in their bottom layers. The tidal variation shows that during high tide, the DO varies from 0.26 to 6.84 mgl^{-1}, with an average of 4.94 mgl^{-1} (**Table 7a**). 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. The spatial distribution shows increasing DO towards upstream. During low tide, well oxygenated water within the study region was observed with all the stations showing DO values above 4.0 mgl^{-1}, except the bottom layer at the mouth station, which showed DO value below 3 mg/l. The observed DO showed a range of variation from 2.81 to 7.77 mgl^{-1}, with an average of 5.98 mgl^{-1} (**Table 7b**). High 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. All the observed DO values are normal and indicate well oxygenated water.

- **Post-monsoon:** Zuari River water shows well oxygenated water, with all the stations showing DO values above 4.5 mgl-1 during this season. During the high tide, the DO shows a variation of 4.47 to 8.45 mgl-1, with an average of 5.88 mgl-1 (Table 7.1a). High 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 and due to low salinity in the surface water layer. All the observed DO values are normal and indicate well oxygenated water. The spatial distribution shows increasing DO towards upstream. During low tide, the Zuari River water shows well oxygenated water, with all the stations showing DO values above 4.5 mgl-1. During the post-monsoonal low tide, the DO variation of 4.73 to 7.52 mgl-1 is observed, with an average of 5.74 mgl-1 (Table 7.1b), with higher DO values in the surface layer relative to bottom water layer. The spatial distribution shows an apparent increase in DO towards upstream. All the observed DO values are normal and indicate well oxygenated water.

- **Pre-monsoon:** Zuari River water shows well oxygenated water, with all the stations showing DO values above 5 mgl-1 during this season. During the high tide, the DO shows a variation of 5.07 to 7.77 mgl-1, with an average of 6.70 mgl-1 (Table 7.2a). Higher values of DO are largely observed in the surface layer relative to bottom water

layer, increasing towards upstream and is 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. All the observed DO values are normal and indicate well oxygenated water. During low tide, the Zuari River water shows well oxygenated water, with all the stations showing DO values above 5 mgl-1, except for one station in the upstream which shows a low DO of 3 mg/l. During the pre-monsoonal low tide, the DO shows a variation of 3.03 to 7.40 mgl-1, with an average of 5.78 mgl-1 (**Table 7.2b**), with higher DO values in the surface layer relative to bottom water layer. The spatial distribution shows a decrease in DO towards upstream. All the observed DO values are normal and indicate well oxygenated water.

ii. Biochemical Oxygen Demand (BOD)

- **Monsoon:** The BOD in Zuari River water remains low and varies from 0.08 to 2.13 mg l-1 with an average of 1.03 mg l–1 during the monsoonal high tide **(Table 7a).** The vertical distribution shows high values of BOD in surface and low in bottom indicating external additions and these additions are more in the estuarine region as compared to those in the mouth and in the upstream region. During low tide, the BOD values though remain low, show an increase slightly and vary from 0.33 to 2.99 mg l-1 with an average of 1.58 mg l–1 **(Table 7b)**, with a similar trend of variation as that of the high tide, in remaining high in the surface and low in bottom water layers. The spatial distribution shows an increase in the estuarine and in the upstream stations. All the observed BOD values are low and indicate low organic matter addition to Zuari River.
- **Post-monsoon:** The BOD values range from 0.80 to 4.71 mg l-1, with an average of 2.57mgl-1 (Table 7.1a) during the high tide in Zuari River. The surface layer indicates distinct high values of BOD with low values in the bottom layer, indicating their addition from external sources. The spatial distribution shows an apparent decrease towards upstream. The high values are observed at the mouth and in the estuarine region. The observed BOD values are slightly higher. During low tide, the BOD values show a decrease and range from 0.82 to 2.96 mg l-1 with an average of 1.91mg l-1 (Table 7.1b). The surface layer shows high BOD values as compared to the bottom layer and the spatial distribution shows no distinct increase towards upstream. This indicated external additions of BOD which are more in the mouth and in the estuarine region. The observed BOD values are within acceptable limits.
- **Pre-monsoon:** The BOD values range from 1.49 to 4.07 mg l-1, with an average of 2.72mgl-1 **(Table 7.2a)** during the high tide in Zuari River. The surface layer largely

indicates high values of BOD in the surface layer, suggesting their addition from external sources. The spatial distribution shows an apparent increase towards upstream. The observed BOD values are considerable. During low tide, the BOD values show a decrease and range from 1.31 to 2.87 mg l-1 with an average of 2.27mg l-1 **(Table 7.2b).** The surface layer shows high BOD values as compared to the bottom layer and the spatial distribution shows an apparent increase towards upstream. This indicated external additions of BOD which are more in the mouth and in the upstream region. The observed BOD values are within acceptable limits.

iii. Faecal Coliform:

- **Monsoon:** The FC varies from 0.00 to 720, with an average of 224, during the high tide **(Table 7g).** FC, though do not show any fixed trend of its vertical variation, the stations largely show high values in surface relative to bottom. Whereas, the spatial distribution shows increase in the upstream. During low tide, the FC varies from 0.00 to 2520, with an average of 367.50 **(Table 7h).** The vertical distribution largely shows higher values in surface indicating external sources, whereas the spatial distribution shows higher values in the upstream. The values indicate some polluting source towards upstream.
- **Post-monsoon:** The FC varies from 0.00 to 174, with an average of 51, during the high tide **(Table 7.1g).** The surface layer shows distinct high values relative to bottom decreasing towards upstream. During low tide, the FC varies from 0.00 to 840, with an average of 237.94 **(Table 7.1h).** The vertical distribution largely shows high values in surface relative to bottom, and the values decrease towards upstream.
- **Pre-monsoon:** The FC remains very low and varies from 1.0 to 10, with an average of 5.75, during the high tide **(Table 7.2g).** The values of FC are very low and only the mid estuarine stations show higher values of the observed range. During low tide, the FC shows a slight increase and this increase is prominent in the upstream stations. The FC variation observed is from 2.00 to 31, with an average of 11.54 **(Table 7.2h)**. The FC show normal values during both the tides of the pre-monsoon season.