नमामि गंगे

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

# WATER QUALITY OF SELECT RIVERS OF GANGA BASIN

# POLLUTION THREATS AND HOTSPOT ASSESSMENT



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**PLANNING AND MANAGEMENT FOR AQUATIC SPECIES CONSERVATION AND MAINTENANCE OF ECOSYSTEM SERVICES IN THE GANGA RIVER BASIN FOR A CLEAN GANGA**

**Progress Report**
Water quality of select rivers of Ganga Basin: Pollution threats and hotspot assessment

**Project Investigators**
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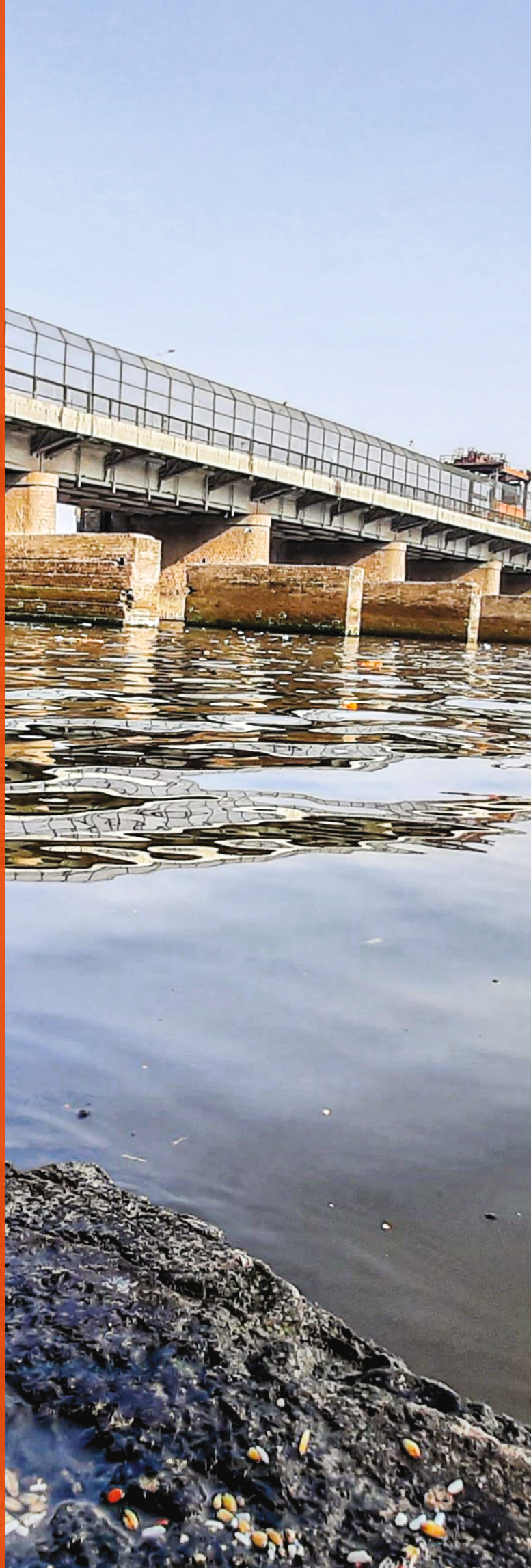



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# Contents


01 Preface

03 Background and Objective

06 Status of Water Quality Parameters in the Ganga River Basin




18

Status of Endocrine Disrupting Chemicals in the Ganga River Basin

32

Pollution threats and hotspots assessment

51

Annexure



# preface

Chemical pollution, climate change, species invasions, and habitat degradation threaten about 27% of all freshwater species catalogued in the IUCN Red List with the risk of extinction. Of particular concern is the pervasive occurrence of chemical pollution from diverse sources, which often plagues aquatic environments with toxic pollutants at levels that could exert profound and detrimental impacts on aquatic biodiversity.

Ganga River Basin (GRB) is the largest river basin in India in terms of catchment area, constituting 26% of the country's land mass (8,61,404 Sq. km) and supporting about 43% of its population. Rapid population growth, unplanned urban development, widespread agricultural practices, and industrial expansion coupled with reduced environmental flow are significant factors contributing to the deterioration of water quality in the Ganga River Basin. Inadequate wastewater treatment plants and improper wastewater discharge management further compounds the river's health issues, and allows for the continuous release of treated, partially treated, and sometimes untreated wastewater into the Ganga River Basin.

Several rivers of Ganga River Basin, serving as important habitats for threatened species, are recorded to be polluted by agricultural runoffs, domestic sewage and industrial effluents. Among the array of toxic groups of pollutants entering the freshwater environments, the occurrence of endocrine-disrupting chemicals (EDCs) in aquatic environments has emerged as a critical ecological concern due to their persistent, bioaccumulative, mobile, and toxic properties. Over recent decades, there has been growing recognition of the detrimental effects of EDCs on a wide range of taxa, such as primary producers, zooplankton, insects, amphibians, fish, birds, reptiles, and aquatic mammals. Even so, the monitoring of EDCs in the Ganga River basin lacks comprehensive and systematic studies, posing a potential threat to the effectiveness of ongoing conservation efforts for endangered species.

The present synthesis fulfils the requirement for the comprehensive spatio-temporal trends of water quality parameters and EDCs in the Ganga River Basin and their associated ecological risks to the aquatic ecosystem. Under this study, ecotoxicological data from 12 rivers and 143 sampling sites along the Ganga River basin has been synthesized and pollution hotspots within each river have been identified.



# BACKGROUND AND OBJECTIVE

**Chemical pollution is identified as one of the major contributors towards the decline in water quality and ecological integrity of Ganga River Basin (GRB) ecosystem. Aquatic species are particularly at higher risk because exposure to chemical toxicants can be life-long and occur through multiple routes, thus bioaccumulation is frequent. Apex predators, characterized by their low population densities, slow population growth rates, extended lifespans, low metabolic capacity, and high lipid reserves, are exceptionally susceptible to chemical pollution resulting from various human activities, encompassing both direct and indirect impacts.**

Considering, that the entire GRB is also home to rich and diverse fauna and several endangered species like otters, crocodiles, turtles, fishes and the Gangetic dolphin, the threat to biodiversity and ecological risks posed by the contaminants needs special attention.

The Ecotoxicology component of the project 'Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga' aims to develop comprehensive contamination profiles of emerging contaminants, and assess their associated risks to aquatic biodiversity within the Ganga River Basin. The overarching objective of this component is to:

i. Investigate the current contamination status and distribution pattern of the contaminants of emerging concerns, in biotic and abiotic matrices, of GRB

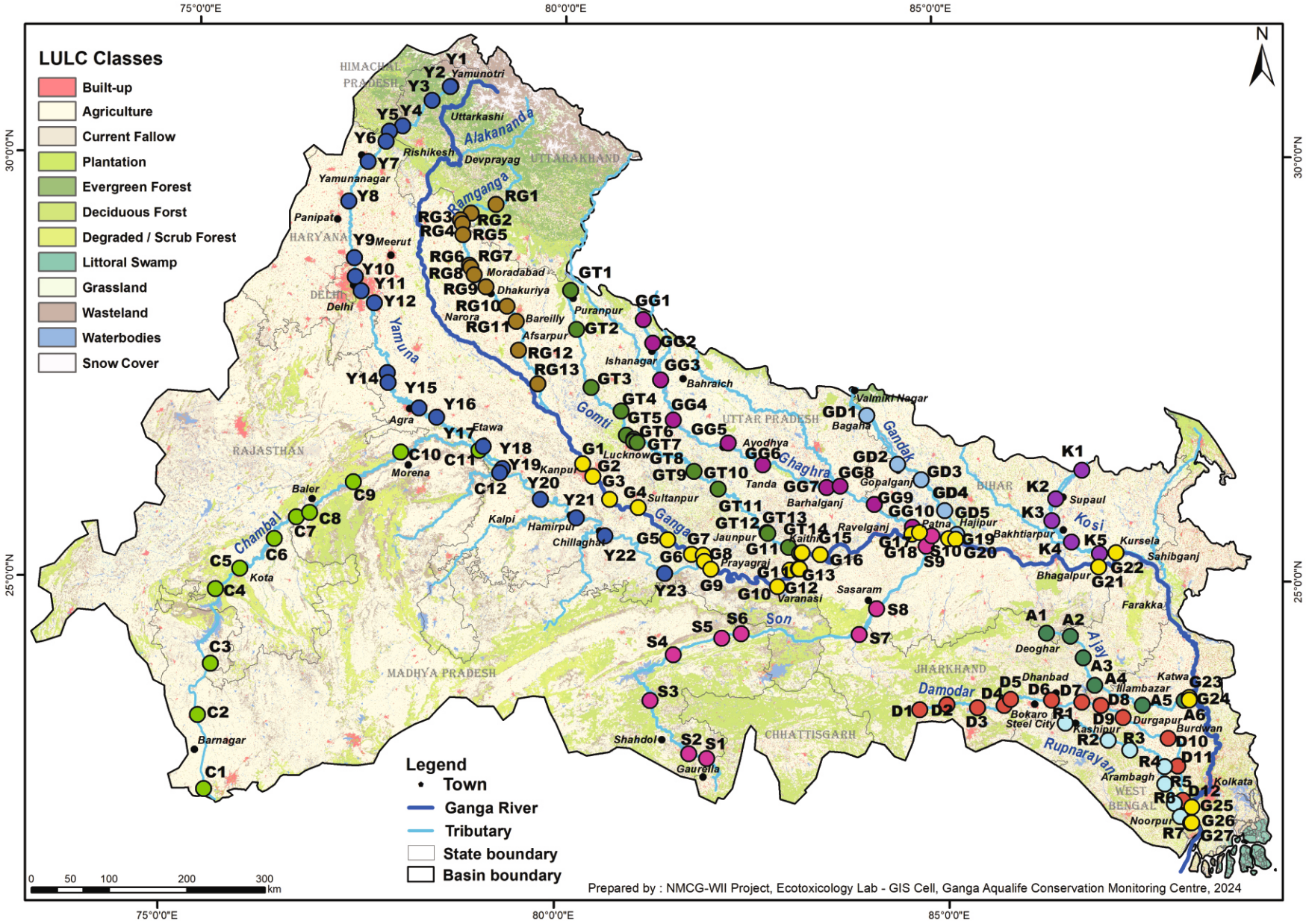
ii. To evaluate the potential eco-toxicological risks posed by each target contaminants towards aquatic organisms of GRB.

This report presents a preliminary assessment of water quality, contamination profiles of chemical toxicants, and addresses the associated ecological risks to aquatic biodiversity within the GRB.The findings are intended to provide a basis to regulatory authorities in designing effective monitoring strategies and formulating appropriate contamination mitigation efforts that would be directed towards sustaining the healthy ecological diversity of GRB.

## Sampling Sites

The ecotoxicological survey was conducted in Post-Winter (PW; April 2021) and Post-Monsoon (PM; October-November 2021) and surface water was collected, covering 12 rivers within theGRB. A total of 143 sampling sites (N) were considered, distributed across Ganga (28), Yamuna (23), Gomti (14), Ghaghra (10), Gandak (5), Kosi (5), Sone (9), Chambal (11), Ajay (6), Damodar (12), Rupnarayan (7), and Ramganga (13) for the ecotoxicological assessment. The survey for Damodar, Rupnarayan, and Ajay was conducted in Post-Winter 2022.

**Figure 1:** Sampling sites within the GRB





# STATUS OF WATER QUALITY PARAMETERS IN THE GANGA RIVER BASIN

**The present chapter discusses the water quality of twelve rivers of the Ganga River Basin as recorded during the post-winter and post-monsoon seasons.The main pollution parameters that have to be considered for surface water quality management, in general, include water temperature, pH, dissolved solids, dissolved oxygen, compounds of nitrogen (Nitrates and Ammonium), conductivity, etc. For the present study, all of the above parameters have been evaluated by using digital YSI ProDSS kit.**

## pH

pH is the negative logarithm of the hydrogen ion ($H^+$) concentration of a solution and is a measure of whether the liquid/solid is alkaline or acid. In fresh water bodies, hydrogen ion is governed by the equilibrium between carbonate ions, carbon dioxide and bicarbonate. The pH scale ranges from 1.0 (very acid, when more [$H^+$]), 7 (neutral, when [$H^+$] = [$OH^-$]) to 14 (very alkaline, when more [$OH^-$]). Atmospheric deposition due to acid rain and wastewater discharges are some of the key contributors that can change the pH. It is likely to increase during the day largely due to the consumption of carbon-dioxide for photosynthetic activity and falls during night due to respiratory processes. pH affects many biological and chemical activities in the water bodies e.g., different organisms flourish within different pH ranges. However, most of the aquatic animals prefers a pH range of 6.5 to 8.5. A pH outside this range could reduce the biodiversity in the water systems as it may stress the physiological systems of many organisms and can reduce their reproduction potential. Additionally, a low pH can result in high mobility and bioavailability of toxic contaminants for uptake by different aquatic plants and animals. This can result in circumstances that are highly toxic to aquatic life, particularly to vulnerable or sensitive species.

| Symbol (physical parameter) | pH |
|---|---|
| Units used for analytical results | pH units |
| Method(s) used for analysis | Digital calibrated water quality probe meter with pH sensitive probe. Calibrated at 3 point calibration range at 4.0 (acidic), 7.0 (neutral) and 10.0 (basic) |
| QC/QA | QC (Standards checked) after analysis |
| Aquatic Life Criteria | 6.5-8.5 is preferable |

**Figure 2:** pH range in the GRB for post-winter (PW) and post-monsoon (PM) seasons

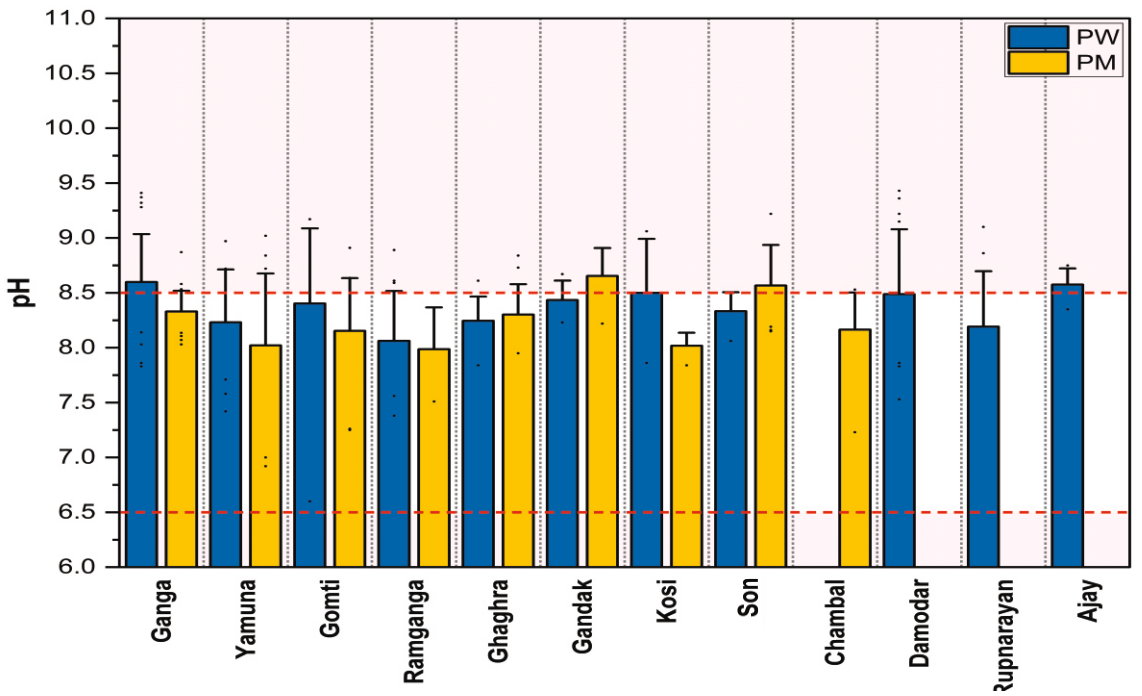
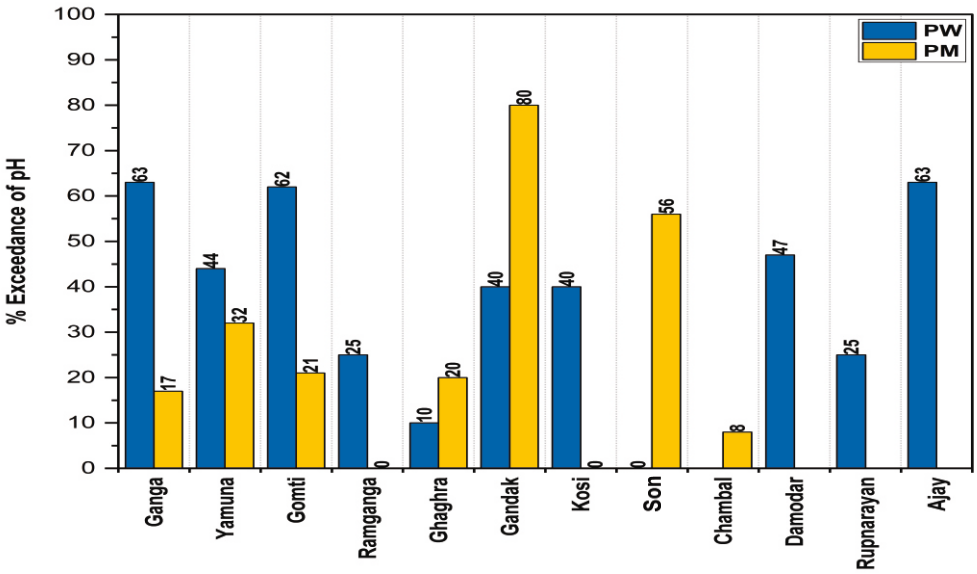


**Figure 3:** Percent exceedance of pH against aquatic life criteria (6.5-8.5)




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*

Figure 2 represents the pH recorded in individual rivers of the GRB during the post-winter and post-monsoon seasons of 2021. The following sections discuss the patterns observed for individual rivers.

## Ganga

In the present study, the pH in the Ganga River ranged from 7.83 - 9.41 (8.598 ± 0.438) in the post-winter and from 8.03 - 8.87 (8.330 ± 0.188) in the post-monsoon season. pH deviated from aquatic life criteria at 63% of the sites in the post-winter and 17% sites in the post-monsoon season.

## Yamuna

In the present study, the observed pH values during the post-monsoon season ranged from 6.92 to 9.02 (8.020 ± 0.654), while the observed pH values during the post-winter season ranged from 7.42 to 8.97 (8.231 ± 0.481). 44% of the river showed deteriorated water quality in terms of pH in the post-winter. The proportion of deterioration decreased to 32% in the post-monsoon.

## Gomti

The pH of the Gomti River ranged from 6.600 - 9.170 (8.402 ± 0.686) in the post-winter, and from 7.250 - 8.910 (8.168 ± 0.466) in the post-monsoon season in the present study. 62% of the river showed pH values beyond the recommended range in the post-winter and 21% in the post-monsoon season.

## Ramganga

In the present study, the pH of the Ramganga's surface water ranged from 7.38 - 8.890 (8.119 ± 0.469) with 27% of the river having pH deviating from the recommended range in the post-winter, and from 7.51 - 8.90 (8.152 ± 0.564) in the post-monsoon season. 20% of the sites deviated from the optimal range in this season.

## Ghaghra

In the present study the range of natural pH, extends from around, 7.84 to 8.61 (8.25 ± 0.22) in the post winter Season, whereas in post monsoon Season, the pH ranged from 7.95 to 8.84 (8.30 ± 0.28) between the 10 sampling points.

The river showed deterioration of 10% and 20% during the post-winter and post-monsoon, respectively.

## Gandak

During the present ecotoxicological survey, pH levels ranged from 8.23 to 8.67 (8.434 ± 0.177) in the post-winter season and 8.22 to 8.85 (8.654 ± 0.255) in the post-monsoon season across the seven sampling stations of Gandak river. Deviation from the recommended range was observed in 40% and 80% of the river in the post-winter and post-monsoon seasons, respectively.

## Kosi

In the current investigation, the natural pH range spans from 7.860 - 9.060 (8.500 ± 0.491) during the post-winter season and from 7.840 - 8.130 (8.018 ± 0.118) during the post-monsoon season across the five sampling points.

The river saw exceedance of the upper limit of pH at 40% of the sites in the post-winter, while all sites had satisfactory pH during the post-monsoon.

## Son

The range of natural pH in Son River extends from 8.06 - 8.48 (8.33 ± 0.17) in the post winter season and 8.15 - 9.22 (8.54 ± 0.36) in the post monsoon season. Exceedance from the recommended limit was observed at 56% of the sites in the post-monsoon season.

## Chambal

In the present study the range of natural pH extends from 7.23 - 8.53 (8.164 ± 0.337) between the twelve sampling points, with an exceedance of 8%.

## Damodar

In this study, we found a natural pH range of 7.530 - 9.430 (8.585 ± 0.575) across thirteen sampling points. Deterioration in terms of pH was observed at 47% of the sites.

## Rupnarayan

In this study, we found a natural pH range from 7.690 to 9.100 with mean value of 8.214 ± 0.542 across seven sampling points, with exceedance of the recommended limit at 25% of the sites.

## Ajay

In this study, we found a natural pH range of 8.350 to 8.750 (8.597 ± 0.168) across six sampling points, with exceedance at 63% of the sites.



# DISSOLVED OXYGEN (DO)

**Dissolved oxygen (DO) is a measure of oxygen in its dissolved form. DO levels decline if more oxygen is consumed than is produced, and some sensitive and vulnerable animals may weaken, diverge, or die. Different biological and chemical processes can result in decline of DO, for example biological decomposition of effluents from wastewater and sewage treatment plants, that contains high amount of organic materials, by microorganisms. The levels of dissolved oxygen can fluctuate seasonally or within a period of 24-hour. They also fluctuate with altitude and water temperature as warm water reportedly holds less oxygen than cold water and also at higher altitudes water holds relatively less oxygen.**

| Symbol (physical parameter) | DO |
|---|---|
| Units used for analytical results | mg/L $O_2$ |
| Method(s) used for analysis | Digital calibrated water quality probe meter with DO sensitive probe |
| QC/QA | QC (Standards checked) after analysis |
| Aquatic Life Criteria | >5 mg/L is preferable |

The following sections provides river-wise assessment of DO in GRB.

**Figure 4:** DO levels recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

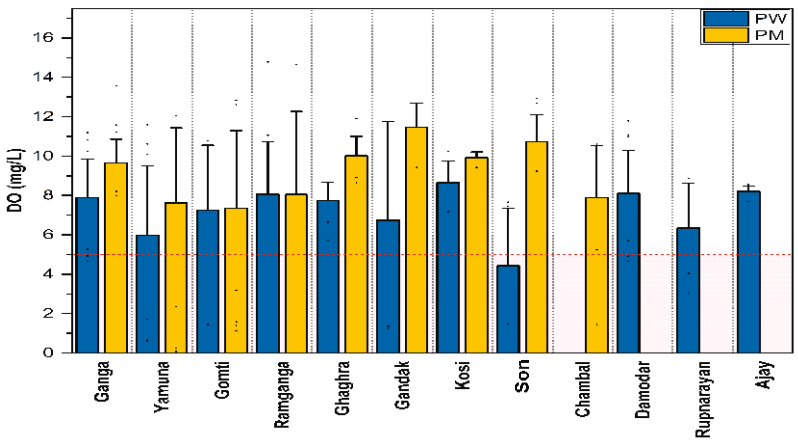
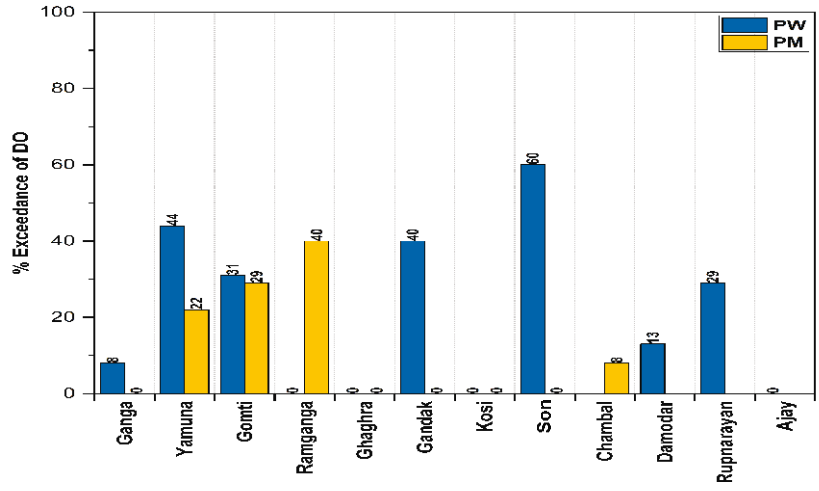



**Figure 5:** Percent exceedance of DO against aquatic life criteria (>5 mg/L)




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*



## Ganga

In the present study, DO ranged from 4.67 -11.20 (8.132 ± 1.824) mg/L in the post-winter and from 7.98 - 13.56 (9.659 ± 1.200) mg/L in the post-monsoon season. The water quality was found to be deteriorated at 8% of the sites in the post-winter season, in terms of DO.

## Yamuna

In the present study, the observed dissolved oxygen values during the post-winter season it varied between 0.59 to 13.62 6.161 ± 3.860 mg/l, while during the post-monsoon season it ranged from 0.08 to 13.84 (7.8039 ± 4.0179) mg/l.

The post-winter and post-monsoon seasons recorded a deterioration of 44% and 22%, respectively.

## Gomti

In the present study, the DO of the Gomti River ranged from 1.430 - 10.770 (7.255 ± 3.296) mg/L in the post-winter and from 1.140 - 15.830 (7.642 ± 4.204) mg/L in the post-monsoon season, with deterioration recorded at 31% and 29% of the sites during the two seasons, respectively.

## Ramganga

In the present study, the DO of the Ramganga ranged from 3.300 to 12.800 (8.380 ± 2.769) mg/L in the post-winter, and from 4.270 - 12.630 (8.016 ± 3.694) mg/L in the post-monsoon season.

DO below the recommended threshold for aquatic life criteria was detected at 9% of the sites in the post-winter and 40% of the sites in the post-monsoon season.

## Ghaghra

In the present study the range of DO, extends from around, 5.74 mg/l to 8.62 mg/l (7.75 ± 0.91) between the 10 sampling points. Similarly in the post monsoon season, the DO ranged from 8.65 mg/l to 15.89 mg/l (10.42 ± 2.05) between the 10 sampling points.

The DO levels recorded in both seasons were within the permissible limit facilitating aquatic life survival (>5 mg/l).

## Gandak

During the present survey, dissolved oxygen (DO) levels in surface water of Gandak river exhibited a range of 1.25 to 11.08 (6.750 ± 5.011) mg/L during the post-winter season and 9.42 to 17.53 (2.680 ± 2.965) mg/L during the post-monsoon sampling season.

Throughout the post-winter survey period, dissolved oxygen (DO) levels at 40% of the sites were observed to fall below the acceptable threshold (>5 mg/L) for supporting aquatic life.

## Kosi

DO range extends from 7.180 to 10.250 (8.656 ± 1.100) mg/L in post-winter and 9.420 to 10.140 (9.914 ± 0.294) mg/L in post monsoon. There is a slight reduction in DO during



the post-winter season, attributed to the lower water volume compared to the post-monsoon season. Agricultural runoff along the riverbank contributes pollutants to the river. However, the overall comparative study indicates that the DO levels are conducive to the survival of aquatic life in both seasons.

## Son

The range of DO extends from 1.48 to 7.66mg/L (4.44 ± 2.90) during post winter season and 9.24 to 12.93 mg/L (11.93 ± 2.93) during the post monsoon season.

All sites during the post monsoon season recorded DO levels conducive for the survival of aquatic life (>5 mg/L). However, 60% of the sites recorded low DO levels during post winter season.

## Chambal

In the present study, the range of DO extends from 1.45 to 10.61 mg/L (7.886 ± 2.635 mg/L) between the twelve sampling points.

DO concentration lower than the threshold for supporting aquatic life was observed at 8% of the sites.

## Damodar

In this study, the dissolved oxygen (DO) range from 5.700 to 11.790 mg/L with a mean of 8.619 ± 1.859. The DO values were recorded to be within the permissible range for aquatic life criteria.

## Rupnarayan

In the present study, the range of Dissolved Oxygen (DO) was determined to be between 3.030 to 8.860 mg/L, with an average value of 6.354 ± 2.264 mg/L. Notably, substantial variations in DO values, falling below the specified aquatic life criteria range (>5 mg/L), were observed at 29% of the sites.

## Ajay

In this study, the dissolved oxygen (DO) range from 7.700 to 8.490 mg/L (8.120 ± 0.272). The DO values were recorded to be within the permissible range for aquatic life criteria.

# CONDUCTIVITY

**The ability of water to pass an electrical current is defined as conductivity and it is measured in microsiemens per centimetre (µS/cm) or micromhos per centimetre (µmhos/cm). The temperature affects the conductivity measurements therefore the standard method for reporting conductivity is the measurement of conductivity recorded at or corrected to 25°C and is defined as specific conductance (uS/cm). One of the important factors that can affect conductivity in water is the presence of dissolved solids or ions. Similarly, conductivity is directly proportional to change in temperature i.e. elevated water temperatures results in higher the conductivity. Industrial, agricultural and sewage discharges to streams can change the conductivity due to the presence of ions. The aquatic life criteria suggest that fresh water systems that have conductivity in the range of 150 to 500 µS/cm support good mixed fisheries.**

| Symbol (physical parameter) | Conductivity © |
|---|---|
| Units used for analytical results | µS/cm |
| Normal method(s) used for analysis | Digital calibrated water quality probe meter with conductivity sensitive probe |
| QC/QA | QC (Standards checked) after analysis |
| Aquatic Life Criteria | <500 µS/cm is preferable |

The following sections provides river-wise assessment of Conductivity within the GRB.

**Figure 6:** Conductivity recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

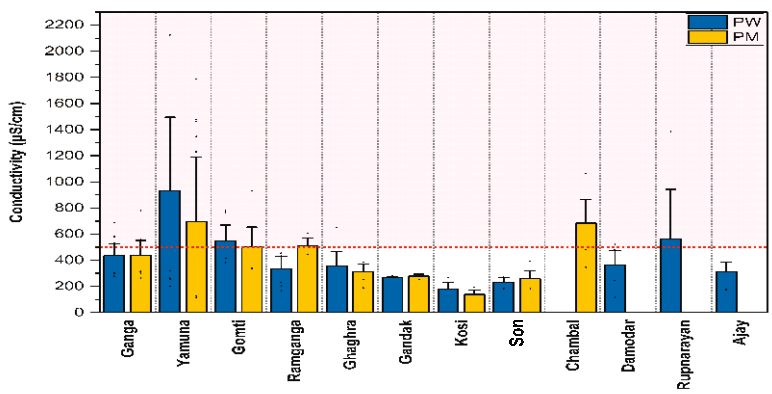
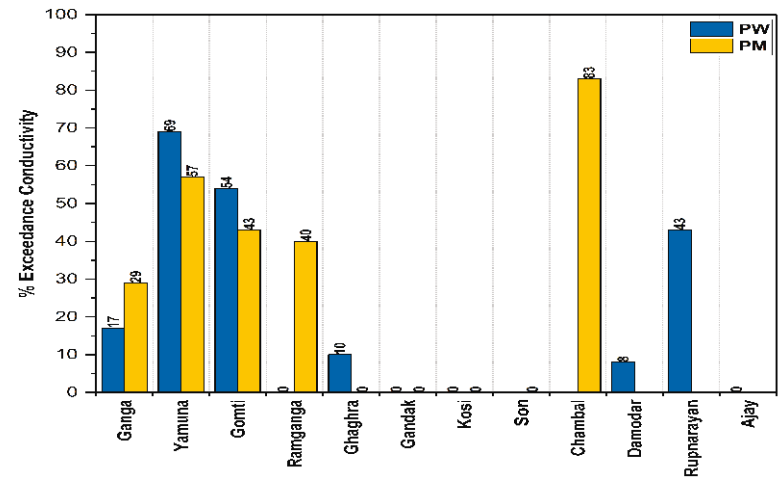



**Figure 7:** Percent exceedance of Conductivity against aquatic life criteria (<500 µS/cm)




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*



## Ganga

Conductivity in the Ganga ranged from 277.930 - 689.000 (435.140 ± 91.781) µS/cm in the post-winter and from 263.250 - 779.000 (434.838 ± 117.322) µS/cm in the post-monsoon season. The per-cent exceedance for this parameter in the post-winter and post-monsoon was 17% and 29% respectively.

## Yamuna

In the present study, observed conductivity values during the post- winter season ranged from 200.63 to 2123.67 (933.740 ± 561.660) µS/cm. Meanwhile, the observed values of conductivity during the post-monsoon season ranged from 115.67 to 1788.5 (696.247 ± 494.907) µS/cm.

In both seasons, the conductivity concentration exceeded the permissible aquatic life criteria at 69% and 57% of the sites respectively.

## Gomti

The conductivity of the Gomti River ranged from 382.630 - 781.000 (546.341 ± 123.346) µS/cm in the post-winter and from 336.550 - 931.670 (505.521 ± 146.385) µS/cm in the post-monsoon season in the present study.

In the post-winter, conductivity exceeded aquatic life criteria at 54% of the sites. In the post-monsoon, this proportion decreased to 43%.

## Ramganga

In the present study, the conductivity in the Ramganga ranged from 169.430 - 454.200 (327.492 ± 102.487) µS/cm in the Post-Winter and from 447.100 - 605.000 (514.060 ± 60.460) µS/cm in the Post-Monsoon season.

Conductivity exceeded the threshold for aquatic life at 60% of the sites in the post-monsoon season.

## Ghaghra

Conductivity ranged from around 252.3 µS/cm to 651 µS/cm (355.89 ± 109.57) between the 10 sampling points in the post winter season. Similarly in the post monsoon season, the conductivity ranged from 189.47 µS/cm to 383.45 µS/cm (313.96 ± 56.09).

The Conductivity value exceeded the aquatic life criteria range of 500 µS/cm at 10% of the sites in the post-winter season.

## Gandak

During the present survey, conductivity levels in the post-winter sampling season varied from 261.13 to 279.03 (267.468 ± 7.073) µS/cm, while during the post-monsoon period, they ranged between 254.45 and 294.1 (278.310 ± 15.636) µS/cm across the sampling stations. Throughout both sampling seasons, specific conductivity at all sites fell within the acceptable range according to aquatic life criteria.

## Kosi

The current investigation reveals a conductivity range of 131.330 to 266.530 µS/cm (178.262 ± 54.958 µS/cm) during the post-winter period and 116.600 to 193.600 µS/cm (138.444 ± 33.223 µS/cm) in the post-monsoon season. Conductivity was observed to be within acceptable limits at all sites.

## Son

Conductivity levels ranged between 183.56 and 270.25 µS/cm (231.34 ± 37.40) during the post winter season and 182.53 to 392.45 µS/cm (263.52 ± 60.64) during the post monsoon season.

The available data indicates that, throughout both seasons, all the sites registered conductivity levels conducive to aquatic life (<500 µS/cm).

## Chambal

In the present study, the Conductivity ranged between 346.70 µS/cm to 1067.00 µS/cm, with a mean value of 683.572 ± 182.832 µS/cm.

The Conductivity exceeded the maximum value for the optimum range for aquatic life at 83% of the sites in the river.

## Damodar

In the presence study the range of Conductivity extends from around 116.160 µS/cm to 522.430 µS/cm (365.994 ± 109.748). The limit for aquatic life criteria was exceeded at 8% of the sites.

## Rupnarayan

In the presence study the range of Conductivity extends from 273.050 µS/cm to 1386.670 µS/cm (562.990 ± 380.108). Exceedance of recommended limit for conductivity was observed at 43% of the sites.

## Ajay

In the presence study the range of Conductivity extends from around 174.900 µS/cm to 382.070 µS/cm with a mean value 311.273 ± 72.565. The conductivity values were recorded to be within the permissible limit throughout the river.



# TOTAL DISSOLVED SOLIDS (TDS)

**In water bodies, total dissolved solids (TDS) consist of different ions (chlorides, calcium, nitrate, phosphorus, iron, sulphur, etc.,) that traverse through a 2 µm filter paper. The levels of TDS can affect the water equilibrium in the cells of aquatic species which in turn can disturb their cell density and eventually the ability to maintain their position in the water system. Elevated levels of TDS can serve as transporters of toxicants, which can readily adhere to suspended particles. This is particularly problematic areas such as in agricultural belts where high amount of pesticides is being used and areas where there is high discharge of untreated industrial effluents.**

| Symbol (physical parameter) | TDS |
|---|---|
| Units used for analytical results | mg/L Dissolved Solids |
| Method(s) used for analysis | Digital calibrated water quality probe meter with TDS sensitive probe |
| Occurrence/Origin | Agricultural runoffs, industrial and sewage discharge |
| QC/QA | QC (Standards checked) after analysis |
| Aquatic Life Criteria | <500 mg/L is preferable |

The following sections provides river-wise assessment of TDS within the GRB.

**Figure : 8** TDS recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

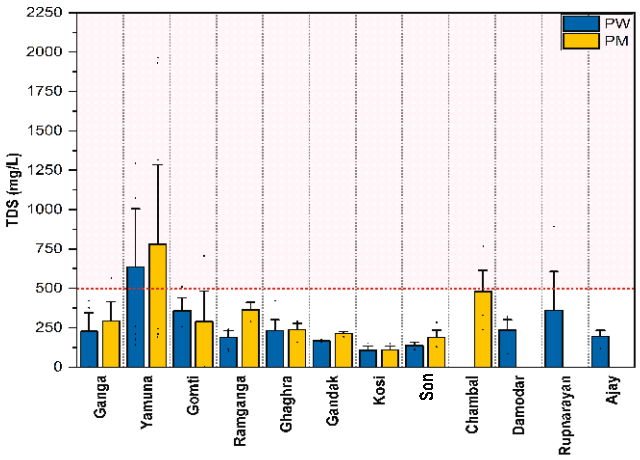
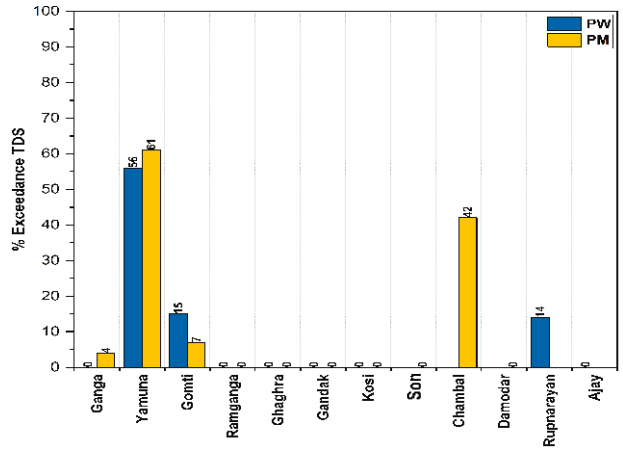



**Figure : 9** Percent exceedance of TDS against aquatic life criteria (<500 mg/L)




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*



## Ganga

TDS ranged from 177.330 - 420.500 (271.323 ± 59.121) mg/L in the post-winter and from 187.500 - 565.000 (318.192 ± 80.427) mg/L in the post-monsoon season in the Ganga River. In the current study, the TDS values in Ganga River were recorded to be within the recommended limit during post winter season. However, the recorded TDS values exceeded the recommended limit at 4% sites during post monsoon season.

## Yamuna

In the present study, the recorded values of total dissolved solids (TDS) during the

post- monsoon season varied between 190.55 to 1964 (781.08 ± 502.93) mg/l. Meanwhile the recorded values of TDS during the post-winter season ranged from 142.83 to 1295.33 (634.118 ± 370.436) mg/l. In the Yamuna River, the recommended limit of TDS exceeded at 56% sites during post winter season and at 61% sites during post monsoon season.

## Gomti

The TDS of the Gomti River, in the present study, ranged from 255.770 - 510.000 (357.867 ± 82.478) mg/L in the post-winter and from 254.000 - 706.000 (381.849 ± 108.082) mg/L in the post-monsoon season.

In the present study, the recommended limit of TDS exceeded at 15% sites during post winter season and at 7% sites during post monsoon season.

## Ramganga

The TDS in the river in the present study, ranged between 100.230 and 252.45 (190.727± 52.703) mg/L in the Post-Winter, and between 290.000 and 416.000 (375.260 ± 49.597) mg/L in the Post-Monsoon season. There was an evident increase in dissolved solids in the river's water in the colder months potentially due to the low volume of water carried by the river in this season.

The TDS was within the recommended range as per aquatic life criteria at all sites during both the seasons.

## Ghaghra

The range of TDS extends from around 173.73 mg/l to 421.50 mg/l (232.18 ± 69.08) in the post winter season. Similarly in the post monsoon season, the TDS ranged from 157.67 mg/l to 289.25 mg/l (238.35 ± 38.67) between the 10 sampling points.

The TDS levels recorded in both seasons were found to be within permissible limit of 500 mg/l conducive for the survival of aquatic life.

## Gandak

The total dissolved solids (TDS) during the post-winter sampling season varied from 159.83 mg/L to 173.03 (165.470 ± 5.178) mg/L. Meanwhile, during the post-monsoon period, TDS levels ranged from 192.5 to 221.6 (213.930 ± 12.188) mg/L across the seven sampling stations of Gandak river. Across both sampling seasons, concentrations of total dissolved solids (TDS) at all sites were identified to be within acceptable limits according to aquatic life criteria (<500 mg/L).

## Kosi

In the current investigation, Total Dissolved Solids (TDS) were measured within the range of 90.000 to 150.000 mg/L (106.000 ± 26.077 mg/L) during the post-winter, and 90.660 to 148.660 mg/L (108.130 ± 24.517 mg/L) in the post-monsoon season across five sampling sites. Importantly, these TDS levels remained within the permissible range (<500 mg/L) established for aquatic life criteria. Notably, a slight increase in TDS levels was observed in the post-monsoon season compared to post-winter. This elevation may be attributed to the influx of pollutants from agricultural activities and solid waste disposed along the river.

## Son

In the present study, the TDS levels ranged between 111.4 to 159.2 mg/L (137.50 ± 21.54) during post winter season and 129.6 to 283 mg/L (194.80 ± 44.24) during the post monsoon season. Highest TDS level was recorded at Govarde (283 mg/L) during post monsoon season and the lowest level recorded at D/S Son-North Koel confluence (111.4 mg/L) during post winter season.

The available data shows that all sites during both the seasons recorded TDS levels conducive for the survival of aquatic life (<500 ppm).

## Chambal

In the present study the TDS ranges from 236.53 mg/L to 767 mg/L, with an average of 480.569 ± 133.675 mg/L.

In Chambal River, the TDS values exceeded the recommended limit at 42% sites during post monsoon season.

## Damodar

In the present study, the range of TDS extends from around 85.460 mg/L to 320 mg/L (236.137 ± 64.300). The TDS values were recorded to be within the permissible limit of 500 mg/L for aquatic life criteria.

## Rupnarayan

In the present study, the range of TDS extends from 170.750 mg/L to 894.670 mg/L (360.126 ± 246.725).

The TDS values in Rupnarayan River exceeded at 14% sites during post winter season.

## Ajay

In the present study Total Dissolved Solids (TDS) range spans from approximately 117.700 mg/L to 224.700 mg/L, with an average value of 192.883 ± 40.015 mg/L. Importantly, the recorded TDS values are within the acceptable limit of <500 mg/L, for aquatic life criteria.

# NITRATES ($NO_3^-$,mg/L)

**Nitrates are essential plant nutrients that are present in several different forms in aquatic and terrestrial ecosystems. Some of these forms of nitrogen include nitrites, ammonia, and nitrates. Mineral origin nitrates ($NO_3^-$) in water bodies are relatively little. Though, microbacterial oxidation and nitrogen fixation by plants can also produce nitrates, most of the nitrates found in rivers is from organic and inorganic sources, like agricultural runoffs and waste discharges. In excess amount Nitrates can cause substantial water quality problems like enhanced eutrophication, and variations in the different plants and animals that inhabits the water systems. This sequentially can affect the other important water quality parameters and indicators like temperature and dissolved oxygen.**

Excessive levels of $NO_3^-$ may result in hypoxia due to low levels of dissolved oxygen and under specific conditions it may result in toxicity to animals at levels >10 mg/L. The natural level of nitrate and ammonia in fresh water systems is usually at low concentration of < 1 mg/L, however with untreated wastewater effluents, it can shoot up to 30 mg/L.

| Symbol (physical parameter) | $NO_3^-$ |
|---|---|
| Units used for analytical results | mg/L of N or mg/L of $NO_3^-$ |
| Method(s) used for analysis | Digital calibrated water quality probe meter with $NO_3^-$ sensitive probe |
| Occurrence/Origin | Oxidation of ammonia, Agricultural fertiliser runoffs, industrial and sewage discharge |
| QC/QA | QC (Standards checked) after analysis |
| Aquatic Life Criteria | <10 mg/L is preferable |

**Figure : 10** Nitrate range recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

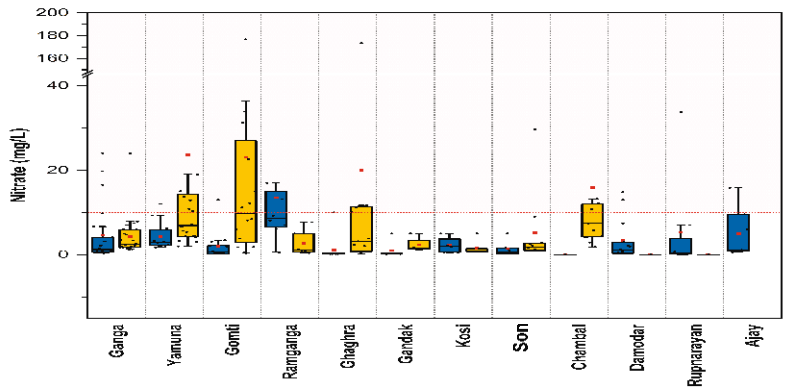
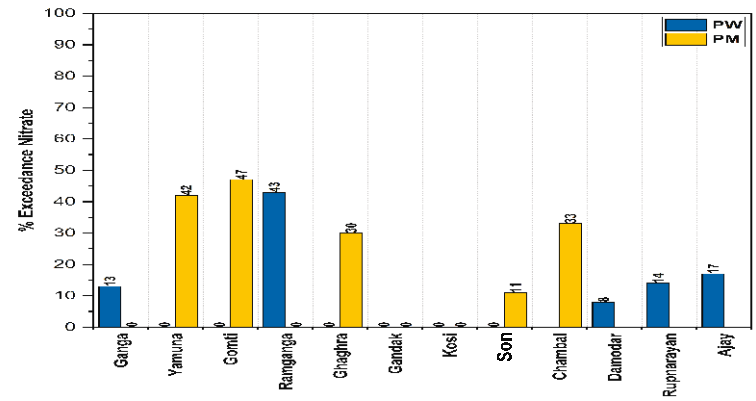



**Figure : 11** Percent exceedance of Nitrate against aquatic life criteria (<10 mg/L)




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*



## Ganga

Nitrate ranged from 0.350- 19.770 (3.854± 5.773) mg/L in the post-winter and from 1.260- 7.887 (3.486± 2.213)mg/L in the post-monsoon season in the Ganga River.

In the present study, the nitrate values in Ganga River exceeded at 13% sites during post winter season. The recorded nitrate values were found within the recommended limit during post monsoon season.

## Yamuna

In the present study, the recorded values of nitrate during the post-monsoon season varied between 1.96 to 123.5 (19.656 ± 36.969). whereas, the recorded values of nitrate during the post-winter season ranged from 1.72 to 9.28 ( 3.612 ± 2.318 ).

In Yamuna River, the nitrate values were found to be within the recommended limit during post winter season, however, the values exceeded at 42% sites during post monsoon season.

## Gomti

The nitrate levels in the Gomti River ranged from 0.210 - 3.420 (1.177 ± 1.167) mg/L in the post-winter and from 0.360 - 176.790 (24.939 ± 45.524) mg/L in the post-monsoon season.

In the present study, the nitrate values were found to be within the recommended limit during post winter season, however, the values exceeded at 47% sites during post monsoon season.

## Ramganga

The nitrate concentrations in the river's water ranged from 0.540 - 46.640 (15.048 ± 14.151) mg/L in the post-winter and from 0.380 - 7.700 (2.917 ± 3.296) mg/L in the post-monsoon season in the present study. The nitrate concentration showed a decrease in value in the post-monsoon season as compared to the post-winter.

In the current investigation, nitrate values exceeded the recommended limit at 60% sites during post winter sampling. However, all the sites reported nitrate values within the permissible limit during post monsoon season.

## Ghaghra

The range of nitrate extends from around 0.14 mg/l to 0.40 mg/l in the post winter season, whereas in post monsoon season, the Nitrate ranged from 0.25 mg/l to 173.55 mg/l between the 10 sampling points.

Nitrate values in Ghaghra River were found to be within the permissible limit during post winter season, however the values exceeded at 30% sites during post monsoon season.

## Gandak

In the current sampling survey, the nitrate concentrations varied between 0.12 and 1.04 (0.381±0.318) mg/L during the post-winter season and from 1.11 to 3.45 (2.119±0.968) mg/L during the post-monsoon season across the seven sampling stations.

Notably, the nitrate levels consistently fell within the acceptable range of <10 mg/L, meeting the criteria for sustaining aquatic life at all designated sites.

## Kosi

In the current investigation, the nitrate concentration ranges from 0.450 to 3.710 mg/L (1.770 ± 1.330 mg/L) in the post-winter period and 0.690 to 1.800 mg/L (0.860 ± 0.308 mg/L) in the post-monsoon season. Throughout the entire river, all recorded nitrate levels fall within the acceptable range (<10 mg/L) established for aquatic life criteria during both seasons.

## Son

In the present study, the nitrate levels ranged between 0.24 to 1.63 mg/L (0.71 ± 0.60) in the post winter season and 0.87 to 29.65 mg/L (4.46 ± 8.88) in the post monsoon season.

In the current investigation, the nitrate values in Son River were found within the permissible limit during post winter season, however, the values exceeded at 11% sites during post monsoon season.

## Chambal

In the present study the range of nitrate, extends from 1.85 mg/L to above 120 mg/L (mean 16.187 ± 32.902 mg/L).

In Chambal River, the nitrate values exceeded the recommended limit at 33% sites during post monsoon season.

## Damodar

In the present study the range of nitrate extends from around 0.210 mg/L to 14.830 mg/L (2.608 ± 4.159).

In the present study, the nitrate values exceeded the permissible limit at 8% during post winter season.

## Rupnarayan

In the present study the range of nitrate extends from around 0.060 mg/L to 33.770 mg/L with an average of 5.041 ± 12.670.

The nitrate values in Rupnarayan River exceeded at 14% sites during post winter season.

## Ajay

In the present study the range of nitrate extends from around 0.600 mg/L to 15.810 mg/L with an average value of 4.798 ± 6.423.

In the present study, the nitrate values were reported to exceed at 17% sites during post winter season.

# SALINITY

## Ganga

Salinity ranged from 0.130-2.510 (0.296- 0.474) ppt in the post-winter and from 0.140- 0.410 (0.241± 0.060) ppt in the post-monsoon season in the Ganga River.

The salinity values in Ganga River exceeded at 4% sites during post winter season., however, the recorded salinity values were found within the recommended limit during post monsoon season.

## Yamuna

In the present study, the observed salinity values during the post- monsoon season varied from 0.08 to 1.04 (0.410±0.285), whereas in the post - winter season it ranged between 0.11 to 1.01 (0.482 ± 0.278).

In Yamuna River, the salinity values were reported to exceed at 53% sites during post winter season and at 32% sites during post monsoon season.

## Gomti

In the present study, the salinity of the Gomti river ranged from 0.190 - 0.380 (0.267 ± 0.061) ppt in the post-winter and from 0.190 - 0.540 (0.286 ± 0.083) ppt in the post-monsoon season.

In the present study, the salinity values were found to be within the recommended limit during post winter season, however, the values exceeded at 7% sites during post monsoon season.

## Ramganga

In the present study, the salinity of the river ranged from 0.080 - 0.180 (0.137 ± 0.031) ppt in the Post-Winter, and from 0.210 - 0.310 (0.273 ± 0.037) ppt in the Post-Monsoon season, displaying an increase in the colder months, likely owing to lower temperatures in the river's upper reaches resulting in lower discharge.

Salinity values were found to be within the permissible limit during both the sampling seasons.

## Ghaghra

Salinity levels ranged between 0.13 ppt and 0.32 ppt (0.17 ± 0.05 ppt) during the Post winter season and 0.12 ppt to 0.22 ppt (0.18 ± 0.03 ppt) during the post monsoon season. The salinity levels recorded in both seasons were found to be within permissible range conducive for the survival of freshwater life.

## Gandak

Salinity levels during the post-winter season ranged from 0.12 to 0.13 (0.124 ± 0.005) ppt, whereas in the post-monsoon period, they fluctuated between 0.14 and 0.17 (0.160 ± 0.012) ppt across the seven sampling stations. Throughout both the survey seasons, salinity remained within the permissible range (<0.5 ppt), ensuring the sustainability of freshwater life.



## Kosi

In the present study , the salinity range were recorded from 0.070 to 0.110 (0.082 ± 0.018) ppt in post -winter and 0.070 to 0.100 (0.078 ± 0.013) ppt in post monsoon season through out the entire stretch of Kosi river , Bihar. Overall values for salinity was observed with in the permissible range (< 0.5 ppt) for the aquatic life criteria for fresh water.

## Son

In the present study, the salinity levels ranged between 0.08 ppt and 0.12 ppt (0.10 ± 0.02) in the post winter season, whereas in the post monsoon season the range extends from 0.09 ppt to over 0.21 ppt (0.14 ± 0.04).

The salinity levels recorded in both seasons were found to be within permissible range conducive for the survival of freshwater life.

## Chambal

In the present study, the salinity ranged from 0.18 to 0.59 (0.364 ± 0.104) ppt, exceeding the recommended limit at 8% sites.

## Damodar

In the present study the range of salinity extends from around 0.060 ppt to 0.230 ppt (0.167 ± 0.052). The salinity values were recorded to be within the permissible range of <0.5 ppt for freshwaters.

## Rupnarayan

In the present study the range of salinity extends from around 0.130 ppt to 0.690 ppt (0.273 ± 0.192).

The salinity values in Rupnarayan River exceeded at 14% sites during post winter season.

## Ajay

In the present study the salinity range spans from approximately 0.100 ppt to 0.170 ppt, with an average value of 0.137 ± 0.031 ppt across the six sampling points. The recorded salinity values fall within the acceptable range of <0.5 ppt.

# STATUS OF ENDOCRINE DISRUPTING CHEMICALS (EDCs) IN THE GANGA RIVER BASIN

**EDCs comprise a highly diverse class of compounds, including natural hormones and man-made substances such as pesticides, pharmaceuticals, plasticizers, industrial chemicals, surfactants, and household and personal care products, all of which mimic estrogenic effects. Convincing evidence supports a causal link between EDCs and disruptions in reproduction and development across various aquatic mammalian species, resulting in observable shifts in local or regional populations. Considering the evidence-based impact of EDCs on aquatic apex predators, research must focus on investigations into EDC contamination and its potential health implications on threatened species. This information is crucial for strengthening conservation efforts and sustaining the overall health of aquatic ecosystems.**

**The following section presents the group-wise and river-wise contamination pattern of EDCs in the GRB.**

The following section presents the group-wise and river-wise contamination pattern of EDCs in the GRB.

**Figure 12 :** BPA concentration recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

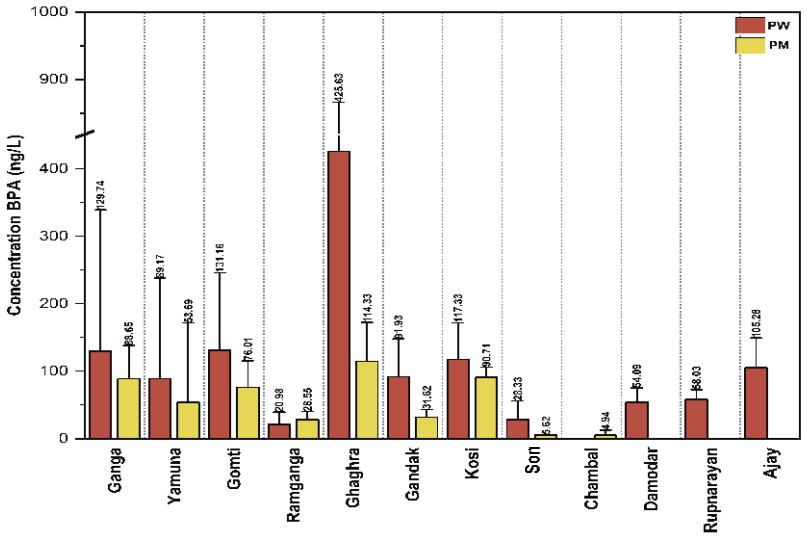
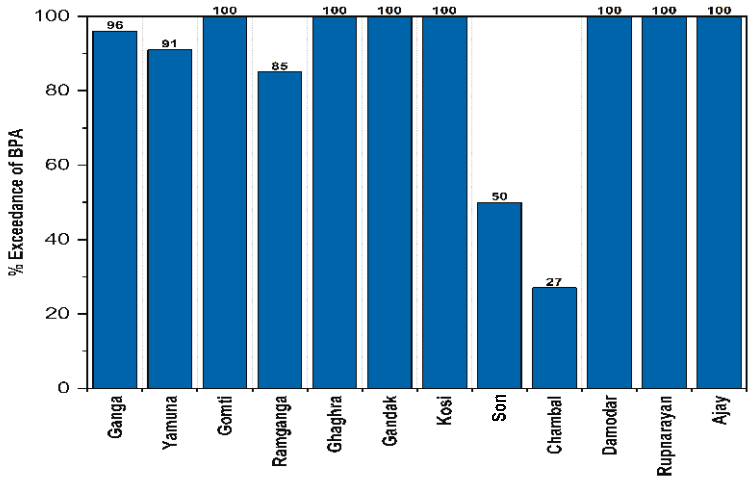



**Figure 13 :** Percent exceedance of BPA




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*

## PLASTICIZERS

### Bisphenol-A (BPA)

Bisphenol A is extensively utilized as a chemical intermediate, playing a pivotal role in the production of polycarbonate and epoxy resin, which, in turn, contributes to the manufacturing of various end-products including food containers, digital media, canned beverages, medical devices (such as dental filling materials), reusable bottles, and thermal papers. Bisphenol-A finds its way into the aquatic environment with plastic wastes, from which it tends to leach into the water. BPA and its alternatives can affect endocrine and immune functions, stress responses and lipid metabolism in cetaceans, potentially posing a threat to the endangered Gangetic dolphin in the GRB as well.

The following sections discuss elaborate on the contamination scenario of surface water in the 12 rivers within the GRB by BPA.

### Ganga

In the Ganga, BPA concentration ranged from 20.740 - 779.060 (125.595 ± 219.906) ng/L in the post-winter. In the post-monsoon, the concentrations ranged from 4.590 - 210.600 (84.536 ± 60.624) ng/L. The contaminant was detected at all sites surveyed in the Ganga River in both the seasons. BPA poses high risk to Ganga's biodiversity at 96% of the surveyed sites.

## Yamuna

In the present study, BPA concentration in the surface water of the Yamuna river ranged from <DL - 607.200 (89.170 ± 148.979) ng/l in the post-winter season, and from 5.16 - 572.59 (53.690 ± 117.668) ng/L during the post-monsoon season. BPA was detected at all sites in the post-monsoon season, but its detection frequency (DF, 87%) was lower during the post-winter season.

BPA poses high risk to river's ecosystem at 91%of the surveyed sites.

## Gomti

In the present study, BPA concentrations in the Gomti River ranged from 27.01 - 419.46 (131.158 ± 115.002) ng/L in the post-winter and from 32.73 - 174.38 (76.009 ± 39.676) in the post-monsoon season. It was detected at all sites in both the seasons.

Concentrations were observed to be high at sites associated with dumping of solid wastes and discharge of effluent.

All of the surveyed sites were estimated to face high risk from BPA contamination.

## Ramganga

In the current study, the investigation into Bisphenol A (BPA) concentrations in surface water during the post-winter season were observed in the range of 0.60 to 53 ng/L (averaging at 20.981 ± 18.268 ng/L). BPA concentrations for the post-monsoon period, ranging from 16.3 to 43.9 ng/L (28.6 ± 11.6 ng/L), with a 100% DF for both seasons.

BPA poses high risk to the river's biodiversity at 85% of the surveyed sites.

## Ghaghra

In the present study, BPA varied in concentration from 28.07 - 1163.54 (425.629 ± 440.583;) in post winter season and 30.96 - 256.76 (105.959 ± 57.468;) in post monsoon season.

BPA poses high risk to the Ghaghra's biodiversity at 100% of the sites.

## Gandak

The present ecotoxicological survey revealed that during the post-winter season concentration of BPA varied between 7.36 and 143.73 (91.926 ± 56.063) ng/L.

During the post-monsoon season, the concentration ranged between 13.69 and 44.22 (31.618 ± 11.825) ng/L.

Notably, the detection frequency remained at 100% during both sampling seasons in the river.

All sites surveyed in the river faced high risk from BPA contamination.

## Kosi

In the current study, the investigation into Bisphenol A (BPA) concentrations in surface water during the post-winter season, BPA concentrations were slightly higher compared to the post-monsoon period, ranging from 76.520 to 203.570 ng/L (117.328 ± 54.500 ng/L), with a 100% detection frequency. The post-monsoon season revealed a range between 65.630 to 103.860 ng/L (90.712 ± 15.514 ng/L) with a detection frequency of 100%. This indicates a seasonal variation with a slight increase in BPA levels during the post-winter period.

BPA posed high risk to all sites surveyed in the Kosi River.

## Son

In the present study, BPA varied in concentration from 5.61 - 5.62 (5.616 ± 0.005; 100%) in post winter season and from 3.719 - 71.063 (28.326 ± 27.831; DF 100%) in post monsoon season.

In Son River, BPA posed a high risk to the biodiversity at 50% of the sampling sites.

## Chambal

The BPA concentrations in the Chambal ranged from <DL - 23.080 (4.531 ± 7.646) ng/L, with a detection frequency of 33%. The highest BPA concentrations were detected near urban centres, indicating the potential presence of point sources of BPA, such as drains and landfills from where plastic waste finds its way into the river.

BPA posed a high risk to the biodiversity of Chambal river at 27% of the sampling sites.

## Damodar

In the present study BPA varied in contamination from 32.530 - 107.340 (53.853 ± 20.208) ng/L in the surface water of the Damodar River. Detection frequency (DF) of BPA was 100%.

BPA posed a high risk to the biodiversity of the Damodar River at 100% of the sampling sites.

## Rupnarayan

In the present study BPA varied in contamination from 29.590- 73.080 (58.026 ± 14.759) ng/L in the surface water of the Rupnarayan River. Its DF in the river was 100%.

In the current investigation, BPA posed a high risk to the biodiversity at all the surveyed sites, reaching 100%.

## Ajay

In the present study BPA varied in contamination from 60.360- 189.410 (105.283 ± 44.009) ng/L in the surface water of the Ajay River, detected at all sites surveyed in the river.

In Ajay River, BPA posed high risk to biodiversity at 100% of the surveyed sites.

# PHTHALIC ACID ESTERS (ΣPAEs)

**Phalate Acid Esters are another widely used ingredient of the plastic industry, their applications ranging from manufacturing of plastic bottles, food packaging, PVC pipes as well as inert ingredients for pesticides and personal care products. Phthalates and their metabolites can potentially affect thyroid function in higher vertebrates including cetaceans.**

**Figure 14 :** ΣPAE range recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

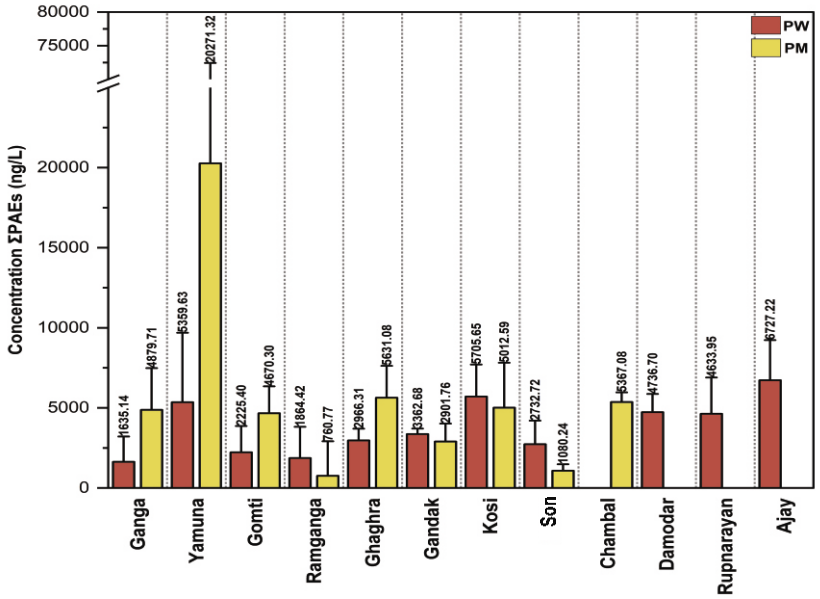
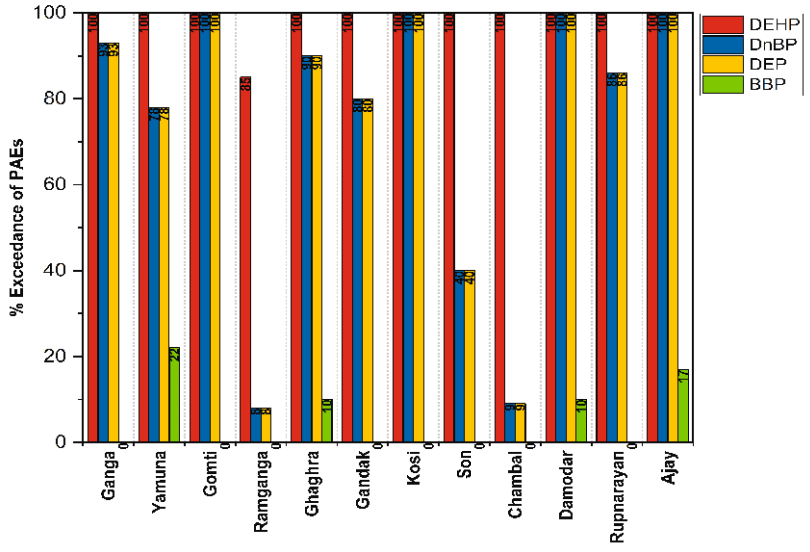



**Figure 15:** Percent exceedance of ΣPAE




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*

**Note:** Σ represents the sum total of all EDCs in each group

## Ganga

ΣPAE concentrations ranged from 13.938 - 7429.626 (1958.031 ± 713.774) ng/L in the post-winter and from 740.134 - 11086.893 (4683.849 ± 3057.746) ng/L in the post-monsoon season.

The contamination pattern was observed to follow the trend DEHP (874.434 ± 195.982 ng/L; 96%) >DnBP (556.255 ± 422.182 ng/L; 96%) > DEP (505.722 ± 359.700 ng/L; 72%) > BBP (13.595 ± 5.558 ng/L; 96%) > DMP (7.894 ± 8.607 ng/L; 56%) >DnOP (0.132 ± 5.875 ng/L; 8%) in the post-winter season.

In the post-monsoon season, the observed trend was DEP (2470.670 ± 2141.237 ng/L; 100%) > DEHP (1676.322 ± 922.568 ng/L; 100%) >DnBP (491.665 ± 289.869 ng/L; 100%) > BBP (23.741 ± 12.714 ng/L; 96%) >DnOP (13.265 ± 16.802 ng/L; 65%) > DMP (8.185 ± 5.786 ng/L; 96%).

In the Ganga, PAEs posed high risk in the order of DEHP (100%) > DEP and DnBP (93%). The other compounds posed no risk.

## Yamuna

In the present study, ΣPAE concentration varied between from <DL-15253.174 (5359.630 ± 4333.713) ng/l during post-winter season, while during the post-monsoon it ranged from 739.384 to 229292.166 (20271.320 ± 52167.999) ng/l. All five PAEs were detected at every sampling sites in both season, however DnOP was found at fewer sites.

Contamination trend in both seasons are as follows:

Post-winter, DEHP (3169.340 ± 3085.273

ng/L; DF 100%) >DnBP (1685.430 ± 2497.991ng/L; 100%) > DEP (818.700 ± 769.408 ng/L; 100%) > BBP (22.830 ± 15.111 ng/L; 100%) > DMP (20.350 ± 12.613ng/L; 100%) >DnOP (0.280 ± 1.093 ng/L; 7%)

Post-monsoon: DnBP (8886.980 ± 26898.959 ng/L; 100%) >DEHP (8417.650 ± 31575.803 ng/L; 100%) > DEP (2218.530 ± 5857.522 ng/L; 100%) > BBP (399.090 ± 1330.930 ng/L; 100%) > DMP (333.090 ± 1227.524 ng/L; 100%) >DnOP (15.980 ± 52.584 ng/L; 13%)

In Yamuna river, risk posed by PAEs followed the trend- DEHP (100%) > DEP and DnBP (78%) > BBP (22%) > DMP (4%) whereas no significant risk was posed by DnOP at the surveyed sites.

## Gomti

ΣPAEs were observed to occur in concentrations from <DL - 4873.957 (2225.399 ± 1645.881) ng/L in the post-winter and from <DL - 7116.262 (4670.297 ± 1676.549) ng/L in the post-monsoon season.

The contamination pattern followed the trend DEHP (1852.866 ± 659.317 ng/L; 100%) > DNBP (840.645 ± 313.154 ng/L; 77%) > DEP (394.070 ± 239.893 ng/L; 77%) > BBP (18.638 ± 10.250 ng/L; 77%) > DMP (9.340 ± 9.456 ng/L; 77%) in the post-winter.

In the post-monsoon, the concentrations for individual PAEs followed the trend DEHP (2145.910 ± 837.004 ng/L; 100%) > DEP (2076.523 ± 478.390 ng/L; 100%) >DnBP (765.672 ± 410.998 ng/L; 100%) > BBP (34.492 ± 9.426 ng/L; 100%) > DMP (6.955 ± 2.043 ng/L; 100%). DnOP was not detected in the river in either season.

Incidents of high PAE concentration detection coincided with sites where solid wastes including plastics were observed, indicating the potential origin of these contaminants from plastic waste.

During the present study in Gomti river risk posed by PAEs- DEP, DnBP and DEHP was 100% at all the sampling stations whereas no significant risk was posed by the remaining PAEs.

## Ramganga

ΣPAEs ranged from < DL-6159 ng/L (averaging at 1864.2 ± 1950 ng/L) in the post-winter. The mean concentration pattern followed the trend: Bis(2-ethylhexyl) phthalate (1114.9 ± 1603.5 ng/L; DF: 100%) > Di-n-butylphthalate (687.600 ± 500.00 ng/L, 100%) > DEP (211.1 ± 154.1 ng/L, 100%) > DMP (15.5 ±15.3 ng/L, 25%) > Butyl benzyl phthalate (4.0 ± 2.0 ng/L, 50%)> Di-n-octyl phthalate (0.3 ng/L, 8 %)

their concentrations in surface water during the post-monsoon season ranged from <DL- 7869.9 ng/L (with an average of 760.8 ± 2160.4 ng/L) across the entire stretch of the river. The descending mean concentration pattern for post monsoon followed the trend: Bis(2-ethylhexyl) phthalate (1730.03 ± 2702.3 ng/L, 100%) > Di-n-butylphthalate (479.1 ± 722.2 ng/L, 100%) > DEP (169.0 ±218.3 ng/L, 100%) > DMP (162.2 ±225.6 ng/L, 50%) > Butyl benzyl phthalate (24.9 ± 29.4 ng/L, 50%)> Di-n-octyl phthalate (3.4 ng/L, 25 %).

PAEs in Ramganga river posed high risk in the following trend: DEHP (85%) > DnBP (8%) > DEP (8%).

## Ghaghra

In the present study, ΣPAEs varied in concentration from 1931.6821 - 4308.5716 (2966.305 ± 729.951) in post winter season and 3090.958 - 8825.3195 (5406.404 ± 1913.450) in post monsoon season.

Their contamination pattern the contamination pattern during post winter was DEHP (1807.858 ± 635.850; DF 100%) >DnBP (826.548 ± 315.609; DF 100%) > DEP (304.824 ± 180.051; DF 100%) > BBP (19.570 ± 6.929; DF 100%) > DMP (7.504 ± 3.379; DF 100%). During post monsoon, contamination pattern followed the trend DEHP (2610.489 ± 1417.130; DF 100%) > DEP (1739.106 ± 815.75; DF 100%) >DnBP (981.460 ± 415.165; DF 100%) > BBP (54.254 ± 19.570; DF 100%) > DMP (21.092 ± 10.108; DF 100%). DnOP was not reported from any sites during both the seasons.

PAEs posed risk to the surrounding biodiversity in the following order DEHP (100%) > DnBP (90%) > DEP (90%) > DBP (10%).

## Gandak

In the post-winter range, ΣPAE concentrations ranged from 3114.415 to 3960.826 (3367.176 ± 345.409) ng/L.

Meanwhile, the following contamination trend was observed: DEHP (1345.242 ± 427.294 ng/L; 100%) >DnBP (1305.393 ± 249.800 ng/L; 100%) > DEP (673.940 ± 368.541 ng/L; 100%) > BBP (27.349 ± 8.239 ng/L; 100%) > DMP (15.252 ± 11.860; 100%).

During the post-monsoon season, ΣPAEs depicted a concentration range of 1265.756 to 4078.316 (2901.759 ± 1119.621) ng/L. The contamination pattern during this season revealed the following trend:

DEHP (1725.263 ± 594.382 ng/L; 100%) > DEP (607.800 ± 508.696; 100%) > DnBP (521.852 ± 287.861 ng/L;100%)> BBP (41.322 ± 32.614 ng/L; 100%) > DMP (5.523 ± 3.322; 100%). DnOP was not detected during either season.

During the present study in Gandak river, PAEs posed high risk following the trend DEHP (100%)>DEP and DnBP (80%) along all the surveyed sites.

## Kosi

In the post-winter season, ΣPAEs concentrations ranged from 3914.707 to 8901.820 ng/L (5705.640 ± 2007.837 ng/L) throughout the entire stretch of the Kosi River. The mean concentration pattern followed the trend: DEHP (2947.438 ± 1993.701 ng/L, 100%) >DnBP (1605.213 ± 444.274 ng/L, 100%)

> DEP (1083.734 ± 522.149 ng/L, 100%) > Butyl benzyl phthalate (43.340 ± 13.935 ng/L, 100%) > DMP (25.921 ± 20.528 ng/L, 100%), with Di-n-octyl phthalate below detection limits.

ΣPAE concentrations during the post-monsoon season ranged from 2745.121 to 8547.078 ng/L (5012.585 ± 2805.059 ng/L) across the entire stretch of the river. The detection frequency (DF) was 100%. The mean concentration pattern followed the trend: DEHP (3461.731 ± 2455.640 ng/L, 100%) > DEP (932.472 ± 340.598 ng/L, 100%) >DnBP (577.254 ± 320.896 ng/L, 100%) > BBP (35.700 ± 21.889 ng/L, 100%) > DMP (5.429 ± 2.487 ng/L, 100%), with Di-n-octyl phthalate observed below detection limits.

In case of the risk posed by PAEs in Kosi River, DEP, DnBP and DEHP posed very high risk at all the sampling sites (100% each), however, DMP, BBP and DnOP did not pose risk to biodiversity at any site.

## Son

In the present study, ΣPAEs varied in concentration from 219.351 - 4059.020 (2732.721 ± 1473.715) ng/L in post winter season and from 418.622 - 1786.315 (1080.238 ± 403.012) ng/L in post monsoon season.

The contamination pattern during post winter was DEHP (1038.564 ± 543.708 ng/L; 100%) >DnBP (993.884 ± 560.845 ng/L; 100%) > DEP (656.451 ± 394.630 ng/L; 100%) > BBP (25.305 ± 15.986 ng/L; 100%) > DMP (17.727 ± 12.197 ng/L; 100%) >DnOP (0.787 ± 1.761 ng/L; 20%).

Their contamination pattern during post monsoon followed the trend DEHP (708.629 ± 263.275 ng/L; 100%) >DnBP (245.106 ± 120.335 ng/L; 100%) > DEP (120.225 ± 75.565 ng/L; 100%) > BBP (5.753 ± 4.265 ng/L; 70%) >DnOP (0.523 ± 1.654 ng/L; 10%). DMP was not detected at any sites during post monsoon season.

The risk posed by PAEs in Son River followed the trend DEHP (100%) > DEP (40%) and DnBP (40%), however, the other phthalates, namely DMP, BBP and DnOP did not pose risk to biodiversity at any site.

## Chambal

The ΣPAE concentrations in the Chambal ranged from 4416.248 - 6313.959 (5360.297 ± 578.852) ng/L in the present study. The average concentrations of individual compounds varied as: DEHP (4246.171 ± 611.563 ng/L; 100%) >DnBP (705.439 ± 218.858 ng/L; 100%) > DEP (347.649 ± 196.277 ng/L; 100%) > BBP (31.325 ± 14.739 ng/L; 100%) > DMP (26.009 ± 9.879 ng/L; 100%) >DnOP 3.705 ± 5.885 ng/L; 33%).

In Chambal River, the risk posed by PAEs followed the trend DEHP (100%) > DEP (9%) and DnBP (9%). DMP, BBP and DnOP were not recorded to pose risk to biodiversity at any site.

## Damodar

In the present study, ΣPAEs varied in concentration from 2850.134- 6212.790 (4714.637± 1078.596) ng/L in the surface water of the Damodar River. The contamination pattern in post-winter followed the trend DEHP (mean 2331.572 ± 704.950; DF 100%) > DEP (1401.785 ± 637.134; 100%) >DnBP (913.710 ± 328.627; 100%) > BBP (60.608 ± 25.313; 100%)> DMP (5.824 ± 3.584; 100%) >DnOP (1.138 ± 3.943; 8%).

In the current study, the risk posed by PAEs followed the trend DEP (100%), DnBP (100%) and DEHP (100%) > BBP (10%). Other phthalates, namely DMP and DnOP were not found to pose any serious threat to the biodiversity.

## Rupnarayan

In the present study ΣPAEs ranged from 1581.955- 8411.257 (4633.950± 2260.591) ng/L in the surface water of the Rupnarayan River. DF of total PAEs is 100%. Out of 6 PAEs the contamination pattern of detected 5 PAEs were DEHP (mean 2060.252 ± 764.661 DF 100%) > DEP (1515.654.175 ± 1179.328; 100%) >DnBP (1008.808; SD 761.285 100%) > BBP (44.144 ± 25.603; 100%)> DMP (5.092 ± 2.261; 100%). DnOP was found to be <DL at all the sites.

In Rupnarayan River, the risk posed by PAEs followed the trend DEHP (100%) > DEP (86%) and DnBP (86%). Other phthalates, namely DMP, BBP and DnOP did not pose any serious threat to the biodiversity of Rupnarayan River.

## Ajay

In the present study ΣPAEs concentration ranged from 4545.740- 11439.510 (6727.220± 2505.199) ng/L in the surface water of the Ajay River. DF of total PAEs is 100%. Out of 6 PAEs the contamination pattern of detected 5 PAEs were DEHP (mean 3110.456 ± 1245.996; DF 100%) > DEP (2066.110 ± 627.220; 100%) >DnBP (1428.565 ± 894.559; 100%) > BBP (94.075 ± 55.193; 100%)> DMP (28.014 ± 7.799; 100%). Di-n-octyl phthalate was found to be <DL at all the sites.

During our study in Ajay River, the risk posed by ?PAEs followed the trend DEP (100%), DnBP (100%) and DEHP (100%) > BBP (17%), however DBP and DnOP did not pose any risks to the biodiversity at the surveyed sites.



# HOUSEHOLD AND PERSONAL CARE PRODUCTS (ΣHPCPs)

**The Household and personal care products considered in the present study comprise of triclosan (TCS) and triclocarban (TCC). These are commonly used anti-microbial agents used in soaps and liquid handwash. These are also known for their endocrine-disrupting effects, and have been recorded to cause thyroid hormone disruption in mammals and coastal cetaceans. These are known to enter the aquatic environment with industrial effluents, municipal wastewater and agricultural runoff.**

**Figure 16 :** ΣHPCPs range recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

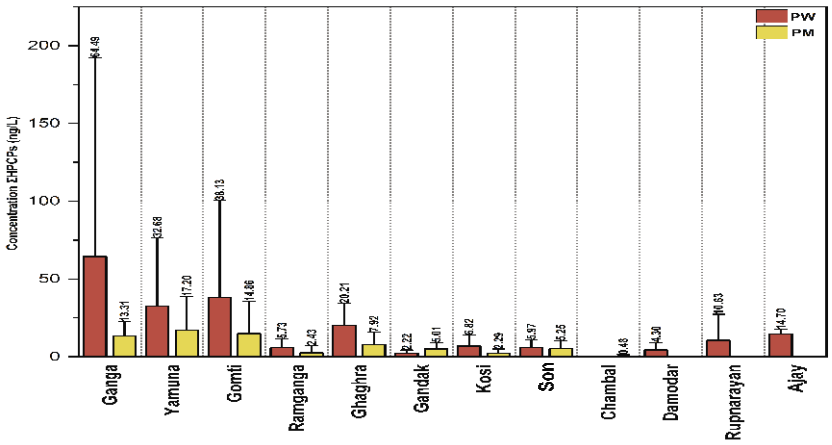
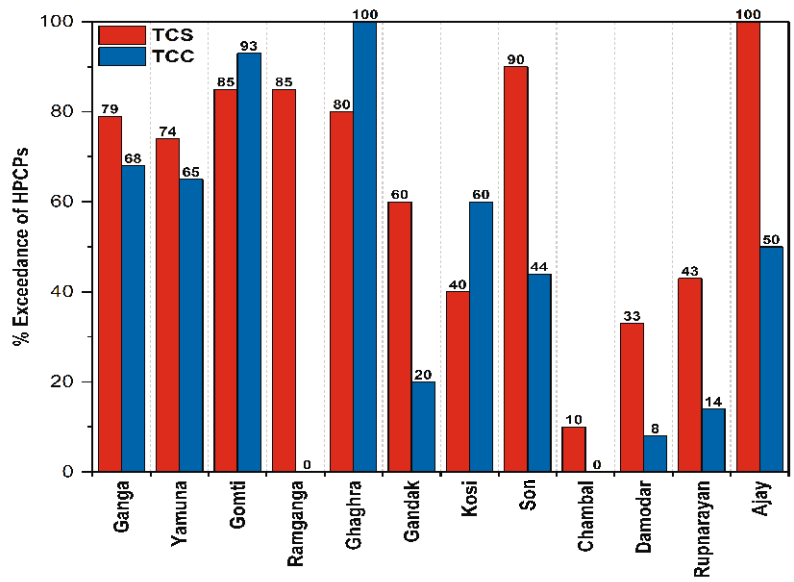



**Figure 17 :** Percent exceedance of ΣHPCPs




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*

## Ganga

ΣHPCPs were observed to range from 0.510 - 115.260 (27.302 ± 24.356) ng/L in the post-winter, and from <DL - 28.980 (13.312 ± 7.590) ng/L in the post-monsoon season.

In the post-winter, the individual HPCPs followed the contamination trend of TCS (17.866 ± 16.472; 100%) > TCC (9.436 ± 11.945 ng/L; 71%). The pattern of contamination by each contaminant was TCS (10.709 ± 6.326 ng/L; 91%) > TCC (2.603 ± 5.500 ng/L; 61%) in the post-monsoon.

In Ganga river, HPCPs posed risk in the following trend-TCS (79%) > TCC (68%).

## Yamuna

In the present study, ΣHPCP concentration during the post-winter season it varied between 0.70 - 157.36 (32.680 ± 43.853) ng/l, while during the post- monsoon period ranged from <DL - 63.41 (17.20 ± 21.645) ng/l.

The contamination patterns during the post-winter season TCS (mean 22.390 ± 28.689 ng/L; 94%) > TCC (11.690 ± 16.518 ng/L; 94%). For the post monsoon season the trend was TCS (15.770 ± 20.418 ng/L; 56%) > TCC (2.110 ± 2.350 ng/L; 91%).

HPCPs in Yamuna river posed risk in the following trend- TCS (74%) > TCC (65%).

## Gomti

In the present study, the concentration of ΣHPCPs ranged from <DL - 193.160 (38.134 ± 62.285) ng/L, and from <DL - 78.950 (14.859 ± 20.892) ng/L in the post-monsoon season.

The highest concentrations in both seasons were associated with sites with high population and urbanization, where municipal sewage is discharged into the river.

In Gomti river, the proportion of the river facing high risk posed by HPCPs followed the trend TCC(93%) > TCS(85%).

## Ramganga

In the present study, ΣHPCP concentrations in surface water during the post-winter season ranged between DL to 21 ng/L with an average 5.7 ± 5.9 ng/L. In the post-monsoon, the value ranged from <DL to 13.6 ng/L (with an average of 2.4 ± 4.7 ng/L).

The contamination pattern followed the trend TCS (6.7 ± 5.8 ng/L; 92 %.) > TCC (0.034 ± 0.116 ng/L; 8%) in the post-winter. In the post-monsoon, only TCS was detected with an average concentration of 7.9 ± 5.5 ng/L and detection frequency 100 %.

In the present study TCS posed high risk at 85% of the surveyed sites whereas no significant risk was posed by TCC in Ramganga river.

## Ghaghra

In the present study, ΣHPCPs varied in concentration from 3.47-39.53 (20.205 ± 14.004) ng/L in post winter season and from 0.32 - 25.82 (7.524 ± 7.454) ng/L in post monsoon season.

The contamination pattern of the HPCPs during post winter season was TCS (12.009 ± 11.412 ng/L; 60%) > TCC (8.196 ± 5.624 ng/L; 100%), and during post monsoon season the contaminants followed the trend TCS (6.386 ± 7.341 ng/L; 64%) > TCC (1.138 ± 0.833 ng/L; 100%).

The risk pattern for HPCPs depicted the following trend- TCC (100%) > TCS (80%) in Ghaghra river.

## Gandak

The combined concentrations of ΣHPCPs ranged from <DL - 5.18 (2.216±2.153) ng/L during the post winter season. The contamination pattern during this season depicted the following trend: TCC (1.448±1.537 ng/L; 100%) > TCS (0.768±1.360 ng/L ;100.00%).

(ΣHPCPs) ranged from 0.53 to 8.84 (5.012±4.059) ng/L during the post-monsoon season and were detected at all seven sampling stations along the Gandak River. The contamination pattern during this season revealed the following trend: TCS (mean 4.142±3.657 ng/L; 100%) > TCC (0.870±0.466 ng/L; 100.00%).

In Gandak river, risk posed by HPCPs followed the trend TCS (60%) > TCC (20%) at all the surveyed sites.

## Kosi

In the present study ΣHPCP concentrations in surface water during the post-winter season, the range for HPCPs in surface water was 1.03 to 16.26 ng/L (averaging at 6.818 ± 7.142 ng/L). The mean concentrations followed the trend Triclocarban (4.690 ± 4.839 ng/L; 100%) > Triclosan (2.128 ± 4.758 ng/L; 20%) compared to in post winter.

During the post-monsoon season, HPCPs ranged from 0.42 to 6.31 ng/L (2.292 ± 2.628 ng/L). The mean concentration of Triclosan was higher at 1.682 ± 2.394 ng/L (40%) compared to Triclocarban at 0.610 ± 0.328 (100%).

In Kosi River, the risk posed by HPCPs followed the trend TCC (60%) > TCS (40%).

## Son

In the present study, ΣHPCPs varied in concentration from 0.27 - 12.42 (5.974 ± 5.020) ng/L in post winter season and from 1.931 - 18.066 (5.249 ± 5.029) ng/L in post monsoon season.

The contamination pattern during post winter season followed the trend TCC (3.502 ± 2.221 ng/L; 100%) > TCS (2.472 ± 3.389 ng/L; 40%).

TCS was the only HPCP reported during the post monsoon season (5.249 ± 5.029 ng/L; 100%).

In our current study, the risk posed by HPCPs in Son River followed the trend TCS (90%) > TCC (44%).

## Chambal

In the present study, ΣHPCPs ranged from <DL - 2.900 (0.438 ± 0.848) ng/L in the surface water of the Chambal River. The contamination pattern followed the trend TCS 0.299 ± 0.871 ng/L; 17%) > TCC 0.178 ± 0.347 ng/L; 42%)

The highest concentrations of HPCPs were detected at sites close to cities with high population, indicating their influx with municipal wastewater.

In case of HPCPs, TCS posed a high risk at 10% of the sampling sites, whereas TCC did not pose any serious risk to the biodiversity of the Chambal River.

## Damodar

In the present study ΣHPCPs varied in concentration from 0.000-14.390 (4.298±4.875) ng/L in the surface water of the Damodar River. DF of total HPCPs is 84.61%. The contamination pattern in post winter of ΣHPCPs followed the trend TCS (mean 2.899 ± 4.454 ng/L; DF 38%) > TCC (mean 1.398 ± 0.865 ng/L; 85%).

The risk posed by HPCPs in Damodar River followed the trend TCS (33%) > TCC (8%).

## Rupnarayan

In the present study, ΣHPCP concentration ranged from 0.260-45.800(10.629±16.613) ng/L in the surface water of the Rupnarayan River. DF of total HPCPs is 100%. The contamination pattern in post winter of ΣHPCPs followed the trend TCS (mean 8.144 ± 13.921 ng/L; DF 43%) > TCC (2.484 ± 2.947 ng/L; 100%).

The risk posed by HPCPs in Rupnarayan followed the trend TCS (43%) > TCC (14%).

## Ajay

In the present study, ΣHPCPs varied from 10.380 - 18.930 (14.695 ± 2.883) ng/L in the surface water of the Ajay River. DF of total HPCPs is 100%. The contamination pattern in post winter of ΣHPCPs followed the trend TCS (mean 12.627 ± 2.408 ng/L; 100%) > TCC (mean 2.068 ± 1.010 ng/L; 100%).

In our study, the risk posed by HPCPs in Ajay River followed the trend TCS (100%) > TCC (50%).

# ΣSTEROIDS

**Both natural and synthetic steroid hormones are classified as endocrine disruptors, and are known to affect reproduction and population dynamics of species. Environmental estrogens can significantly affect the fertilization ability of mammalian sperms, some studies even reporting a higher stimulating effect of environmental estrogens on mammalian sperms than E2. Perinatal exposure to sex hormones has been observed to cause reproductive tract lesions in female mammals. Such agents, including DES, bind to estrogen receptors in mammals and result in endocrine disruption.In the riverine environment, these are derived either naturally from excretions of animals and humans, or from pharmaceuticals such as contraceptives.**

**Figure 18 :** Σsteroids range recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons

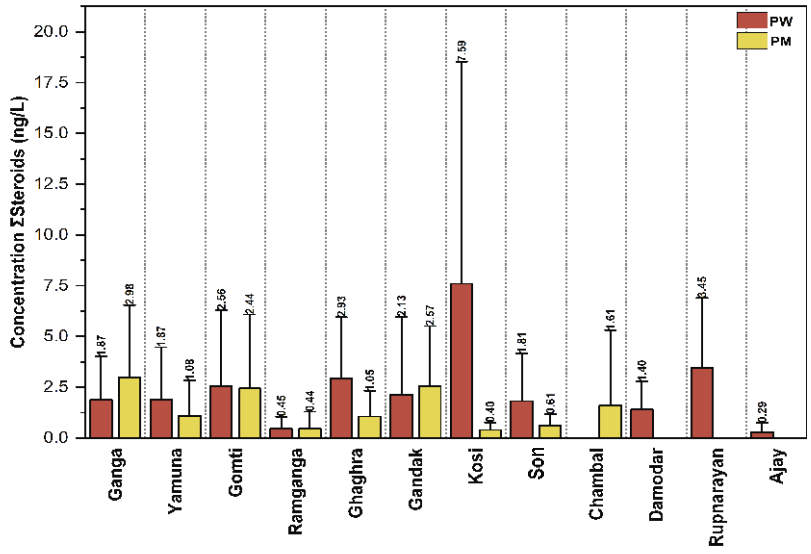
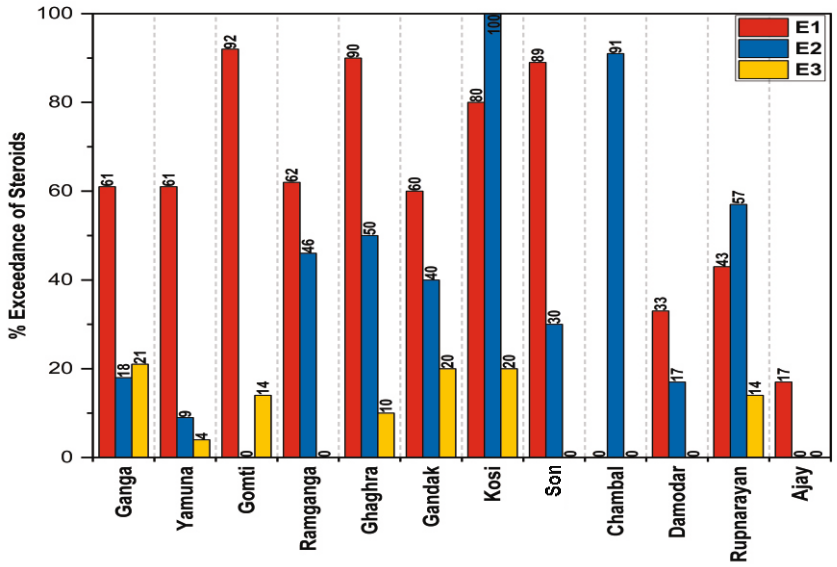



**Figure 19 :** Percent exceedance of Σsteroids




**Note:** *A higher percentage of exceedance indicates a greater risk to aquatic life due to deviations from the recommended range*

## Ganga

ΣSteroid concentrations in the surface water of the Ganga ranged from <DL - 7.860 (1.566 ± 5.820) ng/L in the post-winter and from <DL - 11.170 (3.111 ± 5.796) ng/L in the post-monsoon season.

The contamination trend observed in the post-winter was EE2 (1.355 ± 5.825 ng/L; 44%) > E1 (0.812 ± 5.734 ng/L; 52%) > E3 (0.441 ± 6.057; 12%) > E2 (0.198 ± 5.895 ng/L; 8%) > DES (0.115 ± 5.883 ng/L; 8%). In the post-monsoon, the observed trend was EE2 (2.895 ± 5.804 ng/L; 57%) > E3 (1.740 ± 5.781 ng/L; 35%) > E1 (0.850 ± 5.286 ng/L; 50%) > DES (0.320 ± 5.400 ng/L; 13%) > E2 (0.238 ± 5.391 ng/L; 17%).

Steroids posed risk in the following trend-E1 (61%) > E3 (21%) > E2 (18%). However, DES did not pose any risk at the surveyed sites along Ganga river.

## Yamuna

In the current study, the concentration of ΣSteroids showed range from <DL- 9.58 ( 1.870 ± 2.590 ) ng/L during the post-winter season and from <DL to 5.83 (1.080 ± 1.756) ng/L during the post-monsoon season and. In both seasons, EE2 was not detected at any site, while DES and Estradiol E2 were observed only in one season. The trend of the other remaining contaminant are as follows:

**post-winter:** E1 (1.160 ± 1.032 ng/L; 62%) > E3 (1.070 ± 2.149 ng/L; 25%) > E2 (0.140 ± 0.372 ng/L; 19%),

**post-monsoon:** E1 (0.720 ± 1.182 ng/L; 39%) > E3 (0.380 ± 1.029 ng/L; 17%) > DES (0.040 ± 0.186 ng/L; 4%).

During the present study in Yamuna river, risk posed by steroids followed the trend- E1 (61%) > E2 (9%) > E3 (4%) however no significant risk was posed by DES at the surveyed sites.

## Gomti

In the present study, ΣSteroids ranged from <DL - 12.280 (2.561 ±

3.729) ng/L in the post-winter and from <DL - 13.790 (2.439 ± 3.636) ng/L in the post-monsoon season. In the post-winter, the contamination pattern followed the trend E1 (1.701 ± 2.226 ng/L; DF 62%) > E3 (0.761 ± 1.877 ng/L; 31%). In the post-monsoon season, this trend was reversed as E3 (1.233 ± 3.146 ng/L; 23%) > E1 (0.933 ± 0.962 ng/L; 62%). The remaining compounds were not detected in the Gomti in either season.

In Gomti river, steroids posed risk in the order E1 (92%) > E3 (14%).

## Ramganga

In the current study, during the post-winter period, concentrations ranged from below the detection limit (DL) to 1.7 ng/L (with an average of 0.508 ± 0.600 ng/L). In contrast, the ΣSteroids concentration in the surface water of the Ramganga River ranged from below the detection limit (DL) to 2.6 ng/L (with an average of 0.44 ± 0.841 ng/L) during the post-monsoon season.

Of the all estrogens E1, E2, E3 were detected in most sites for both seasons. For post-winter the trend was E2 (0.57 ± 0.09 ng/l; 33 %) > E1 (0.37 ± 0.2 ng/l; 50 %) > E3 (0.14 ± 0.5 ng/l; 8 %) while for post monsoon season, the concentrations followed the trend of E1 (1.93 ± 0.129 ng/l; 50 %) > E2 (0.663 ± 0.21 ng/l; 50 %) > E3 (0.14 ± 0.28 ng/l; 25 %). DES and EE2 were not detected for both seasons.

In the present study in Ramganga river, steroids posed risk in the trend E1 (62%) > E2 (46%).

## Ghaghra

In the present study, ΣSteroids varied in concentration from <DL-9.72 (2.926 ± 3.014) ng/L in post winter season, and from <DL - 3.28 (1.043 ± 1.146) ng/L in post monsoon season.

In the post winter season, the contamination trend was E3 (1.281 ± 2.577 ng/L; 30%) > E1 (0.773 ± 0.547 ng/L; 80%) > E2 (0.41 ± 0.711 ng/L; 30%) > DES (0.282 ± 0.891 ng/L; 10%) > EE2 (0.18 ± 0.569 ng/L; 10%).

The contamination pattern for the steroids in post monsoon season followed the trend E3 (0.646 ± 0.751 ng/L; 55%) > DES (0.215 ± 0.371 ng/L; 27%) > E2 (0.147 ± 0.329 ng/L; 18%) > E1 (0.129 ± 0.293 ng/L; 18%). EE2 was not detected in any sites during post monsoon season.

In Ghaghra river, steroids posed high risk in the order E1 (90%) > E2 (50%) > E3 (10%).

## Gandak

During the current sampling survey, ΣSteroids varied from <DL-8.97 (2.128 ± 3.849) ng/L during the post winter season revealing the contamination trend: E3 (1.496 ± 3.345 ng/L; 20%) > DES (0.280 ± 0.383 ng/L; 40%) > E2 (0.192 ± 0.429 ng/L; 20%) > E1 (0.160 ± 0.358 ng/L; 20%).

Σsteroids ranged from <DL-7.48 (2.566 ± 2.941) ng/L in the post-monsoon season. The contamination trends observed were as follows: E2 (0.364 ± 0.506 ng/L; 40%) > DES (0.302 ± 0.415 ng/L; 40%) > E1 (0.240 ± 0.329 ng/L; 40%) > E3 (0.164 ± 0.367 ng/L; 20%).



However, EE2 was not detected in either of the sampling seasons.

Steroids posed significant risk in the following trend E1 (60%) > E2 (40%) > E3 (20%) in Gandak river, however DES did not pose high risk at any of the surveyed sites during the present study.

## Kosi

In the current study, the ΣSteroids concentration in the surface water of the Kosi River exhibited variation with concentrations ranging from 0.95- 26.83 ng/L (7.594 ± 10.931 ng/L) during the post-winter period. In post-winter, the concentration pattern followed the trend E2 (3.83 ± 6.748 ng/L; DF 60%) > E3 (2.03 ± 4.539 ng/L; 20%) > EE2 (1.17 ± 2.616 ng/L; 20%) > E1 (0.564 ± 0.541 ng/L, 60%). DES was not detected at any sites during post winter sampling.

In contrast, during the post-monsoon season the concentration ranged from <DL - 0.690 ng/L (0.396 ± 0.363 ng/L). Notably, most steroids were not detected in the post-monsoon season. The reported steroids followed the trend E1 (0.258 ± 0.354 ng/L; 40%) > DES (0.138 ± 0.386 ng/L; 20%).

In the present study, the risk posed by steroids in Kosi River followed the trend E2 (100%) > E1 (80%) > E3 (20%), however, DES did not pose high risk to biodiversity at any site.

## Son

Concentration of ΣSteroids in Sone river varied from <DL - 5.68 (1.812 ± 2.353) ng/L in post winter season and <DL - 1.935 (0.548 ± 0.567) ng/L in post monsoon season.

During post winter season, the contamination trend was E3 (1.242 ± 1.807 ng/L; 40%) > E2 (0.228 ± 0.509 ng/L; 20%) > E1 (0.204 ± 0.456 ng/L; 20%) > DES (0.138 ± 0.308 ng/L; 20%). EE2 was not detected at any site during post winter season.

The contamination pattern for the steroids in post monsoon season followed the trend E1 (0.358 ± 0.236 ng/L; 80%) > E2 (0.114 ± 0.245 ng/L; 20%) > E3 (0.075 ± 0.238 ng/L; 10%). DES and EE2 were not detected at any sites during post monsoon season.

The risk posed by steroids in Son River followed the trend E1 (89%) > E2 (30%), however, DES and E3 did not pose any risk to the biodiversity.

## Chambal

In the present study, ΣSteroids varied in concentration from <DL - 12.550 (1.478 ± 3.554) ng/L in the surface water of the Chambal River. DES and E1 were not detected at any of the sites in the river. The contamination pattern for the remaining steroids followed the trend E2 (1.129 ± 3.608 ng/L; DF 17%) > E3 (0.243 ± 0.449 ng/L; DF 25%) > EE2 (0.106 ± 0.367 ng/L; DF 8%).

The highest concentrations occurred at sites surrounded by villages where agriculture and animal husbandry were the major anthropogenic activities. Animal wastes are identified as a source of natural estrogens, and the cattle and other animals reared in the region are a likely source of these compounds in the river.

In our study, E2 posed high risk at 91% of the sampling sites, however, other steroids, namely DES, E1 and E3 did not pose any serious threat to the biodiversity of Chambal River.

## Damodar

In the present study ΣSteroids ranged from 0.000-4.190 (1.400 ± 1.381) ng/L in the surface water of the Damodar River. In post winter out of 5 steroids the contamination pattern of detected 4 steroids followed by E1 (mean 0.371 ± 0.563 ng/L; DF 31%)> E2 (0.360 ± 0.921 ng/L; 15%) > E3 (0.349 ± 1.210 ng/L; 15%) > DES (0.320 ± 0.482 ng/L; 31%). EE2 were found to be <DL at all the sites.

The risk posed by steroids in the current study followed the trend E1 (33%) > E2 (17%). DES and E3 did not pose any serious threat to the biodiversity of the river.

## Rupnarayan

In the present study ΣSteroids ranged from 0.670-10.340 (3.453 ± 3.440) ng/L in the surface water of the Rupnarayan River. In post winter out of 5 steroids the contamination pattern of detected 3 steroids followed by E3 (mean 1.931 ± 3.367 ng/L; DF 43%)> E2 (0.917 ± 0.967 ng/L; 570%) > E1 (0.604 ± 0.945 ng/L; 43%). The other steroids DES, EE2 were found to be <DL at all the sites.

The risk posed by steroids in the current study followed the trend E2 (57%) > E1 (43%) > E3 (14%). DES did not pose any serious threat to the biodiversity of the river.

## Ajay

In the present study Σsteroids ranged from <DL-1.00 (0.287±0.453) ng/L in the surface water of the Ajay River. DF of total Steroids is 33%. In post winter out of 5 steroids only DES (mean 0.167 ± 0.408 ng/L; DF 17%) > E1 (0.120 ± 0.294 ng/L; 17%) were detected. The other steroids E2, E3, and EE2 were found to be <DL at all the sites.

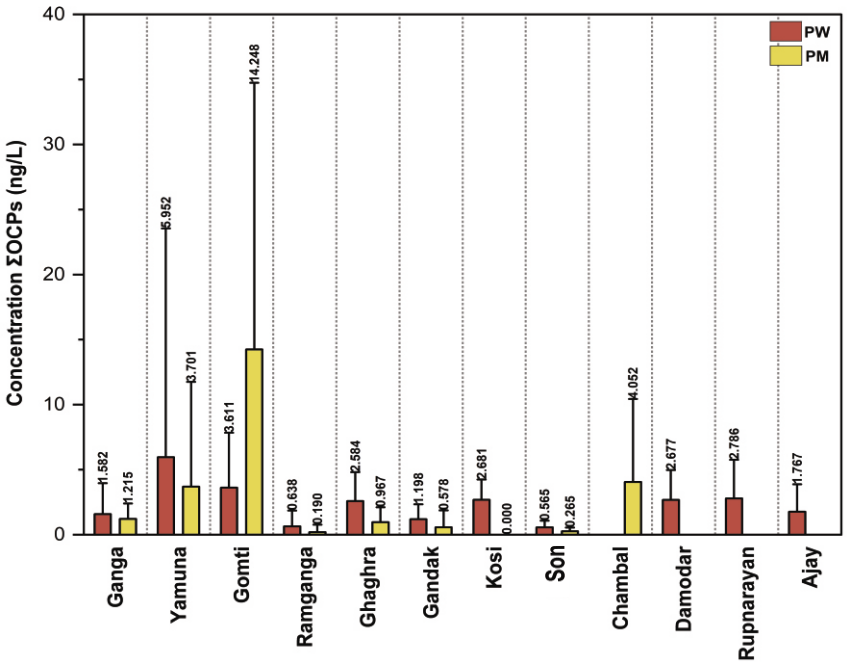
In our study, E1 (17%) was the only steroid that posed a serious risk to the biodiversity of Ajay River. The other steroids DES, E2 and E3 did not pose significant risks at the surveyed sites.



# ORGANOCHLORINE PESTICIDES

**Organochlorine pesticides (OCPs) have been extensively used both in agriculture and for control of malaria vector in public health programme. The OCPs have been shown to affect reproduction in birds, reptiles and mammals, and most notably cause catastrophic population declines in birds of prey that accumulate large quantities of these compounds from their prey.**

**Figure 20:** ΣOCPs range recorded in the GRB for post-winter (PW) and post-monsoon (PM) seasons




## Ganga

ΣOCP concentrations in the Ganga River ranged from <DL - 7.358 (1.516 ± 5.923) ng/L in the post-winter season and from <DL - 3.553 (1.215 ± 5.253) ng/L in the post-monsoon season.

In the post-winter, the contamination pattern followed the trend p',p'-DDT (0.562 ± 5.876 ng/L; 16%) > gamma-BHC (0.498 ± 5.854 ng/L; 44%) > delta-BHC (0.191 ± 5.890 ng/L; 8%) > beta-BHC (0.180 ± 5.854 ng/L; 28%) >p',p'-DDE (0.050 ± 5.886 ng/L; 8%) >p',p'-DDD (0.036 ± 5.884 ng/L; 4%).

The trend observed in the post-monsoon was delta-BHC (0.322 ± 5.350 ng/L; 57%) > Dieldrin (0.227 ± 5.368 ng/L; 22%) > Gamma-BHC (0.297 ± 5.388 ng/L; 48%) > Beta-BHC (0.152 ± 5.382 ng/L; 30%) > Endrin ketone (0.112 ± 5.395 ng/L; 13%) > Heptachlor epoxide (0.054 ± 5.406 ng/L; 9%) > Trans-Chlordane (0.046 ± 5.408 ng/L; 9%) >P',p'-DDD (0.002 ± 5.421 ng/L; 4%).

In Ganga river, DDTp'p' posed risk at 4% of the surveyed sites whereas the other OCPs did not pose any risk at the surveyed sites.

A comparison with our previous survey revealed that the concentrations of OCPs determined in the present study were significantly lower than those detected in the year 2017-2018, which is an indication of the successful application of both scientific monitoring and management, and community involvement in the mitigation of pesticide pollution in the Ganga. This approach can be expected to be useful in ameliorating the environment of other contaminated rivers as well.

## Yamuna

In the present study, the ΣOCP concentration ranged from <DL to 71.627 (5.950 ± 17.597) ng/l during the post-winter season, while during the post-winter season the concentration varied from <DL to 38.260 (3.700 ± 8.049) ng/L. Certain OCPs were not detected at any site. The remaining detected OCPs followed the following contamination trend:

In post-winter the trend was DDT-p,p(4.20 ± 15.911 ng/L; 13%)> gamma-BHC (0.960 ± 1.211 ng/L; 67%) > DDE-p',p' (0.290 ± 0.921 ng/L; 13%) > beta-BHC (0.280 ± 0.325 ng/L ;47%) > Chlordecone (0.180 ± 0.489 ng/L; 13%)> Endosulfansulfate (0.160 ± 0.427 ng/L; 13%) > alpha -BHC (0.130 ± 0.392 ng/L; 13%) > Endrin aldehyde (0.090 ± 0.360 ng/L; 7%) > trans-Chlordane (0.050 ± 0.142 ng/L; 13%)

In post-monsoon the trend was Methoxychlor, DDD-p,p' (1.100 ± 5.289 ng/L; 4%) > DDT-p,p' (1.310 ± 2.612 ng/L; 30%) > gamma-BHC (0.800 ± 0.766 ng/L; 57%) > beta-BHC (0.260 ± 0.378 ng/L; 35%) > DDE-p,p' (0.220 ± 0.400 ng/L; 26%).

In Yamuna river, risk posed by OCPs followed the trend-DDTp'p' (13%) >DDEp'p'(9%).

## Gomti

In the present study, ΣOCPs ranged from <DL - 12.715 (3.611 ± 4.229) ng/L in the post-winter, and from <DL - 60.620 (14.248 ± 20.495) ng/L in the post-monsoon season.

In the post-winter, the contaminants followed the trend BHC-delta (1.322 ± 1.23 ng/L; 46%) > Chlordecone (1.029 ±

0.716 ng/L; 54%) > BHC- beta (0.955 ± 0.759 ng/L; 54%) > BHC-gamma (0.69 ± 0.654 ng/L; 46%) > BHC-Alpha (0.285 ± 0.329 ng/L; 38%) > DDT-p,p' (0.27 ± 0.853ng/L; 8%) >Endosulfansulfate (0.241 ± 0.509 ng/L; 15%) > DDE-p,p' (0.138 ± 0.29 ng/L; 15%) > Endrin aldehyde (0.095 ± 0.3 ng/L; 8%) > Aldrin (0.034 ± 0.102 ng/L; 8%), while the remaining OCPs remained undetected.

In the post-monsoon, the OCPs followed the trend BHC-delta (8.29 ± 12.129 ng/L; 54%) > BHC-gamma (4.458 ± 5.946 ng/L; 85%) > BHC- beta (1.303 ± 1.511 ng/L; 62%) > BHC-Alpha (1.059 ± 1.542 ng/L; 54%) > Endosulfansulfate (0.233 ± 0.569 ng/L; DF 15%). The remaining OCPs were not detected in this season.

In Gomti river, OCPs did not pose any significant risk along the sampling stations.

## Ramganga

In the post-winter season, observed concentrations for OCPs varied from below detection limit to 4.3 ng/L (with an average of 0.6 ± 1.2 ng/L). The concentrations ranged from <DL to 1.9 ng/L with average 0.2 ± 0.6 ng/L in the post-monsoon.

The mean concentrations for the detected OCPs followed the trend DDT-p,p' (1.1 ± 0.7 ng/L, DF: 33%) > DDE (0.4 ± 0.3 ng/L; 33%) > DDD (0.240 ± 0.610 ng/L' 58%) >Endosulfan Sulfate (0.1 ± 0.1 ng/L, DF: 83%) for Post winter season. For Post monsoon the trend followed was DDT-p,p' (1.1 ± ng/L DF: 25%) > DDE (0.3 ng/L; 25%) > Endosulfan Sulfate (0.2 ± 0.3 ng/L, DF: 100%) > DDD (0.015 ± 0.02 ng/L; 50%).

In Ramganga river, OCPs did not pose any high risk at any of the sampling stations.

## Gandak

During the post-winter season, ΣOCPs ranged from <DL-3.114 (1.198±1.149), revealing contamination trends as BHC-gamma (0.783 ± 0.440 ng/L; 100%) > DDT-p,p (0.415 ± 0.929; 20%), with the other OCPs not being detected during this season.

Comparatively, the concentration of ΣOCPs exhibited a range of <DL - 2.891 (0.578±1.293) ng/L in the post-monsoon season, however only DDT p'p'(0.578 ± 1.293 ng/L; 20%) was detected during this season, while the remaining OCPs were not detected.

In Gandak river, no significant risk was posed by OCPs at the surveying sites.

## Kosi

In this study, concentrations of Organochlorine Pesticides (ΣOCPs) were found to be in the range of <DL to 1.813 ng/L (with an average of 1.213 ± 0.753 ng/L) in the post-winter season. The mean concentrations for the detected OCPs followed the trend of BHC-delta (0.838 ± 0.480 ng/L, 80%) >endosulfan I (0.098 ± 0.219 ng/L; 20%) > DDT-p,p' (0.277 ± 0.380 ng/L; 40%).

All OCPs were below detection limit during the post-monsoon season.

In the present study, OCPs did not pose any serious risk to the biodiversity of Kosi River.

## Ghaghra

In the present study, ΣOCPs varied in concentration from <DL - 7.874 (2.583 ± 2.221) ng/L in post winter season, and from <DL - 2.949 (1.086 ± 1.063) ng/L in post monsoon season.

Post winter season reported more OCPs than post monsoon season and the contamination trend was Chlordecone (1.341 ± 0.746 ng/L; DF 80%) > ΣBHC (0.552 ± 0.476 ng/L; 60%) > DDE-p,p' (0.269 ± 0.348 ng/L; 40%) > Endrin aldehyde (0.256 ± 0.562 ng/L; 20%) >Endosulfansulfate (0.236 ± 0.746 ng/L; 10%) > ΣBHC (0.047 ± 0.150 ng/L; 10%).

The contamination pattern of OCPs reported during post monsoon season followed the trend ΣBHC (0.585 ± 0.568 ng/L; 55%) > DDT-p,p' (0.422 ± 0.948 ng/L; 18%) > ΣBHC (0.079 ± 0.262 ng/L; 9%).

All the surveyed sites were found at risk from OCPs (100%).

## Son

In the present study, ΣOCPs varied in concentration from <DL - 1.0213 (0.564 ± 0.518) ng/L in post winter season, and from 0.032 - 0.887 (0.265 ± 0.284) ng/L in post monsoon season.

ΣBHC (0.564 ± 0.518 ng/L; DF 60%) was the only OCP detected during post winter season.

The contamination pattern of OCPs reported during post monsoon season followed the trend DDT-p,p' (0.106 ± 0.185 ng/L; DF 80%) > DDD-p,p' (0.086 ± 0.094 ng/L; DF 90%) >Endosulfansulfate (0.062 ± 0.053 ng/L; DF 80%) > DDE-p,p' (0.010 ± 0.022 ng/L; DF 40%).

In the present study, OCPs did not pose any serious risk to the biodiversity of Son River.

## Chambal

In the present study, ΣOCPs were detected in the range of <DL - 22.007 (3.714 ± 6.199) ng/L in the Chambal River.

Only 6 of the target OCPs were detected in the samples collected from the Chambal River, and these followed the trend Endrin ketone (1.585 ± 5.492 ng/L; DF 8%) > Endrin aldehyde (0.919 ± 1.418 ng/L; 33%) > BHC-beta (0.339 ± 0.253 ng/L; 67%) > BHC-gamma (0.243 ± 0.441 ng/L; 25%) >p'p'-DDE (0.240 ± 0.356 ng/L; 33%) > BHC-alpha (0.132 ± 0.239 ng/L; 25%).

In the current investigation, OCPs did not pose any immediate risk to the biodiversity of Chambal River.

## Damodar

In the present study ΣOCPs in the Damodar River ranged from <DL-8.438 (2.677± 2.293) ng/L. Out of 21 OCPs the contamination pattern of detected 5 OCPs were DDT-p,p' (mean1.171 ± 1.745; DF 31%) > gamma-BHC (1.032 ± 0.519 ng/L; 85%) >delta-BHC (0.346 ± 0.634 ng/L; 23%) > beta-BHC (0.079 ± 0.274 ng/L; 8%) > alpha-BHC (0.048 ± 0.167 ng/L; 8%). The other OCPs were found to be <DL at all the sites.

OCPs did not pose any serious risk to the biodiversity of Damodar River.

## Rupnarayan

In the present study ΣOCPs varied in contamination from <DL- 7.395 (2.786 ± 2.978) ng/L in the surface water of the Rupnarayan River. DF of total OCPs is 71%. Out of 21 OCPs the contamination pattern of detected 3 OCPs were DDT-p,p' (mean 1.659 ± 2.083 ng/L; DF 43%) > gamma-BHC (0.987 ± 0.832 ng/L; 71%) >delta-BHC (0.140 ± 0.369 ng/L; 14%). The other OCPS were found to be <DL at all the sites.

In the present study, OCPs did not pose any serious risk to the biodiversity of Rupnarayan River.

## Ajay

In the present study ΣOCP concentrations varied from < DL-5.342 (1.767 ± 2.117) ng/L in the surface water of the Ajay River. DF of total OCPs is 67%. Out of 21 OCPs the contamination pattern of detected 4 OCPs were DDT-p,p' (mean 0.475 ± 1.164 ng/L; DF 17%) > gamma-BHC (0.761 ± 0.605 ng/L; 67%) >delta-BHC (0.363 ± 0.596 ng/L; 33%) > beta-BHC (0.167 ± 0.259; 33%). The other OCPs were found to be <DL at all the sites.

In the current investigation, ΣOCPs did not pose any serious risk to the biodiversity of Ajay River.



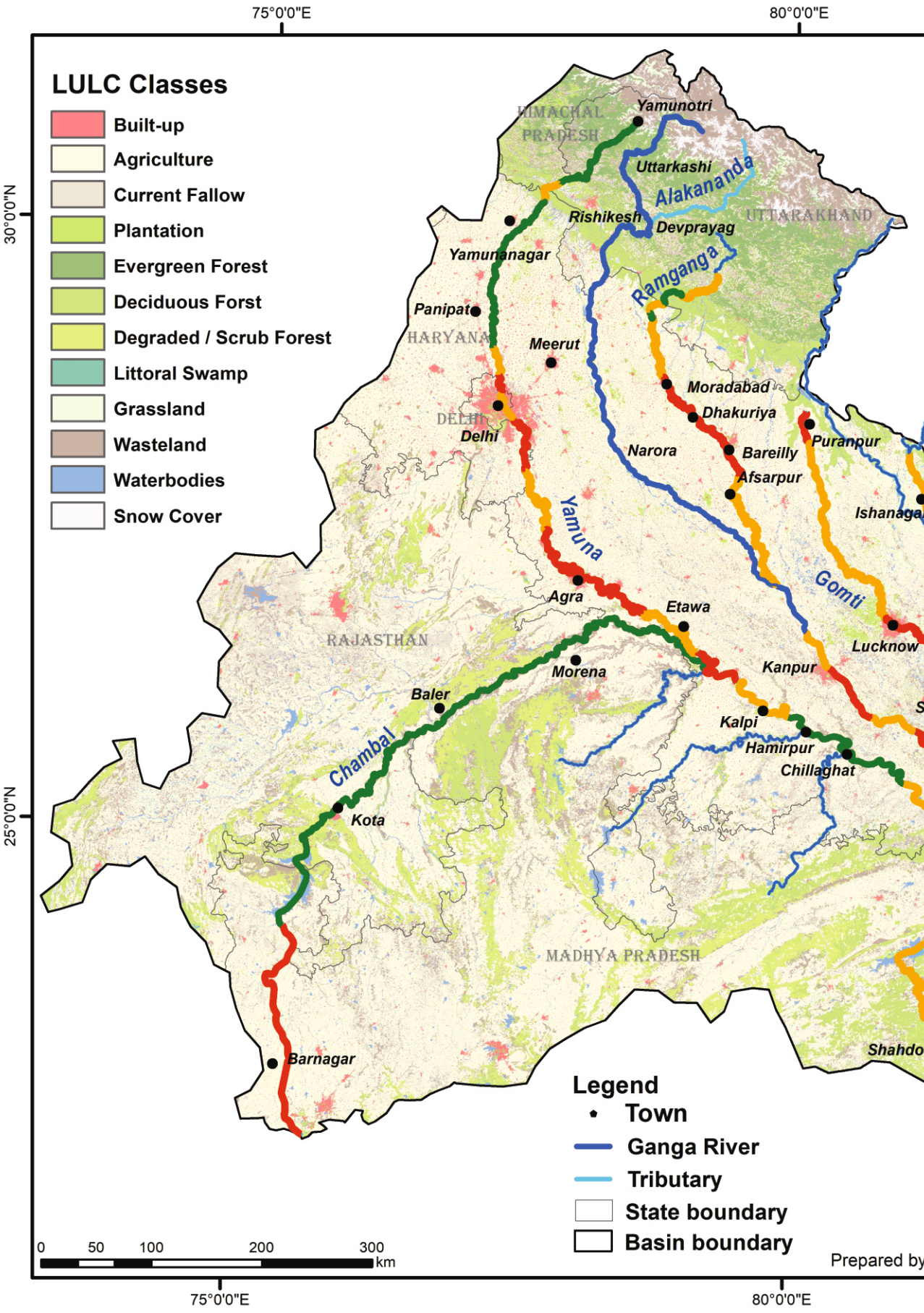


# POLLUTION THREATS AND HOTSPOTS ASSESSMENT

**The following section discusses the degree of risk posed by the contaminants detected in the Ganga River Basin based on their effects at three trophic levels. Each river is divided into stretches of high, medium and low risk, which represent the pollution hotspots in the same.**

**A prevalent risk to multiple pollutants is apparent in the majority of river stretches. The subsequent classification of these segments into high and moderate pollution hotspots points to areas with notably increased ecological risks, albeit with varying degrees of severity.**

**The subsequent section presents the results for the pollution threats and hotspots identified for each river.**


LULC Classes
Built-up
Agriculture
Current Fallow
Plantation
Evergreen Forest
Deciduous Forst
Degraded / Scrub Forest
Littoral Swamp
Grassland
Wasteland
Waterbodies
Snow Cover
75°0'0"E
80°0'0"E
30°0'0"N
25°0'0"N
HIMACHAL PRADESH
UTTARAKHAND
HARYANA
DELHI
RAJASTHAN
MADHYA PRADESH
Yamunotri
Uttarkashi
Alakananda
Rishikesh
Devprayag
Yamunanagar
Ramganga
Panipat
Meerut
Delhi
Moradabad
Dhakuriya
Puranpur
Narora
Bareilly
Afsarpur
Ishanaga
Yamuna
Gomti
Agra
Etawa
Lucknow
Morena
Kanpur
Baler
Kalpi
Hamirpur
Chillaghat
Chambal
Kota
Barnagar
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Town
Ganga River
Tributary
State boundary
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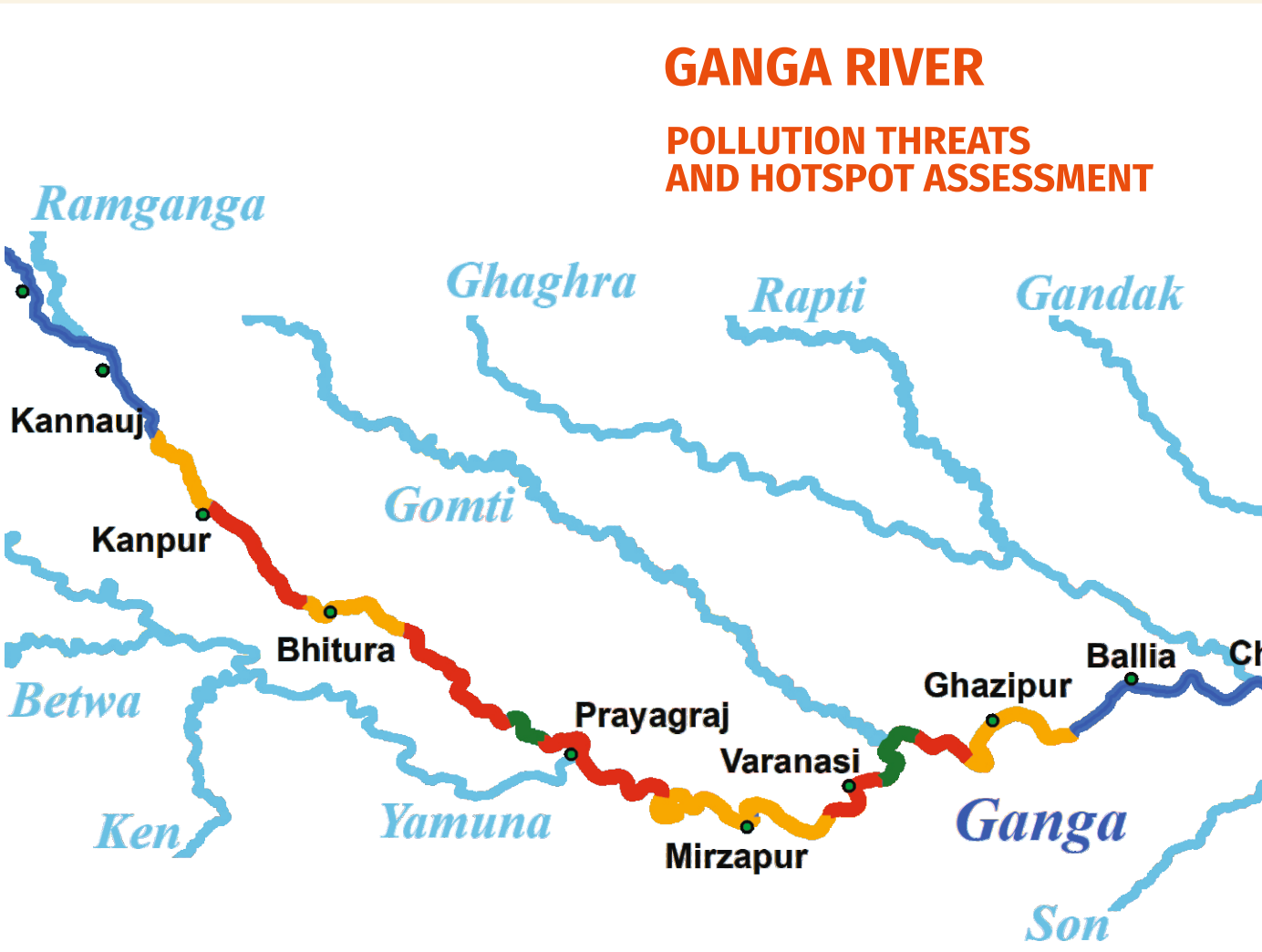
km
Prepared by




: NMCG-WII Project, Ecotoxicology Lab - GIS Cell, Ganga Aqualife Conservation Monitoring Centre, 2024




## POLLUTION THREATS

### Municipal Sewage & Industrial Effluents

- In the investigated stretch (Uttar Pradesh) of Ganga River, total discharge of454.00 MLD is estimated in the form of sewage and industrial effluent, eitherthrough 85 untapped drains or direct discharge in the river. In this stretch discharge of 454.00 MLD is estimated in the form of sewage and industrial effluent, either through 85 untapped drains or direct discharge in the river.
- The catchment area of the Ganga River, spanning from Kannauj to Varanasi and encompassing 08 major cities, generates a total of 2765.61 TPD solid waste, highlighting a deficiency in processing facilities.
- Widespread usage and poor solid waste management of plasticizers, associated with discarded plastic waste, fishing nets, consumer household products, and medical devices is also identified as the potential pollution threats

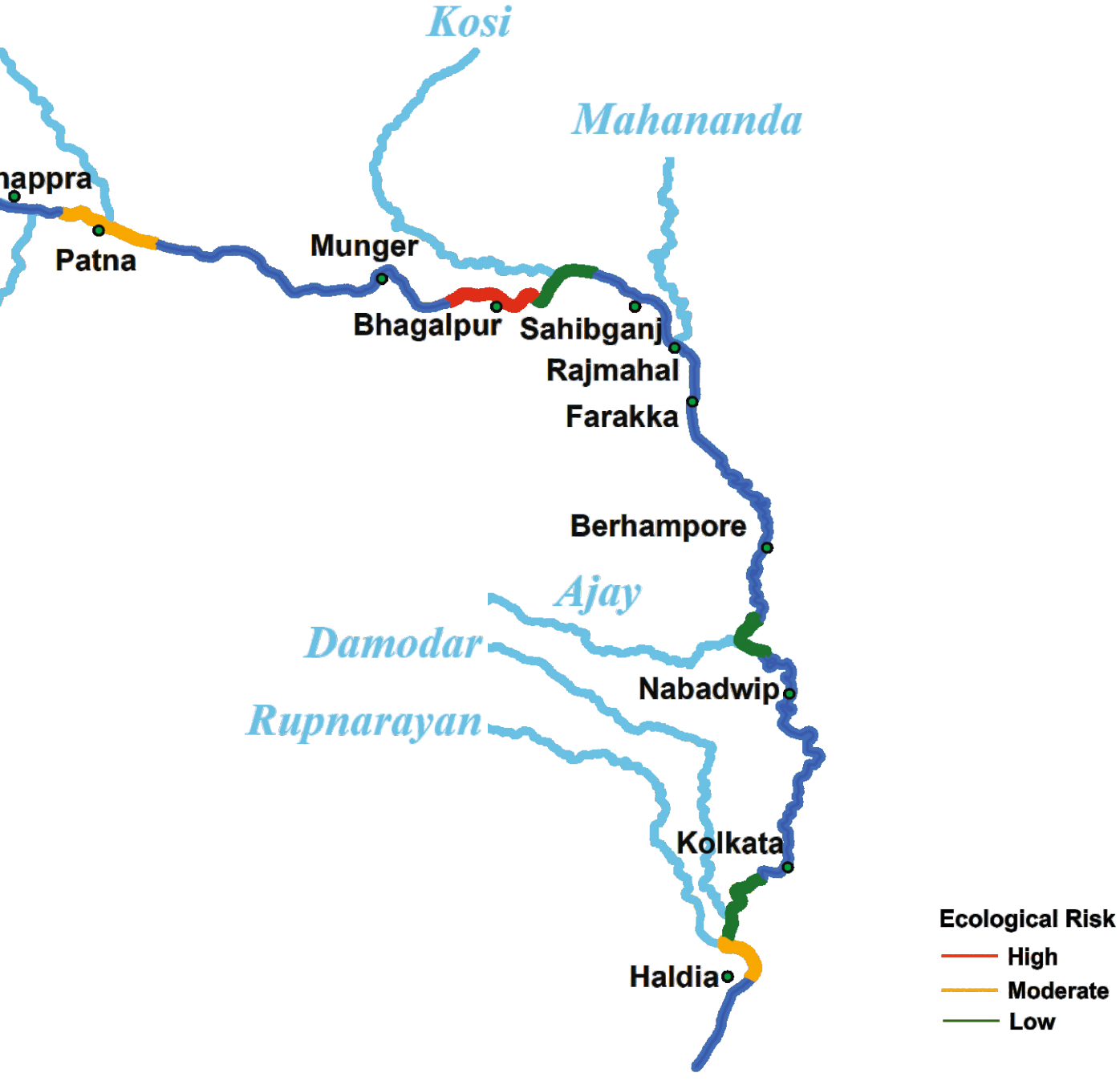
### Agricultural Settlements

The catchment of the Ganga is an area of intensive agriculture activity. The Ganga stateshas a high net irrigation to sown ratio (62.6%) compared to that of the entire country (44%). During the dry season (January to May), the riverbed cultivation of seasonalvegetables is a common practice in the dry riverbeds of the Ganga. Various stretches of the Ganga River have reported elevated levels of pesticide contamination.

## POLLUTION HOTSPOT ASSESSMENT

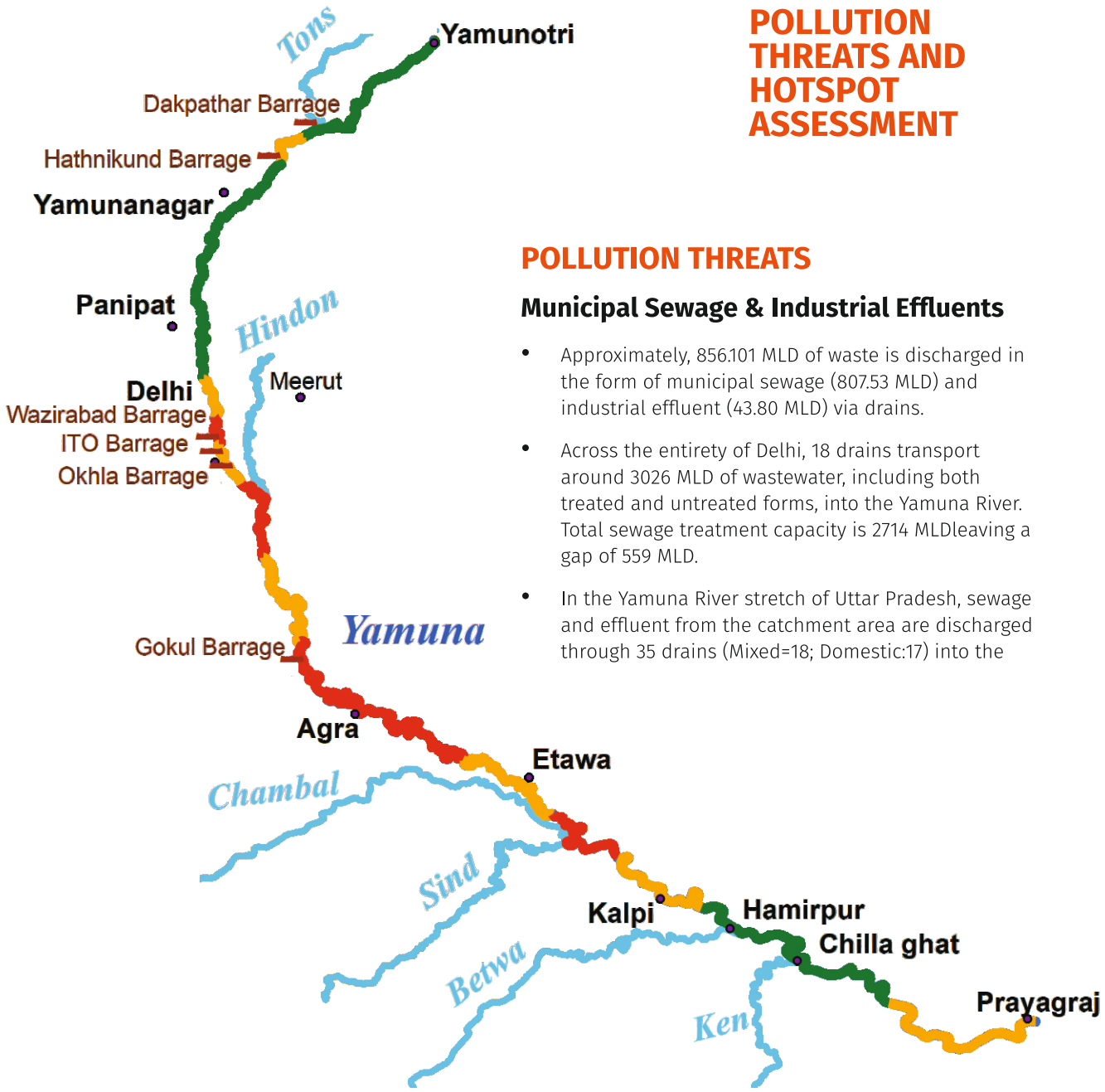
Exceedance for multiple pollution stressors is observed in over 95% of the Ganga River. Hotspots, identified through ecological risk assessments of water quality parameters and chemical pollutants, spotlight specific areas demanding focused intervention. The identified pollution hotspots are

| Risk Zone (%stretch of river) | Sampling Site | Districts |
|---|---|---|
| High Risk Zone (36%) | Pumping House-Chandrika Ghat | Kanpur |
| | Manikpur | Pratapgarh |
| | Phaphamau Bridge-Mannaiya | Prayagraj |
| | Assi Ghat-Kunda Kala | Varanasi |
| | Saidpur | Ghazipur |
| | U/S Kosi Confluence | Bhagalpur |
| Moderate Risk Zone (32%) | Fattepur | Kanpur |
| | Bhitoura | Fatehpur |
| | Adalpura | Mirzapur |
| | Ghazipur-Ghaghra Confluence | Ghazipur, Bhojpur, Saran |
| | U/S Gandak Confluence-Gandak Confluence | Patna, Vaishali |
| | Rupnarayan Confluence | Purba Medinipur |



# YAMUNA RIVER

## POLLUTION THREATS AND HOTSPOT ASSESSMENT




## POLLUTION THREATS

### Municipal Sewage & Industrial Effluents

- Approximately, 856.101 MLD of waste is discharged in the form of municipal sewage (807.53 MLD) and industrial effluent (43.80 MLD) via drains.
- Across the entirety of Delhi, 18 drains transport around 3026 MLD of wastewater, including both treated and untreated forms, into the Yamuna River. Total sewage treatment capacity is 2714 MLDleaving a gap of 559 MLD.
- In the Yamuna River stretch of Uttar Pradesh, sewage and effluent from the catchment area are discharged through 35 drains (Mixed=18; Domestic:17) into the river. A significant gap of approximately 70% exists between treated and untreated wastewater. The catchment houses 300 grossly polluting industries (GPIs), with major industrial units involved in Pulp & Paper, sugar, Textile, Distillery, and other sectors.
- Widespread usage and poor solid waste management of plasticizers, associated with discarded plastic waste, fishing nets, consumer household products, and medical devices is also identified as the potential pollution threats.

## Agricultural Settlements

The Yamuna basin, particularly in Haryana and the western districts of Uttar Pradesh, is known for its high fertility and abundant food grain yield. Various stretches of the Yamuna River have reported elevated levels of pesticide contamination.

## POLLUTION HOTSPOT ASSESSMENT

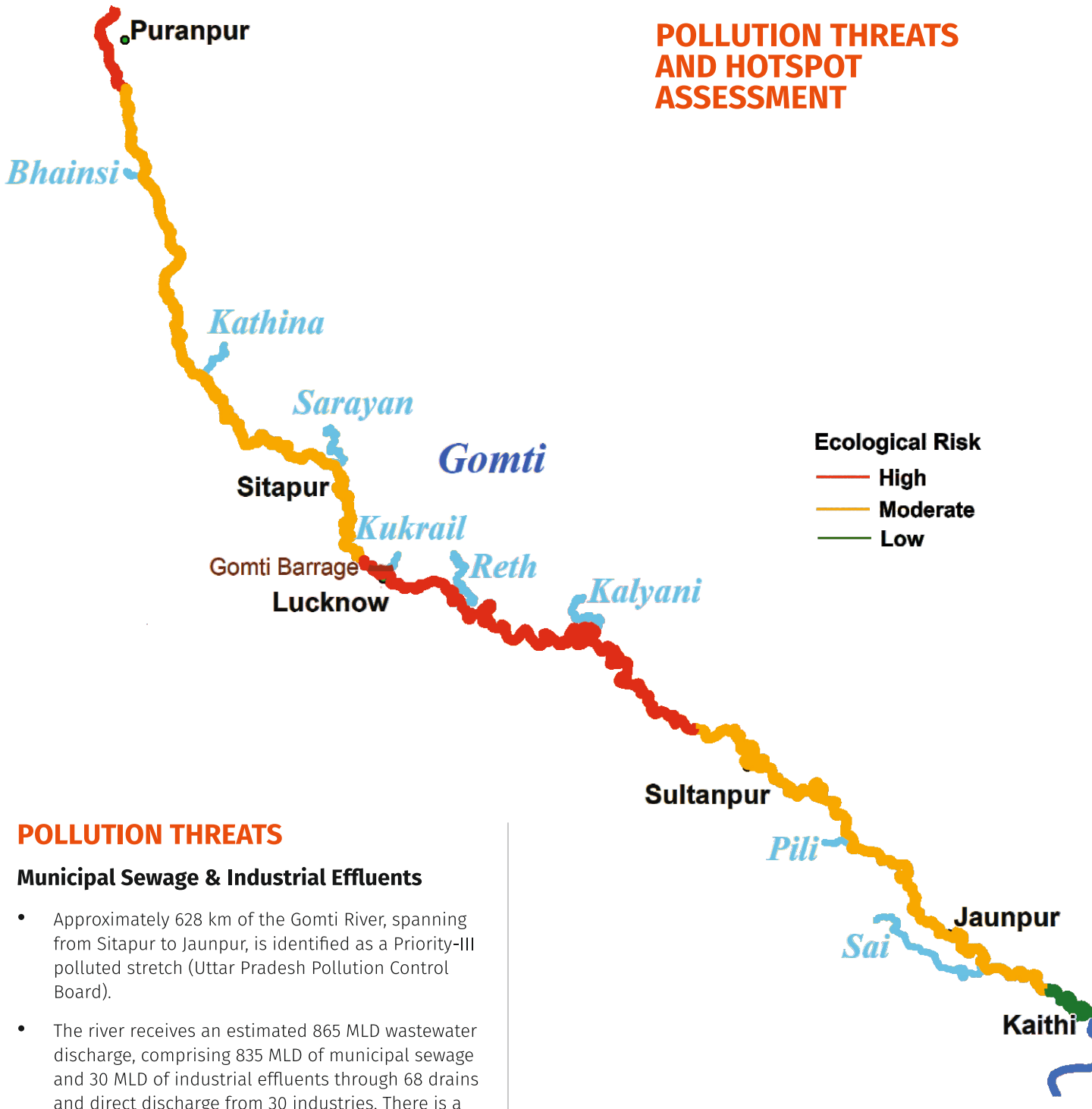
Exceedance for multiple pollution stressors is observed in over 90% of the Yamuna River. Hotspots, identified through ecological risk assessments of water quality parameters and chemical pollutants, spotlight specific areas demanding focused intervention. The identified pollution hotspots are

| Risk Zone (%stretch of river) | Sampling Site | Districts |
|---|---|---|
| High Risk Zone (13%) | Wazirazbad Barrage -Hindon Confl.Mathura-Shahidpur Chambal Confluence | Delhi, Gautam Budh Nagar Mathura, Agra Etawa |
| Moderate Risk Zone (22%) | Paonta Sahib, Baghpat Vrindavan Etawa Kalpi | Sirmaur Baghpat Mathura Etawa Jalaun |



# GOMTI RIVER

## POLLUTION THREATS AND HOTSPOT ASSESSMENT




## POLLUTION THREATS

### Municipal Sewage & Industrial Effluents

- Approximately 628 km of the Gomti River, spanning from Sitapur to Jaunpur, is identified as a Priority-III polluted stretch (Uttar Pradesh Pollution Control Board).
- The river receives an estimated 865 MLD wastewater discharge, comprising 835 MLD of municipal sewage and 30 MLD of industrial effluents through 68 drains and direct discharge from 30 industries. There is a 47% gap between treated and untreated sewage in the polluted stretch of the Gomti River.
- In the polluted stretch, Municipal Solid Waste totals 1798.84 TPD, with processing facilities available only in Lucknow and Barabanki (1230 TPD capacity). Other districts lack processing facilities, creating a gap of 568.84 TPD in the catchment area.
- Widespread usage and poor solid waste management of plasticizers, associated with discarded plastic waste, fishing nets, consumer household products, and medical devices is also identified as the potential pollution threats.

## Agricultural Settlements

As part of highly fertile and agriculturally productive Uttar Pradesh, agriculture comprises the major land-use pattern in the Gomti Basin. This exerts multiple pressures on the river, including water abstraction and pesticide pollution.

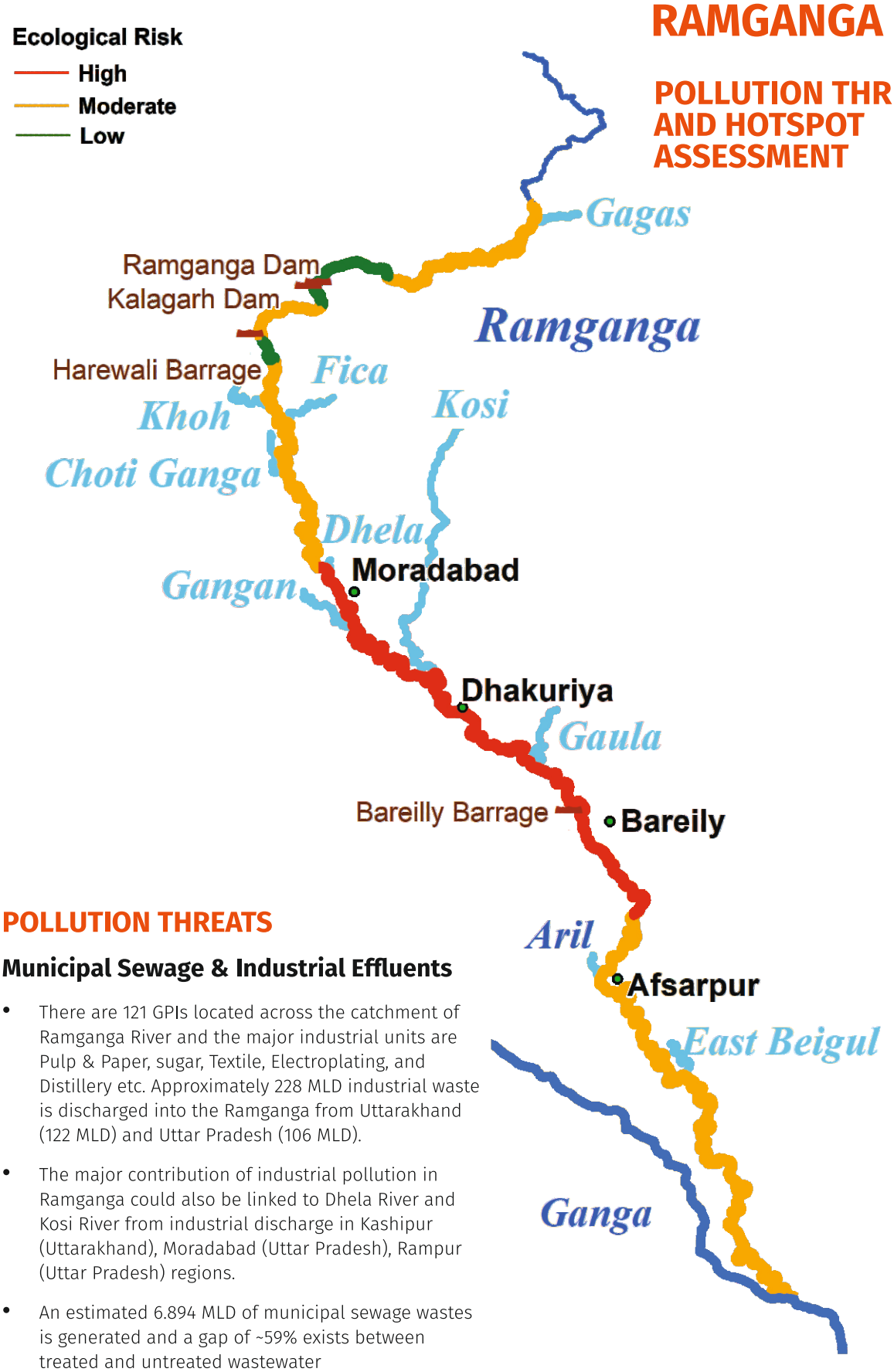
## POLLUTION HOTSPOT ASSESSMENT

Exceedance for multiple pollution stressors is observed in the entire Gomti River. Hotspots, identified through ecological risk assessment of water quality parameters and chemical pollutants, spotlight specific areas demanding focused intervention. The identified hotspots are:

| Risk Zone (%stretch of river) | Sampling Site | Districts |
|---|---|---|
| High Risk Zone (36%) | Origin<br>D/S Kukrail Confluence-Pipri<br>Jaunpur | Pilibhit<br>Lucknow<br>Jaunpur |
| Moderate Risk Zone (57%) | Puranpur-Kukrail Confluence<br>Sultanpur<br>D/S Jaunpur-Chandwak Bridge | Shahjahanpur, Sitapur<br>Lucknow<br>Sultanpur<br>Jaunpur |








## POLLUTION THREATS

### Municipal Sewage & Industrial Effluents

- There are 121 GPIs located across the catchment of Ramganga River and the major industrial units are Pulp & Paper, sugar, Textile, Electroplating, and Distillery etc. Approximately 228 MLD industrial waste is discharged into the Ramganga from Uttarakhand (122 MLD) and Uttar Pradesh (106 MLD).
- The major contribution of industrial pollution in Ramganga could also be linked to Dhela River and Kosi River from industrial discharge in Kashipur (Uttarakhand), Moradabad (Uttar Pradesh), Rampur (Uttar Pradesh) regions.
- An estimated 6.894 MLD of municipal sewage wastes is generated and a gap of ~59% exists between treated and untreated wastewater

- Moradabad, Rampur & Bareilly contributes approx. total 801.93 TPD Solid Waste and there has been lack of processing facility in the catchment.
- Widespread usage and poor solid waste management of plasticizers, associated with discarded plastic waste, fishing nets, consumer household products, and medical devices is also identified as the potential pollution threats.

## Agricultural Settlements

The major land use in Ramganga basin is agriculture settlements and high level of pesticides contamination have been reported from different stretches of Ramganga mainly along the Bijnor to Moradabad district.

## POLLUTION HOTSPOTS ASSESSMENT

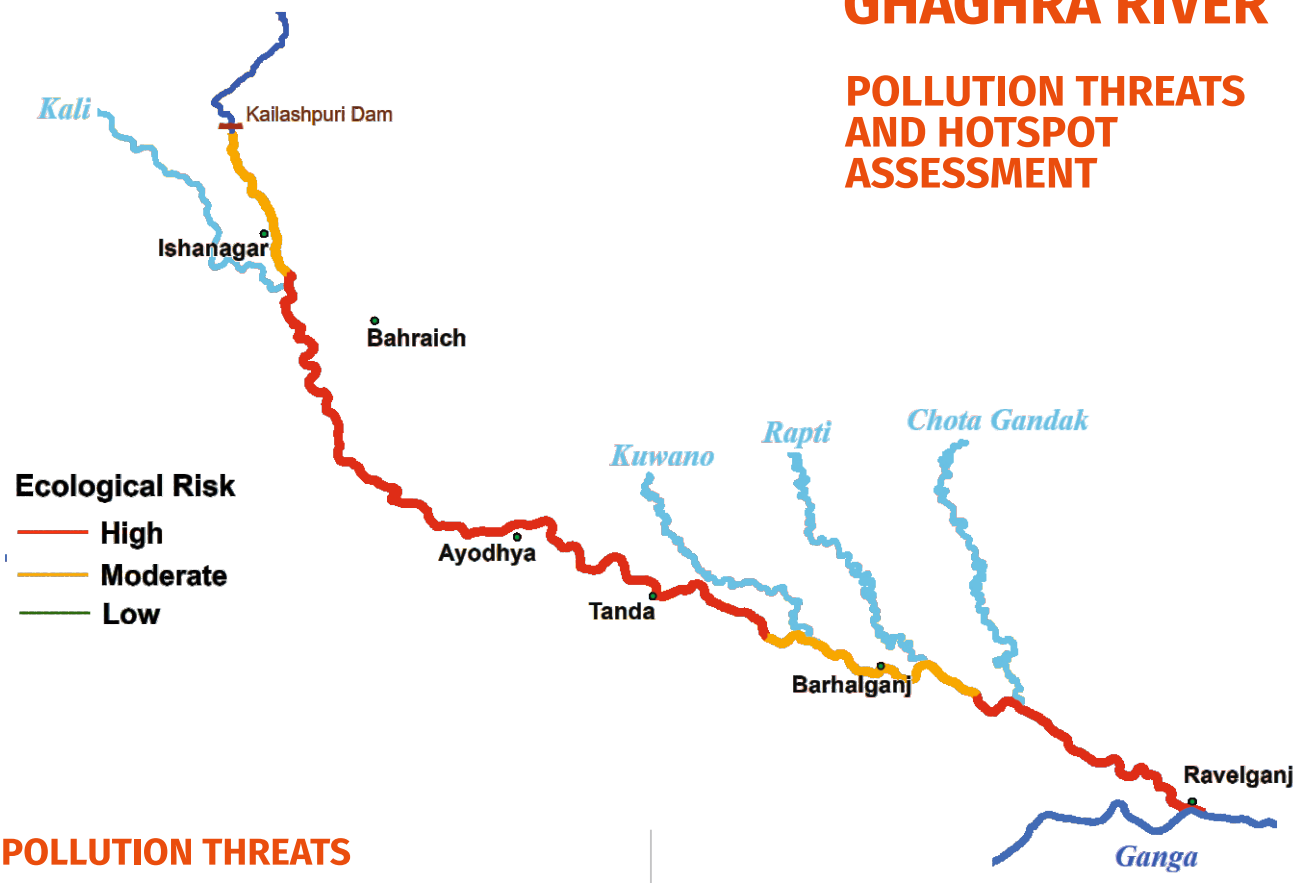
Exceedance for multiple pollution stressors is observed in over 85% of the Ramganga River. Hotspots, identified through ecological risk assessments of water quality parameters and chemical pollutants, spotlight specific areas demanding focused intervention. The identified pollution hotspots are:

| Risk Zone (%stretch of river) | Sampling Site | Districts |
|---|---|---|
| High Risk Zone (31%) | D/S Moradabad-Goula Confluence | Moradabad, Rampur, Bareilly |
| Moderate Risk Zone (56%) | Marchula<br>Nagina Barrage<br>Dhampur<br>Farrukhabad | Ramnagar<br>Nagina<br>Bijnor<br>Shahjahanpur |



# GHAGHRA RIVER

## POLLUTION THREATS AND HOTSPOT ASSESSMENT




## POLLUTION THREATS

### Municipal Sewage

- The Gorakhpur - Deoria stretch is classified as polluted stretch by CPCB and UPPCB, and receives untreated municipal sewage by 9 drains. There is gap of 21.11 MLD in sewage treatment in this stretch owing to the absence of a sewage treatment facility.
- Approximately 142.30 TPD of solid waste is generated in this stretch, with no facilities for its treatment.
- Widespread usage and poor solid waste management of plasticizers, associated with discarded plastic waste, fishing nets, consumer household products, and medical devices is also identified as the potential pollution threats.

### Agricultural Settlements

Agricultural land forms the major class of land use in the Ghaghra basin. There is therefore a potential risk of pesticide pollution through surface runoff.

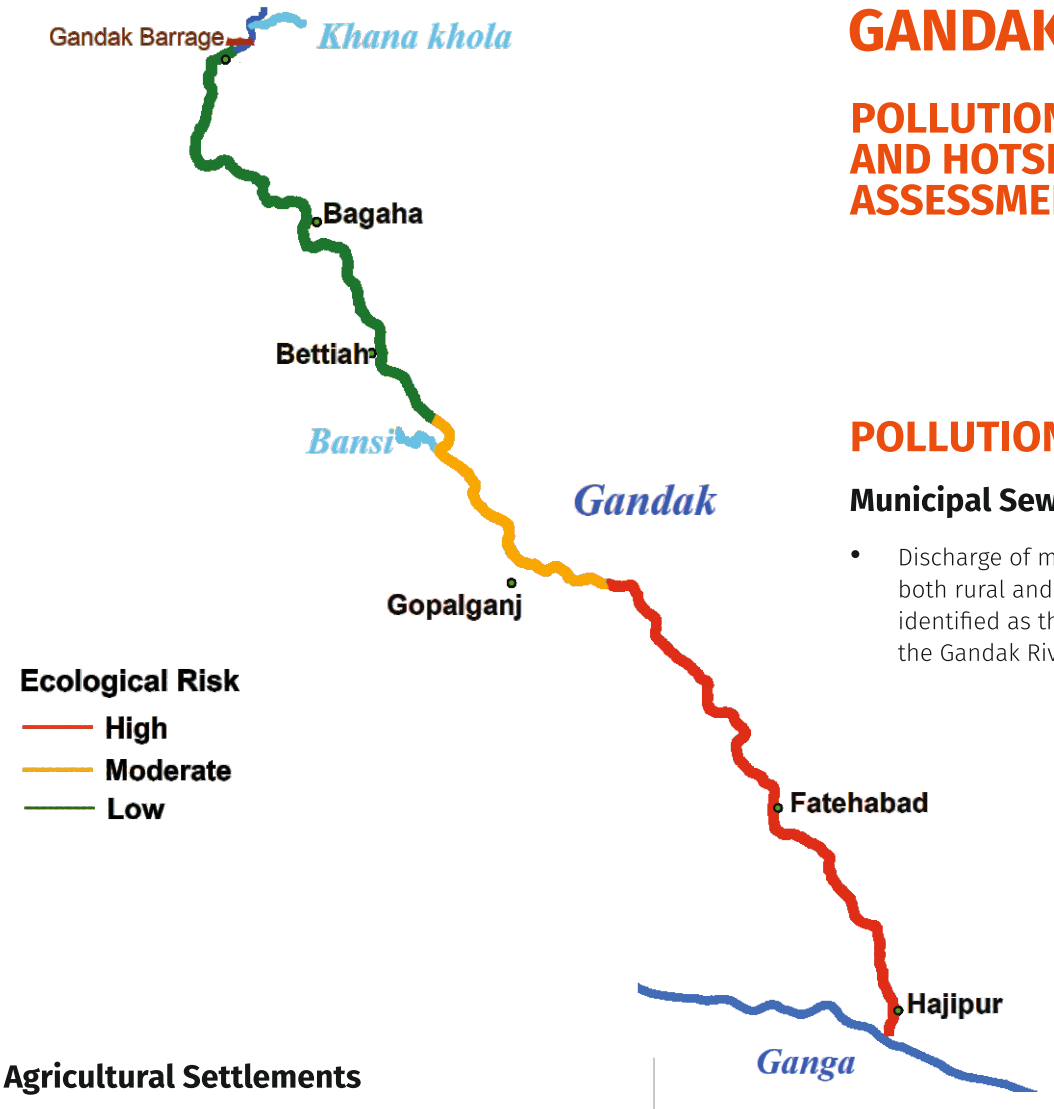
## POLLUTION HOTSPOT ASSESSMENT

Exceedance for multiple pollution stressors is observed in entire river stretch of the Ghaghra. Ecological Risk Assessment of water quality and pollutant concentrations reveal the following high- and moderate-risk hotspots in the river:

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| High Risk Zone (60%) | Chahlari ghat - Tanda<br>Darauli - Revelganj | Ayodhya<br>Ambedkar Nagar<br>Siwan<br>Saran |
| Moderate Risk Zone (40%) | Kailashpuri - Zalimnagar Pul<br>Barhalganj - Rapti confluence | Bahraich<br>Gorakhpur<br>Deoria |

# GANDAK RIVER

## POLLUTION THREATS AND HOTSPOT ASSESSMENT




## POLLUTION THREATS

### Municipal Sewage

- Discharge of municipal sewage from both rural and urban settlements is identified as the pollution threat in the Gandak River

### Agricultural Settlements

Potential pesticide pollution through surface runoff from agricultural area, which comprises majority of the land use.

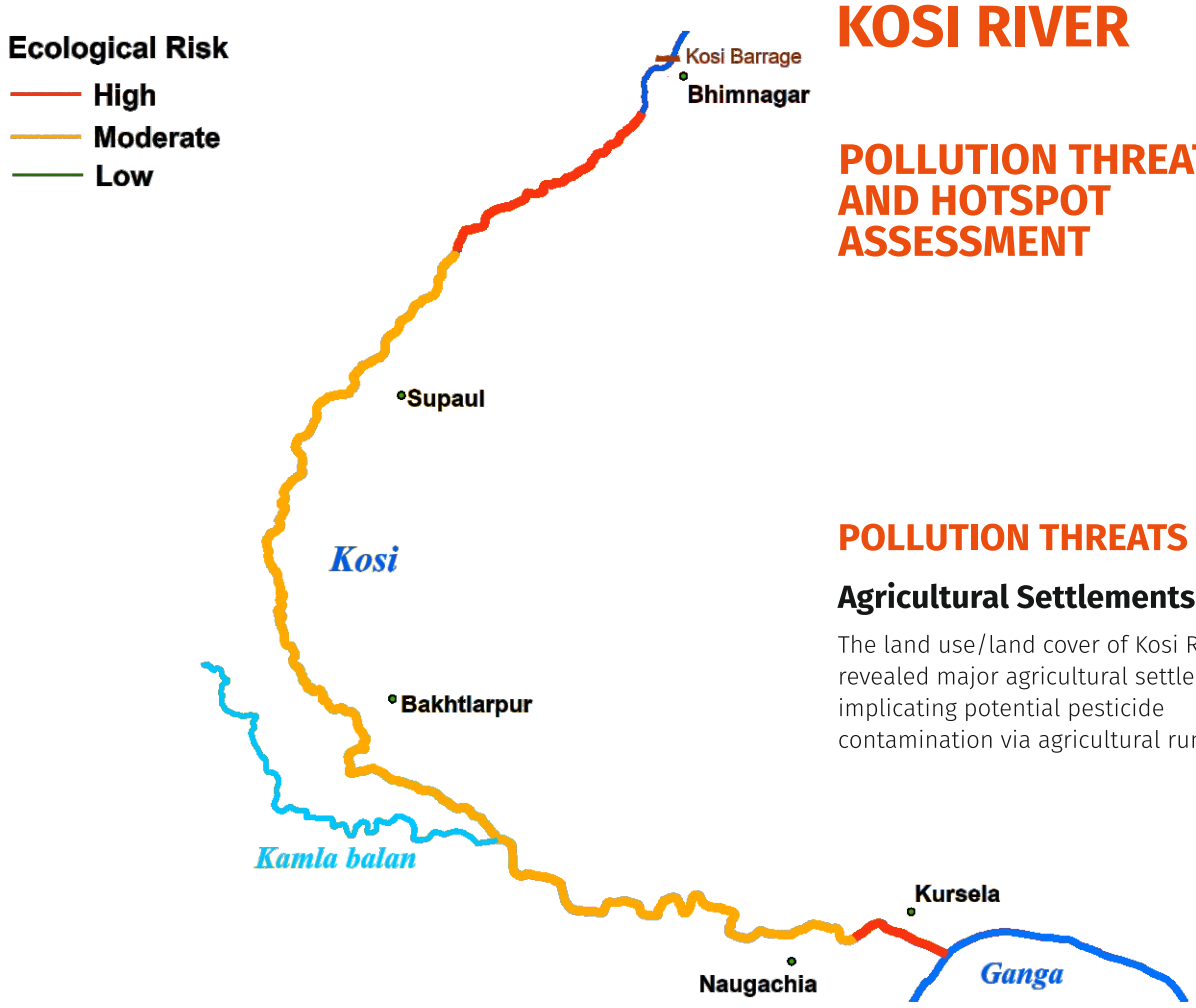
## POLLUTION HOTSPOT ASSESSMENT

Exceedance for multiple pollution stressors is observed in entire river stretch of the Gandak. Ecological Risk Assessment of water quality and pollutant concentrations reveal the following high- and moderate-risk hotspots in the river:

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| High Risk Zone (60%) | Dumariaghat - Sonepur-Hajipur Bridge | Gopalganj Chappra Vaishali |
| Moderate Risk Zone (20%) | Gopalganj | Gopalganj |



# KOSI RIVER




## POLLUTION THREATS AND HOTSPOT ASSESSMENT

## POLLUTION THREATS

### Agricultural Settlements

The land use/land cover of Kosi River revealed major agricultural settlements implicating potential pesticide contamination via agricultural run-off.

## POLLUTION HOTSPOT ASSESSMENT

Exceedance for multiple pollution stressors, particularly plasticizers, is observed in entire river stretch of the Kosi.

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| High Risk Zone (40%) | Piprahigot<br>Kursela Bridge | Supaul<br>Katihar |
| Moderate Risk Zone (60%) | Nemua-Agrahan | Supaul<br>Saharsa<br>Munger |



# SON RIVER

## POLLUTION THREATS AND HOTSPOT ASSESSMENT




### Agricultural Settlements

The land use/land cover of Son River revealed agricultural settlements at some stretches implicating potential pesticide contamination via agricultural run-off.

## POLLUTION HOTSPOT ASSESSMENT

Exceedance for multiple pollution stressors is observed in over 90% of the Son River.

Ecological Risk Assessment of water quality and pollutant concentrations reveal the following high- and moderate-risk hotspots in the Son:

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| High Risk Zone (11%) | Gopad river Confluence, Bardi | Sidhi |
| Moderate Risk Zone (78%) | Cholna - Jogdaha Bridge | Anooppur<br>Shahdol<br>Rewa<br>Sidhi |

## POLLUTION THREATS

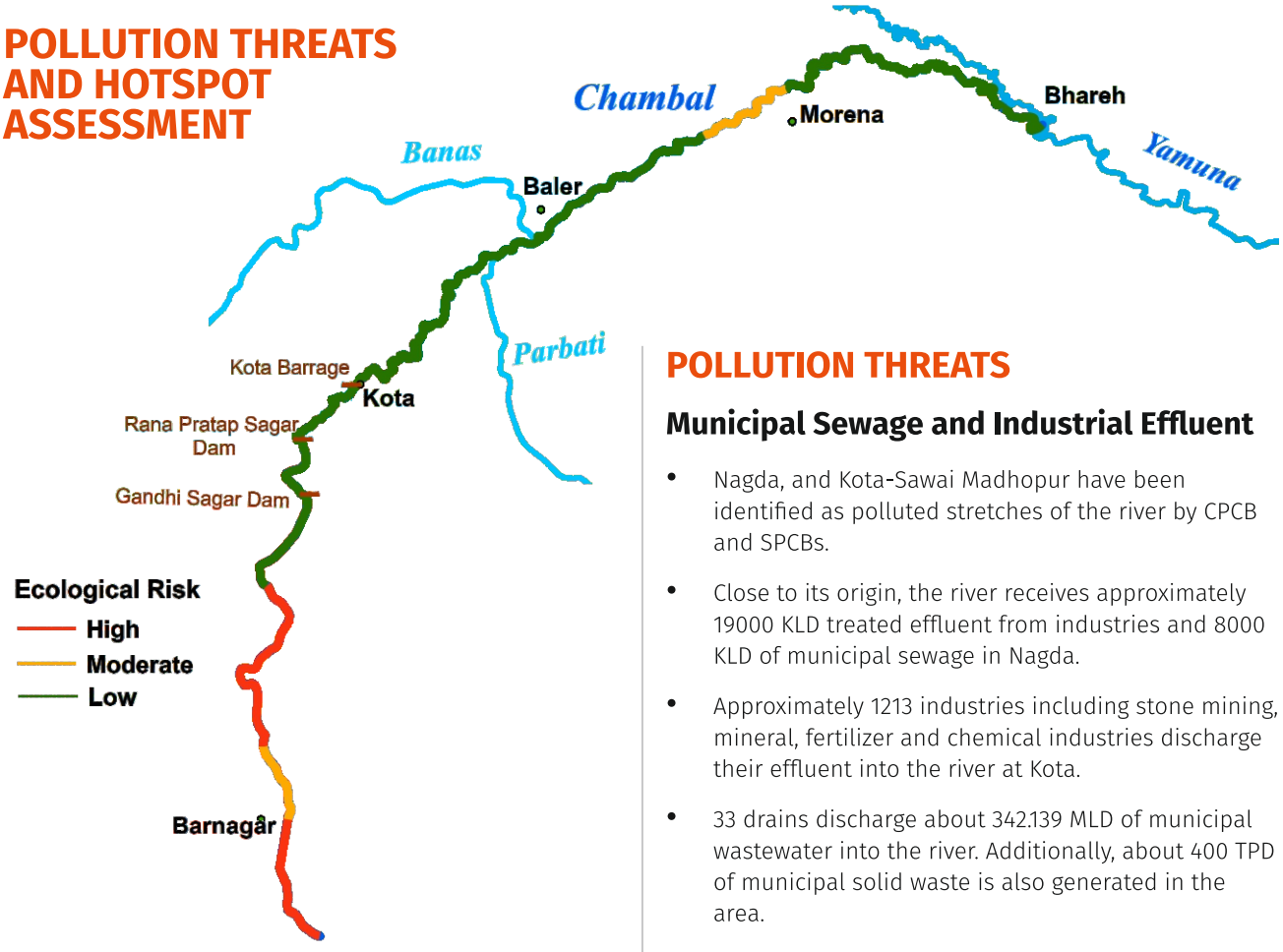
### Agricultural Settlements

- Municipal sewage is discharged into the son via 5 drains in MP.
- Effluents from coal mines and paper industries also pollute the river.



# CHAMBAL RIVER

## POLLUTION THREATS AND HOTSPOT ASSESSMENT




### Agricultural Settlements

Agriculture is extensively practiced downstream of Kota and forms about 35% of the area's land use, posing as a potential source of pesticides for the river.

## POLLUTION HOTSPOT ASSESSMENT

Exceedance for multiple pollution stressors is observed in over 27% stretch of the Sone River. Ecological Risk Assessment of water quality and pollutant concentrations reveal the following high- and moderate-risk hotspots in the river:

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| High Risk Zone (27%) | Origin<br>Kalisindh Confluence | Indore<br>Mandsaur |
| Moderate Risk Zone (18%) | Nagda<br>Dholpur | Ujjain<br>Dholpur |

## POLLUTION THREATS

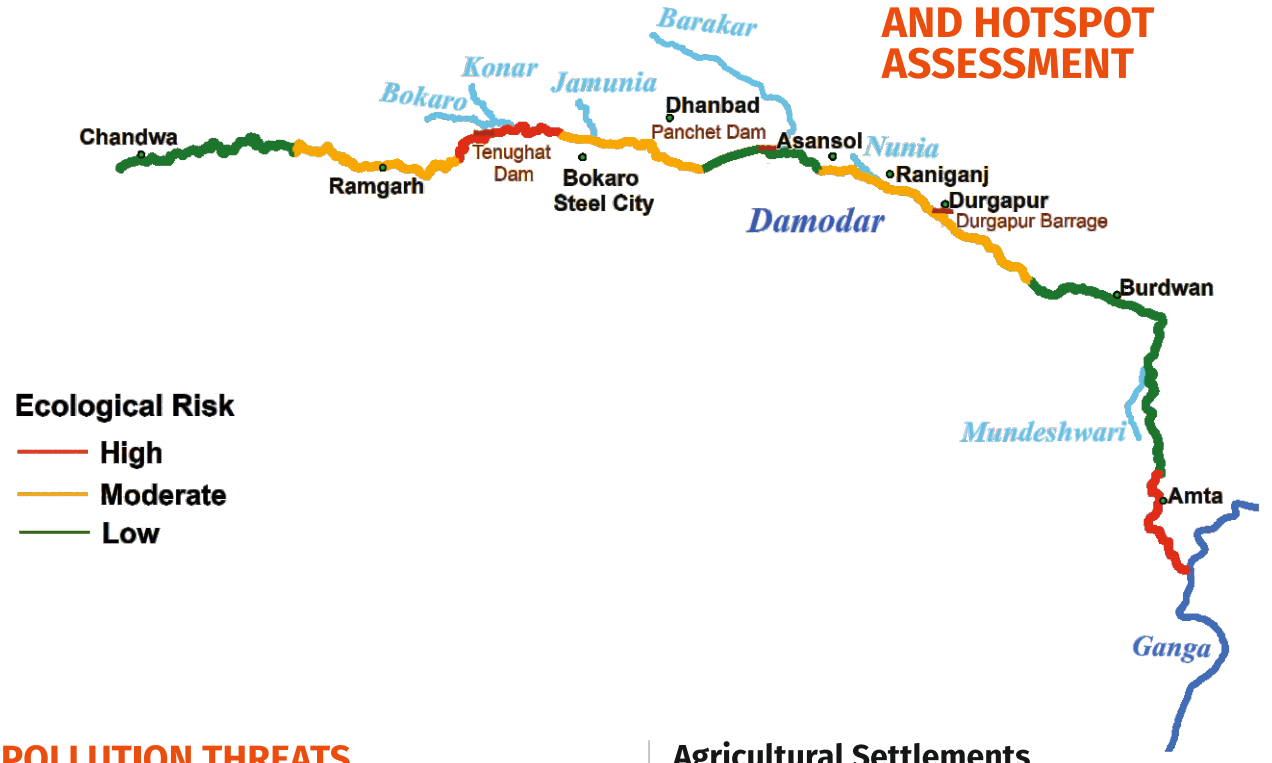
### Municipal Sewage and Industrial Effluent

- Nagda, and Kota-Sawai Madhopur have been identified as polluted stretches of the river by CPCB and SPCBs.
- Close to its origin, the river receives approximately 19000 KLD treated effluent from industries and 8000 KLD of municipal sewage in Nagda.
- Approximately 1213 industries including stone mining, mineral, fertilizer and chemical industries discharge their effluent into the river at Kota.
- 33 drains discharge about 342.139 MLD of municipal wastewater into the river. Additionally, about 400 TPD of municipal solid waste is also generated in the area.



# DAMODAR RIVER

## POLLUTION THREATS AND HOTSPOT ASSESSMENT




## POLLUTION THREATS

### Municipal Sewage and Industrial Effluent

- The river is polluted by over 19000 KDL of municipal wastewater recieved from 9 drains in Jharkhand and 184 MLD from 11 drains in West Bengal. The gap between municipal wastewater generation and treatment is over 170 MLD.
- 3600 KLD of industrial effluent is discharged into the river in Jharkhand. In West Bengal, 30 industries directly discharge 99000 KLD of treated wastewater into the river. The major industries contributing to pollution in the river are coal mining and coal washery, thermal power plants, steel plants and fertilizer industry.

### Agricultural Settlements

Agriculture accounts for 46% of the land use in the Damodar catchment, posing the potential risk of pesticide exposure to the river via surface runoff.

## POLLUTION HOTSPOT ASSESSMENT

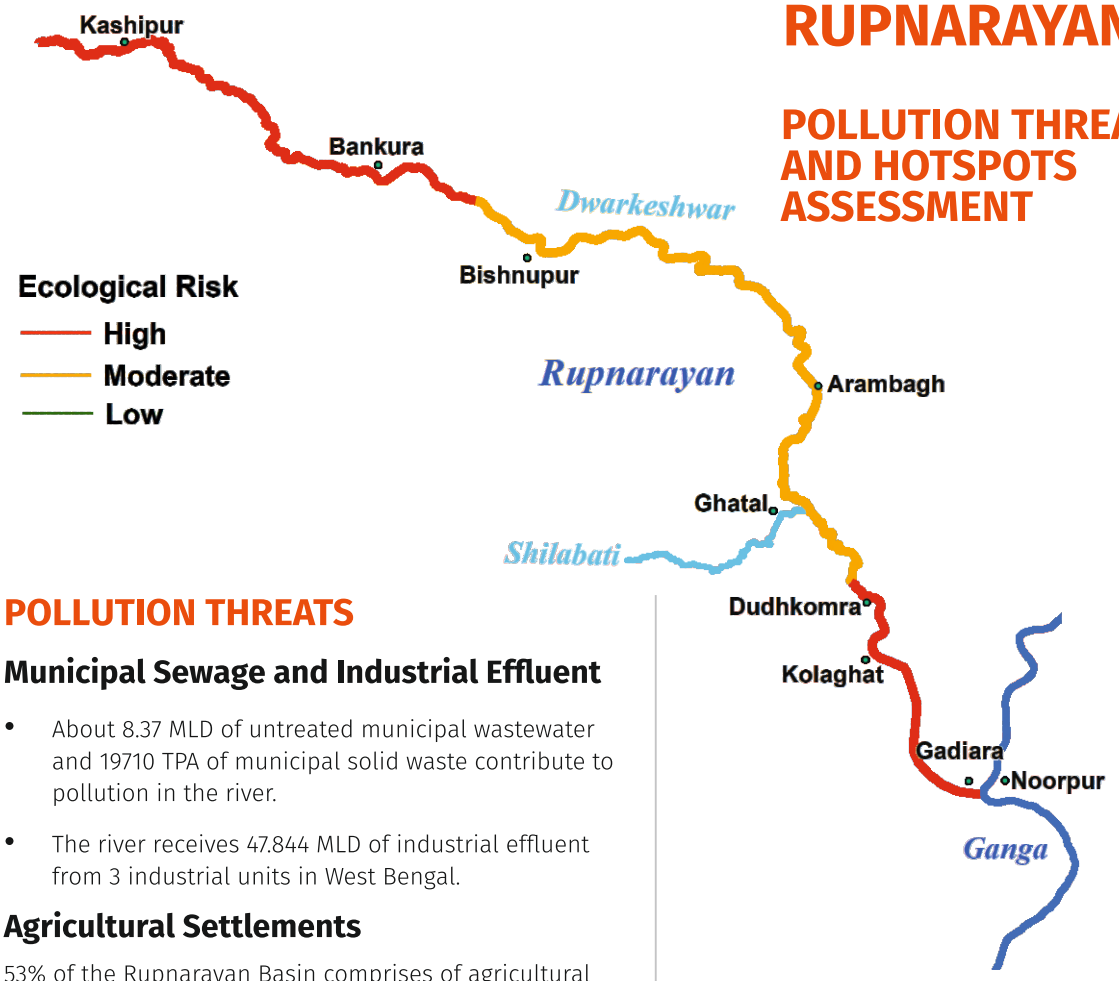
Exceedance of thresholds for multiple pollution stressors was observed in entire stretch of the Damodar River.

Ecological Risk Assessment of water quality and pollutant concentrations reveal the following high- and moderate-risk hotspots in the river:

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| High Risk Zone (17%) | D/S Tenuaghat Reservoir<br>Kulgachia | Bokaro<br>Howrah |
| Moderate Risk Zone (42%) | Basaria - Gadhaunia<br>D/S Kapat Ghat<br>Asansol - Durgapur | Dhanbad<br>Ramgarh<br>Bokaro<br>Paschim Bardhaman<br>Bankura |

# RUPNARAYAN RIVER

## POLLUTION THREATS AND HOTSPOTS ASSESSMENT




## POLLUTION THREATS

### Municipal Sewage and Industrial Effluent

- About 8.37 MLD of untreated municipal wastewater and 19710 TPA of municipal solid waste contribute to pollution in the river.
- The river receives 47.844 MLD of industrial effluent from 3 industrial units in West Bengal.

### Agricultural Settlements

53% of the Rupnarayan Basin comprises of agricultural land, posing the risk of introducing agrochemicals into the river through surface runoff.

## POLLUTION HOTSPOT ASSESSMENT

Exceedance of safe thresholds for multiple pollution stressors was observed entire stretch of the Rupnarayan River.

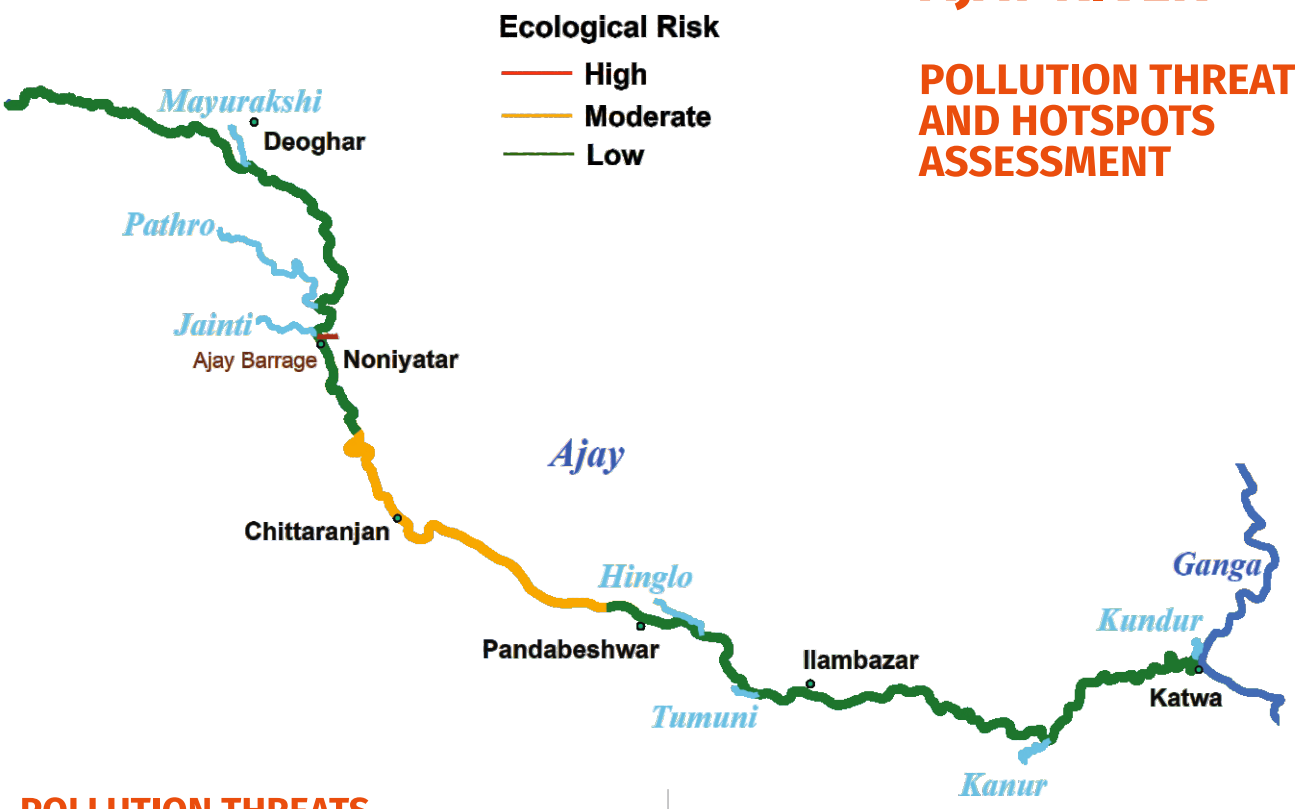
Ecological Risk Assessment of water quality and pollutant concentrations reveal the following high- and moderate-risk hotspots in the river:

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| High Risk Zone (57%) | Origin - Dwarakeshwar Bridge | Purulia |
| | Kolaghat - Tamluk | Bankura<br>East Medinipur |
| Moderate Risk Zone (43%) | Dom Doma Ferry Ghat - Shilabati Confluence | Bankura<br>Hoogly<br>West Medinipur |



# AJAY RIVER

## POLLUTION THREATS AND HOTSPOTS ASSESSMENT




## POLLUTION THREATS

### Municipal Sewage and Industrial Effluent

- 29% of the Ajay River basin is represented by residential land use, and therefore receives both municipal wastewater and solid waste as pollutants.

### Agricultural Settlements

Agriculture is practiced in 71% of the basin area of the Ajay River, posing a potential risk to the river's ecosystem through pesticide pollution.

## POLLUTION HOTSPOT ASSESSMENT

Exceedance of thresholds for multiple pollution stressors was observed in entire stretch of Ajay River.

Ecological Risk Assessment of water quality and pollutant concentrations reveal the following high- and moderate-risk hotspots in the river:

| Risk Zone (% stretch of River) | Stretch | District |
|---|---|---|
| Moderate Risk Zone (17%) | Sidhu kanhu Bridge | West Burdwan |



# ANNEXURE I

**Table 1:** Sampling sites with coordinates and Area of Concerns (AOCs) in rivers of GRB

| River | Sites Name | Lat | Log | Code | AOC |
|---|---|---|---|---|---|
| Ganga | Fattepur | 26.56128 | 80.30086 | G1 | FA,WC,CB,AR |
| Ganga | 1km D/S Pumping House | 26.4137 | 80.43648 | G2 | SW |
| Ganga | Chandrika Ghat | 26.14197 | 80.66195 | G3 | SW,DM,IE |
| Ganga | Bhitoura | 26.05049 | 81.03466 | G4 | SW,DM,IE |
| Ganga | Manikpur | 25.66972 | 81.42156 | G5 | FA,CB, AR,CR |
| Ganga | Shrimgverpur | 25.49732 | 81.73499 | G6 | WC,CB,SW,CR,DM,LF |
| Ganga | 2.5km D/S Of Phaphamau | 25.48803 | 81.88915 | G7 | WC,CB,B, AR, SW |
| Ganga | Sangam D/S 500m | 25.41621 | 81.90139 | G8 | CB, B, NH,SW,CR,MB, RA |
| Ganga | 2.5 Km D/S Mannaiya | 25.32322 | 81.98741 | G9 | A,WC,CB,AR, SW,CR,DM,SM |
| Ganga | Adalpura | 25.11586 | 82.8535 | G10 | FA,WC,CB,B, AR, SW,CR, MB |
| Ganga | Assi Ghat | 25.30888 | 83.01508 | G11 | CB, DM, IE, MB ,RA |
| Ganga | Kunda Kala | 25.32331 | 83.12623 | G12 | FA,WC,AR, MB |
| Ganga | Mughalsarai Drain (50m) D/S | 25.32211 | 83.14206 | G13 | FA,WC,CB,AR, NH, SW,CR,DM,IE,SM, LF |
| Ganga | Confluence Gomti | 25.50896 | 83.17147 | G14 | FA, WC, CB, AR, SW, CR, DM, SM |
| Ganga | Saidpur | 25.51312 | 83.17429 | G15 | FA,WC,CB, B, AR, NH, SW,CR,DM,SM, LF |
| Ganga | Ghazipur | 25.48761 | 83.41164 | G16 | FA,WC,CB,B, NH, SW,CR,DM,SM |
| Ganga | Ghaghra conf U/S-Ganga | 25.71683 | 84.61353 | G17 | AR, CR, SM, SW, RW, FA |
| Ganga | Ghaghra Confluence | 25.73539 | 84.71231 | G18 | AR, B, SM, FA, MB, NH |
| Ganga | Sone Conf | 25.69245 | 84.87264 | G19 | WC, CR, AR, MB, SM |
| Ganga | Gandak Confl U/S-Ganga | 25.64094 | 85.04513 | G20 | FA,AR,B,NH,SW,CR,MB,RA |
| Ganga | Gandak Confl | 25.61581 | 85.20322 | G21 | FA,WC,CB,AR,B,NH,SW,MB |
| Ganga | U/S Kosi Confl | 25.26729 | 87.03449 | G22 | FA, NH, B, AR, CR, SW, RA ,CB |
| Ganga | Kosi Confl | 25.43025 | 87.26685 | G23 | FA, NH, B, AR, SW, MB, CR, Railways, |
| Ganga | U/S Ajay Conf | 23.682933 | 88.13965 | G24 | WC, CB, MB, SW, Ferry |
| Ganga | Ajay Conf | 23.648086 | 88.139552 | G25 | FA, WC, CB, CR, DM, MB, RA, SM |
| Ganga | U/s Damodar Confl | 22.38641 | 88.09985 | G26 | FA, SW, MB |
| Ganga | Damodar Conf | 22.34898 | 88.08888 | G27 | FA, CB, SW, MB |
| Ganga | Rupnarayan | 22.19971 | 88.10165 | G28 | FA, CB, SW, MB, RA |
| Yamuna | Trekking Path, Janki Chatti | 30.98084 | 78.443455 | Y1 | SW |
| Yamuna | Kharseli Bridge, Janki Chatti | 30.97518 | 78.438204 | Y2 | B, DM, SW |
| Yamuna | Kanseru | 30.80839 | 78.194571 | Y3 | FA |
| Yamuna | Dakpathar | 30.501157 | 77.80347 | Y4 | SW |
| Yamuna | Poanta Sahib | 30.43309 | 77.626927 | Y5 | SW, CB, B, |
| Yamuna | Hathnikund Barrage | 30.31311 | 77.586026 | Y6 | SW, CB, B, |
| Yamuna | Yamuna nagar | 30.06948 | 77.353576 | Y7 | FA, WC, CB, B, NH, SW, CR, SM |
| Yamuna | Karnal | 29.59672 | 77.109152 | Y8 | FA, WC, CB, AR, B, NH, SW, CR, MB, SM, |
| Yamuna | Baghpath | 28.93231 | 77.212149 | Y9 | AR, SW |
| Yamuna | Wazirazbad Barrage | 28.71045 | 77.23181 | Y10 | FA, CB, AR, B, NH, SW, DM, SM |
| Yamuna | Okhla Barrage | 28.54361 | 77.314523 | Y11 | AF, DM |
| Yamuna | Hindon Confl. | 28.40807 | 77.49702 | Y12 | DM, AF, SW |
| Yamuna | Virndavan | 27.5881 | 77.69864 | Y13 | CB, DM or IE, CR |
| Yamuna | Mathura | 27.47347 | 77.71193 | Y14 | DM or IE, AF |
| Yamuna | D/S Tajmahal | 27.18085 | 78.130848 | Y15 | SW, B, DM |
| Yamuna | Shahidpur | 27.07867 | 78.36761 | Y16 | CR, SW |
| Yamuna | Etawah | 26.74591 | 78.98891 | Y17 | B, AR, FA, Religious activity |
| Yamuna | Chambal Conf. | 26.4911 | 79.25059 | Y18 | AR, CR |
| Yamuna | Panchnada | 26.43969 | 79.21265 | Y19 | AR, FA, Confluence point with high pollution load |
| Yamuna | Kalpi | 26.13239 | 79.75364 | Y20 | FA, CB, AR, B, NH, CR, DM, SW, Electric lines, Railways |

| River | Sites Name | Lat | Log | Code | AOC |
|---|---|---|---|---|---|
| Yamuna | Betwa Confl. | 25.91964 | 80.22696 | Y21 | FA, CB, B, MB, Algal growth |
| Yamuna | Rajapur | 25.71316 | 80.60314 | Y22 | AF, FA, B, NH, SM |
| Yamuna | Mau | 25.27121 | 81.38674 | Y23 | FA, WC, CB, AR, B, SW |
| Gomti | Origin Gomti | 28.6056 | 80.11448 | GT1 | SW, AR, Algal bloom, Macrophytes |
| Gomti | Puranpur Road Gomti | 28.1471 | 80.20034 | GT2 | AR,B, NH, CR, WC,CB, SW |
| Gomti | Dadhnamau | 27.46383 | 80.401951 | GT3 | FA, WC, CB, AR, B, NH, SW, SM |
| Gomti | Bhatpur Ghat | 27.18905 | 80.80186 | GT4 | FA, WC,CB, B, NH, SW, CR |
| Gomti | Manjhi Ghat | 26.90308 | 80.874139 | GT5 | AR, WC, CB, FA, B, NH, SW CR, DM, IE, LF |
| Gomti | Kukrail River Confl. | 26.85703 | 80.96943 | GT6 | FA, B, NH, SW, CR, DM, RA |
| Gomti | D/S Kukrail Confluence | 26.83268 | 80.96909 | GT7 | FA, B, NH, SW, CR, DM, RA, |
| Gomti | Gomti Bridge, Lucknow | 26.81772 | 81.01683 | GT8 | FA, WC, CB, B, NH, SW CR, DM, IE, LF |
| Gomti | Pipri | 26.4815 | 81.767027 | GT9 | FA,WC, CB,AR,SW,CR, DM ,SM |
| Gomti | Sultanpur | 26.2703 | 82.08086 | GT10 | FA, WC, CB, AR, B, NH, SW, CR, DM,RA, LF |
| Gomti | Ramghat, Jaunpur | 25.75582 | 82.71905 | GT11 | FA, WC, CB, AR, B, SW, CR, DM, LF |
| Gomti | D/S, Jaunpur | 25.74499 | 82.73074 | GT12 | FA, WC, AR, B, SW, CR |
| Gomti | ChandwakBridgeBalua | 25.5797 | 82.99986 | GT13 | AR, CB, WC, FA, NH,B, SW, CR |
| Gomti | Rajwari | 25.50663 | 83.14118 | GT14 | FA, CB, B, NH, CR,AR |
| Ramganga | Marchula | 29.60585 | 79.09283 | RG1 | DM, NH, B, SW |
| Ramganga | Kalagarh | 29.49509 | 78.76012 | RG2 | B, NH |
| Ramganga | Nagina barrage | 29.41329 | 78.618 | RG3 | DM, NH, FA |
| Ramganga | Salawatpurgirdhar, dhampur | 29.36957 | 78.6477 | RG4 | AR, DM |
| Ramganga | Dhampur | 29.23834 | 78.657 | RG5 | FA, AR, CR, B |
| Ramganga | Dhela river u/s confluence 2.5 km | 28.88012 | 78.753271 | RG6 | CB, AR, SW, DM, NH, LF |
| Ramganga | Dhelaramganga d/s confluence | 28.85559 | 78.772404 | RG7 | CR, FA, CB |
| Ramganga | D/s Moradabad kharagpurbaze | 28.76969 | 78.81956 | RG8 | FA, AR, DM |
| Ramganga | Mukutpur, kosi confluence | 28.62972 | 78.98182 | RG9 | AR, CB, SW, NH, CR |
| Ramganga | Goula confluence | 28.40843 | 79.2663 | RG10 | Non native Eicchornia abundance, AR |
| Ramganga | Peepalgoutia | 28.23219 | 79.39261 | RG11 | FA, CB, AR, B, NH, SW |
| Ramganga | Hazratpur | 27.88997 | 79.43159 | RG12 | FA, SW, B, AR, Animal carcasses |
| Ramganga | Farukhabad | 27.49809 | 79.69661 | RG13 | NH, AR, FA, B, |
| Ghaghra | Kailashpuri | 28.27025 | 81.08643 | GG1 | FA, CB, AR, B, CR, RA |
| Ghaghra | Zalimnagar Pul | 27.99375 | 81.21505 | GG2 | FA, WC, CB, AR, B, MB |
| Ghaghra | Chahlari ghat | 27.55848 | 81.32238 | GG3 | FA, B, NH, SW,AR |
| Ghaghra | Tappe Sipah | 27.08593 | 81.49202 | GG4 | FA, WC, CB, B, NH, SW, CR, MB, RA |
| Ghaghra | Ayodhya | 26.81438 | 82.21482 | GG5 | WC, CB, B, NH, AR, SW, CR, DM, MB, RA, |
| Ghaghra | Tanda | 26.55542 | 82.66941 | GG6 | FA, WC, CB, AR, SW, CR, DM, IE, SM, LF, Thermal Industry |
| Ghaghra | Barhalganj | 26.28041 | 83.50766 | GG7 | FA, WC, CB, B, NH, SW, CR, DM, IE, MB |
| Ghaghra | RaptiConfl. | 26.29538 | 83.68113 | GG8 | FA, CR, MB |
| Ghaghra | Darauli | 26.07482 | 84.12639 | GG9 | FA, WC, CB, SW, CR, DM, B |
| Ghaghra | Revelganj | 25.79711 | 84.62031 | GG10 | FA, WC, CB, NH, SW, CR, DM, IE, MB |
| Gandak | Bagaha | 27.12655 | 84.04715 | GD1 | FA,WC,CB,AR,CR,MB |
| Gandak | D/S Gopalganj Bridge Dipau | 26.54518 | 84.44159 | GD2 | FA,WC,CB,B |
| Gandak | D/S Dumariaghat, Dipau | 26.35856 | 84.7481 | GD3 | FA,WC,CB,AR,B,NH,SW,CR |
| Gandak | Rewaghat, Muzaffarpur | 25.9864 | 85.047021 | GD4 | CR, B |
| Gandak | Sonepur | 25.7007 | 85.196983 | GD5 | FA, AR |
| Kosi | Piprahigot | 26.4176 | 86.8582 | K1 | FA, SW, NH, AR |
| Kosi | Nemua | 26.08912 | 86.50601 | K2 | FA, SW, NH, CR, MB |
| Kosi | Mahapura | 25.83331 | 86.44517 | K3 | FA, SW, NH |
| Kosi | Agrahan | 25.5729 | 86.69209 | K4 | FA, , NH, B, AR,SM |

| River | Sites Name | Lat | Log | Code | AOC |
|---|---|---|---|---|---|
| Kosi | Kursela Bridge | 25.42598 | 87.05358 | K5 | FA, NH, B , AR |
| Son | Cholna | 23.08141 | 81.93208 | S1 | FA, CB, SW, CR, B |
| Son | Annupur | 23.13924 | 81.70208 | S2 | WC, CB, SW, SM, B |
| Son | Govarde | 23.76672 | 81.206 | S3 | AR, NH, SW, SM, B |
| Son | Khairi | 24.31045 | 81.5007 | S4 | AR, CR |
| Son | Jogdaha Bridge | 24.50782 | 82.129 | S5 | WC, CB, SW |
| Son | Confluence gopad river, bardi | 24.55939 | 82.3785 | S6 | WC, CB, FA |
| Son | D/S North Sone riverkoelconff | 24.53836 | 83.90747 | S7 | FA, WC, CB, SW, CR |
| Son | Indrapuri Dam D/S 500 m Patnawa | 24.83977 | 84.13728 | S8 | FA, WC, CB, AR, NH, SW, CR, RA, SM, NH, B |
| Son | Koilwar | 25.57125 | 84.79529 | S9 | FA, NH, B, SM |
| Chambal | Origin | 22.58986 | 75.51741 | C1 | SW, CB |
| Chambal | Nagda | 23.46008 | 75.39754 | C2 | SW, B, Eutrophication |
| Chambal | Kalisindh Confl. | 24.07524 | 75.52952 | C3 | CB, CR, B |
| Chambal | D/S Ranapratap Sagar Dam | 24.96025 | 75.55304 | C4 | AR, FA, RA |
| Chambal | D/S Kota Barrage | 25.21595 | 75.85842 | C5 | DM, IE, SW,AR |
| Chambal | D/S Makhida Bridge | 25.58201 | 76.29103 | C6 | AR, B |
| Chambal | Parbati Confl. | 25.84707 | 76.56647 | C7 | AR,RA,MB |
| Chambal | Banas Confl. | 25.90808 | 76.73865 | C8 | AR,RA |
| Chambal | Sabalgarh | 26.28722 | 77.29707 | C9 | AR,WC |
| Chambal | Dholpur | 26.65737 | 77.90439 | C10 | AR,SM,MB |
| Chambal | Bhind | 26.6982 | 78.9331 | C11 | B, NH, SW |
| Chambal | U/S Yamuna Confluence | 26.4849 | 79.24419 | C12 | AR, Settlements, Grazing |
| Damodar | Origin | 23.63677 | 84.67194 | D1 | WC,CB, B, IE, |
| Damodar | Rohini Project | 23.69062 | 85.02197 | D2 | WC, CB,SW,CR, IE |
| Damodar | Basaria | 23.64657 | 85.41619 | D3 | WC, CB, SW,DE, Water Pump |
| Damodar | Gadhaunia | 23.66435 | 85.75631 | D4 | FA, WC, CB, AR,SW |
| Damodar | D/S Tenughat Reservoir | 23.73617 | 85.84285 | D5 | WC. CB, B, NH, SW, SM |
| Damodar | D/S Kapat Ghat | 23.71186 | 86.36854 | D6 | WC, CB, SW; Water Pump |
| Damodar | D/S Panchet Reservoir | 23.67729 | 86.75753 | D7 | FA, WC, CB, AR, B, NH, SW, SM; Brick kiln |
| Damodar | Asansol | 23.62887 | 87.00028 | D8 | WC, CB, SM |
| Damodar | Durgapur | 23.47661 | 87.27953 | D9 | FA, WC, CB |
| Damodar | Bardhaman | 23.21048 | 87.84692 | D10 | WC, CB, SW, SM |
| Damodar | Keshabchak | 22.87759 | 87.95345 | D11 | FA, WC, CB, B, SW, SM |
| Damodar | Kulgachia | 22.468 | 87.99828 | D12 | CB, B, NH, CR, RA, Oil spill |
| Rupnarayan | Origin | 23.43198 | 86.5348 | R1 | FA, WC, CB, SW, Presence of Macrophyte |
| Rupnarayan | Dwarakeshwar Bridge | 23.21267 | 87.07784 | R2 | FA, WC, CB, B, CR, DM, SM, NH |
| Rupnarayan | Dom Doma-Ferry Ghat | 23.08876 | 87.34774 | R3 | FA, CB, B, CR, DM |
| Rupnarayan | Arambagh | 22.87709 | 87.78355 | R4 | FA, WC, CB, B, SW, DM, RA |
| Rupnarayan | Shilabati Confl. | 22.66949 | 87.77914 | R5 | FA, WC, CB |
| Rupnarayan | Kolaghat | 22.43702 | 87.8904 | R6 | FA, WC, CB, B, NH, SW, MB |
| Rupnarayan | Tamluk | 22.27979 | 87.95916 | R7 | FA, SW, MB |
| Ajay | Origin | 24.50613 | 86.32866 | A1 | FA, WC, CB, AR, SW, Macrophytes |
| Ajay | Deoghar | 24.45944 | 86.63743 | A2 | WC, CB, SM, Water pump |
| Ajay | Barmariya | 24.19935 | 86.7932 | A3 | WC, CB, AR, B, NH, SW, SM, Brick kiln |
| Ajay | Sidhu kanhu Bridge | 23.87008 | 86.93092 | A4 | WC, CB, AR, B, NH, SW |
| Ajay | Ilambazaar Bridge | 23.61384 | 87.53363 | A5 | FA, WC, CB, B, SW, CR, RA, SM |
| Ajay | Chorki Bridge | 23.64937 | 88.073881 | A6 | FA, WC, CB, B, NH |

*D/S: Downstream; U/S: Upstream; FA: Fishing Activities, CB- community bathing; CR- cremation and post cremation activity (e.g. disposing of ashes etc.); DM- domestic effluents (point and nonpoint); AR- agricultural runoff, RA,-recreational activities ; WC: Washing Clothes; B-Bridge; NH-National Highway; SW-Solid Waste; MB-Motor Boat; IE-Industrial Effluent

**Table 2:** List of Target EDCs included in the report

| Group | Category | Target EDCs |
|---|---|---|
| Alkyl Phenol | Plasticizer | Bisphenol A (BPA) |
| Phthalates (PAEs) | | Dimethyl phthalate (DMP) |
| | | Diethyl phthalate (DEP) |
| | | Di-n-butyl phthalate (DnBP) |
| | | Butyl benzyl phthalate (BBP) |
| | | Bis (2-ethylhexyl) phthalate (DEHP) |
| | | Di-n-octyl phthalate (DnOP) |
| Steroid | Natural Hormone | Estrone (E1) |
| | | 17-beta-estradiol (E2) |
| | | Estriol (E3) |
| | Pharmaceutical Synthetic Hormone | 17alpha-ethinylestradiol (Ee2) |
| | | Diethylstilbestrol (DES) |
| Household Personal Care Products (HPCPs) | Antimicrobials | Triclosan (TCS)<br>Triclocarban (TCC) |
| Pesticides | Organochlorine Pesticides (OCPs) | alpha-BHC/HCH |
| | | beta-BHC/HCH |
| | | gamma-BHC/HCH(Lindane) |
| | | delta-BHC/HCH |
| | | 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-benzene] (DDT-p,p') |
| | | 1,1-Dichloro-2,2-bis(p-chlorophenyl) ethylene (DDE-p,p') |
| | | 1,1-Dichloro-2,2-bis(pchlorophenyl) ethane (DDD-p,p') |
| | | Chlordecone |
| | | Methoxychlor |
| | | Aldrin |
| | | Dieldrin |
| | | Endrin |
| | | Endrin Ketone |
| | | Chlordane-trans |
| | | Chlordane-cis |
| | | Heptachlor |
| | | Heptachlor epoxide |
| | | Endosulfan I |
| | | Endosulfan II |

## NMCG

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## GACMC/CRR

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