



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 Terekhol River

March 2019

Contents

Executive Summary	4
Introduction	10
1. Brief about Terekhol River:	14
1.1. River Terekhol:.....	14
1.2. Source Identifications.....	15
1.3. Water Sampling Results.....	16
1.4. Data Analysis and interpretation	18
1.5. Action Plan Strategies.....	19
1.6. Major Concerns.....	19
2. Source Control:	20
3. River Catchment Management:	21
4. Flood Plane Zone:.....	21
5. Greenery Development – Plantation Plan:	22
6. Ecological / Environmental Flow (E-Flow):.....	22
7. Action Plan Strategies:.....	23
7.1. Conclusion & Remark:	25
Annexure 1:.....	26

Index of Tables

Table 1 Water Sample Testing points on Terekhol River	15
Table 2 NWMP locations along stretch under priority on Terekhol River	16
Table 3 Terekhol River parameter near Ferry point Tiracol.....	17

Table of Maps

Map 1 Map showing the Terekhol River Stretch.....	10
Map 2 Terekhol –Polluted Stretch From Terekhol.....	11
Map 3 Map showing the stretch of Terekhol River	14
Map 4 Map showing sampling points under MWNP on Terekhol River.....	15
Map 5 Map showing the salinity point on Terekhol River	16
Map 6 Storm Water Drains / nallah in Terekhol River	20

Table of Images

Image 1 Terekhol River.....	5
Image 2 Plantation along the Terekhol River	7
Image 3 Terekhol Fort.....	10
Image 4 Coconut trees along Terekhol River	11

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
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 – Council of Scientific & Industrial Research July 2013.

Executive Summary

The Terekhol River originates at Manohargad in the Sahyadris in Western Ghats of Maharashtra and flows in a south-westerly direction to meet the Arabian Sea. It forms the boundary between Sindhudurg district of Maharashtra state and the North Goa district of Goa state for some distance. The river in its upper reaches is known as the Banda River and in the lower reaches as the Terekhol River. As far as Banda, about fifteen miles from the sea, it is tidal and navigable by medium sized vessels, but larger crafts cannot pass beyond Aronda which is three miles upstream from the estuary. Torxe, Khadshi and Pedne are its main tributaries.

The total length of the River Terekhol in Goa State is 26 Km¹ and the full stretch is effected by tides and is in Saline Zone. The Goa State Pollution Control Board (GSPCB) monitors the water quality of River Terekhol at one locations at Terekhol near Ferry Point. The NGT / CPCB has declared the Terekhol River as Polluted Stretch. The said monitoring 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 Terekhol is classified as SW II (for bathing, contact water sports and commercial fishing). On the basis of GSPCB monitoring reports, Central Pollution Control Board (CPCB) has classified Terekhol River under Priority V, having BOD level of 3.9 mg/lit.

The River Terekhol has in all 6 six storm water drains/ Nallahs along Maharashtra and four storm water drains/ Nallahs along Goa. Out of four identified storm water drains / Nallahs along Goa , 3 outfalls have domestic sewage discharge which drains into the Terekhol River. These 3 outfalls are main sources of domestic sewage discharge into the Terekhol River along Goa.

The Report of GSPCB Monitoring for the period April 2015 to December 2018 at one 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 along Tiracol as can be seen from the GSPCB monitoring reports and NIO report are well above the desired level of 4 mg/l required for bathing water quality. The observed BOD levels in the polluted river stretch along Tiracol as can be seen from the GSPCB monitoring reports and NIO report are well below the desired level of 3 mg/l required for bathing water quality. The observed FC levels in the polluted river stretch along Tiracol as can be seen from the GSPCB monitoring reports are above the desired levels of 500 MPN/ 100ML for

¹ : ICZM studies for Goa, National institute of Oceanography July 2013.

bathing water quality. The reports of NIO of 2013 also indicate pollutions source in the polluted stretch along Tiracol.



Image 1 Terekhol River

The proposed action plan for Terekhol 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. It was observed during the Physical Survey that there is no discharge from Industry into the River or into the storm water drains leading to the River along Goa.

b) Channelization, Treatment, Utilisation and Disposal of Treated Domestic Sewage:

The physical survey carried out during January February 2019, the domestic untreated sewage discharge is observed from the natural storm water drains / Nallahs in areas like Aronda, Savarjua, Talawane, Kindla, Kavthani, Satarda villages along Maharashtra and Tambosa, Nanerwada, Bhalkhajan, Querim-Tiracol villages along Goa. The population density in these areas is very low and area along both the Banks is Rural.

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 / Nallah.
- 2) Installation of Bio-toilet.
- 3) Construction of septic tank and soak pits by residential houses.

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 explored and critical zones:**

- a) The ground water table in the region is 2 to 5 MBGL in post monsoon and lower by less than 2 m from the post monsoon. There is no such variation in the ground water table in the region throughout the year. The decadal variation in the ground table is about 2 -5 MBGL². The ground water table is high in the region. In view of this fact no further action is proposed in the action plan on this issue.
- b) The polluted stretch of the river Terekhol, 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, domestic untreated sewage disposal in the storm water drains / Nallah is observed in the polluted stretch. The Directorate of Panchayats and Directorate of Health Services through the Village Panchayat and the Health Officer will ensure disconnection off the direct discharges.
- 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 within the state. The baled non-biodegradable waste is thereafter transported to cement plants in Karnataka for

² Aquifer system of Goa by Central ground water board Sept. 2013, Map Plate 12, 13 & 17 P. N. 33.

co incineration. Village Panchayats and Pernem Municipal Council are predominantly having single dwelling units and there is no major issue disposal of biodegradable waste.

However improvement in the house to house collection of segregated waste 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.

- iii. **Greenery Development – Plantation Plan:** The total stretch of the Terekhol River is under salinity zone wherein the Mangrove cover is observed in 24.6 Ha³. It was also observed during the Physical Survey that there are Orchards along both the banks of the River.

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

- i. **Issues relating to E- Flow:** The Polluted stretch of the Terekhol River and 26 Km stretch which under the influence of tides. There is no issue of E-Flow in the polluted stretch of Terekhol River.
- ii. **Irrigation practices:** The entire polluted stretch of the river Terekhol is in saline zone / tidal affected and not used for irrigation purpose.



Image 2 Plantation along the Terekhol River

³ NIO studies ICZM July 2013. P. No.69

Action Plan Strategies:

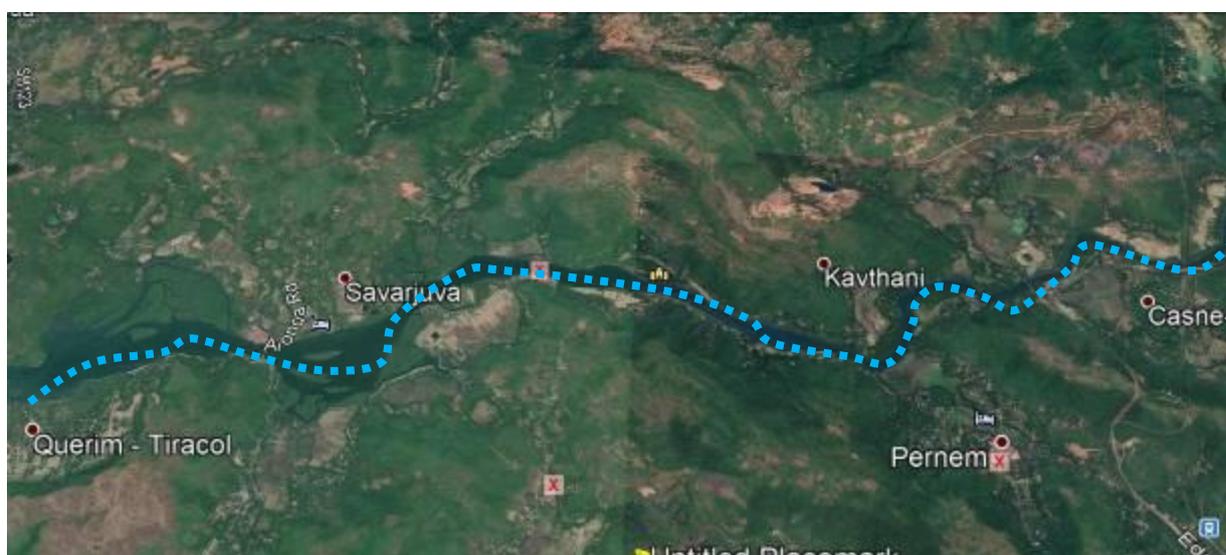
The action plan strategies based on the sampling analysis of the GSPCB and observation made in the NIO reports of 2013, site survey and observations are listed below. These strategies are classified on the basis of the existing proposal in place, recommended up gradation in order to achieve the desired 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 Terekhol 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.	Along Terekhol River 1. Tambosa 2. Nanerwada 3. Bhalkhajan 4. Querim - Tiracol	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 Terekhol River.	a) Querim- Tiracol b) Paliyem c) Corgao d) Pernem municipal council e) Casne – Amberem – poroscadem f) Tamboxem- Mopa-Uguem g) Torxem	Respective Village Panchayat and Directorate of Panchayat	12 months
3.	Expansion of Saligao Waste Management facility from 125 tons per day to 250 + 20% (300 tons per day). Project cost i.e. 82 cr.			9 months

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
4.	<p>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.</p>		Goa Waste Management Corporation	18 months
5.	<p>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.</p>		Goa Waste Management Corporation	ongoing

Introduction

The Terekhol River originates at Manohargad in the Sahyadris in Western Ghats of Maharashtra and flows in a south-westerly direction to meet the Arabian Sea. It forms the boundary between Sindhudurg district of Maharashtra state and the North Goa district of Goa state for some distance. The river in its upper reaches is known as the Banda River and in the lower reaches as the Terekhol River. As far as Banda, about fifteen miles from the sea, it is tidal and navigable by medium sized vessels, but larger crafts cannot pass beyond Aronda which is three miles upstream from the estuary. Terekhol is navigable up to a considerable distance upstream in the fair weather season, as well as during the monsoonal season.



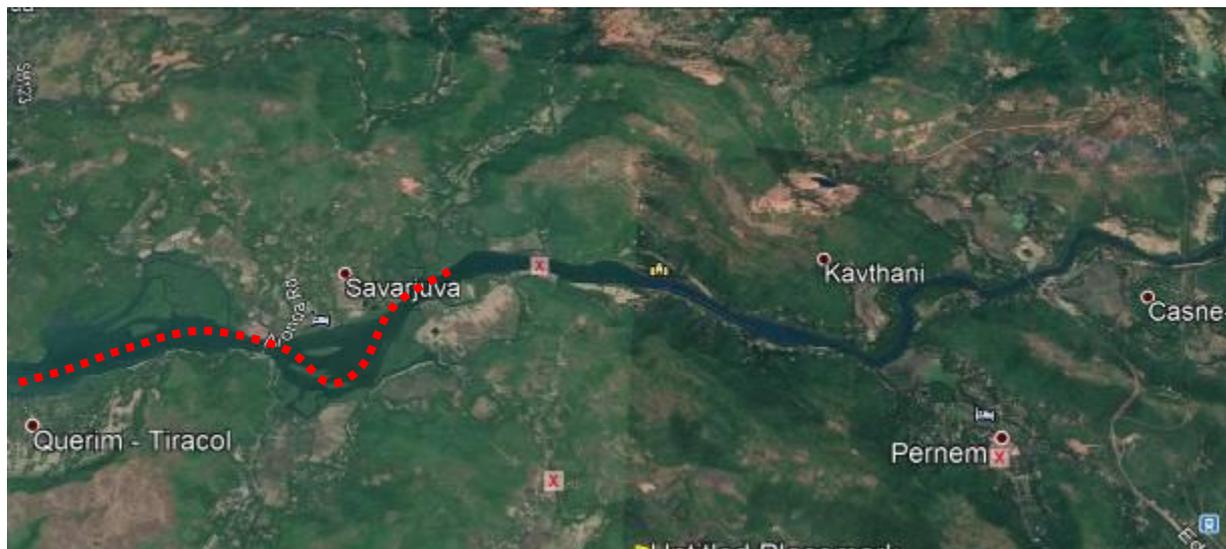
Map 1 Map showing the Terekhol River Stretch.



Image 3 Terekhol Fort

The Goa State Pollution Control Board (GSPCB) monitors the water quality on a monthly basis throughout the year of Terekhol River near the Ferry point under the Central Pollution

Control Board Programme. On the basis of GSPCB reports, central Pollution Control Board (CPCB) has classified Terekhol River under priority V, having BOD level of 3.9 mg/lit.



Map 2 Terekhol –Polluted Stretch From Terekhol.

a) Objective

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 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.



Image 4 Coconut trees along Terekhol River

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.

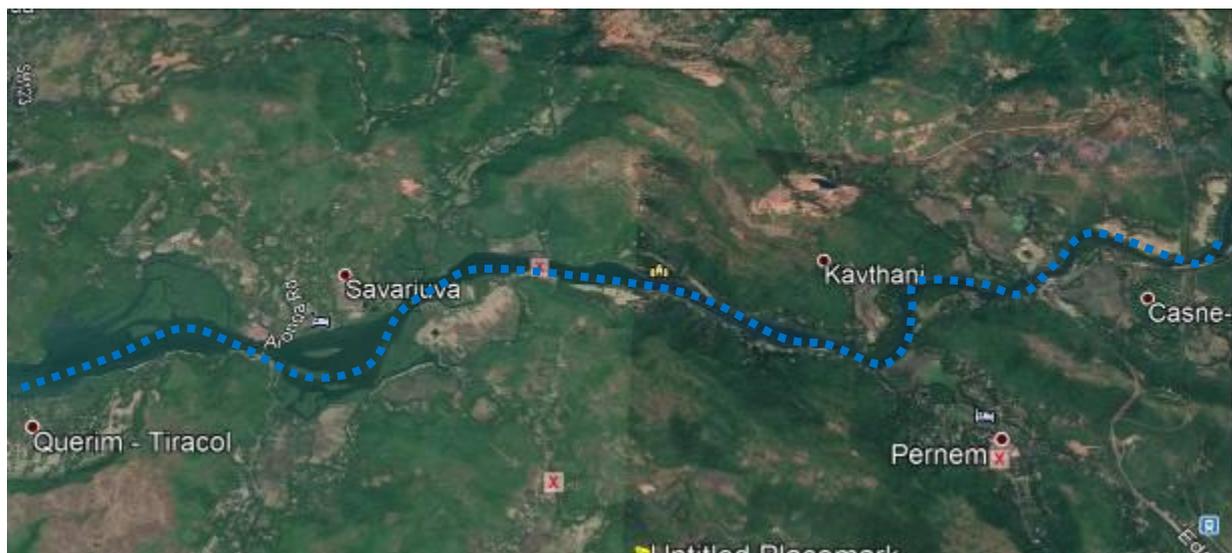
The Hon'ble NGT has directed to ensure that the action plan should have definite or specific timelines for execution steps. The State Government is required to set up a special environment surveillance task force in terms of this order. The said task force has to ensure that no illegal mining takes place 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.

1. Brief about Terekhol River:

1.1. River Terekhol:

The Terekhol is the interstate River originates at Manohargad in the Sahyadri hillock ranges of Maharashtra State. The river flows in the south western direction and discharges into the Arabian Sea near Terekhol in Goa. It forms the boundary between North Goa district of Goa state & Sindhudurg of Maharashtra.

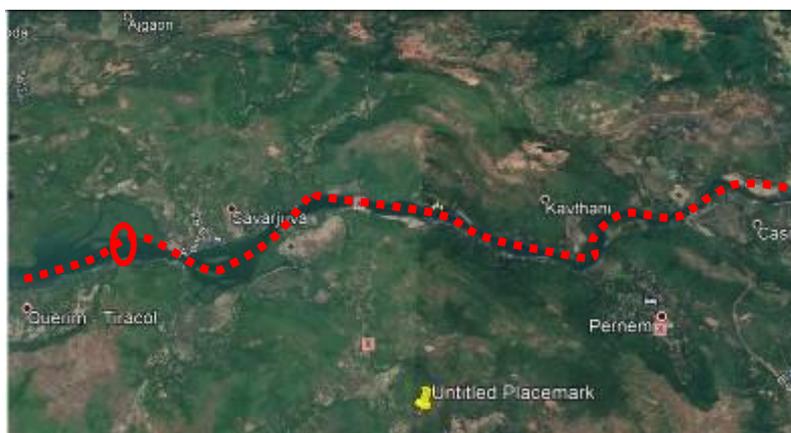


Map 3 Map showing the stretch of Terekhol River

The salinity mapping was carried out by GSPCB under NWMP, for Terekhol River and the saline stretch is observed along the full length of 26Km from the Arabian Sea. The table below indicates the salinity levels in the river.

Table 1 Water Sample Testing points on Terekhol River⁴

Location	Co-ordinates		Salinity in ppt
River Terekhol	15° 43' 8.86" N	73° 41'33.22" E	8.73



Map 4 Map showing sampling points under MWNP on Terekhol River

Nomenclature

Identification



Terekhol river stretch



Salinity Stretch on the river

1.2. Source Identifications

For the purpose of conceptualising the plan of action for the polluted river stretch of Terekhol 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 was also considered for conceptualisation of the Action Plan.

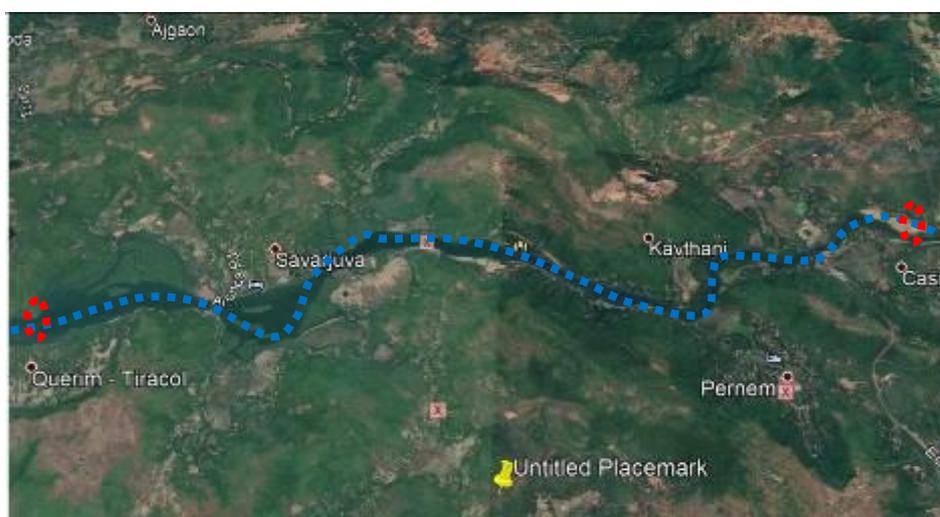
The sampling results of GSPCB at locations mentioned in the table below have been considered.

⁴ Salinity Report by GSPCB

Table 2 NWMP locations along stretch under priority on Terekhol River⁵

Location	Co-ordinates		Salinity in ppt
Sakarali Torshen (Downstream)	15 ⁰ 47' 12.7" N	73 ⁰ 50' 53.5" E	22.72
Banda Sherle Market (upstream)	15 ⁰ 48' 58.3" N	73 ⁰ 51' 32.4" E	17.13

The map showing the locations of the salinity mapping point is attached herewith.



Map 5 Map showing the salinity point on Terekhol River

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.

⁵ Annual Sampling Stations by GSPCB under NWMP program

Table 3 Terekhol River parameter near Ferry point Tiracol⁶

Sr. No.	Year Parameters	2015	2016	2017	2018	Average
Pre - Monsoon (January to May)						
1.	DO (mg/l)	5.8 - 6.5	6 - 7.5	5.8 - 6.4	5.5 - 7.8	5.5 - 7.8
2.	BOD (mg/l)	1 - 2.7	1.7 - 3.6	1.5 - 3	1.4 - 2.6	1 - 3.6
3.	Faecal Coliform (MPN/100ml)	230 - 490	23 - 490	13 - 240	7.8 - 790	13 - 790
Monsoon (June to September)						
1.	DO (mg/l)	4.4 - 7.1	6.9 - 7.2	5.7 - 7.3	6.1 - 7.2	4.4 - 7.3
2.	BOD (mg/l)	2 - 3.6	1 - 3.6	1.1 - 1.9	0.7 - 2.7	0.7 - 3.6
3.	Faecal Coliform (MPN/100ml)	230 - 790	130 - 1300	33 - 2300	490 - 790	33 - 2300
Post - Monsoon (October to December)						
1.	DO (mg/l)	6.3 - 6.8	4.1 - 6.1	6.2 - 6.9	5.1 - 7.9	4.1 - 7.9
2.	BOD (mg/l)	1.1 - 1.7	0.9 - 3.5	1.9 - 2.2	2.2 - 3.3	0.9 - 3.5
3.	Faecal Coliform (MPN/100ml)	23 - 230	230 - 240	790 - 5400	78 - 220	23 - 5400

The DO in Terekhol River near Ferry point Tiracol during pre-monsoon season varies from 5.5 mg/l to 7.8 mg/l and 4.4 mg/l to 7.3 mg/l during monsoon and 4.1 mg/l to 7.9mg/l in post monsoon.

The BOD in Terekhol River near Ferry point Tiracol during pre-monsoon season varies from 1 mg/l to 3.60 mg/l and 0.7 mg/l to 3.6 mg/l during monsoon and 0.9 mg/l to 3.5 mg/l in post monsoon.

The FC in Terekhol River near Ferry point Tiracol during pre-monsoon season varies from 13 MPN/ 100ml to 790 MPN/ 100ml and 33 MPN/ 100ml to 2300 MPN/ 100ml during monsoon and 2300 MPN/ 100ml to 4500 MPN/ 100ml in post monsoon.

⁶ GSPCB Sampling under NWMP

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 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 Terekhol River.

- **Faecal Coliform**

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.

1.4. Data Analysis and interpretation

The results of the water sampling carried out by Goa state Pollution Control Board at One locations in the Terekhol River i.e. Ferry Point Tiracol 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 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 November, 2018 of GSPCB at One 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 along Tiracol as can be seen from the GSPCB monitoring reports and the NIO report are well 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 along Tiracol as can be seen from the GSPCB monitoring reports and the NIO report are well below the desired level of 3 mg/l required for bathing water quality. However only on one occasion it was observed to be 3.6 mg/l during the period under consideration i.e 2015-2018.

- **Coliforms**

The observed FC levels in the polluted river stretch along Tiracol 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 also indicate pollutions source in the polluted stretch along Tiracol in view of the presence of Faecal Coliform levels observed during these Studies.

1.5. Action Plan Strategies

This Terekhol 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 Terekhol 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 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 for the polluted stretch as well as along the upstream side during the month of Jan. & Feb. 2019. The objective of this study is to analyse the sources of pollutants and other site related issues.

a) Industrial Pollution Control

During the physical survey carried out in the month of January, February 2019 it has been observed there is no discharge from industrial units into the River Terekhol except overflow during monsoon from the Mining in Maharashtra state.

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

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

i. Sources of Pollutants:

The polluted river survey carried out, the domestic untreated sewage discharge is observed from the storm water drains/ nallahs from the areas like Aronda, Savarjuva, Talawane, Kindla, Kavthani, Satarda villages along Maharashtra and Tambosa, Nanerwada, Bhalkhajan, Querim-Tiracol villages along Goa of which domestic sewage discharge was observed at 3 locations namely Nanerwada, Bhalkhajan, Querim-Tiracol villages. The population density in these areas is very low.



Map 6 Storm Water Drains / nallah in Terekhol River

3. River Catchment Management:

The river Terekhol has the catchment area of 71 sq. Kms. with an average runoff of 164.3 MCM⁷. 26 km stretch of the river is in the saline zone and the stretch between Aronda to Terekhol is under polluted stretch having total 10 storm water drains/ Nallahs of which four are in Goa and three have domestic sewage discharges. There are pre-dominantly orchards along both the banks of the River Terekhol.

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

The ground water table in the region is 2 to 5 MBGL in post monsoon and lower downs by less than 2 m from the post monsoon ground water table. There is no such variation in the ground water table in the region throughout the year. The decadal variation in the ground table is about 2 -5 MBGL⁸. The ground water table is high in the region. In view of this fact no further action is proposed in the action plan on this issue.

The complete portion of the polluted stretch of Terekhol River 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, domestic untreated sewage disposal in the storm water drains/Nallahs is observed in the polluted stretch. The Directorate of Panchayats and Directorate of Health Services through the Village Panchayat and the Health Officer will ensure disconnection off the direct discharges.
- 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 within the state. The baled non-biodegradable waste is thereafter transported to cement plants in Karnataka for co incineration. Village Panchayats and Pernem Municipal Council are predominantly having single dwelling units and there is no major issue disposal of biodegradable waste.

⁷ NIO studies ICZM July 2013. P. No. 125

⁸ Aquifer system of Goa by Central ground water board Sept. 2013, Map Plate 1213 & 17 P. N. 33.

However improvement in the house to house collection of segregated waste 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.

5. Greenery Development – Plantation Plan:

The total stretch of the Terekhol River is under salinity zone wherein the Mangrove cover is observed in 24.6 Ha⁹. It was also observed during the Physical Survey that there are Orchards along both the banks of the River.

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

- i. **Issues relating to E- Flow:** The Polluted stretch of the Terekhol River and 26 Km stretch which under the influence of tides. There is no issue of E-Flow in the polluted stretch of Terekhol River.
- ii. **Irrigation practices:** The entire polluted stretch of the river Terekhol is in saline zone / tidal affected and not used for irrigation purpose.

⁹ NIO studies ICZM July 2013. P. No.69

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, 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 Terekhol River/storm water drains/nallahs.</p> <p>4. Disconnection of the direct discharge into the river/storm water drains/Nallahs.</p> <p>5. Installation of Bio-toilet.</p> <p>6. Construction of septic tank and soak pits by residential houses.</p>	<p>Along Terekhol River</p> <p>1. Tambosa</p> <p>2. Nanerwada</p> <p>3. Bhalkhajan</p> <p>4. Querim - Tiracol</p>	<p>Directorate of Panchayat and Directorate of Health</p>	6 months
2.	<p>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 Terekhol River.</p>	<p>a) Querim- Tiracol</p> <p>b) Paliyem</p> <p>c) Corgao</p> <p>d) Pernem municipal council</p> <p>e) Casne –Amberem – poroscadem</p> <p>f) Tamboxem-Mopa-Uguem</p> <p>g) Torxem</p>	<p>Respective Village Panchayat and Directorate of Panchayat</p>	12 months
3.	<p>Expansion of Saligao Waste Management facility from 125 tons per day to 250 + 20% (300 tons per day).</p> <p>Project cost i.e. 82 cr.</p>			9 months
4.	<p>The State of Goa has identified site for construction of Common</p>		Goa Waste Management	18 months

Sr. No.	Action Strategy	River Stretch	Agency	Time Frame
	<p>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.</p>		corporation	
5.	<p>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.</p>		Goa Waste Management Corporation	ongoing

7.1. Conclusion & Remark:

- i) The stretch of River Terekhol is categorized as Priority V. 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. The cause of pollution is mostly due to the direct discharge of domestic sewage into the River and into the storm water drains /Nallahs leading to the River.
- ii) The action plan strategies have been elaborated in chapters above and will be implemented by concerned stake holder departments/ corporations by making necessary provision in their budgets.
- iii) 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:** Terekhol River shows well oxygenated water with all the stations showing DO values above 4.5 mg l^{-1} , indicating higher DO. The tidal variation shows that during high tide, the DO varies from 4.61 to 7.46 mg l^{-1} , with an average of 6.73 mg l^{-1} (**Table 4a**). Higher values of DO are observed in the surface layer relative to bottom water layer, in all station except the mouth station, and is due to more dissolution of atmospheric oxygen due to its direct contact with the surface layer. During low tide, well oxygenated water within the study region was observed with all the stations showing DO values above 6.5 mg l^{-1} . The observed DO showed a range of variation from 6.92 to 7.75 mg l^{-1} , with an average of 7.37 mg l^{-1} (**Table 4b**). High values of DO are observed in the surface layer (av. 7.45 mg l^{-1}) relative to bottom water layer (av. 7.26 mg l^{-1}) 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:** The Terekhol River water shows well oxygenated water, with all the stations showing DO values above 5 mg l^{-1} during this season, except the bottom water at stns. T5 and T6 showing values slightly less than 5 mg l^{-1} . During the high tide, a DO variation of 4.70 to 6.50 mg l^{-1} , is observed, with an average of 5.77 mg l^{-1} (Table 4.1a). High values of DO are observed in the surface layer (av. 6.30mg l^{-1}) relative to bottom water layer (av. 5.23 mg l^{-1}) 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 Terekhol River water shows well oxygenated water, with all the stations showing DO values above 5 mg l^{-1} , except the bottom water at stn. T6, which show DO values slightly less than 5 mg l^{-1} . During post-monsoonal low tide, the DO variation of 4.34 to 7.20 mg l^{-1} is observed, with an average of 6.05 mg l^{-1} (Table 4.1b), with higher DO values in the surface layer (av. 6.57 mg l^{-1}) relative to bottom water layer (av. 5.33 mg l^{-1}). All the observed DO values are normal and indicate well oxygenated water.
- **Pre-monsoon:** The Terekhol River water shows well oxygenated water, with all the stations showing DO values above 4.5 mg l^{-1} during this season. During the high tide, a DO variation of 4.61 to 7.46 mg l^{-1} , is observed, with an average of 6.74 mg l^{-1}

(Table 4.2a). Except the mouth station which shows a reverse due to turbulence, other stations show high values of DO in surface and low in bottom 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. All the observed DO values are normal and indicate apparent increase in DO towards upstream. During low tide, the Terekhol River water shows well oxygenated water, with all the stations showing DO values above 6 mg/l and vary from 6.92 to 7.75 mg/l, with an average of 7.36 mg/l (Table 4.2b), with distinct higher DO values in the surface layer relative to bottom water layer, increasing towards upstream. All the observed DO values are normal and indicate well oxygenated water.

ii) Biochemical Oxygen Demand (BOD)

- **Monsoon:** The BOD in Terekhol River water shows low values during high and low tides. During high tide, the BOD values range from 0.27 to 1.43 mg l⁻¹ with an average of 0.67 mg l⁻¹ and thereby indicate low values (Table 4a). Vertical distribution does not show a distinct trend of its variation in surface and bottom water layers as some stations show higher values of the range, while others show lower values. During low tide, the BOD values vary from 0.24 to 1.15 mg l⁻¹ with an average of 0.8 mg l⁻¹ and thereby indicate low values (Table 4b), with a similar trend of variation as that of the high tide, between the surface and bottom water layers. All the observed BOD values are low and indicate low organic matter addition to Terekhol River.
- **Post-monsoon:** The BOD values range from 0.47 to 1.45 mg l⁻¹, with an average of 0.86mg/l (Table 4.1a) during the high tide. The surface layer indicates average low value of 0.69 mg l⁻¹ and a high value of 1.03 mg l⁻¹ in the bottom layer, whereas, the higher values of the observed range are seen in the mouth and in the estuarine region as compared to the upstream region, indicating localised input of BOD. During low tide, the BOD values range from 0.73 to 2.09 mg l⁻¹ with an average of 1.41mg l⁻¹ (Table 4.1b), with surface water showing low BOD values of the range (0.73 to 1.61 mg l⁻¹; av. 1.14 mg l⁻¹) and bottom water layer showing slightly higher values ranging from 1.17 to 2.09 mg l⁻¹; av. 1.69 mg l⁻¹. High BOD values of the range are apparently observed in the mouth and estuarine region, decreasing in the upstream, indicating the localised input of BOD in the estuarine region. The observed BOD values are low and are well within acceptable limits.

- **Pre-monsoon:** The BOD values remain low and range from 0.27 to 1.43 mg l⁻¹, with an average of 0.67mg l⁻¹ (Table 4.2a) during the high tide. The vertical distribution shows no fixed trend in its variation as some stations show high values in surface layer while others show higher values in bottom layer indicating addition in surface and bottom. The spatial distribution shows lower values towards upstream region, indicating low input of BOD from upstream. The observed BOD values are normal. During low tide, the BOD values range from 0.24 to 1.15 mg l⁻¹ with an average of 0.80mg l⁻¹ (Table 4.2b), with a similar trend of its vertical variation. However, the spatial distribution shows higher values at mouth and in upstream, indicating the localised input of BOD in these regions. The observed BOD values are low and are well within acceptable limits.

iii) Faecal Coliform

- **Monsoon:** The FC varies from 0.00 to 750, with an average of 183, during the high tide. Only the 2 stations mouth and near mouth (T2 and T3) show high values of FC, with no fixed trend of its vertical variation, whereas all other stations show nil FC during the high tide (Table 4g). During low tide, the FC varies from 0.00 to 1040, with an average of 153 (Table 4h). The spatial distribution shows nearly a similar pattern as that of the high tide, wherein the FC remain higher at 2 stations (T2 and T3), with slightly lower values as compared to those seen during the high tide. The last station (T6) also shows some FC in its bottom water layer during both the tides, indicating some polluting source.
- **Post-monsoon:** The FC varies from 120 to 1320, with an average of 483, during the high tide (Table 4.1g). There is no fixed trend in its vertical variation, as some stations show low values in surface while others show a reverse trend. Apparently, the spatial distribution shows increasing values towards upstream. During low tide, the FC varies from 0.00 to 470, with an average of 212 (Table 4.1h). The spatial distribution shows nearly a similar pattern as that of the high tide, wherein the FC remain higher at 2 stations (T2 and T3), with increasing values towards the upstream. The mouth (T2) and the last station (T6) show high FC values, indicating some pollution source.
- **Pre-monsoon:** The FC varies from 0.00 to 750, with an average of 183, during the high tide (Table 4.2g). The higher values of FC are observe in only 2 stations (mouth

and near mouth and one last stn. T6) in the upstream. There is no fixed trend in its vertical variation, as some stations show low values in surface while others show a reverse trend. Apparently, the spatial distribution shows significant decreasing values towards upstream. This indicated at some kind of polluting source at the bottom layer at the mouth and near mount stations. During low tide, the FC varies from 0.00 to 1040, with an average of 153 (Table 4.2h). The spatial distribution shows higher FC at the mouth station, with decreasing values towards the upstream. The mouth (T2) and the near mouth station (T3) show high FC values, indicating some pollution source.