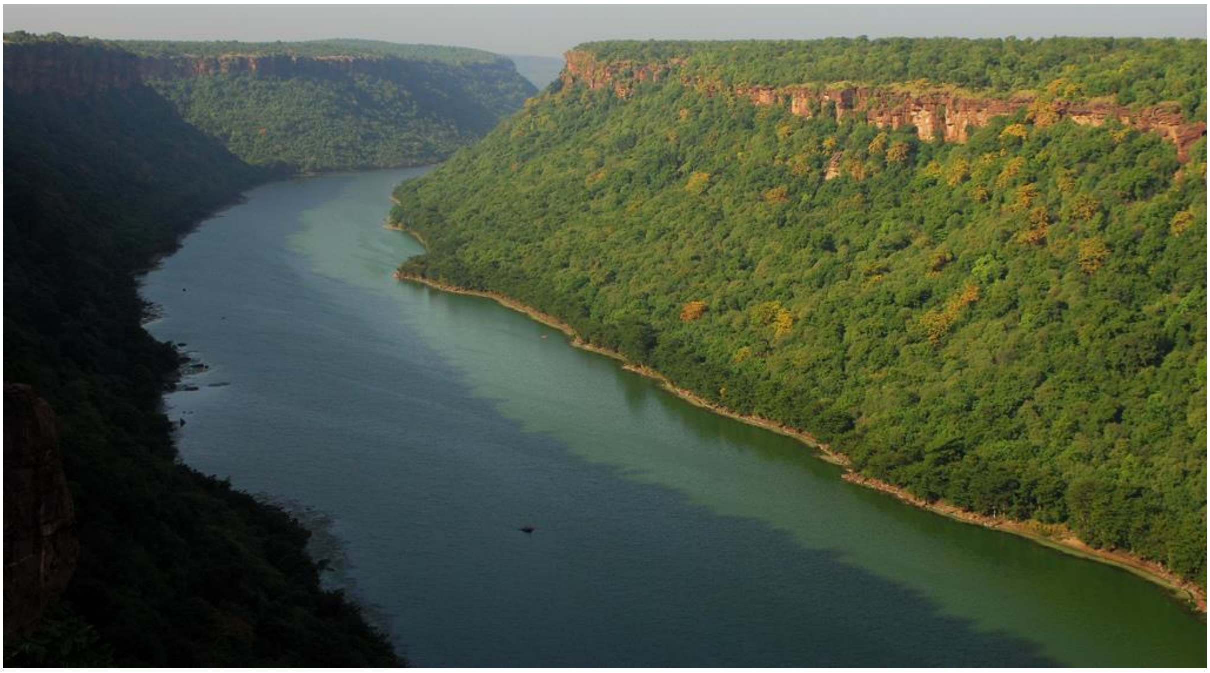
Final Report on Prevention and Control of Pollution in River Chambal and Banas: An Action Plan for River Rejuvenation

(Submitted in Compliance to Hon'ble National Green Tribunals (NGT) Order dated 20/09/2018)



Department of Civil Engineering

Malaviya National Institute of Technology JAIPUR

(Rajasthan)

December 2018

Report on

Prevention and Control of Pollution in River Chambal and Banas: An Action Plan for River Rejuvenation (Rajasthan State)

(Submitted in Compliance to Hon'ble National Green Tribunals (NGT) Order dated 20/09/2018)

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List of Abbreviations

BGL:	Below Ground Level
BOD:	Bio-chemical Oxygen Demand
CETP:	Common Effluent Treatment Plant
CGWB:	Central Ground Water Board
COD:	Chemical Oxygen Demand
CPCB:	Central Pollution Control Board
CWC:	Central Water Commission
DO:	Dissolved Oxygen
DWDSC:	Department of Watershed Development and Soil Conservation
ETP:	Effluent Treatment Plant
FC:	Faecal Coliform
GPI:	Grossly Polluting Industries
GWD:	Ground Water Department, Government of Rajasthan
HP:	Hand Pump
IWMP:	Integrated Watershed Management Programme
LSG:	Local Self Government, Government of Rajasthan
LULC:	Land Use Land Cover
MLD:	Millions of Litres per Day
MNIT:	Malaviya National Institute of Technology Jaipur
MPN:	Most Probable Number
NGT:	National Green Tribunal
NPS:	Non-Point Sources
PHED:	Public Health Engineering Department
RIICO:	Rajasthan State Industrial Development and Investment Corporation
RO:	Reverse Osmosis, Regional Officer (RSPCB)
RSPCB:	Rajasthan State Pollution Control Board
RUIDP:	Rajasthan Urban Infrastructure Development Project
SCADA:	Supervisory Control and Data Acquisition
SPV:	Special Purpose Vehicle
STP:	Sewage Treatment Plant
TC:	Total Coliform
TPD:	Tonnes Per Day
TSS:	Total Suspended Solids
TW:	Tube Well
UDH:	Urban Development and Housing
WRD:	Water Resources Department, Government of Rajasthan

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The authors wish to thank Rajasthan State Pollution Control Board for providing funds and necessary support for this study and Director (MNIT) for providing the facilities of the institute for the same.

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Chapter 1: Introduction

Hon'ble National Green Tribunal (NGT) in the matter of Original Application No. 673/2018 on 20.09.2018 has identified 351 stretches of various rivers in India, where water quality is not meeting the desired standard of BOD concentration of <= 3.0 mg/L. Two such stretches are identified in Rajasthan State. Which are

(a) Banas River (Priority level III with BOD between 10-20 mg/L)

(b) Chambal River (Priority level V with BOD between 3-6 mg/L)

All States and Union Territories are directed by NGT to prepare action plans within two months for bringing all the polluted river stretches to be fit at least for bathing purposes (i.e. BOD < 3 mg/L and FC < 500 MPN/100 ml) and implement those plans within six months from the date of finalisation of the action plans. In view of above, Hon'ble NGT has directed the Rajasthan state to prepare action plans to restore the polluted river stretches identified above, to the prescribed standards.

As per CPCB document, "The plan for restoration of polluted river stretches is proposed to be executed through two-fold concepts. One concept is to target enhancement of river flow through interventions on the water sheds/catchment areas for conservation and recharge of rain water for subsequent releases during lean flow period in a year. This concept will work on dilution of pollutants in the rivers and streams to reduce concentration to meet desired level of water quality. Other concept is of regulation and enforcement of standards in conjunction with the available flow in rivers /streams and allocation of discharges with stipulated norms".

Restoration of river health back to an accepted historical state of the river can be achieved by avoiding direct entry of domestic sewage and industrial effluents into the river. Regulatory progress in controlling point sources of chemical river pollution has progressively thrown the attention of public policy towards anthropogenic physical impacts, many of which are scaled to the catchment via the runoff/sediment system. At the same time, concern over diffuse chemical pollution has reinforced 'catchment consciousness': land-use and land-management planning and control must be considered to conserve or restore river ecosystem integrity (Malcolm Newson 2010). However, river rejuvenation should not be limited to improving water quality by reducing organic pollution, eutrophication or inflow of toxic substances. Another important aspect on which the ''Success'' of river rejuvenation depends is the flow of a river; the most significant variable of a river system. Besides performing various functions, environmental flow gives self-cleaning and healing powers to a river. Broadly environmental flow refers to the magnitude and quality of freshwater flow at different times in a season so that the dynamic equilibrium in the river basin is not drastically altered, and the river ecosystem is sustained. The river keeps performing functions like sediment transport groundwater recharge etc. and is able to retain cultural connection to its basin. Further, environmental flow ensures that water resources are used equitably and sustainably (WWF 2011). Sinha et al. (2013) also emphasize on estimation of river recovery potential and path along with threshold conditions for sustainable management of the river systems in the Ganga River basin. Hence, by adhering to the environmental flows we can sustainably exploit the river resource and enjoy the river ecosystem benefits.

1.1 Chambal River Basin

Chambal river basin is located in the south-eastern part of Rajasthan. It stretches between 23° 31' 03.91" to 26° 56' 03.72" North latitudes and between 74° 45' 15.00'' to 78° 13' 33.86'' East longitudes. It is bounded primarily by the Banas river basin in the west, partly by Mahi, Gambhir and Parbati river Basins. The total catchment area of the Chambal basin is approximately 31,239 km^2 within the state of Rajasthan (excluding Banas river basin which is tributary to Chambal River). River Chambal is a principal tributary of river Yamuna and originates in the Vindhyan ranges near Mhow in Indore District of Madhya Pradesh, entering through a deep gorge in Rajasthan at Chourasigarh, about 96 km upstream of Kota. The deep gorge extends up to Kota and the river then flows for about 226 km within Rajasthan in a north-easterly direction, and then forms the boundary between MP and Rajasthan for about 252 km. Based on locations of water quality monitoring stations on the river Chambal, part of Chambal river basin as shown in Fig. 1.1, has been initially considered in this study. Sub-basins upstream of Gandhi Sagar dam (Point A in Fig. 1.1), sub-basins of Kali Sindh (Point B) and Parbati (Point C) rivers are excluded as most of the area of these parts are falling outside the Rajasthan state.

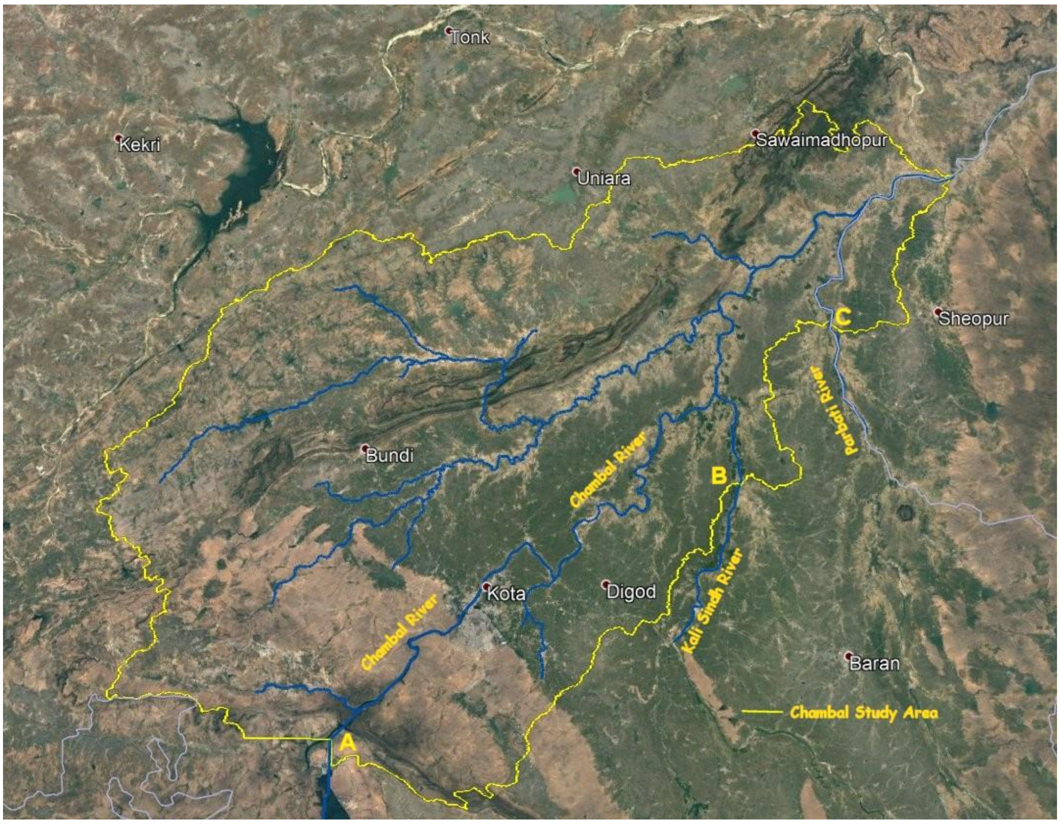


Figure 1.1. River Chambal sub-basin

Climate:

Chambal river basin falls within Semi-arid to Sub-humid climatic regions. It is very cold from November to February while turning hot from March to June when the maximum temperature rises up to 48^{o}C. Mean Annual Rainfall in Chambal Basin is 784.90 mm. Maximum temperature ranges from 44.67-47.10°C with a mean value of 45.88°C, while minimum temperature ranges from 2.93-7.60°C with a mean value of 5.11°C. Most of the rainfall is received during the Monsoon months between June/July to September. Months of September and October are very pleasant before onset of winters.

Topography:

High elevation areas surround the central low-lying parts of basin from east, south and western sides. The river flows in the north eastern direction and a narrow part extends through Karauli and Dhaulpur districts. The minimum elevation in the basin is 111 m amsl in Dhaulpur district where the river drains out of the basin and the maximum elevation is approximately 605 m amsl in Bhilwara district. Nearly half of the basin is hilly while rest is undulating plains. Fig. 1.2 shows the digital elevation model of the sub-basin.

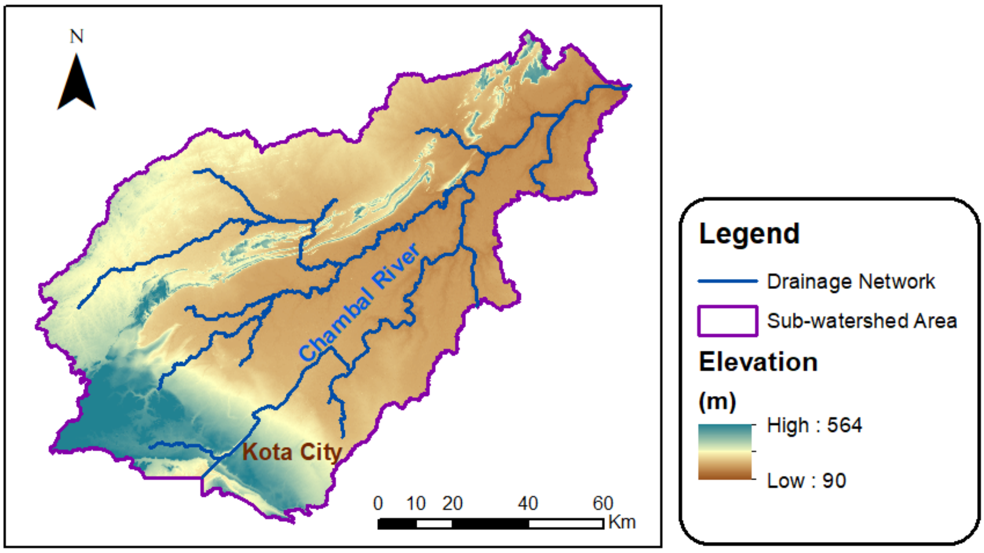


Figure 1.2. Digital elevation model of River Chambal sub-basin

Land use/Land Cover (LULC):

LULC maps of the Chambal sub-basin, discussed above were prepared based on supervised classification of LANDSAT data available online. Maps of year 2002 as well as 2018 have been prepared. Fig. 1.3 shows LULC maps of year 2002 and 2018. Table 1.1 shows the area falling under different categories

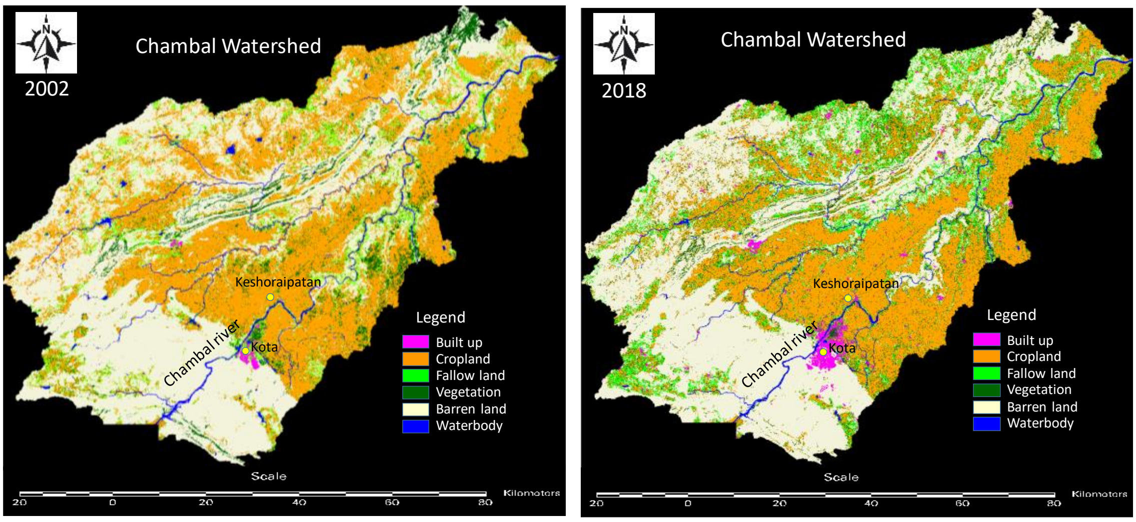


Figure 1.3. LULC maps of River Chambal sub-basin

Table 1.1: Area falling under different LULC categories

LULC Class	2002		2018	
	Area (Ha)	Area (%)	Area (Ha)	Area (%)
Cropland	402125.8	37.4	375751.4	35.0
Fallowland	82476.3	7.7	97682.7	9.1
Builtup	3159.6	0.3	14804.9	1.4
Barren	500318.1	46.6	486723.5	45.3
Vegetation	70708.8	6.6	91296.1	8.5
Waterbody	15544.7	1.4	8074.7	0.7

It can be seen that built-up area has increased from 0.3% to 1.4, whereas water bodies have decreased from 1.4% to 0.7%.

Hydrogeological formations:

The main hydrogeological formations in the basin are Older Alluvium, Bhander Sandstone, Deccan Traps, Limestone, Phyllite & Schist, Shale, Quartzite and Gneisses (B.G.C.).

Aquifers:

Vindhyans constitute principal aquifers in the basin (sandstones around 35%, followed by shales and limestones around 10% each) mostly in the central parts of the basin. Basaltic aquifers are also significant as they occupy around 22% of the basin area, dominantly present in the southern part of the basin. Alluvial aquifers are present in Kota, Baran and Bundi districts towards northern parts of the basin.

Groundwater status:

There is a decline in groundwater levels in the basin with an average rate of change of 0.13 m/yr for pre-monsoon season which can be considered significant. As per pre-monsoon 2010 data, the general groundwater levels in the basin are 2-20 m bgl. Shallow groundwater levels of less than 2-5 m bgl mostly occurs in Parwati, Mej and Chambal Upstream Sub-basins. Deeper groundwater levels of 20-60 m bgl occur in central part of Chambal Basin in the Kalisindh and Chambal Downstream Sub-basin.

As per pre-monsoon 2010 groundwater quality data, about 0.5%, 25%, 2% and 4% of the basin area has more than maximum permissible (as per BIS drinking water standards) chloride, fluoride, nitrate and electrical conductivity concentrations in groundwater, respectively.

The annual fresh dynamic groundwater resource in the basin for the year 2010 is 1,999.54 Mm^3 against which the groundwater draft is 2,236.13 Mm^3. Accordingly, the stage of groundwater development in the basin is 111.83% and the basin is categorised as groundwater over-exploited basin. The saline dynamic annual groundwater resources assessed for the basin in year 2010 is 26.33 Mm^3. The assessed fresh and saline static groundwater resource in the basin for year 2010 are 953.39 Mm^3 and 22.09 Mm^3, respectively.

1.2 Banas River Basin

Banas river basin is located in eastern part of Rajasthan and occupies significant area in the east of Aravali mountain range. It stretches between 24° 17' 14.22” to 27° 18' 15.24” North latitude and 73° 20' 54.84’’ to 77° 00' 36.49’’East longitudes. It is bounded in the east by Chambal river basin, in the north by Gambhir and Banganga river basins, in the west by Shekhawati and Luni river basins and in the south by Sabarmati and Mahi river basins. It is a tributary to Chambal River, which in turn flows into Yamuna River. Originating in the Khamnor Hills of the Aravali Range, about 5 km from Kumbhalgarh in Rajsamand District the Banas River flows for its entire length through Rajasthan only. It flows northeastwards through Mewar region of Rajasthan, meets the Chambal river near the village of Rameshwar in Khandar Block of Sawai Madhopur District. Based on locations of water quality monitoring stations on the river Banas, part of Banas river basin as shown in Fig. 1.4, has been initially considered in this study. Sub-basins upstream of Bisalpur dam (Point A in Fig. 1.4), sub-basins of Bandi (Point B) and Morel (Point C) rivers are not considered as contaminations are not reported in these stretches. Nevta Dam on Morel river, which has reported higher level of BOD has been separately taken.

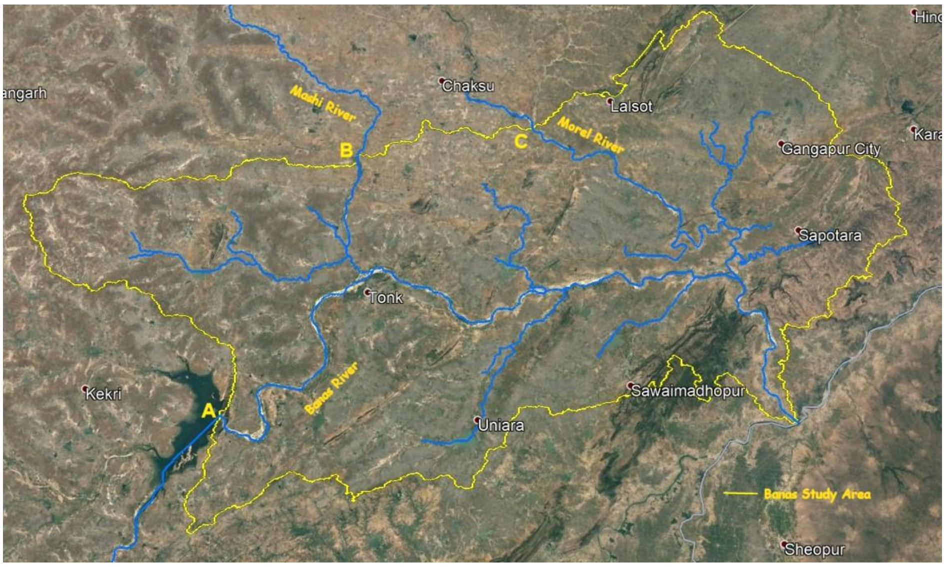


Figure 1.4. River Banas sub-basin

Climate:

Mean Annual Rainfall in Banas Basin is 588.80 mm. Maximum temperature ranges from 43.19-46.3°C with a mean value of 44.89°C, while minimum temperature ranges from 1.76-6.05°C with a mean value of 3.79°C. Winter sets in the month of October and lasts till February while warmer period turning hot extends from March to July. The basin receives good rainfall during the four Monsoon months (July-September). Large tracts of the basin are suitable for agriculture practices.

Topography:

The western part of the Basin is marked by hilly terrain belonging to the Aravali chain. East of the hills lies an alluvial plain with a gentle eastward slope. Ground elevations in the western hilly part range approximately from about 850 m above mean sea level (m amsl) to about 1,291 m amsl, while the alluvial plain elevations range approximately from 450 m amsl to 176 m amsl where river meets the river Chambal. Fig. 1.5 shows the digital elevation model of the sub-basin.

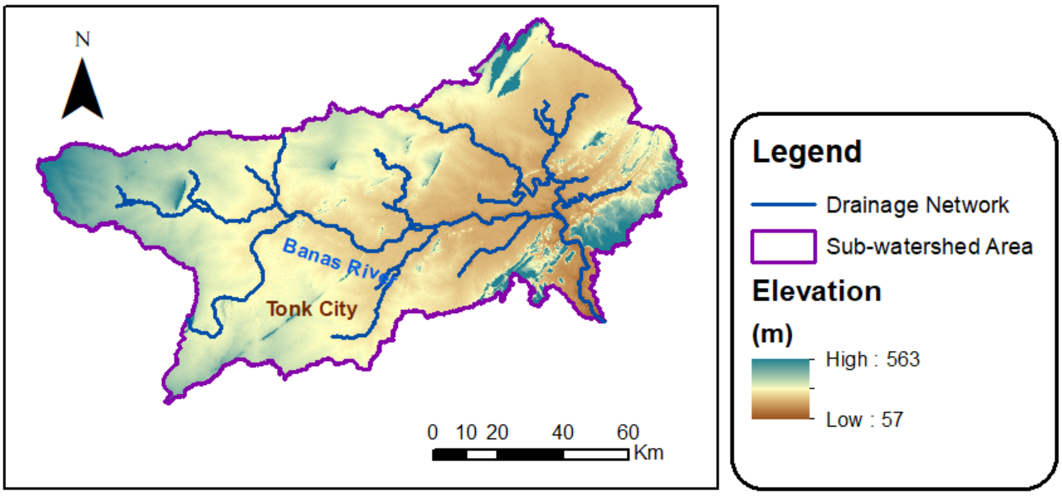


Figure 1.5. Digital elevation model of River Banas sub-basin

Hydrogeological formations:

The main hydrogeological formations in the basin are Gneisses (B.G.C.), Phyllite & Schist, Older Alluvium, Younger Alluvium, Shale, Quartzite, Bhander Sandstone and Limestone. Other hydrogeological formations like Deccan Traps, Gneisses and Erinpura Granite occupy relatively small area in the basin.

Aquifers:

Aquifers in Banas river basin are largely formed in hard rock areas wherein Gneisses and Schists together constitute more 64% of the total basin area. Alluvial aquifers also occupy significant areas amounting to approximately 20% of the basin occurring mainly in the northern part of the Jaipur, Dausa and Karauli districts.

Groundwater status:

There is a decline in groundwater levels in the basin with an average rate of change of 0.18 m/yr for pre-monsoon season which is significant. As per pre-monsoon 2010 data, the groundwater levels in the basin are in the range of 20-60 mbgl in parts of Morel and Mashi Sub-basin; 10-40 m bgl in Berach, Khari, Banas and Sodra Sub-basins. Depth to groundwater level of 5-10 m bgl occur in the central part of Banas Basin in Kothari, Khari and Banas Sub-basins. Deeper groundwater levels of 60-80 m bgl occurs only in Mashi and Morel Sub-basins.

As per pre-monsoon 2010 groundwater quality data, about 9%, 40%, 17% and 30% of the basin area has more than maximum permissible (as per BIS drinking water standards) chloride, fluoride, nitrate and electrical conductivity concentrations in groundwater, respectively. The annual fresh dynamic groundwater resource in the basin for the year 2010 is 2,282.73 Mm^3 against which the groundwater draft is 3,380.23 Mm^3. Accordingly, the stage of groundwater development in the basin is 148.08% and the basin is categorised as groundwater over-exploited basin. The saline dynamic annual groundwater resources assessed for the basin in year 2010 is 107.65 Mm^3. The assessed fresh and saline static groundwater resource in the basin for year 2010 are 1,808.90 Mm^3 and 90.42 Mm^3, respectively.

Chapter 2: Identification of river stretches considered in the study

According to CPCB standards, river water is considered to be fit for bathing when it meets the criteria of having Bio-chemical Oxygen Demand (BOD) less than 3.0 mg/L, Dissolved Oxygen more than 5.0 mg/L and Faecal Coliform bacteria to be less than 500 MPN/100 ml. According to latest assessment by the CPCB, there are 351 polluted river stretches in India i.e. where the BOD content is more than 3mg/L. CPCB has divided the polluted river stretches in five priority categories i.e., I, II, III, IV, V depending upon the level of BOD. In Rajasthan two stretches are identified by the CPCB as mentioned in Table 2.1 below and fall under the priority III and V.

Table 2.1: River stretches identified in Rajasthan State

State	River Name	River Stretch	BOD Range/Max Value (mg/L)	Priority
Rajasthan	Banas	Along Bisalpur Dam, Swaroopganj, Newta Dam	13.2	III
Rajasthan	Chambal	Sawaimadhopur to Kota	3.2-4.8	V

Following are the parameters considered by CPCB for the priority III and V.

III. Criteria for Priority III
(a) Monitoring locations having BOD between 10-20 mg/L.
(b) All monitoring locations exceeding BOD concentration 6 mg/L on all occasions.

V. Criteria for Priority V
(a) Monitoring locations having BOD between 3-6 mg/l.
(b) The locations exceeding desired water quality of 3mg/l BOD.

In Rajasthan there are two different stretches of river Banas. One, flowing through districts of Udaipur, Rajsamand, Chittorgarh, Bhilwara, Ajmer, Tonk, Jaipur, Dausa, Sawai Madhopur and Karauli before meeting Chambal river at Rameshwar Ghat. Bisalpur Dam and Nevta dam are specifically mentioned locations for this river. Second, known as West Banas, flows through districts of Pali, Sirohi (99.67% catchment area) and Udaipur (Tahal Report #4.2, Pg. xiii) and then flows towards the Gujarat state. Location Swaroopganj (Dhannari Dam) is also identified in CPCB report and falls on the west Banas river.

Monthly River water quality data of 9 stations from year 2104 to September 2018 were provided by RPCB as per the details given in Table 2.2 below. Sample data sheets provided are shown in Appendix 2.1. Data included parameters such as BOD (mg/L), COD (mg/L), Fecal Coliform, FC (MPN/100ml), Total Coliform, TC (MPN/100ml), Ammonia Nitrogen, NH4-N (mg/L), Chloride (mg/L), Nitrate as N, NO3-N (mg/L) besides many other routine parameters. Average values of BOD and FC have been summarized over year as well as over individual quarters for some stations and are shown in Appendix 2.2. Table 2.2 lists various stations for which data are available and the codes with which these will be referred in the report.

Temporal variation in BOD, DO and FC for Dhanari Dam, near Swaroopganj, Sirohi is plotted in Fig. 2.1 deriving information from the available individual data sheets. As can be seen, BOD remains below 3 mg/l and FC below 25 MPN/100ml. DO is mostly above 5 mg/l except at few occasions, where also it is still above 4.5 mg/l. So Swaroopganj area is meeting the required standards for clean river and has not been further considered in this report.

Table 2.2: Water Quality Monitoring Stations (Source: RSPCB)

S. No.	Station Code	Station Name	Referred as
1.	2955	River Chambal entering in Rajasthan at Gandhi Sagar Dam, Kota, Rajasthan	GSD
2.	1288	River Chambal at Akelgarh, Kota u/s Kota barrage at intake point of PHED, Rajasthan	AK
3.	1289	River Chambal at Rangpur, Kota d/s (2 Km. from city), Rajasthan	RP
4.	10029	River Chambal at Keshoraipatan u/s near Shri Raj Rajeshwar Mahadev temple, District Bundi, Rajasthan	RRM
5.	10030	River Chambal at Keshoraipatan d/s near Ambedkar Nagar, district Bundi, Rajasthan	AN
6.	1413	River Chambal at Rameshwar Ghat near Sawaimadhopur, Rajasthan	RG
7.	2951	Bisalpur Dam, Tonk, Rajasthan	BD
8.	2952	Newta Dam, Jaipur, Rajasthan	ND
9.	2950	Dhanari Dam, near Swaroopganj, Sirohi, Rajasthan	DD

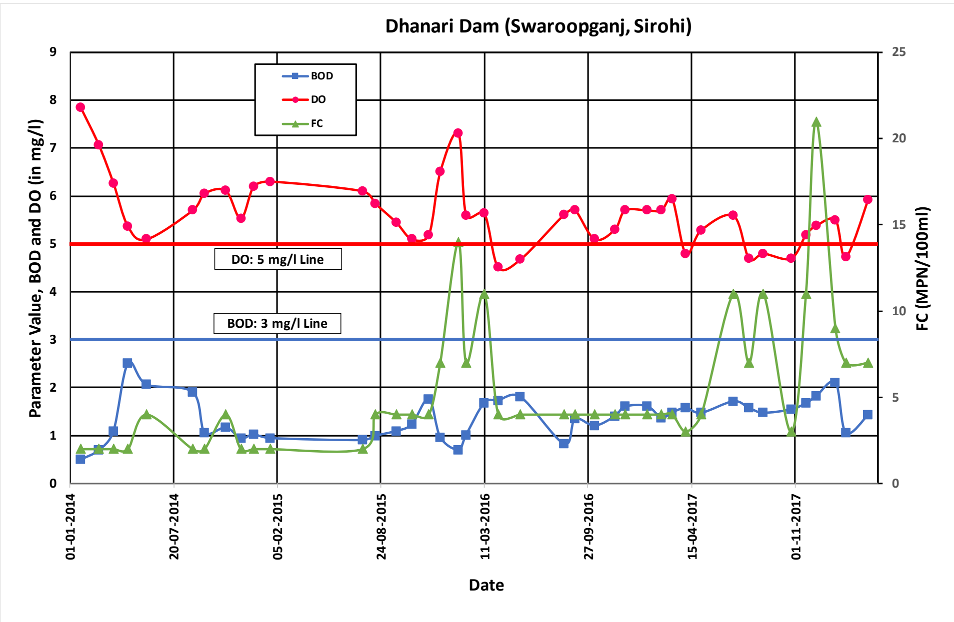


Fig. 2.1: River water quality at Dhanari Dam, Swaroopganj, Sirohi

Similarly, Fig. 2.2 shows the water quality variations from year 2014 to 2018 for the Bisalpur Dam, Banas River. It is seen that BOD remains below 3 mg/l except for one point in August 2018 when it has touched 3.2 and FC always remained below 12 MPN/100ml levels. DO mostly remains above 5 mg/l and only once fell below 4 mg/l. So Bisalpur Dam area is also meeting the standard and hence been excluded from the current study for further detailing.

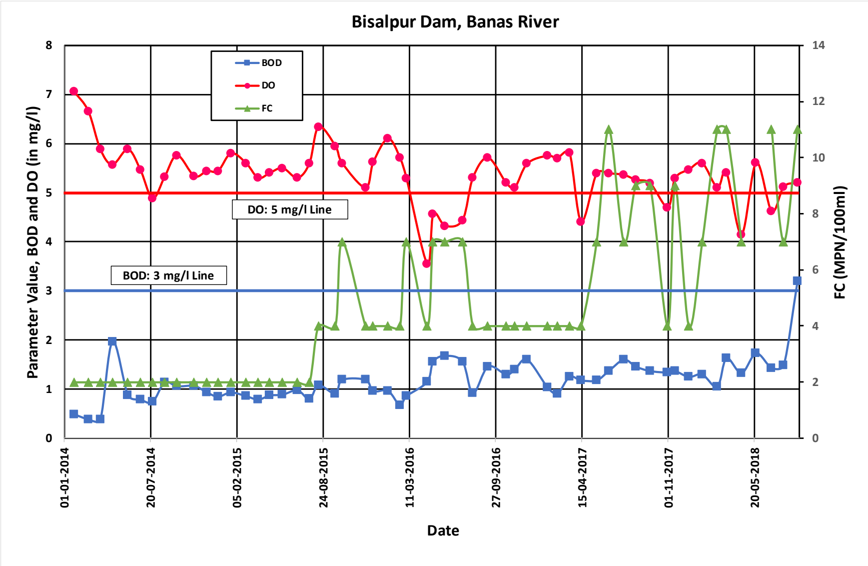


Fig. 2.2: River water quality at Bisalpur Dam, Banas River

Fig. 2.3 shows the water quality variations for the Rameshwar Ghat, where Banas river is meeting Chambal river. It is seen that BOD always remained below 3 mg/ and FC always remained below 40 MPN/100ml levels. DO mostly remains above 5 mg/l and only once fell below 4 mg/l. So Rameshwar Ghat area is also meeting the standard and hence been excluded from detailing in the present study.

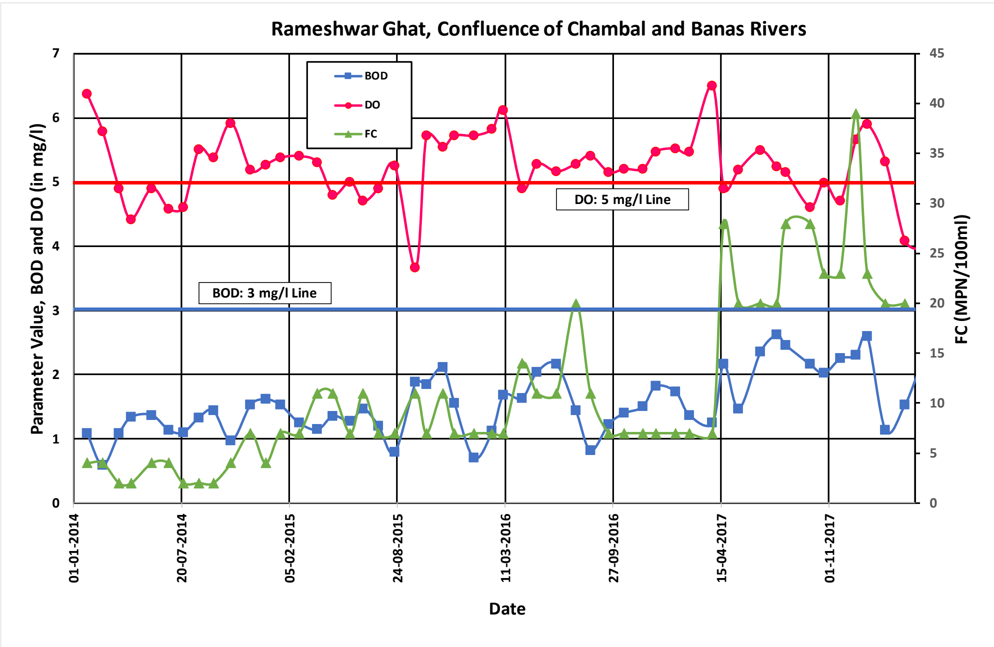


Fig. 2.3: River water quality at Rameshwar Ghat

Similarly, Fig. 2.4 indicates that river quality standards are also met at station Gandhi Sagar Dam station and hence excluded for further detailing in this report.

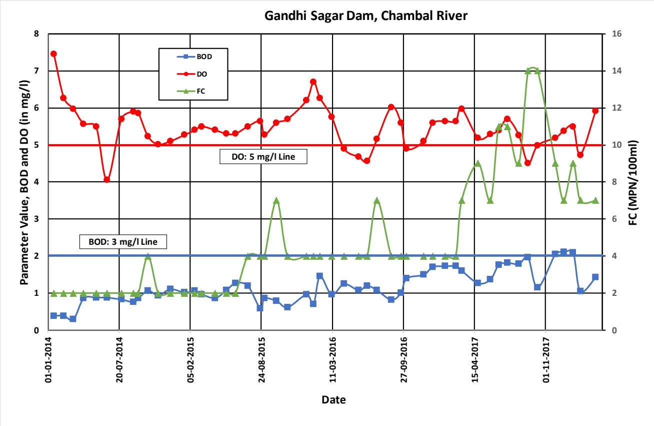
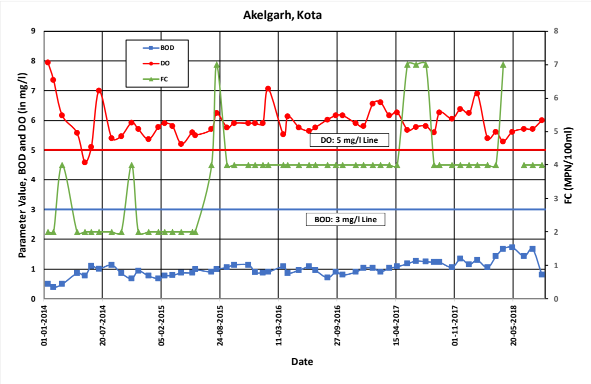


Fig. 2.4: River water quality at Gandhi Sagar Dam

Similar plots were also made for remaining stations. Fig. 2.5 below shows the water quality plots for Akelgarh and Rangpur stations Kota. Though BOD levels are breaching 3 mg/l level only at 3 occasions in the 5-year period, this stretch of Kota district as shown in Fig. 2.6, has been incorporated in detailed action plan.



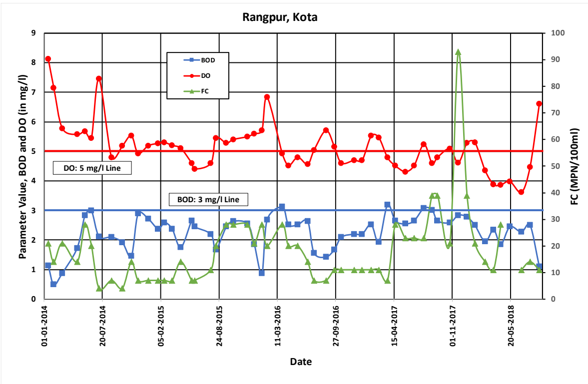


Fig. 2.5: River water quality at Akelgarh and Rangpur, Kota

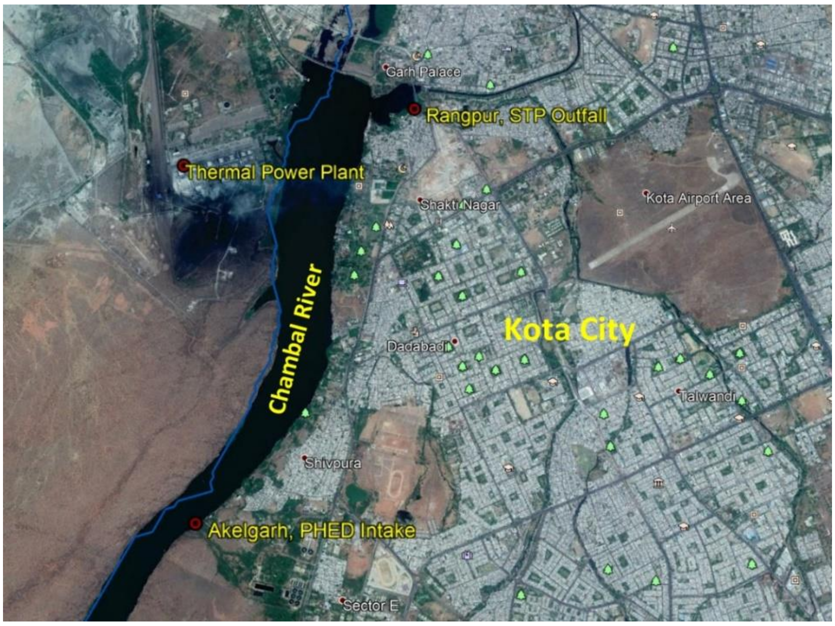


Fig. 2.6: Chambal river stretch, Kotaon Google Earth Image

Fig. 2.7 below shows the water quality plots for stations near Keshoraipatan city. It can be seen that BOD levels are typically more than 3 mg/l level at Ambedkar Nagar and therefore Keshoraipatan stretch as shown in Fig. 2.8 has been incorporated in the action plan.

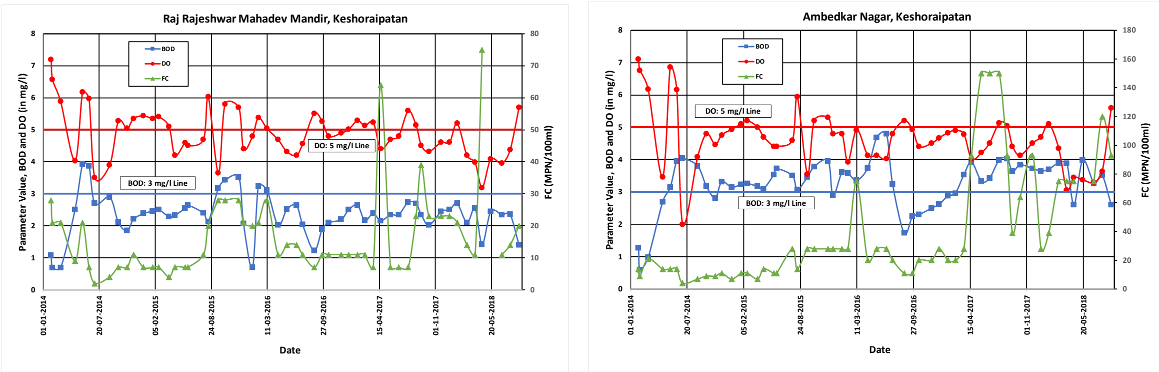


Fig. 2.7: River water quality at Raj Rajeswar Mahadev Mandir and Ambedkar Nagar, Keshoraipatan

Fig. 2.8: Chambal river stretch, Keshoraipatan on Google Earth Image

Fig. 2.9 shows the Nevta dam water quality from year 2014 to 2018. It can be seen that water quality is bad most of the time. BOD level reaches to the level of 15 mg/l and DO level remains below 4 mg/l. However, FC meets the standard and remains lower than 150 MPN/100 ml.

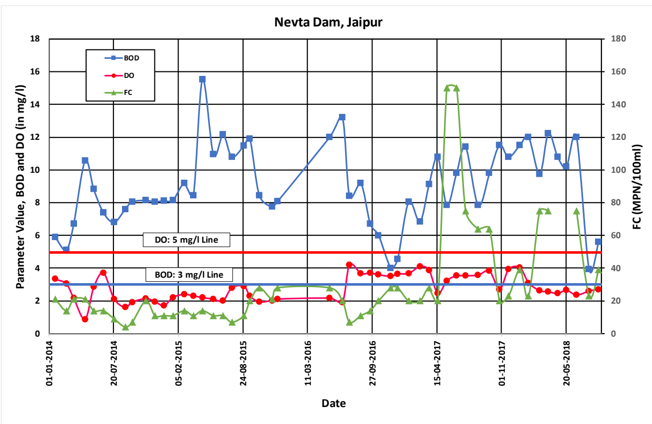


Fig. 2.9: River water quality at Nevta Dam, Jaipur

When information about Nevta dam was gathered from Water Resources Department and its catchment area was demarcated and plotted as shown in Fig. 2.10, it was found that the dam has a small catchment area of only 51 Km^2, mostly south-west of Jaipur city and that Nevta Dam has not overflown in last 30 years of its history. In fact, Nevta Dam is fed from Dravyavati River through a diversion channel (Shown as yellow line in Fig. 2.10) and is never allowed to fill beyond its capacity. Nevta dam therefore does not influence the Banas river water quality in any manner and is not responsible for the deterioration of water quality of the river. Nevertheless, since Dravyavati River project is presently taken up by Jaipur Development Authority and is in advance phase of implementation, information has been collected and an action plan has been suggested for Nevta Dam in this report.

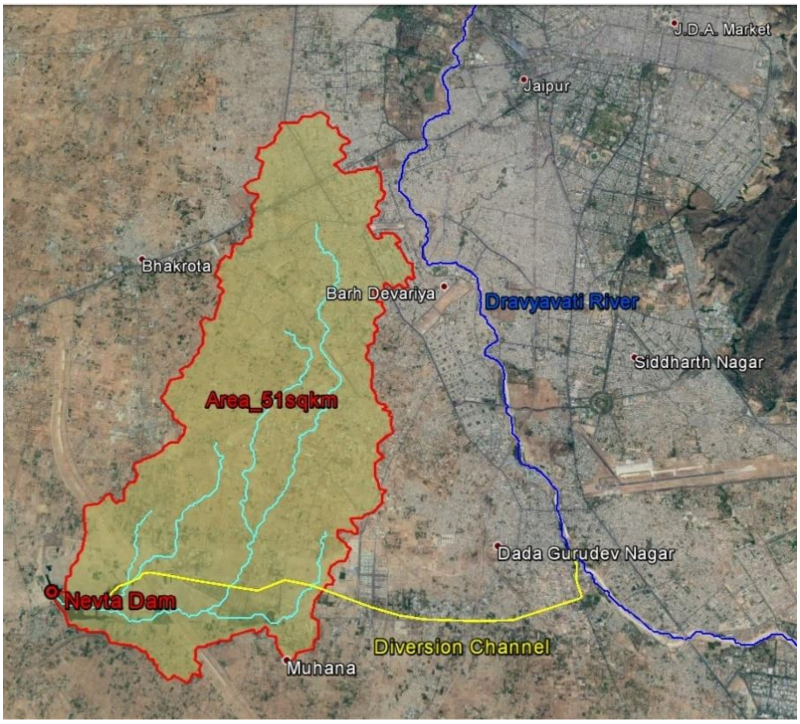


Fig. 2.10: Nevta Dam stretch on Google Earth Image

Therefore, three stretches, namely Kota, Keshoraipatan and Nevta dam have been retained for the preparation of detailed action plan.

Chapter 3: Action plan for Kota stretch of Chambal river

Kota stretch lies between upstream section at PHED drinking water intake at Akelgarh, Kota to a section defined at 2 kms downstream of Kota (Rangpur). Kota city is situated along the eastern bank of river Chambal in southern part of Rajasthan. Kota is known for stone mining, mineral-based industries, cement factories, fertiliser and chemical units, and plants that produce synthetic fibres, textile and rayon. The partially developed sewerage system in Kota city are affecting the water quality of Chambal River by the discharge of untreated sewage through the open drains.

Reported BOD levels are maximum of 1.73 mg/l between January 2014 to August 2018 at the u/s Akelgarh section. Maximum BOD levels reported between this period at the d/s section of Rangpur is 3.19, however it has crossed the level of 3 at 3-4 times. FC has been within the prescribed standard at both the stations. Kota is an industrial town, lately known as city for preparation of competitive examinations and therefore with big floating students population. Being close to perennial river, Chambal, Kota city has 24 hours water supply, as a consequence of which sewage is lot more diluted as compared to other cities of Rajasthan state. Though the dilution has indicated relatively tolerable pollution of Chambal river despite lot of untreated sewage reaching it, we have to be careful about certain observations that may have implications, if unattended. The Chambal water quality is indicating borderline parameters as the river offers a high dilution due to its enormous flow, its terrain is relatively steep and offers good re-aeration capacity resulting in its high assimilative capacity. As the population of the city would increase these parameters may increase significantly.

Industries: As per information from RSPCB, total 1213 industries are operational in Kota district at present. List of water intensive industries falling under category 17 (6 in number) and red category (GPI, 1 in number), as provided by RSPCB is shown in Appendix 3.1. These industries have online SCADA monitoring system for flow measurements and regular monitoring of water quality is carried out. Table 3.1 shows the water quality parameters at the ETP outlet of two industries, namely M/s DCM Shriram Ltd. and M/s Shri Ram Rayons and their compliance to the standard.

Pointwise information about waste water generation and management of Kota city as provided by Local Self Government (LSG)/RUIDP Kota is given below.

- Sewage generation as on 2016 was 159.42 MLD
- Sewage Treatment facility available at present is 50 MLD
- Partial Completed Sewage Treatment facility is 6 MLD (to be completed in 2017 – 2023)
- Sewage Treatment Facility under process- 55 MLD (by 2023)
- Population Coverage under existing/ongoing/sanctioned projects (50+6+55, total 111 MLD) is 64.51%.
- Balance: 35.49% will not have sewage treatment facility. The execution of sewerage system in the balance area of town will be taken up as per availability of funds in a phased manner. For remaining 35.49% population in Kota the co treatment of faecal sludge is proposed in existing STPs.
- Reuse of treated waste water = 30MLD (by 2018)
- There are 33 drains discharging about total 342.139 MLD in river Chambal. Out of 342 MLD, 232 MLD untreated sewage is falling in Chambal.

Table 3.1: Compliance of major industry discharging treated effluent in Chambal river

Name of Industry	M/s DCM Shriram Ltd		M/s Shri Ram Rayons	
Point of Collection	Outlet of ETP	Outlet of ETP	Outlet of ETP	Outlet of ETP
Date of Sampling	22-11-2017	12-09-2018		15.10.2018
pH	7.7	7.58	7.38	7.86
TSS	68	48	42	28
COD	65.04		110.57	80.3
BOD	18.24		19.2	12
Oil & Grease	3.2	6.4	6.4	3.2
RCl2	Nil			
Ammonical N	2.88	13.5		
Nitrate as N	1.5	2.56		
TKN	4.2	27.44		
Phosphate	1.1			
Sulphide	Nil		1.25	0.71
Fluoride	1.15			
Free Ammonia	0.09	0.027		

(Source: RSPCB)

Analysis of flow of major of these 33 drains is shown below in Table 3.2. It can be seen that first four drains cover 69.5% discharge and first 7 covers 80.5% discharge. Analysis reports of water samples drawn from 33 drains of Kota discharging into Chambal river were provided by the RPCB (Appendix 3.2), which pertain to one-time sampling on September 21, 2017 and analysis of certain parameters. The major observations derived from these results are as follows:

- Three major drains contributing about 63% of the total flow indicate a BOD range of 8-11 mg/L and of relatively low concern from the point of view of quality.
- The next four drains covering an additional flow of about 17% indicate a relatively higher BOD of 14-32 mg/L. This may indicate dilute sewage/sullage reaching these drains as this was post monsoon period hence relatively free from any storm water ingress.
- Among the other 26 drains, some had a high BOD of 30-52 mg/L. Though these constitute very little volumetrically, further investigations are needed to establish the reasons (open defecation, leaching from solid waste dump site, contributions from some small scale industrial/commercial clusters) and an action for its scientific management can help reduce this pollution reaching the river.

Information about municipal solid waste management system was obtained from LSG and is mentioned below. Information on Swachh Bharat Scheme under the Ministry of Housing and Urban Affairs is shown in Appendix 3.3. Fig. 3.1 shows the location of the landfill site.

- Quantity of waste generated = 400 TPD
- Area of city from which municipal waste is collected = 527 km^2
- Current City Population = 1301219
- Distance from Chambal river = 3.5 km
- Waste to energy plant of capacity 400 TPD is proposed. Tender is under process.

Table 3.2: Analysis of major drains of Kota city (Source: RUIDP, Kota)

Total flow for Kota, MLD			342.1	
S. No.	Location of Nalla	Daily Average Flow, MLD	% of Total Flow	Cumulative % Flow
1	Saji Dehra Nalla	100.6	29.4%	29.4%
2	Fatehgari	66.8	19.5%	48.9%
3	Shivpura Hazari basti	48.8	14.3%	63.2%
4	Near Kishorpura	21.4	6.3%	69.5%
5	Godavary Dham	13.0	3.8%	73.3%
6	Shamshan Road	12.7	3.7%	77.0%
7	Chasme ki Barvi	12.0	3.5%	80.5%

Fig. 3.1: Landfill site location, Kota city

As per information provided by RSPCB, one common Biomedical waste treatment & Disposal facility (CBWTDF) for both Kota & Bundi was located at Rawatbhata road, Kota – M/s Rajdeep Biotech. However, this facility has been closed by CPCB for non-compliances and violations. For Kota and Bundi Biomedical waste treatment facility directions have been issued and tender are invited by Kota Municipal Corporation. As per RSPCB, A temporary facility to handle biomedical and hazardous waste is under process and would be operational by end of January 2019.

Information about progress of drip and sprinkler irrigation systems was obtained from agriculture department and is mentioned in Table 3.3 for Kota region, which indicates that there is a consistent increase in the coverage of both interventions. This will not only conserve water for irrigation practices but will also result in lesser run offs being generated from agricultural fields eventually reducing river pollution.

Similarly, fertilizer and pesticide consumption data of Kota area was obtained from agriculture department and shown in Table 3.4 below. It is clear from the table that fertilizer consumption in 2018 has reduced considerably as compared to 2016. The reduction in fertilizer consumption can eventually reduce NH_4, NO_3 and PO_4-P in agricultural run-off, which ultimately goes in Chambal river in Kota. However, information on integrated fertilizer and pesticide management, any analysis and identification of targets to be achieved in future is not available.

Table 3.3: Year-wise progress on various irrigation systems under micro-irrigation scheme. (Source: Agriculture Department)

Year	Kota, Area in Hectare		
	Drip Irrigation	Sprinkler Irrigation	Total
2015-16	43.89	354	397.89
2016-17	77.09	474	551.09
2017-18	40.05	982.5	1022.55
Till Nov. 2018	10.5	138.5	149
Total	171.53	1949	2120.53

Table 3.4: Fertilizer and Pesticide consumption data of Kota

Fertilizer Consumption (Tonnes) Kota					
Year	Urea	DAP	SSP	Others	Total
2015-16	85595	69272	19089	4046	178002
2016-17	81821	41615	18443	2506	144385
2017-18	80574	37487	15052	3400	136513

Year wise consumption of Pesticides in Technical Grade Material (In MT)	
Year	Total
2015-16	270
2016-17	270
2017-18	215
2018-19 (Proposed)	150
Total	**905**

(Source: Agriculture Department)

Groundwater data has been collected from State Ground Water and Central Ground Water Departments. Appendix 3.4 shows some of the groundwater quality maps of the Kota area, which are prepared based on water quality data of observation wells provided by CGWB and GWD, Government of Rajasthan. It can be seen that most of the parameter are falling within permissible range. Iron is exceeding the limit of 1 mg/l towards the southern part of the Kota city, however this is unlikely to affect the Chambal river water quality in Kota stretch. Fig. 3.2 shows the various village level zones falling under different level of groundwater exploitation zones. It is clear that groundwater resources around Chambal stretch are over-exploited due to rapid urbanization and industrialization. The depth of water table in Kota district is around 260 to 440m (below ground level, bgl). The primary reason is the hilly terrain with limited seepage for ensuring groundwater recharge. An analysis should be made to assess the usage of this groundwater for various purposes and bring out some remedial measures.

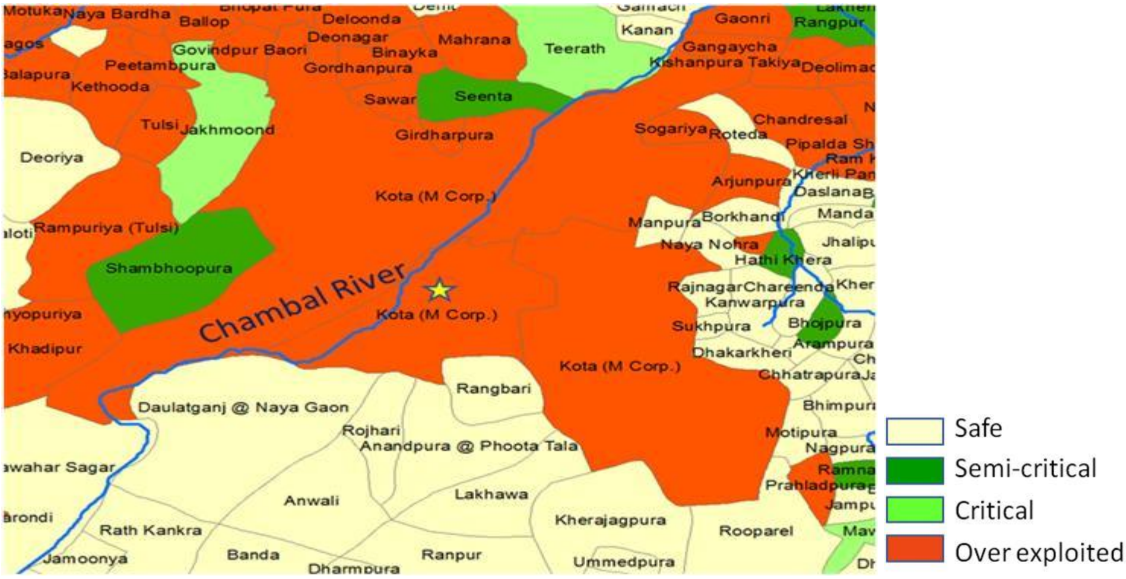


Fig. 3.2: Groundwater exploitation zones of Kota area

Information about water harvesting structures created under Integrated Watershed Management Programme (IWMP) was made from Department of Watershed Development and Soil Conservation (DWDSC). They have indicated that around 657 water harvesting structures are built in Kota district with an expenditure of 6.12 crore Rs. It is well known fact that without proper annual maintenance before onset of monsoon each year, these structures would lose their purpose and would become defunct. Further proper monitoring must be carried out to determine effect of these structures on groundwater regime.

While discussing with the officials of PHED, Rajasthan and GWD, Jaipur, they have told that only surface water is used for drinking purpose in area around Kota city and therefore tube wells/hand pumps (TW/HP) are not used.

Information on e-flow was collected from RSPCB. It is found that 5000 cusec of water is released for 35 minutes from Kota Barrage each Monday during non-monsoon period only. Water quality is checked at two stations before and after release and is shown in Appendix 3.5. It is seen that BOD level above 3 are persisting even after the release of e-flow. Also, TC levels are high during certain period as compared to other.

Primary survey was also carried out and number of samples were collected from river, drains, hand pumps etc. Fig. 3.3 shows the location of these samples. Table 3.5 gives the water quality of these samples collected during the field visit.

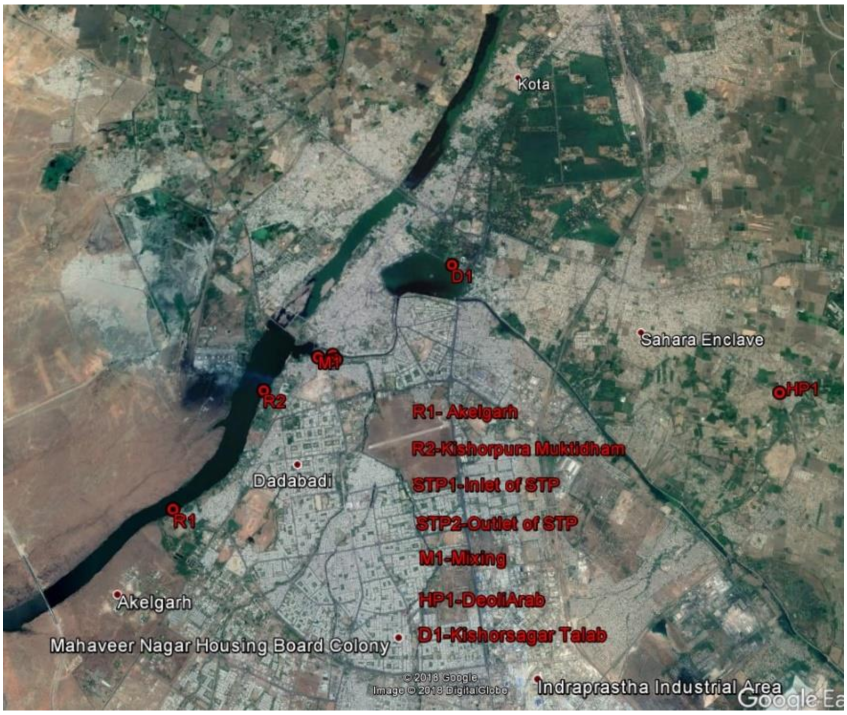


Fig. 3.3: Field survey locations, Kota

Table 3.5: Water quality parameters of primary samples

Name	R1	R2	D1	STP1-Inlet	STP2-Outlet	M1	HP1	TW1
Ammonium Nitrate	0.315	0.272	0.358	25.3	13.2	24.3	0.428	0.837
Ca+	13.7	12	10.7	12.8	14	11.8	47.3	33.6
NO3	1.68	1.31	0.929	1.34	1.11	1.58	3.72	1.73
Na	19.8	19.9	19.6	19.6	29.5	31.3	139	60.5
F	0.28	0.206	0.221	0.268	0.227	0.261	0.745	0.322
pH	8.22	8.16	8.25	8.16	8.26	8.21	7.82	7.83
TDS	190	180	180	380	360	390	710	480
Coliform	17800	3600	3250	$1.17x10^{7}$	310	$1.2x10^{7}$	Nil	Nil
Turbidity	1.67	0.92	1.83	19.92	20.87	18.43	2.59	8.96
Cl	38	42	38	76	74	74	94	118
BOD	10.2	12.1	8.3	22.8	18.6	28.6	Nil	Nil
COD	144	174	90	102	85	120	Nil	Nil
Hardness	92	92	96	110	92	96	286	188
K+	5.5	5.2	5.1	17.3	16.5	18	42.1	15.8
Sulphate	19.325	20.475	19.955	36.358	29.309	31.451	81.004	37.81

Here R1-Akhelgarh_Kota; R2-Kishorpura Mutidham_Opp. to KTPP_Kota; D1-KishoreSagar Talab_Kota; STP1-Inlet of STP_Kota; STP2-Outlet of STP_Kota; M1-Sajedheda Nala_Mixing_Kota; HP1-Deoliarab-Kota; TW1-Tube well @ Sajidheda STP, Kota.

Some of the photographs of STP inlet/outlet, taken during the field visit are shown in Appendix 3.6.

An important observation is that the BOD of "sewage" reaching the STP is very low, ranging between 13 to 57 mg/L in the secondary data provided to us by the RPCB (Table 3.6) and 18.6 mg/L as per our own sample drawn. These cannot pertain to raw sewage as these are very low and cannot be fully explained with ample availability of water supply in the region. It indicates dilution from some other sources. The possible explanation as per the discussions made with some local engineers is that a lot of seepage from canals is perhaps reaching these open drains carrying sewage and also from some water pipelines through leakages as the city has highly extended supply hours. If the sewage is brought to the STP through close conduits (if feasible), the problem can be solved. Detailed investigations will be needed to establish this fact. Low inlet BOD would prevent proper functioning of the existing and planned STPs of Kota city as microbiological growth will be adversely affected in the absence of adequate substrate.

Table 3.6: Sewage Treatment Plant, Sajidehra (30 MLD) - Inlet sample

Collection Date	Bio-Chemical Oxygen Demand (BOD) (3days at 27° C) [mg/l]	Chemical Oxygen Demand (COD) [mg/l]	Oil & Grease [mg/l]	pH	Phosphate as PO_4 [mg/l]	Total Suspended Solids [mg/l]
30/08/2017	57	112	5.8	7.75	[N/A]	52
21/02/2018	20	158.3	6	6.84	1.8	140
23/04/2018	22	107.7	3.8	7.76	1.6	23
18/05/2018	21	142	5.6	7.81	2.8	105
27/06/2018	47	427	14.6	6.83	2.9	988
26/07/2018	20	160	6.2	7.36	1.8	84
16/08/2018	13	105	4.2	7.44	1.6	94
28/09/2018	13.2	112	3.8	7.64	1.9	36

(Source: RPCB)

In order to understand the reasons for contamination of this river stretch, water quality parameters of stations falling in this stretch are plotted below. Fig. 3.4 shows the BOD, COD, Ammonia (NH4-N), Chloride and COD/BOD ratio for the u/s Akelgrah and d/s Rangpur stations. Chloride having much higher value than other parameters is plotted on right axis and remaining parameters on left axis. Chloride levels are very less (Maximum 65mg/l) at Akelgarh as compared for Rangpur (Maximum 260 mg/l), indicating that lot of human sewage is reaching Chambal river between the two sections. They have shown an increasing trend at both the sections since year 2016, indicating that more and more human sewage is reaching this river stretch. Also, in general it can be seen that the water quality is deteriorating at the onset of monsoon. This may be attributed to first flush as explained below. High COD/BOD ratio indicates predominance of dispersed sources from agriculture activities and solid waste/sullage disposal. This needs to be corroborated with the collection and analysis of water quality at the onset of the monsoon for at least 2-3 years for the first few flushed reaching Chambal river. However, COD/BOD levels are low at Rangpur station since the year 2016, confirming further that more human sewage is reaching between the two sections than what was coming previously.

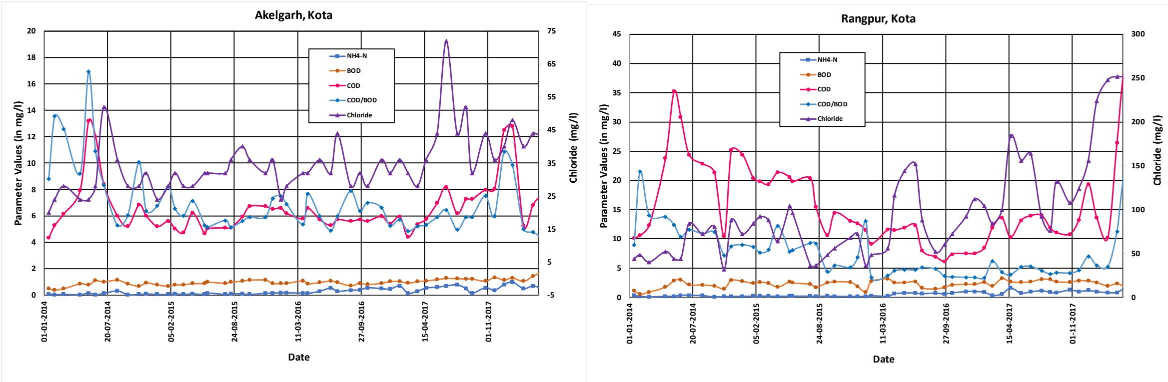


Fig. 3.4: River water quality at Kota stations

Similar water quality graphs of Ammonia (NH_4-N), Phosphate as PO_4 and Nitrate as N (NO_3-N) are plotted in Fig. 3.5 that indicate the dominant contribution is coming from the same source, namely, dispersed agriculture run off. Further both NH_4-N and NO_3-N are showing increasing trends at both the sections, indicating increasing agriculture non-point pollution reaching Chambal river, besides human sewage. This may be further confirmed by analyzing some samples for pesticides. The increasing levels of these parameters indicate that integrated fertilizer and pesticide management is required to ensure that level of these water quality parameters are checked in future.

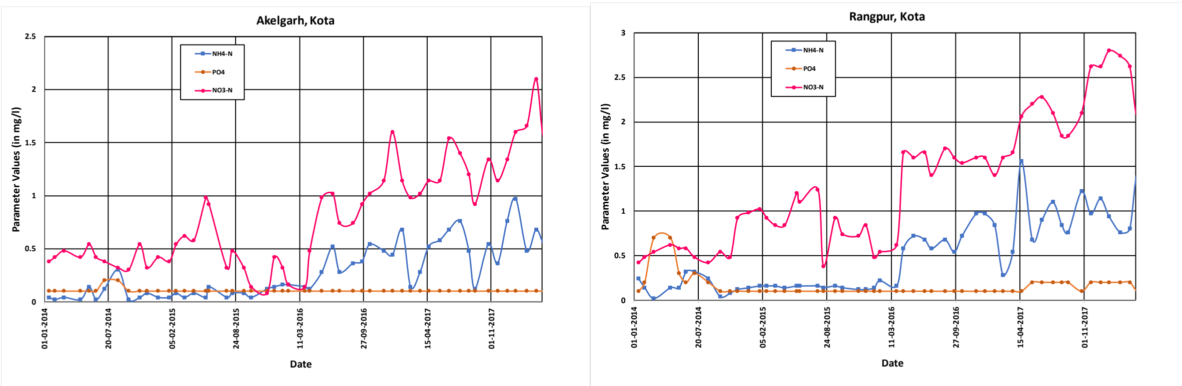


Fig. 3.5: NH_4-N, PO_4 and NO_3-N parameters at Kota stations

Water quality graphs depicting Faecal Coliforms (FC), Total Coliforms (TC) and Chlorides are plotted in Fig. 3.6 for these stations. Chloride is plotted on right axis. Very low values of TC (Maximum 20 MPN/100 ml) are reported for Akelgarh station whereas the same is maximum 2400 MPN/100 ml for the Rangpur station. This value needs to be further checked as 2400 MPN/100 mL may be the maximum that can be recorded in the method. Suitable dilution should be made to bring out correct MPN values for this station as the contamination level is relatively high at this location. Values of TC and FC indicate that river has sufficient assimilative capacity, which may be primarily attributed to a high dilution ratio being available besides a relatively steep rocky strata contributing to reaeration. High values of TC till 2016 at Rangpur station, indicate dominance of dispersed pollutants rather than domestic sewage and after 2016, human sewage interference has started increasing the FC.

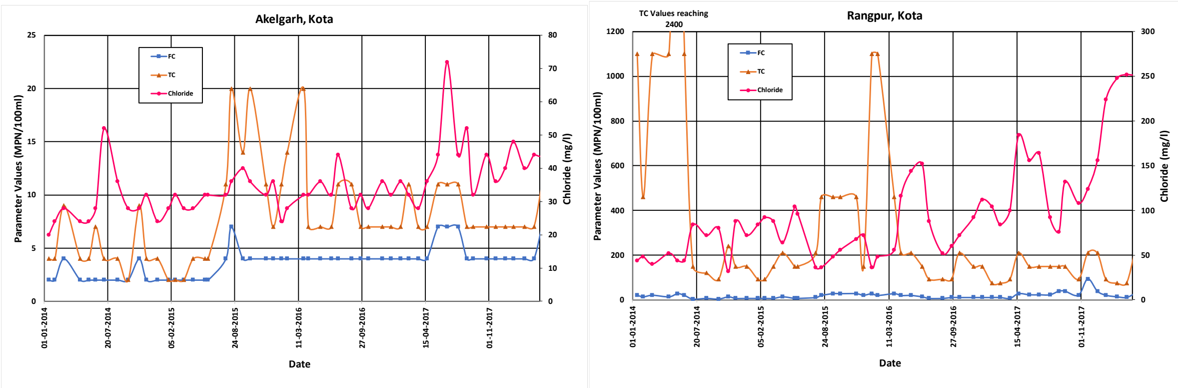


Fig. 3.6: FC, TC and Chloride parameters at Kota stations

When any river water quality station is installed, care is taken to facilitate a representative sample of the river, which is free from some immediate local sources. Sometimes, samples drawn from other locations may have a bias for the local contributions. Thus, a primary survey of the area was also conducted which indicates that COD/BOD ratios are similar to those found in historical data, but values are on higher side.

3.1 Action Plan

Therefore, considering the observed data, following action plan is proposed for the Kota area

1. First Flush

Pollutants deposited on to exposed areas can be dislodged and entrained by the rainfall-runoff process. Usually the storm water that initially runs off an area will be more polluted than the storm water that runs off later, after the rainfall has 'cleansed' the catchment. The storm water containing this high initial pollutant load is called the 'first flush'. In a study, it was found that first flush carrying storm water to Jal Mahal, Jaipur had BOD levels of about 1000 mg/L (Gupta et al., 2010), which dropped to the levels of 50 by the third flush. In Indian context, first flush contains lot of organic matter also as open defecation of both humans and cattle is common and all the deposited solids are flushed in the first couple of rains adding significantly to the pollution of the receiving water body. Thus, the strategy to combat the same has to be derived accordingly as detailed below.

The following actions are suggested to control first flush

- Characterisation of first four storm water flows by taking samples from main drains just after first four major rainfall events.
- Wherever there is high fraction of organic pollutants and/or industrial hazardous waste, attempt should be made to divert the first flush through drainage works to capture the most polluted portion of the site's storm water runoff.
- Appropriate waste disposal techniques like installation of a detention basin, if needed, with provision for aeration must be made before permitting it to discharge in the water body as has been done in the case of Mansagar lake of Jaipur (Gupta et al., 1999)
- Clearing the blocked sewer or storm water drains before onset of monsoon. Based on their inorganic/organic content, these fractions may be utilized for various engineering applications. Some references (Gupta 2017; Choudhary 2017) have been compiled for such studies in India and abroad. Cleaning before the onset of monsoons should essentially be in

the agenda of the local bodies taking care of solid waste pollution. A Delhi Jal Nigam related study has been carried out at MNIT Jaipur (Gupta, 2017).

- Re-use or disposal of first flush water quickly and properly. Alkaline first flush water has been successfully re-used at concrete batching plants for many years. Recently, collected storm water has been employed at a hot-mix bitumen emulsion plant and intensive horticultural premises. Agricultural sites, parks/garden have the potential to re-use nutrient-rich storm water for irrigation.

2. Biomedical and hazardous waste collection

- Since existing facilities for biomedical wastes and hazardous waste collection and disposal has been closed in Kota and Bundi area, replacement for this service must be identified in time bound manner and made operational.
- For Kota and Bundi Biomedical waste treatment facility directions have been issued and tender are invited by Kota Municipal Corporation. However, biomedical plant establishment will be completed after award of work. Services should be made operational within 12 months after award of work and environmental clearance. As per RSPCB, A temporary facility to handle biomedical and hazardous waste is under process and would be operational by end of January 2019.

3. Non-point Source (NPS) control

The NPS pollutants are contaminants of surface and subsurface soil and water resources (e.g., sediment, fertilizers, pesticides, salts, and trace elements) that are diffuse in nature and cannot be traced to a point location. Often times, NPS pollutants are the direct consequence of human activities (e.g., agriculture, urban runoff, hydro modification, and resource extraction).

The following actions are needed to control NPS in the present context

- Reduce run-off from agricultural fields by adopting water conserving farming systems such as on farm water management/sprinkler and drip irrigation practices. This will not only improve water use efficiency in this water scarce area but also will prevent the flow of nutrients in to the river and affecting its ecological condition. As per data provided by the agriculture department, this has been initiated in this area. Government of Rajasthan has also taken an initiative to provide 20% additional subsidy for drip irrigation system. However, Agriculture department should collect information on irrigation water used/hectare for different seasons for different crops for different areas and evaluate whether the use of irrigation water/hectare has decreased or not. Information must be analysed spatially and temporally to optimize any planning in future. Proper assessment of potential of achieving such practices must be made and based on the same, targets must be drawn for the next few years.
- Best management practices for fertilizer should be used to reduce nutrient run-off from fields. Data provided by agriculture department does indicates reduction in use of fertilizers from 2015-16 (1,78,002 tonnes) to 2017-18 (1,36,513 tonnes).
- Monitor the presence of pesticides in the groundwater in areas of intensive agriculture activity, especially in locations having high nitrate or NH_3-N levels representing intensive irrigation with the use of chemicals. One single report of 2014 of organo-chlorine group of pesticides was provided by the RPCB (Appendix 3.6). This shows that across the stretch of Chambal river tested, the presence of all pesticides except for DDT was "not traceable". The

concentration of DDT at stations P-91 to P-94 along the Chambal river was relatively higher than that observed at other sources, but it varied from 90-283 ng/L, which is much lesser than the drinking water standards of 1000 ng/L prescribed by BIS 10500-2012. This observation again confirms that the dilutions available in the river have prevented any alarming pollution levels in it till date, but as the DDT is banned for a long time, its presence in river water calls for stricter controls over the use of this pesticide in agriculture/domestic sector. This further calls for a regular monitoring of pesticides, including analysis of other groups also in addition to organo-chlorines for assuring a long-term safety against pollution.

- Promotion of Organic Farming as Rajasthan is endowed with 16 % cattle population of India and has a potential to achieve 100% organic farming.
- Farmer education would be key factor in achieving ambitious targets. Mass awareness programmes through media must be provided in vernacular languages to the farmers by the Rajasthan State Irrigation and Agriculture Departments. Therefore, adequate funds must be allocated for such programs.

4. Point Source control

(a) Industrial Pollution Control

Point source control includes industrial pollution control and treatment and disposal of domestic sewage as detailed below. Industries details are given in Appendix 3.1. It has been found that SCADA system is used to monitor discharge in category 17 and red category (GPI). It is recommended that the SCADA system also should include general water quality parameters like pH and TDS to ensure prevention of any serious violation. Further, there should be a continuous analysis made of the data received through SCADA with punitive provisions for violations established.

(i) *Marker pollutants identification*- It is important that drains passing through industrial area are identified and tested occasionally for marker pollutants based on types of industries in the regional laboratory of RPCB or any other designated accredited laboratory. It is equally important that contamination levels beyond standard values are identified and steps should be taken to prevent any violations and punitive action initiated on continued violations.

(ii) Recycling of treated effluent by industries itself by treating trade effluent up to reuse level. Compliance of this must be checked by RSPCB. RIICO may assist RSPCB in the compliance.

(iii) Small Scale Industries: Identification of clusters of small-scale industries in the Kota city. CETP should be establish for these clusters. RIICO has proposed that CETPs would be established and operated by Special Purpose Vehicle (SPV) created by beneficiary industries as per the guidelines issued by RSPCB. Financial assistance required for setting up and operation of CETPs would be collected by SPV from beneficiary industries under Polluter Pays Principle.

(b) Domestic sewage control

- Analysis reports of water samples drawn from 33 major drains of Kota discharging into Chambal river were provided by the RPCB (Appendix 3.7), which pertain to one-time sampling on September 21, 2017 and analysis of certain parameters. The major observations derived from these results are as follows:
    - Three major drains contributing about 63% of the total flow indicate a BOD range of 8-11 mg/L and of relatively low concern from the point of view of quality.

- The next four drains covering an additional flow of about 17% indicate a relatively higher BOD of 14-32 mg/L. This may indicate dilute sewage/sullage reaching these drains as this was post monsoon period hence relatively free from any storm water ingress.
- Among the other 26 drains, some had a high BOD of 30-52 mg/L. Though these constitute very little volumetrically, further investigations are needed to establish the reasons (open defecation, leaching from solid waste dump site, contributions from some small scale industrial/commercial clusters) and an action for its scientific management can help reduce this pollution reaching the river.

- Detailed investigations will be needed to establish the reasons for low BOD levels of sewage reaching the STP. Low inlet BOD would prevent proper functioning of the existing and planned STPs of Kota city as microbiological growth will be adversely affected in the absence of adequate substrate. Possibility of closed conduit sewerage system reaching STP must be explored.
- Establishment of proper sewerage system and STP is required in Kota city. Sewage generation on 2016 was 159.42 MLD. Presently Sewage Treatment facility available at present is 50 MLD (Ref. LSG and RUIDP). Sewage Treatment Facility under process is 55MLD +6 MLD (by 2023). This indicates population Coverage 64.51%. Ensure diluted sewage is not reaching planned STPs. Explore possibility of closed conduit sewerage system for STP or else possibility of decentralized STPs to avoid dilution by other streams than domestic sewage
- The execution of sewerage system in the balance area (35.49%) of city should also be considered in a targeted time manner to reduce pollution load in river, unless it means very high cost due to difficult terrain. In case of any impediments due to the difficult terrain requiring high capital investments, onsite treatment systems may be adopted, with a provision of scientific management of faecal sludge.
- India's first laboratory on fecal sludge characterization has been established at Nimli, Tijara, Rajasthan. Though they are presently not providing any testing facility to outside agency. Help may be sought from the same in establishment of such lab. Also, lot of work is going on at some institutions including IISc Bangalore for deriving useful nutrients from fecal sludge through the installation of central biogas co-fermentation system for treatment of the delivered sludge. Co-digestion with municipal solid waste/cattle excreta etc. may also be attempted. Information may be derived from these sources to frame a good network for such interventions, which are presently supported by the Bill & Melinda Gates foundation also in India (Vyas, 2018).
- Develop innovative methods and techniques to reduce, recycle and re-use the sanitation waste, to protect the aquifers and to reduce the land footprint.
- Proper management strategies and regulation implementation urgently needed to cope with Solid waste management. Presently there is solid waste dumping ground/landfill site about 3.5 km from the Chambal river. It is proposed that proper sanitary landfill site must be developed with leachate collection and treatment system, proper groundwater monitoring. Landfills sites need careful siting and sealing to prevent contamination of groundwater through conversion to secured landfills. The leachate coming from such landfills should be collected and treated before being allowed access to the water body.
- New Residential Developments to have their own fully functional sewage treatment systems and recycling and reuse systems

- Building byelaws to be amended and made mandatory for new townships, flat schemes, colonies for opting dual piping system for flushing from treated wastewater

4. Groundwater Management

i) It was discussed that periodic water quality assessment of all tube wells/hand pumps (TW/HP) used for drinking water purpose is made. Also, an immediate remedial action of sealing of infected TW/HP is taken. Subsequently if it is determined that infected TW/HP could be recovered by disinfection, it is recovered, otherwise it is abandoned. However, no database of such action is easily available. Similar monitoring and action must also be taken on non-drinking water TW/HP of these stretches. Standard for non-drinking TW/HP must be framed.

ii) There are many overexploited regions in Kota stretch. Many rainwater harvesting structures are constructed. Regular monitoring and maintenance must be carried out before monsoon

5. Greenery development

Rajasthan State Govt. (Rajasthan State Irrigation Department) should identify /demarcate plantation area and regulate the activities. Also, encroachments along river stretch must be checked-By District/Local administration.

6. Environmental Flow (E-Flow) and Floodplain zone

It is found that e-flow release system is in place at the Chambal Barrage. E-flow of 5000 cusec is released for 35 minutes from Kota Barrage every Monday during non-e-flow period only, i.e. all Mondays during January to onset of Monsoon. Also, it was discussed during the meetings that there is no flood prone zone in the area and therefore zoning has not been carried out. Construction activities close to river, must be regulated.

Chapter 4: Action plan for Keshoraipatan stretch of Chambal river

A brief description of Keshoraipatan stretch of Chambal river is given below. The entire town is spread over 33 Sq.kms and lies predominantly on the Chambal river bank with a population of 24630 (Census 2017). The town is located around 17 kms downstream from Kota barrage. There are no prevalent industries (small scale, cottage, household etc.) which can potentially pollute the river, hence most wastewater streams flowing into the river are domestic in nature arising from anthropogenic activities such as bathing, toilet flush, washing etc. On one side of the Chambal river lies the Keshoraipatan and on the other side of the Chambal river, lies Rangpur Ghats shown in Fig. 2.8.

This stretch has reported BOD levels between 3 to 6 mg/l and therefore falls under the priority V. Analysis of BOD and FC indicates that BOD levels are below 3 mg/l most of the time and have reduced since 2016 at the upstream section, i.e. Raj Rajeshwar Mahadev Temple station, but are beyond 3 mg/l at the downstream section of Ambedkar Nagar Station. FC has been within the prescribed standard at both the stations.

Wastewater generated from households is discharged directly into network of open drains before emptying into the river at 6 outfall points. In addition, faecal sludge when collected from containment units is also discharged in to the river/natural drains leading to the river. Fig. 4.1 shows the locations of the 6 drains discharging to the river Chambal. Dry flow is 1249 KLD from these drains as mentioned in Table 4.1. Table 4.2 shows the waste water characteristics of these drains and as can be seen, drains 4, 5 and 6 carry about 80% of the flow and are most contaminated when COD values are compared. These drains must be dealt first.

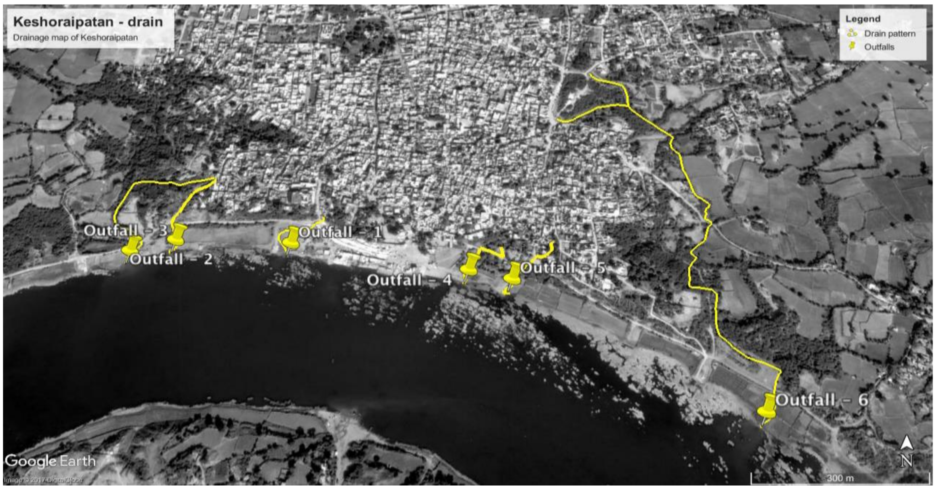


Fig. 4.1: Map of drains and outfalls in to River Chambal

Table 4.1: Dry flow from six outfalls in Chambal river (Keshoraipatan)

Outfalls	Dry flow, KLD
Outfall 1, 2, 3	261
Outfall 4, 5, 6	988

(Source: RUIDP)

Table 4.2: Wastewater characteristics of samples from six outfalls

Date	Outfall	P^H	Turbidity (NTU)	TDS (mg/l)	E.C micro mhos/cm	C.O.D (mg/l)	Colour
4-8-17	Outfall 1	7.5	104	2640	3680	344	Black
4-8-17	Outfall 2	7.75	197	2800	3890	168	Black
4-8-17	Outfall 3	7.52	72	3040	4230	392	Yellow
4-8-17	Outfall 4	7.69	34	2320	3230	920	Yellow
4-8-17	Outfall 5	7.84	45	2880	4010	1000	Yellow
4-8-17	Outfall 6	7.72	48	2770	3860	1024	Greenish yellow

(Source: RUIDP)

Keshoraipatan waste water generation and management data were collected from the LSG and are given below.

- Present sewage generation - 1.576 MLD
- Sewage treatment facility at present - Nil
- Establishment of fecal sludge treatment facility by 2020
- Sewage Treatment plant for effluent from drains by 2020
- Recycle and reuse of treated waste water in agriculture by 2020
- Fig. 4.2 shows the proposed drainage and STP plan (Table 4.3) for Keshoraipatan city.

Fig. 4.2: Proposed drainage plan for outfalls (Source: RUIDP)

Table 4.3: Proposed STP capacity at Keshoripatan

Location	Treatment size
Site 1	680 KLD
Site 2	2.6 MLD

Information on Swachh Bharat Scheme under the Ministry of Housing and Urban Affairs in shown in Appendix 4.1.

Municipal waste management: (Source LSG)

- Quantity of Waste generated = 8.03 TPD
- Area of the city under the municipal waste collection = 26 km^2
- Distance from water body = 0.9 km
- DPR preparation for solid waste management is under process.
- Location of landfill site is shown in Fig. 2.8

Biomedical waste treatment & Disposal facility is common for both Kota & Bundi and therefore also for Keshoraipatan. As discussed above, tender for replacement of this facility is under process and temporary facility till would be operational by end of Jan. 2019.

Information about progress of drip and sprinkler irrigation systems was obtained from agriculture department and is mentioned in Table 4.4 for Keshoraipatan region.

Table 4.4: Year-wise progress on various irrigation systems under micro-irrigation scheme. (Source: Agriculture Department)

Year	Keshoraipatan		
	Drip Irrigation	Sprinkler Irrigation	Total
2015-16	38.48	0	38.48
2016-17	30.61	67	97.61
2017-18	161.99	40.5	202.49
Till Nov. 2018	15.67	4.5	20.17
Total	246.75	112	358.75

Fertilizer Consumption data of Bundi: It is clear from Table 4.5 that fertilizer consumption in 2018 has reduced considerably as compared to 2016. The reduction in fertilizer consumption can eventually reduce NH4 and NO3 in agricultural run-off, which ultimately goes in Chambal river.

Groundwater resource status along Chambal stretch of Keshoraipatan: Groundwater quality maps of Keshoraipatan area are shown in Appendix 4.2. As per the map prepared using groundwater level data obtained from CGWB it is clear that groundwater resources around Chambal stretch are in semi-critical and some in over exploited zone. The depth of water table in Bundi district is around 260 to

440m (bgl). DWDSC have mentioned that around 1008 water harvesting structures are built in Bundi district with an expenditure of 9.87 crore Rs.

Table 4.5: Fertilizer consumption data of Bundi

Fertilizer Consumption (Tonnes) Bundi					
Year	Urea	DAP	SSP	Others	Total
2015-16	83511	35701	11519	1176	131907
2016-17	79774	25833	9868	1046	116521
2017-18	78097	22908	10100	1162	112267

Officials of PHED, Rajasthan and GWD, Jaipur discussed that periodic water quality assessment of all tube wells/hand pumps (TW/HP) used for drinking water purpose, is made. Also, an immediate remedial action of sealing of infected TW/HP is taken. Subsequently if it is determined that infected TW/HP could be recovered by disinfection, it is recovered, otherwise it is abandoned.

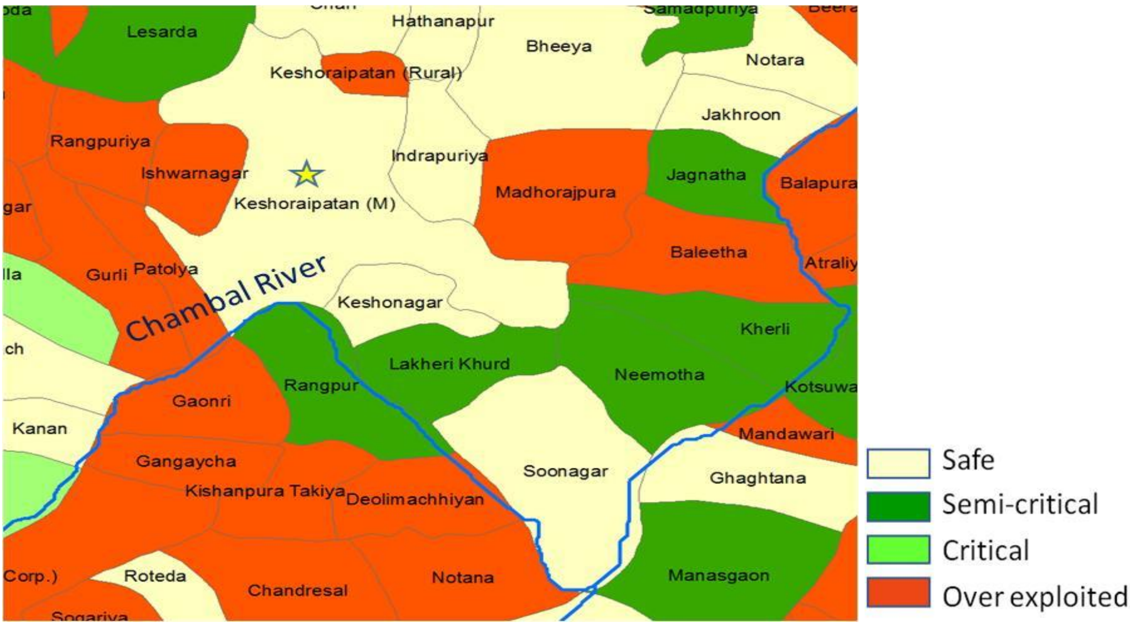


Fig. 4.3: Groundwater exploitation map

Primary survey was also carried out and number of samples were collected from river, drains, hand pumps etc. Fig. 4.4 shows the location of these samples. Table 4.6 gives the water quality of these samples collected during the field visit and assessed at MNIT Jaipur.

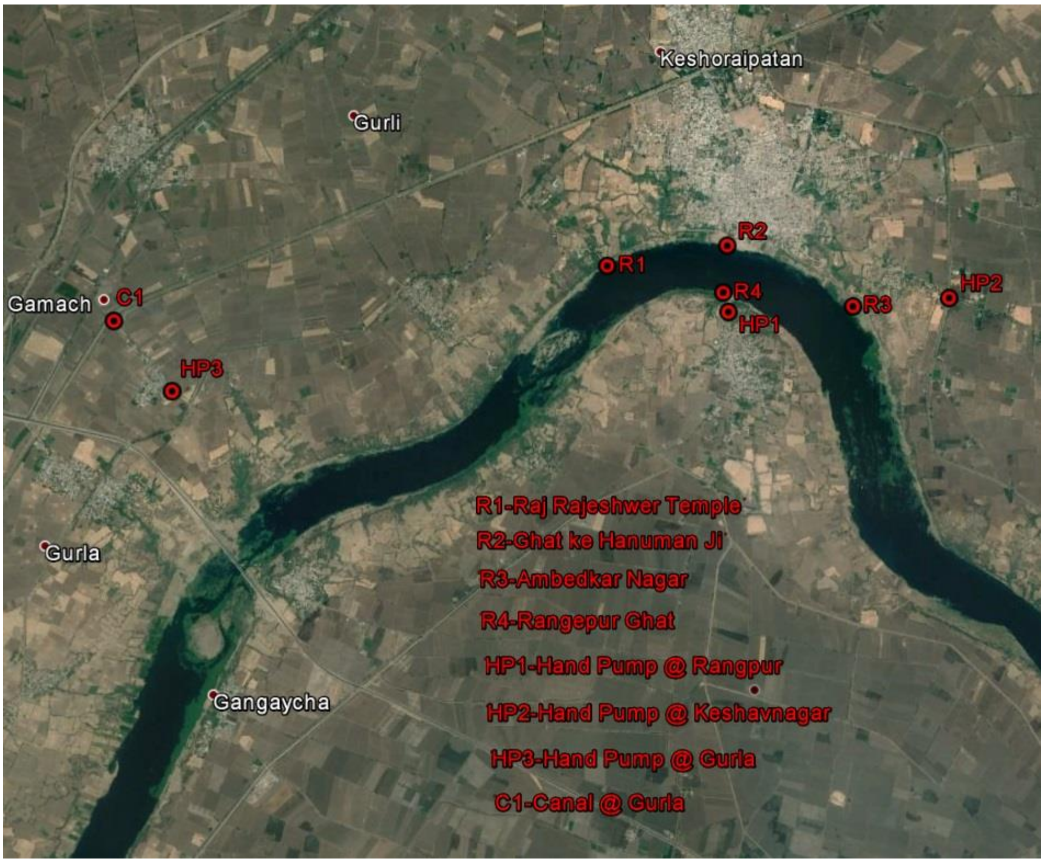


Fig. 4.4: Field survey locations, Keshoraipatan

Table 4.6: Water quality parameters of primary samples

Name	R1	R2	R3	R4	C1	HP1	HP2	HP3
Ammonium Nitrate	0.21	0.564	1.87	0.188	0.503	0.285	0.338	0.248
Ca+	10.1	12.8	12.8	13.9	7.8	44.1	18	14.8
NO3	1.75	4.89	1.87	2.12	1.24	12.7	3.27	8.39
Na	34.6	49.1	57.5	34.6	19.4	246	68	232
F	0.354	0.378	0.427	0.324	0.209	0.663	0.83	1.22
pH	8.67	8.36	8.75	8.57	8.59	7.97	8.33	8.19
TDS	270	370	350	280	180	1000	510	540
Coliform	48800	58000	15600	8160	11200	Nil	Nil	Nil
Turbidity	1.76	4.57	25.76	3.97	0.9	9.86	13.45	4.49
Chloride	54	68	68	52	36	164	86	48
BOD	3.8	9.1	8.6	19.9	10.8	Nil	6.6	Nil
COD	75	125	122	173	153	Nil	98	Nil
Hardness	96	132	112	112	96	200	232	168
K+	7.5	10.3	11.3	7.9	5.1	3.1	2	1.71
Sulphate	40.311	73.567	69.403	43.857	21.423	165.49	80.625	39.598

Where R1-Raj RajeshwerTemple_KRP; R2-Ghat ke Hanuman Ji @ KRP; R3-Ambedkar Nagar_KRP; R4-Rangpur Ghat_Kota; C1-Canal @ GurlaVillage_KRP; HP1-Rangpur_Kota; HP2-Keshavnagar_KRP; HP3-Gurla Village_KRP

A broad analysis of primary data indicates that COD/BOD ratios are similar to those found in historical data but values are on higher side. So is the case with Chlorides, which indicates that sewage from nearby area (Ghat/temples) is discharged directly into the river. TC in surface water sample is high though it is not affecting the groundwater quality. BOD levels are high on the Rangpur side of the river bank. Few photographs of the field visit as well as from RUIDP reports are shown in Appendix 4.3.

In order to understand the reasons for contamination of this river stretch, water quality parameters of stations falling in this stretch are plotted below. Fig. 4.5 shows the BOD, COD, Ammonia (NH4-N), Chloride and COD/BOD ratio for the Raj Rajeshwar Mahadev Temple and Ambedkar Nagar sections. Chloride having much higher value than other parameters is plotted on right axis and remaining parameters on left axis. It can be seen in general that water quality is deteriorating at the onset of monsoon. This needs to be corroborated with the collection and analysis of water quality at the onset of the monsoon for at least two years. Chloride levels are showing increasing trend at both the section since year 2016, indicating that more and more human sewage is reaching this river stretch. High COD/BOD ratio indicates predominance of dispersed sources from agriculture activities and solid waste/sullage disposal. Also, at different time, sudden drop in COD levels may be due to sudden release of water from Kota barrage, typically during the monsoon period.

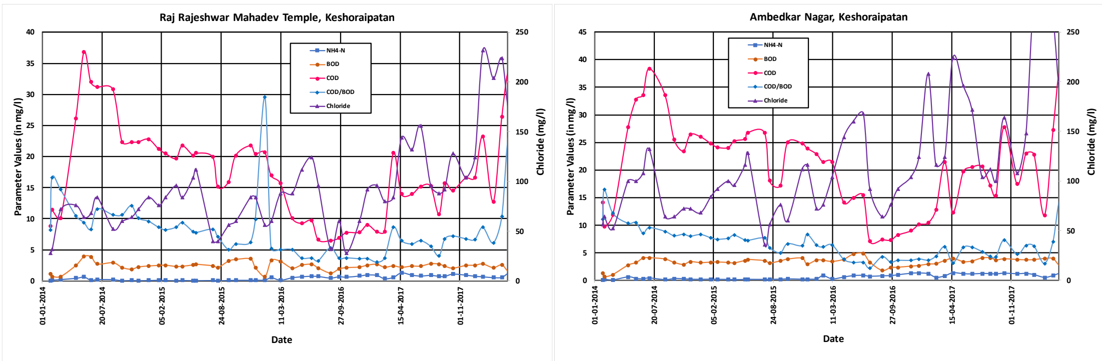


Fig. 4.5: River water quality at Keshoraipatan stations

Similar water quality graphs of Ammonia (NH_4-N), Phosphate as PO_4 and Nitrate as N (NO_3-N) are plotted in Fig. 4.6 which indicate that dominant contribution is coming from the same source, namely, dispersed agriculture run off. This may be further confirmed by analyzing some samples for pesticides, which are also of the same origin. The increasing levels of these parameters indicate that integrated fertilizer and pest management is required in order to ensure that level of these water quality parameters are checked in future.

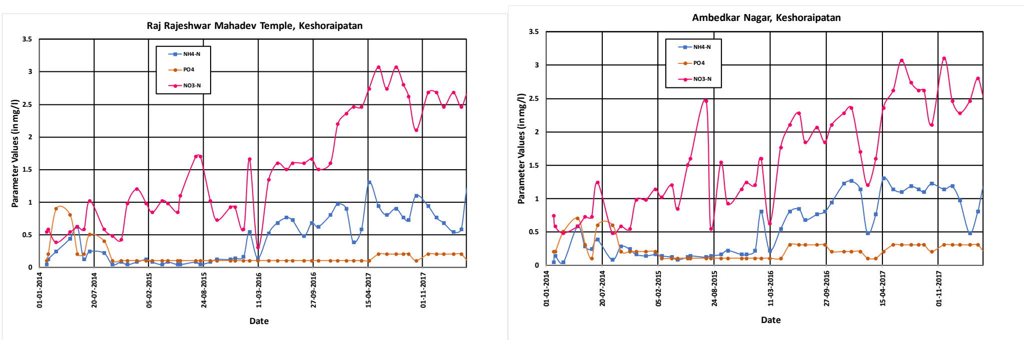


Fig. 4.6: NH_4-N, PO_4 and NO_3-N parameters at Keshoraipatan stations

Water quality graphs depicting Faecal Coliforms (FC), Total Coliforms (TC) and Chlorides are plotted in Fig. 4.7. Chloride is plotted on right axis. Values of TC and FC indicate that river has sufficient assimilative capacity, which may be primarily attributed to a high dilution ratio being available besides a relatively steep rocky strata contributing to reaeration. High values of TC till 2016, indicate dominance of dispersed pollutants rather than domestic sewage and after 2016, human sewage interference has started increasing the FC.

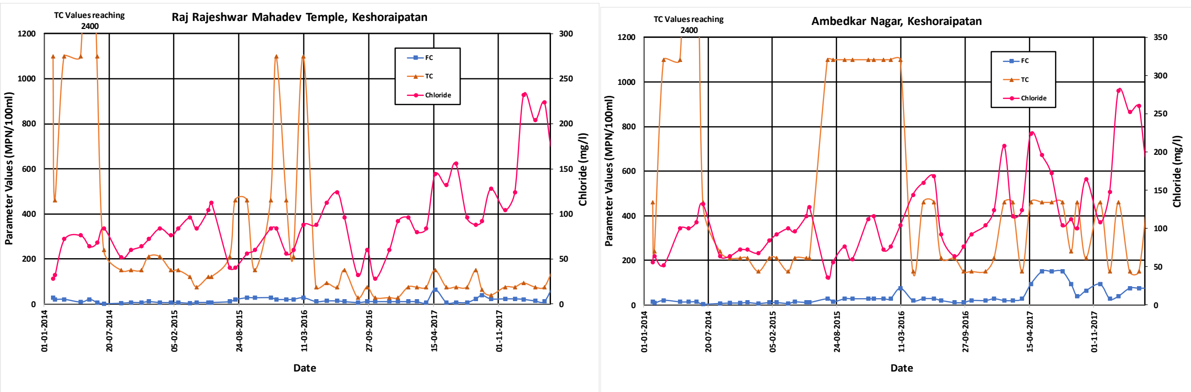


Fig. 4.7: FC, TC and Chloride parameters at Keshoraipatan stations

When any river water quality station is installed, care is taken to facilitate a representative sample of the river, which is free from some immediate local sources. Sometimes, samples drawn from other locations may have a bias for the local contributions. Thus, a primary survey of the area was also conducted which indicates that COD/BOD ratios are similar to those found in historical data, but values are on higher side. Higher values of chlorides indicate that sewage from nearby area (Ghat/temples) is directly going into the river and therefore there is need of proper management of such point sources. In fact, the difference of parametric values on the two sides of the bank was large due to perhaps very different level of human activities and we could draw samples only from places close to the banks. The downstream sample shows adequate equalization of the values. The major indication is that the river parameters are only occasionally exceeding the desired limits and a robust environmental management of these point sources in terms toilet wastewater treatment and disposal; solid waste including garlands/flowers offered to the deity; and control of washing activity on the Ghat can vastly improve the situation. The redeeming point is, despite the fact that TC in surface water sample is high, it has not affected the groundwater quality in terms of microbiological pollution perhaps due to very deep groundwater table.

4.1 Action Plan

Therefore, considering the observed data, following action plan is proposed for the Keshoraipatan area

1. First Flush:

Observation are same as in case of Kota stretch. Following additional point is made

- Minimize the availability of organic pollutants to be entrained by first flush in river through controlling open defecation. As per information provided by Local Self Government (LSG) Department, Keshoraipatan area would be open defecation free by the end of 2019. A time bound implementation and monitoring must be ensured. Treatment and disposal of septage must also be achieved.

2. Biomedical and hazardous waste collection

- Since facilities for Kota city was also used for Bundi area and therefore Keshoraipatan, so observation of Kota stretch as mentioned in Chapter 3 are applicable.

3. Non-point Source (NPS) control:

Observation are same as in case of Kota stretch.

- Maintain Septic tanks and establishment of adequate and effective toilets for public.
- Establishment of effective garbage collection, transport, treatment and disposal facilities in the town, with adequate resources available for effective O&M

4. Point Source control: There are no major prevalent industries which can significantly pollute the river, hence most of the wastewater streams flowing into the river are domestic in nature arising from anthropogenic activities such as bathing, toilet flush, washing etc.

- Presently there is no sewage treatment facility, however, RUIDP document indicates plan for two sewage treatment plants of 3.28 MLD capacities by the year 2020. It is important that these sewage treatment plants must be planned along with associated sewerage collection system. In past at many locations there has been mismatch in the two leading to contamination of surface water till the STP is fully functional. Remediating it later is always very costly.
- Analysis reports of water samples drawn from 6 major drains of Keshoraipatan discharging into Chambal river were provided by the RPCB (Appendix 4.4), which pertain to one-time sampling on September 22, 2017 and analysis of certain parameters. These indicate a BOD range of 29-38 mg/L, which indicates dilute sewage/sullage reaching these drains as this was post monsoon period hence relatively free from any storm water ingress. Converting the whole area in to "open defecation free" and covering all domestic/public toilets with scientific faecal sludge management can help reduce this pollution reaching the river.
- LSG has indicated that concept note for faecal sludge treatment has been prepared but no funds have been allocated for the same. It is proposed that till STPs are made in the long term, faecal sludge treatment must be achieved in time bound manner to reduce the potential of such onsite systems for polluting groundwater and also the water of Chambal through seepage in to the drains. Therefore, proposal for budget allocation to be prepared by LSG within 2 months for Keshoraipatan. DPR for FSTP must be prepared after budget allocation. Construction will take minimum one year after that.
- Integrated solid waste management practices should be adopted. Presently there is solid waste dumping ground about 900 m from the Chambal river. It is proposed that proper sanitary landfill site must be developed with leachate collection and treatment system, proper groundwater monitoring. As per LSG, For Keshoraipatan, ISWM plant tender will be invited soon after budget allocation of Rs. 5 crore and after that construction will take minimum 1 year. Till this is developed, it is proposed that groundwater monitoring must be started.

5. Ghat management: Analysis of samples of field visit indicates that lot of anthropogenic pollution is reaching river due to improper ghat management and dumping of solid waste from ghats, temples and muktidham into the river.

- Proper management strategies and regulation implementation urgently needed to cope with Solid waste management.
- If socially acceptable and based on cost assessment, e-crematorium may be proposed for the area.
- Public toilets must be planned at the ghats. Primary data analysis indicates higher level of pollution at the other side of the Ghat (i.e. Rangpur Ghat). So proper toilets must also be planned for that area.
- Waste water should be disposed after proper treatment.

6. Ground water management:
Observation are same as in case of Kota stretch.

7. Greenery development
Observation are same as in case of Kota stretch.

8. Environmental Flow (E-Flow) and Floodplain zone
Observation are same as in case of Kota stretch.

Chapter 5: Action plan for Nevta Dam, Banas river

Nevta dam station has reported high BOD levels of more than 10 mg/l and therefore falls under the priority III. The catchment area of Nevta dam is small and has very less urbanization. The Nevta dam receives waste water through diversion channel from Dravyawati river (fig. 2.10). The Dravyawati river originates from the foothills of Nahargarh, passes through Vishwakarma Industrial area, Shastri Nagar, C-Scheme, Kartarpura, Gopalpura Bye-pass, Durgapura, Maharani Farm, Sanganer, Goner & ultimately terminates into morel river (Distt-Dausa).

As has been discussed in Chapter 02 and seen in Fig. 2.10, Nevta dam has small catchment area of only 51 km^2. It is approximately 14 m high dam, which receives water diverted through a diversion channel from the Gular dam on Dravyawati river. Diversion channel has control gates and therefore only enough water is diverted to Nevta dam so that it does not overflow from Nevta dam. Dam has never overflown in its last 30 years history and is not likely to do so in future as well. Therefore, Nevta dam is not likely to cause deterioration of water quality in Banas river, however, is important due to proximity of state capital, Jaipur.

Presently there is a JDA project going on for the improvement of Dravyawati river. Salient objectives of the project are

1. Develop Amanishah Nallah (previously known as Dravyawati river) as a center of attraction and an important natural asset for the city of Jaipur;
2. Stop raw sewage or effluent entering into natural available stream by intercepting and treating such effluent;
3. Use the treated sewage to rejuvenate the flow into the existing Nallah;
4. Ensure perennial water flow in Nallah;
5. Restoration of Ground Water Recharge of erstwhile Dravyawati river;
6. Ensure a better management of floods and reduce risk thereof in the nearby commercial and habitable areas;
7. Develop land parcels within or adjoining areas of the Nallah for public use and for social and commercial infrastructure;
8. Develop a Master Plan for the reclaimed areas.

Following work in under process in the project.

- 5 Sewage Treatment plants (STPs) of total 170 MLD cumulative capacity have been constructed along the stretch of Dravyawati river, the details are as mentioned below:
- 20 MLD STP, Bassi Sitarampura, Ambabari, Sikar Road, Jaipur
- 15 MLD STP, Devari, Shipra Path, Mansarovar, Jaipur
- 100 MLD RIICO STP, Near Mansarovar Ind.Area, Jaipur
- 25 MLD STP, Bambala, Pratap Nagar, Jaipur.
- 10 MLD STP, Goner, Jaipur.
- Out of five STPs, three STPs at Bassi Sitarampura (20 MLD), Devari (15 MLD) and RIICO Mansarovar (100 MLD) are under trial run.
- Construction of CETP of capacity 12.3 MLD at Sanganer is under progress. The CETP having provision of Reverse osmosis (RO) plant to maintain ZLD status. The effluent will be conveyed up to CETP through close conduit pipe line arrangements of approximately 42 km length and

treated effluent will be supplied to the member units for reusing in process. The work of CETP is under progress.

Groundwater data has been collected from State Ground Water and Central Ground Water Departments. Fig. 5.1 shows the various village level zones falling under different level of groundwater exploitation zones. It is clear that groundwater resources around Nevta dam stretch are over-exploited due to rapid urbanization and industrialization. DWDSC have mentioned that around 1172 water harvesting structures are built in Jaipur district with an expenditure of 11.02 crore Rs.

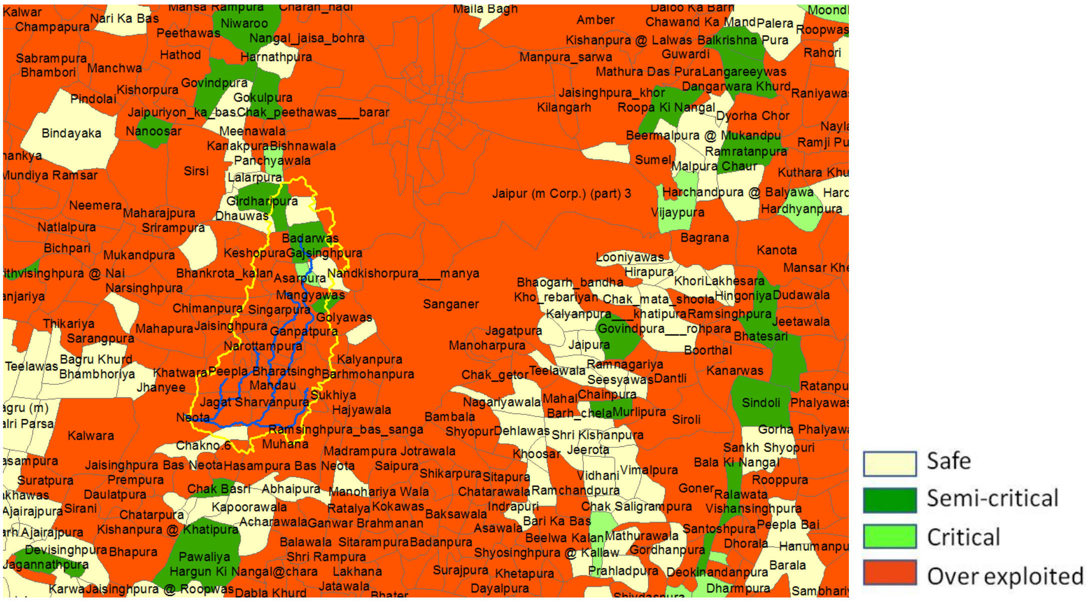


Fig. 5.1: Groundwater exploitation map of Nevta dam region

5.1 Action Plan

As per the inferences drawn from water quality parameters of Nevta dam station, the major reasons identified for the deterioration of water quality of Nevta dam are effect of first flush, contributions from non-point sources, and impact of point sources like sewage and industrial discharges. The proposed action plan for Nevta Dam along these lines is discussed in the following sections:

Some of the action points such as for first flush, non-point source control, groundwater management, greenery development, environmental flow (E-Flow) and irrigation practices etc. are similar to what has been described in previous chapters and hence not repeated here.

1. Biomedical and hazardous waste collection

- M/s Insrtromedix India Pvt. Ltd., Jaipur has been identified for Jaipur city, Jaipur rural and Dausa. For Jaipur area, monitoring and technical auditing of such system must be carried out.

2. Point Source control

The catchment area of Nevta dam has very less urbanization and no major industries exist in the area. But Nevta dam receives waste water through diversion channel from Dravyawati river. Major actions (as per the available information provided to us) already initiated by the local authorities under

Dravyawati project include construction of 5 STPs along the stretch of Dravyawati river, a diversion of which feeds this dam; and CETP construction for the Sanganer- Bagru textile belt which is already under commissioning. Recent analysis results of one SBR based STP on Dravyawati river has shown a good performance, when tested in MNIT laboratory. These measures are expected to fetch good results in improving the water quality of the dam.

Banas river is ephemeral and flows for a short duration across the year, which makes it highly sensitive to the rainfall in its catchment. In the climate change scenario, such rivers may respond very significantly to weather modifications and hence a detailed analysis is required to protect such rivers. A report "Uncomfortable Nexus" is available that attempts different climate change scenarios using certain established forecast models to address the aforementioned issues (Appendix 5.1). A more detailed hydrological analysis attempting further quantitative estimations along with a plan to cope up with enough resilience these projected climate change scenarios is suggested for its sustainable management.

Chapter 6: Summarized Action Plan

This action points are summarized in the table below, along with the action already initiated/ action proposed, agency responsible and suggested timelines.

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
1.	Contamination reaching river stretch due to first flush	1. Characterisation of runoff of main drains for first four storm water flows		RUIDP/UIT for Kota with RSPCB LSG for K.Patan With RSPCB	One month after monsoon (August 2019)	Outcome would be: 1. Identification of most contaminated drains and level of contamination 2. Quantity of water to be handled, based on available flow data
		2. Based on 1st step, design of detention basin, if needed		RUIDP/UIT for Kota LSG for K.Patan	Feb. 2020	Proposal should include plan for reuse of first flush water as well as silt etc. (Example: Delhi Jal Board Nigam)
2.	Drains are chocked before monsoon	Clearing of drains and disposal of extracted material before monsoon Process must be strengthened and checked for its efficiency in an organized manner	Ongoing process, however, contamination still reaching rivers in first flush	Local bodies	Before arrival of next monsoon (Till May 2019)	Based on their contents, Possibilities of utilizing it for various engineering applications may be explored.
3.	Biomedical waste disposal	Agency identified but closed. Replacement must be identified and made operational	For Kota and Bundi Biomedical waste treatment facility directions have been issued and tender	LSG	12 months after award of work and environmental clearance.	

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
			are invited by Kota Municipal Corporation. However, biomedical plant establishment will be completed after award of work. As per RSPCB, A temporary facility to handle biomedical and hazardous waste is under process and would be operational by end of January 2019.			
		For Jaipur area, monitoring and technical auditing of such system must be carried out by Health Department and RSPCB.	Agency working for Jaipur area.	RSPCB/ Health Department/ LSG	As per LSG, a policy has been framed to take view on biomedical waste treatment and review/monitoring of processing plant. Regular monitoring report must be submitted to RSPCB and action to be taken on non-compliance must be identified by RSPCB in advance.	
		Adopting water conservation practices like	Already some action has been initiated.	Agriculture department	One year	Information must be analysed spatially and

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
4.	Runoff from agriculture fields is reaching river stretches. Also, fertilizers and pesticides are found in river water	drip and sprinkler irrigation systems. Agriculture department should collect information on irrigation water used/hectare for different seasons for different crops for different areas and evaluate whether the use of irrigation water/hectare has decreased or not.	Information on area under different systems is available. Also, subsidy to farmers is offered for using drip irrigation			temporally to optimize any planning in future
		Adopting best management practices for fertilizer and pesticide usage. However, like runoff spatial and temporal data may be collected and analysed	Already action being taken. Information on usage of fertilizer and pesticide is available and show decreasing trends.	Agriculture department	One year	Information must be analysed spatially and temporally to optimize any planning in future
		Farmer education for reducing runoff, use of fertilizer and pesticides as well as reducing groundwater over exploitation etc. Also, organic farming must be encouraged in these stretched.		Agriculture department	Six months to design such training workshops and then next one year for organizing such workshops	Design mass awareness program in vernacular language for farmers Help of Agriculture Universities of the state may be sought.

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
		Monitor presence of pesticides in water samples including analysis of other groups also in addition to organo-chlorines	One-time sampling report available, shows presence of DDT much below standard limit.	RSPCB/ Agriculture department	At regular interval (suggested twice every year)	Help from agriculture research lab of Durgapura Jaipur may be taken.
5.	Solid waste dumping sites without proper sanitary landfill sites	Develop landfill site with leachate collection (with its scientific treatment before disposal) and monitoring well	In Kota, 400 TPD, waste to energy plant is under tendering process. Landfill site would also be developed with leachate collection. In Keshoraipatan ISWM DPR is prepared but funds not yet allocated.	DLB GWD for groundwater monitoring	As per LSG, for Kota waste to energy plant tender is under process, however, development of plant will take 1-2 years after award of contract. For Keshoraipatan, ISWM plant tender will be invited soon after budget allocation of Rs. 5 crore. And after that construction will take minimum 1 year. As per LSG, groundwater monitoring is part of GWD and regularly conducted by them. Since communication between two department may not be effective in timely identifying the leakages from sanitary fill and taking associated preventive measures, a policy needs to be adopted for the same and implemented.	Groundwater monitoring must be started till landfill site development project is completed and groundwater monitoring should continue as part of these projects to access the efficacy of the measures taken.

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
6.	Industrial untreated/ partially treated waste is reaching river in Kota stretch	Drains passing through industrial area must be identified and marker pollutants (based on industries) should be regularly monitored. Steps should be taken to prevent any violations and punitive action initiated on continued violations.	One-time monitoring by RSPCB	RSPCB/ RIICO	At regular interval (suggested four times every year)	
		Recycling of treated effluent by industries itself by treating trade effluent up to reuse level. Check compliance.	Already done by few industries.	RSPCB, Assisted by RIICO	Three months	
		Identification of clusters of small-scale industries in the Kota city. CETP should be establish for these clusters		RIICO	Six months for DPR preparation and tendering process	RIICO has already proposed that CETPs would be established and operated by Special Purpose Vehicle (SPV) created by beneficiary industries as per the guidelines issued by RSPCB. Financial assistance required for setting up and operation of CETPs would be collected by SPV from beneficiary industries

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
						under Polluter Pays Principle.
7.	Out of 33 drains monitored one time in Kota, some have high BOD range. Similar in Keshoraipatan area	Identify reason for high BOD (open defecation, leaching from solid waste dump site, contributions from some small scale industrial/commercial clusters). Take scientific measures to control that. Action based on analysis.		UDH/RUIDP	Six months	
8.	Low level of BOD in sewage reaching existing STP. Microbial growth would be adversely affected due to low BOD.	Explore possibility of closed conduit sewerage system for STP or identify sources of dilution and propose action plan for the same.		UDH/RUIDP	Six months to identify sources of leakage and propose action on the same.	Explore possibility of in-situ bio remediation for select streams, in case it is not possible to develop closed conduit system. Similar action was planned for Pushkar Lake restoration by RUIDP/NIH
9.	In Kota additional 55MLD +6 MLD STPs are under process. This would lead to 65% population coverage	Ensure diluted sewage is not reaching planned STPs. Explore possibility of closed conduit sewerage system for STP or else possibility of decentralized STPs to avoid		UDH/RUIDP	STPs are presently under litigation and would be constructed in three years, subject to the outcome of the litigation.	

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
		dilution by other streams than domestic sewage				
10.	35% of Kota population is still not covered under sewerage system. Also, no sewerage system at Keshoraipatan.	Faecal sludge characterization lab may be established in any existing institute/research lab. Scientific management of faecal sludge should be carried out for on-site treatment facilities. For remaining 35% population in Kota the co treatment of faecal sludge is proposed in existing STPs.	Similarly, in Keshoraipatan, concept note for FSTP is made but funds not allocated	RUIDP for Kota LSG for K.Patan	FSM proposal for Kota for remaining 30% population within 3 months by RUIDP. Proposal for budget allocation to be prepared by LSG within 2 months for Keshoraipatan. DPR for FSTP to prepared after budget allocation. Construction will take minimum one year after that. For collection and transportation of faecal sludge, annual rate contract for cesspool vehicles have been finalized. ULB would procure as per their requirement.	India's first laboratory on feacal sludge characterization has been established by CSE, New Delhi at Nimli, Tijara, Rajasthan. Though they are presently not providing any testing facility to outside agency. Help may be sought from the same in establishment of such lab. Information may be derived from the initiatives of Bill & Melinda Gates foundation/IISc Bangalore
11.	Poor ghat/temple management leading to pollution of river at Keshoraipatan	Public toilets must be prepared. Proper solid waste management system should be developed. (Also, at Rangpur, other side of Chambal river)		LSG	Six Months	

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
12.	It was discussed that periodic water quality assessment of all tube wells/hand pumps (TW/HP) used for drinking water purpose is made. Also, an immediate remedial action of sealing of infected TW/HP is taken. Subsequently if it is determined that infected TW/HP could be recovered by disinfection, it is recovered, otherwise it is abandoned. However, no database of such action is easily available	Similar monitoring and action must also be taken on non-drinking water TW/HP of these stretches. Standard for non-drinking TW/HP must be framed. Database of such reporting and action taken must be available		GWD/PHED	Six months	
13.	Over exploited groundwater regions in Kota, Keshoraipatan and Nevta Dam stretches	Many RWH structures constructed. Regular monitoring and maintenance must be carried out before monsoon	Many RWH structures constructed.	DWDSC/Water Resources/ River Basin Authority etc.	Maintenance for next year must start from March 2019.	
14.	Requirement of e-flow must be maintained		E-flow of 5000 cusec released for 35 minutes from Kota Barrage every Monday during non-	Water Resources		

S. No.	Observation	Action proposed	Action already initiated	Agency responsible	Time lines	Remarks
			e-flow period only, i.e. all Mondays during January to onset of Monsoon.			

Appendix 2.1: Sample monitoring report received from RSPCB (Approx. 90 pages of information for 9 stations)

Rajasthan State Pollution Control Board

National Water Monitoring Programme (NWMP)

Printed On: 13/11/2018

Station Name: RIVER CHAMBAL AT KESHORAIPATAN D/S NEAR AMBEDKAR NAGAR, DISTRICT BUNDI, RAJASTHAN

Station Code: 10030

From / To Date: Till Date

Parameter	18/01/2018	22/02/2018	23/03/2018	17/04/2018	18/05/2018	27/06/2018	26/07/2018	27/08/2018
Ammonia Nitrogen(mg/l)	0.97	0.48	0.8	1.22	0.94	0.97	0.58	0.52
B.O.D.(mg/l)	3.7	3.9	3.88	2.60	3.98	3.28	3.5	2.6
Boron Dissolved(mg/l)	0.36	0.27	0.26	0.26	0.27	0.33	0.31	0.27
C.O.D.(mg/l)	22.80	11.75	27.20	38.07	26.80	32.53	27.2	17.28
Calcium as Ca(mg/l)	38.4	40	43.2	44.8	43.2	44.8	41.6	30.4
Chloride(mg/l)	280	252	260	188	252	296	168	76
Conductivity (μmho/cm)	970	810	790	860	1010	880	610	320
Dissolved Oxygen(mg/l)	5.1	4.35	3.06	3.44	3.37	3.28	3.63	5.6
Fecal Coliform (MPN/100ml)	39	75	75	75	[N/A]	75	120	93
Fixed Dissolved Solids(mg/l)	484	464	468	480	508	516	344	172
Fluoride As F(mg/l)	0.92	0.86	0.92	0.82	0.9	0.82	0.92	0.82
Magnesium as Mg(mg/l)	15.616	18.544	17.568	17.56	19.52	21.472	15.544	14.64
Nitrate as N(mg/l)	2.28	2.46	2.8	2.46	2.46	3.14	2.62	3.07
pH	8.31	8.37	8.4	8.43	8.46	8.49	7.67	7.73
Phenolphthalein Alkalinity	4	8	8	8	8	8	NIL	nil
Phosphate As PO4(mg/l)	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3
Potassium As K (mg/l)	1.5	1.9	2.3	2.1	2.1	2.5	1.6	1.8
Sodium(mg/l)	90	85	88	82	150	150	84	45
Sulphate(mg/l)	185	177.5	162.5	270	157.5	137.5	117.5	54
Temperature(0C)	21	23	27	30	30	30	28	30
Total Alkalinity (mg/l)	164	184	184	196	192	208	192	140
Total Coliform(MPN/100ml)	460	150	150	460	[N/A]	150	210	240
Total Dissolved Solids(mg/l)	622	588	638	650	678	674	462	242
Total Hardness As CaCO3(mg/l)	160	176	180	184	188	200	180	136
Total KJELDAHL Nitrogen(mg/l)	5.6	5.6	5.88	4.76	5.6	7.56	7	6.72
Total Suspended Solids(mg/l)	25	25	25	9	15	25	40	47
Turbidity(JTU/NTU)	4	2.9	3	3.6	3.8	4.1	3.5	12.1

Rajasthan State Pollution Control Board

National Water Monitoring Programme (NWMP)

Printed On: 14/11/2018

Station Name: NEWTA DAM, JAIPUR, RAJASTHAN **Station Code:** 2952

From / To Date: Till Date

Parameter	18/01/2017	22/02/2017	22/03/2017	18/04/2017	16/05/2017	15/06/2017	13/07/2017	21/08/2017	25/09/2017	26/10/2017	23/11/2017	28/12/2017
Ammonia Nitrogen(mg/l)	1.18	0.76	0.97	1.36	1.26	1.22	0.97	1.1	0.94	1.22	1.1	0.97
B.O.D.(mg/l)	8.05	6.84	9.12	10.78	7.84	9.8	11.4	7.84	9.8	11.52	10.78	11.52
Boron Dissolved(mg/l)	0.35	0.27	0.42	0.56	0.56	0.52	0.35	0.3	0.26	0.52	0.27	0.21
C.O.D.(mg/l)	25.26	55.88	64	65.19	90.2	98.4	90.64	61.12	85	71.14	65.88	90.68
Calcium as Ca(mg/l)	62.4	49.6	48	56	54.4	51.2	75.2	56	54.4	56	52.8	54.4
Chloride(mg/l)	332	356	276	340	464	316	252	184	400	340	440	460
Conductivity (µmho/cm)	1480	1520	1740	1800	2100	2000	1730	1190	1470	1800	1790	1880
Dissolved Oxygen(mg/l)	3.68	4.10	3.88	2.45	3.23	3.53	3.53	3.58	3.82	2688	3.92	4.03
Fecal Coliform (MPN/100ml)	20	20	28	20	150	150	75	64	64	20	23	39
Fixed Dissolved Solids(mg/l)	728	684	752	1040	1392	1196	1008	604	812	1088	800	908
Fluoride As F(mg/l)	0.92	0.86	0.9	1.1	0.92	0.98	1.06	0.98	0.86	1.22	0.92	0.82
Magnesium as Mg(mg/l)	33.184	20.496	40.016	60.512	70.272	64.416	36.112	37.08	33.184	18.544	17.568	37.088
Nitrate as N(mg/l)	2.1	3.16	3.15	3.1	3.16	3.15	3.14	2.74	3.1	3.15	3.15	2.8
pH	8.58	8.4	8.2	8.55	8.6	8.47	8.36	8.31	8.53	8.48	8.4	8.42
Phenolphthalein Alkalinity	8	4	NIL	16	24	20	8	8	8	12	12	12
Phosphate As PO4(mg/l)	0.2	0.3	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.4	0.2
Potassium As K (mg/l)	1.2	1.4	1.5	4.5	2.5	2.2	2.3	2.0	1.8	4.6	2.2	2.9
Sodium(mg/l)	205	335	375	680	750	680	520	300	365	800	340	410
Sulphate(mg/l)	270	86	200	137.5	400	385	370	150	167.5	130	150	167.5
Temperature(0C)	16	19	30	31	35	30	32	32	32	27	22	19
Total Alkalinity (mg/l)	304	96	340	520	528	436	464	408	384	324	316	328
Total Chromium as Cr(mg/l)	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]	[N/A]
Total Coliform(MPN/100ml)	150	150	210	150	460	460	150	210	210	150	93	150
Total Dissolved Solids(mg/l)	942	1072	1292	1720	1812	1592	1292	1004	1128	1380	1208	1168
Total Hardness As CaCO3(mg/l)	292	208	284	388	424	392	336	292	272	216	204	288
Total KJELDAHL Nitrogen(mg/l)	5.04	4.2	4.48	5.6	5.32	5.6	5.88	5.04	5.32	6.16	5.88	5.6

Appendix 2.2 Summarized BOD and FC Data

Year wise and Quarter wise summarized data of BOD and FC of selected stations

Year	Quarterly and Yearly Average BOD					Quarterly and Yearly Average FC				
	AK	AN	ND	RRM	RP	AK	AN	ND	RRM	RP
2014	0.79	2.74	7.60	2.24	1.94	2.33	11.08	13.92	12.08	13.42
Qtr1	0.46	0.95	5.89	0.82	0.83	2.67	14.67	18.67	23.33	18.67
Qtr2	0.91	3.26	8.92	3.43	2.52	2.00	14.00	16.33	12.33	20.67
Qtr3	1.00	3.67	7.49	2.57	2.05	2.00	6.67	6.67	4.33	5.00
Qtr4	0.80	3.09	8.11	2.14	2.36	2.67	9.00	14.00	8.33	9.33
2015	0.92	3.39	10.24	2.63	2.30	3.25	18.25	15.58	14.58	15.42
Qtr1	0.75	3.22	8.60	2.42	2.45	2.00	9.67	12.00	6.00	7.00
Qtr2	0.91	3.45	12.88	2.51	2.28	2.00	12.00	12.00	7.00	9.33
Qtr3	0.98	3.34	11.39	2.57	2.11	5.00	23.33	12.67	19.67	19.67
Qtr4	1.06	3.54	8.09	3.01	2.35	4.00	28.00	25.67	25.67	25.67
2016	0.92	3.20	8.01	2.19	2.13	4.00	26.42	19.50	14.17	15.67
Qtr1	0.95	3.52		2.36	2.23	4.00	43.67		23.00	25.33
Qtr2	0.97	4.41	12.60	2.39	2.56	4.00	25.33	24.00	13.00	18.00
Qtr3	0.86	2.40	8.10	1.72	1.56	4.00	14.00	10.67	9.67	8.33
Qtr4	0.91	2.47	4.85	2.27	2.17	4.00	22.67	25.33	11.00	11.00
2017	1.15	3.58	9.61	2.40	2.71	4.75	77.33	56.08	20.42	29.75
Qtr1	0.99	3.12	8.00	2.40	2.55	4.00	22.67	22.67	9.67	9.67
Qtr2	1.18	3.56	9.47	2.29	2.62	6.00	131.00	106.67	26.00	24.67
Qtr3	1.24	3.88	9.68	2.59	2.92	5.00	94.00	67.67	23.00	33.67
Qtr4	1.18	3.74	11.27	2.32	2.74	4.00	61.67	27.33	23.00	51.00
2018	1.39	3.43	9.56	2.17	2.12	4.43	78.86	51.67	23.71	15.71
Qtr1	1.26	3.83	11.33	2.45	2.27	4.00	63.00	57.67	15.33	15.33
Qtr2	1.61	3.29	11.00	2.07	2.19	5.50	75.00	75.00	43.00	19.50
Qtr3	1.24	3.05	4.76	1.88	1.81	4.00	106.50	31.00	17.00	12.50

AK: Akelgarh, Kota, AN: Ambedkar Nagar, Keshoraipatan, ND: Nevta Dam, Jaipur, RPM: Raj Rajshwar, Keshoriapatan, RP: Rangpur, Kota

Appendix 3.1: list of category 17 and red category (GPI) industries of Kota district

Sl No	Name of industry	location	Category
1	M/s Coromandal International Limited, Bhimpura Industrial Area, NH-12, Kota	Kota	17 category (Phosphorus Fertilizer)
2	M/s Jagdamba Phosphate, Plot no: 20(B), Bhimpura Industrial Area, NH-12, Kota	Kota	17 category (Phosphorus Fertilizer)
3	M/s DCM Industrial Complex, Shriram Nagar, Kota	Kota	17 category ➢ Chloro Alkali-Cuastic Soda Plant ➢ 125.3 MW Coal Power Plant for captive use at DCM industrial complex ➢ Urea-Nitrogen Fertilizer
4	M/s Chambal Fertilizers & Chemical Limited, Gadepan Line I SPG Line II Line III	Kota	17 category (Urea-Nitrogen Fertilizer) 17 category (Captive Power Plant) 17 category (Urea-Nitrogen Fertilizer) 17 category (Urea-Nitrogen Fertilizer)
5	M/s KTPS, Kota Stage I Stage II Stage III Stage IV Stage V	Kota	17 category (Coal based Power Plant) 17 category (Coal based Power Plant) 17 category (Coal based Power Plant) 17 category (Coal based Power Plant) 17 category (Coal based Power Plant)
6	Surya Chambal Power Ltd, Rangpur	Kota	17 category (Husk based Power Plant)
7	M/s Shriram Rayons, Kota	Kota	Red category (GPI) (9.2 MW Husk/coal based Power Plant for captive use at Rayon cord manufacturing plant)

Appendix 3.2: Water quality analysis report of waste water from different nallah

S. No.	Station	Phosphate as PO4 (mg/l)	pH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	Oil & Grease (mg/l)	Daily Flow, MLD
1	Saji Dehra Nallah	2	7.2	11	17	9	0.6	100.4
2	Fatehgarhi Nallah	1.8	7.06	56	23	11	0.4	66.8
3	Nallah Near Harijan Basti, Shivpura	0.1	7.34	43	34.66	4	0.8	48.8
4	Kishorpura Nallah	3.4	6.78	114	71	18	2	21.4
5	Godavari Dham Nallah Near Aadhar Shila	2.1	6.92	33	37	19	2.6	13
6	Nallah Near Godavari Dham (Ram Dham)	2.6	6.71	54	67.3	8.5	1.8	13
7	Shamshan Road Nallah	1.7	6.93	66	76	32	2.8	12.7
8	Chashme ki Barori Nallah	2.2	6.93	46	31	14	1.6	12
9	Harijan Basti Nallah	2.4	6.96	14	53	26	1.2	10.2
10	Kahi Road Nallah	2	7.15	45	9	3	0.2	6.8
11	Lalaji ka Ghat Nallah	0.5	8.08	20	10	3	0	4.6
12	Barrage Colony Nallah	2.2	6.95	25	39	18	0.8	4.1
13	Kota Barrage Nallah B	1.5	6.67	93	85.03	11	4.2	4.1
14	Sakatpura Nallah	1.8	6.96	15	82	39	1.6	3.8
15	Kunhar Nallah	2.1	7.31	18	20	8	0.4	3.4
16	Shivpura Basti Nallah	0.2	7.38	22	21	8	0.8	3
17	Gawadi Civil Lines Nallah	1.8	7.68	202	62	28	1.8	1.9
18	Bhitariya Kund Nallah	2	6.82	22	26	12	1.4	1.1
19	Nanda ki Bari Nallah	2	7.12	51	44	17	1.6	1.1
20	Sudarshan Mill Nallah	3.2	6.87	56	59	12	2.4	1.1
21	Bamulia Ghat Nallah	2.1	6.89	83	69	31	2.4	1

S. No.	Station	Phosphate as PO4 (mg/l)	pH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	Oil & Grease (mg/l)	Daily Flow, MLD
22	Rajbhawan Road Nallah	1.9	7.05	87	20	8	0.6	0.6
23	Karbala Nallah	2.1	7.17	28	35	17	0.6	0.5
24	Chandmari ke Balaji Nallah	3.1	8.41	38	36	12	1.8	0.5
25	Mukti Marg Nallah	2.4	6.92	157	29	15	0.8	0.4
26	Ghoom Chakkar Nallah	2.8	6.93	52	77	40	2.2	0.4
27	Balita Nallah No. 2	2.8	7.31	284	170.9	22	7.8	0.4
28	Nallah at Balita	0.2	7.67	14	19.48	4.4	1.4	0.4
29	Bhatji Ka Ghat Nallah	1.8	6.96	53	30	16	1.2	0.3
30	Near Lala ji ka Ghat, Nallah No. 2	3.2	6.8	171	348.2	43	12	0.3
31	Karbala Nallah No. 2	3	6.88	257	443.7	53	18	0.3
32	Choti Samadh Nallah	2	7.03	15	34	18	0.6	0.2
33	Karbala Nallah No. 3	3.4	7.26	1237	255.7	31	8.6	0.2
34	Deoli Arab Nallah	2.8	7.15	31	29	14	0.8	
35	Nallah Near Railway Bridge		7.82	78	221.1	23.28	6.8	

Source: RSPCB

Appendix 3.3: City Sanitation Plan, Kota, Ministry of Housing and Urban Affairs, Government of India

Dated : 16/11/2018

State : Rajasthan District : Bundi ULBName : Keshoraipatan (M)

Existing Situation Analysis

Statutory Town(Y/N)	Y	Total No. of Wards	20
Area of the City (Sq. Km)	26.000	No. of HouseHolds 2011 Census	4720
No. of Slums	5	Current City Population	26400
No. of wards with 100% D2D Collection	20	No. of wards with 100% Source Segregation	20
Waste Generated (Other than C&D) (in TPD)	0.000	C&D Waste Generated (in TPD)	8.030
Total Solid Waste Generated (in TPD)	8.030	Waste Transported (Other than C&D) (in TPD)	0.000
C&D Waste Transported (in TPD)	8.030	Total Waste Transported (in TPD)	8.030
Waste Treated (Other than C&D) (in TPD)	0.000	C&D Waste Treated (in TPD)	5.620
Total Waste Treated (in TPD)	5.620	Dry Waste Generated (in TPD)	1.920
Dry Waste Segregated (in TPD)	1.730	Bio Degradable Waste Segregated (in TPD)	0.000
Domestic Hazardous Waste Segregated (in TPD)	0.000	Domestic Hazardous Waste Generated (in TPD)	0.000
C&D Waste Segregated (in TPD)	0.000	Total Waste Segregated (in TPD)	0.000
Decentralized Processing Capacity (in TPD)	0.000	No. of Wards Covered under Decentralized Processing	0
Total Waste Collected (in TPD)	8.030		

Population	Year	Total Population	Slum Population	Floating Population
	2001	21163	1100	1060
	2011	24627	1800	1231
	2019 Projected	28250	2050	1412
	2025 Projected	30500	2300	1525

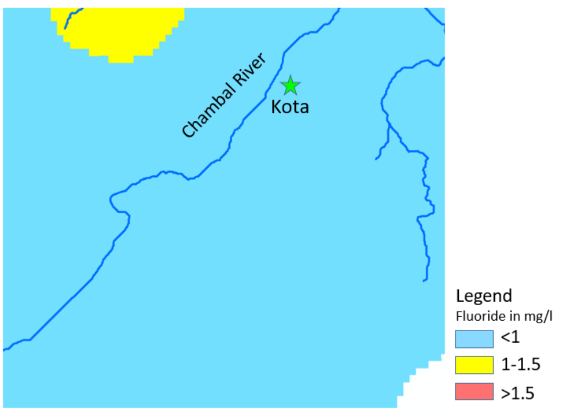
Assumption %age for floating population	5.00

	As per 2011 Census	Projected up to 2019	Justification for the Projection	Current Status
No. of Urban HHs resorting to Open Defecation	1539	100	NA	ODA : 1471
No. of Urban HHs having Pit latrines	0	0	NA	Pit : 0
No. of Urban HHs having Insanitary Latrines	711	0	NA	Insanitary : 0

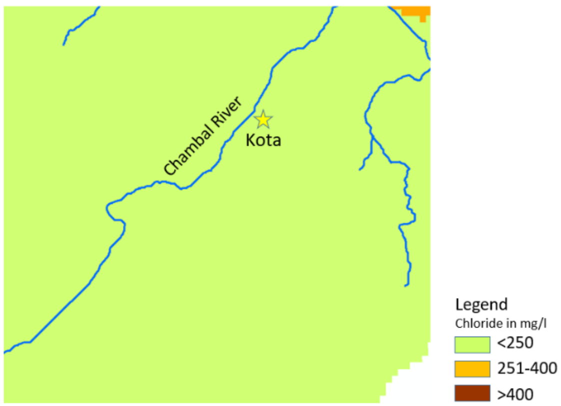
Is Anti Litering Law Incorporated by Law ? Yes/No	N	No. of spot fine made	0
Amount Generated(In Rupees)	0.00	Is User Fee Incorporated by Law ? Yes/No	N
Amount of user fee Generated Residential (In Rupees)	0.00	Amount of user fee Generated Commercial (In Rupees)	0.00
Capacity Building Current Status(Count)	0	Public Awareness IEC Status	15

Appendix 3.4: Groundwater quality maps of Kota area (Source: data provided by CGWB and GWD, Jaipur)

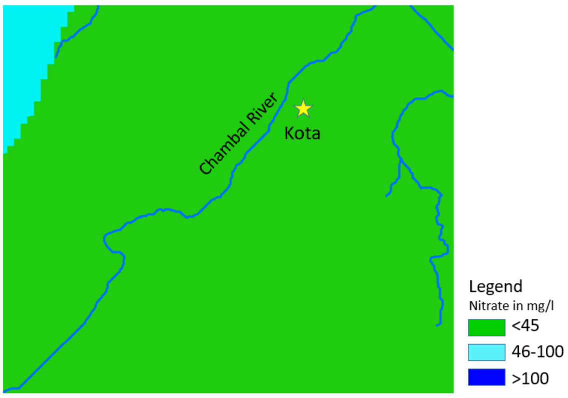
Fluoride (Kota)



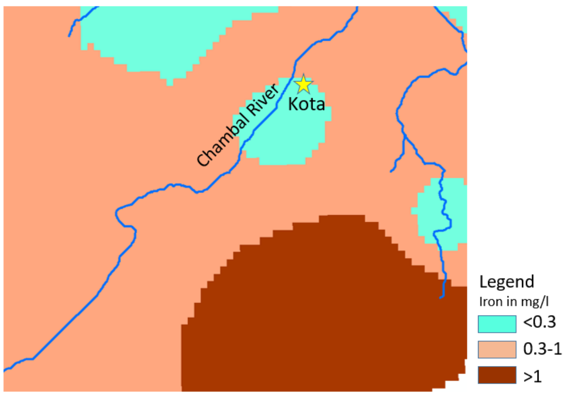
Chloride (Kota)



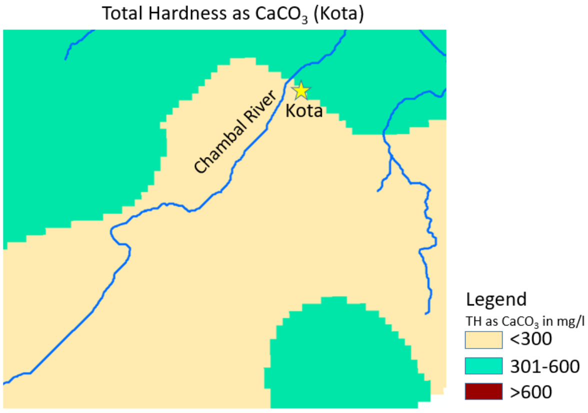
Nitrate (Kota)



Iron (Kota)



Total Hardness as $CaCO_3$ (Kota)



Appendix 3.5: E-flow quality before and after discharge

Before discharge

Date	At Shmshan Ghat of Khedli Phatak Before flow discharge				AT Karbala, Before flow discharge			
	Total Coliform (MPN/100 ml)	pH	DO (mg/l)	B.O.D. (mg/l)	Total Coliform (MPN/100 ml)	pH	DO (mg/l)	B.O.D. (mg/l)
	*Shall be 5000 or less	*Between 6 to 9	*4 mg/l or more	*3 mg/l or less	*Shall be 5000 or less	*Between 6 to 9	*4 mg/l or more	*3 mg/l or less
03-04-2017	460	8.58	3.23	17.15	150	7.91	3.33	16.76
01-05-2017	460	8.04	4.11	3.63	75	8.17	4.31	3.43
08-05-2017	240	7.87	4.41	4.51	120	7.28	4.61	3.92
15-05-2017	240	8.48	4.61	3.82	210	8.2	4.8	3.63
22-05-2017	460	8.61	4.9	3.8	460	8.45	5.2	3.6
29-05-2017	1100	8.09	5.1	3.9	1100	7.95	5.8	3.5
05-06-2017	≥2400	8.13	4.8	4.4	≥2400	8.18	5.4	4.2
12-06-2017	≥2400	8.2	4.9	4.31	1100	8.13	5.68	4.02
19-06-2017	2400	8.25	5.1	4.6	1100	8.17	5.6	4.3
27-06-2017	1100	7.88	5.7	3.8	460	7.64	6	3.8
08-01-2018	460	7.85	4.7	8	460	7.71	4.61	4.15
15-01-2018	240	7.74	6.53	0.77	210	7.66	2.5	0.8
22-01-2018	240	7.73	5.4	2.4	210	7.59	6.5	1.2
29-01-2018	460	7.35	3.4	1.2	120	7.46	2.9	2.4
05-02-2018	210	7.7	5.5	1.3	120	7.53	2.8	2
12-02-2018	460	7.89	4	2	150	7.37	1.1	2.5
19-02-2018	240	7.9	3.98	4.8	120	7.53	2.9	2.3
26-02-2018	210	7.23	2.9	3.5	150	7	2.6	3.2
05-03-2018	240	7.49	4.18	5.6	150	7.32	2.75	3.6
12-03-2018	210	7.76	3.5	2	120	6.81	3.4	5
19-03-2018	240	7.69	3.77	4.6	150	7.48	2.85	4
26-03-2018	460	7.87	4.59	3.7	210	7.74	3.57	4
02-04-2018	240	8.13	5.3	5	210	7.91	3.26	5
09-04-2018	240	8.06	3.47	1	210	7.88	2.96	2.14
16-04-2018	240	7.93	3.7	4.26	150	7.79	3.53	4.86
23-04-2018	460	7.61	3.61	2.35	210	6.8	3.19	2.94
30-04-2018	*	6.92	3.02	2	*	6.81	4.37	2.6
07-05-2018	*	6.95	3.3	5	*	6.89	3.1	3
14-05-2018	*	7.96	4.41	2.31	*	7.72	4.09	2.2
21-05-2018	*	7.84	4.3	3.2	*	7.67	3.9	5.2
28-05-2018	*	7.92	3.88	5	*	7.81	3.04	5
04-06-2018	*	7.96	3.99	3.89	*	7.43	3.36	4.1
11-06-2018	*	7.36	3.36	4	*	6.84	3	7
18-06-2018	*	7.63	3.8	4.2	*	6.71	3.32	4
25-06-2018	*	7.15	3.26	1.8	*	6.78	3.16	4.5

After discharge

Date	At Shmshan Ghat of Khedli Phatak After flow discharge				AT Karbala, After flow discharge			
	Total Coliform (MPN/100 ml)	pH	DO (mg/l)	B.O.D. (mg/l)	Total Coliform (MPN/100 ml)	pH	DO (mg/l)	B.O.D. (mg/l)
	*Shall be 5000 or less	*Between 6 to 9	*4 mg/l or more	*3 mg/l or less	*Shall be 5000 or less	*Between 6 to 9	*4 mg/l or more	*3 mg/l or less
24-04-2017	210	8.63	5.8	4.2	75	8.34	6.7	3.4
01-05-2017	150	7.94	5.1	3.14	20	7.39	6.37	2.16
09-05-2017	93	7.94	5.39	3.23	64	7.69	6.1	2.74
15-05-2017	210	8.25	5.49	3.04	150	8.06	6.17	2.65
22-05-2017	460	8.46	6.2	3.1	240	8.35	6.5	2.6
29-05-2017	1100	8	6.1	2.8	460	7.84	6.7	2.3
05-06-2017	$\geq$2400	8.06	5.9	3.9	1100	7.92	6.4	3.6
12-06-2017	1100	8.22	5.88	3.53	460	8.07	6.56	3.33
19-06-2017	2400	8.15	5.7	3.8	460	8	6.6	3.5
27-06-2017	1100	7.72	6	3.3	460	7.59	6.8	3.1
08-01-2018	210	7.78	5.86	4.13	240	7.59	3.26	2.21
15-01-2018	150	7.7	6.24	0.5	210	7.53	2.4	1.25
22-01-2018	150	7.68	4.5	3.9	150	7.64	2.5	2.2
29-01-2018	240	7.56	4.9	1.8	64	7.24	1.7	4
05-02-2018	120	7.76	6	1.3	75	7.48	3.6	1.8
12-02-2018	210	7.83	5.3	1.4	75	7.51	3.7	2
19-02-2018	460	7.79	4.28	2.5	64	7.63	2.95	2.57
26-02-2018	120	7.46	3.15	4.2	75	7.36	2.7	3.3
05-03-2018	210	7.58	5.8	4.8	75	7.25	3.98	3.2
12-03-2018	150	7.64	4.6	2	64	6.88	4.3	3
19-03-2018	150	7.73	4.69	3	75	7.56	3.16	3.6
26-03-2018	240	7.78	5.51	2.6	120	7.61	4.69	3.1
02-04-2018	210	8.19	6.12	3	150	8.1	4.26	3.2
09-04-2018	210	7.95	4.08	2.96	150	7.71	3.37	1.12
16-04-2018	150	7.65	5.12	2.6	120	7.88	2.89	10
23-04-2018	240	7.84	3.78	3.36	150	6.87	3.11	5.71
30-04-2018	*	7.26	4.45	1	*	6.73	3.86	1.8
07-05-2018	*	6.78	3.65	4.6	*	6.7	3.48	2.6
14-05-2018	*	8.03	3.9	1.15	*	7.84	3.57	1.26
21-05-2018	*	7.96	4.7	2.6	*	7.79	4.2	3.8
28-05-2018	*	8.03	4.09	4.2	*	7.72	3.36	4.7
04-06-2018	*	8.06	4.41	3.36	*	7.2	4.41	3.15
11-06-2018	*	7.25	4.2	3.36	*	6.73	3.36	6.72
18-06-2018	*	7.96	3.28	5.2	*	6.83	3.44	4.8
25-06-2018	*	7.4	3.2	2.2	*	6.71	4.2	3.8

*Total Coliform (MPN/100 ml) could not be analyzed after 27/04/2018 due to instrument failure

Appendix 3.6: Photographs of Kota STP Inlet, outlet etc. taken during the field visit

30MLD STP inlet at sajidheda– Kota

STP out let at sajidheda – Kota

Mixing of STP outlet with untreated effluent

Appendix 3.7: Report on Organo Chlorine Pesticides (OCP) by RSPCB

केन्द्रीय प्रदूषण नियंत्रण बोर्ड
CENTRAL POLLUTION CONTROL BOARD
(पर्यावरण एवं वन मंत्रालय, भारत सरकार)
(MINISTRY OF ENVIRONMENT & FORESTS, GOVT. OF INDIA)

C-11012/25/2008-NRTOL/ 5177

August 29, 2014

To

Member Secretary
Rajasthan State Pollution Control Board
A-4, Jalane Dungri Institutional Area
Jaipur-302 004
Rajasthan

Supdt 30 (BRC)
21
9/8/14

Sub: Analysis report of Organo Chlorine Pesticides (OCPs) analysis in water samples forwarded by Rajasthan State Pollution Control Board, Kota – regarding.

Ref: Registration No. 11283/Inst-109/2K14.

Dear Sir,

With reference to above, please find enclosed herewith the analysis report of water samples for Organo Chlorine Pesticides (OCPs) analysis (109 Nos.), forwarded by Rajasthan State Pollution Control Board, Kota for analysis. Kindly acknowledge the receipt of analysis report.

Yours faithfully,

Encl: As above.

C.S.O

(Dr. C S Sharma)
Senior Scientist &
I/c NRTOL

13537
9/9/14

परिवेश भवन, पूर्वी अर्जुन नगर, दिल्ली-110032
Parivesh Bhawan, East Arjun Nagar, Delhi - 110032
Fax 22305793, 22307078, 22307079, 22301932, 22304948
Website : www.cpcb.nic.in

CENTRAL POLLUTION CONTROL BOARD
Parivesh Bhawan, East Arjun Nagar, Delhi-110 032

National Reference Trace Organics Laboratory

Pesticide Analysis Report (OCPs)

1. Report no. & issue date : Pest/Inst-06 Dt.28/08/2014
2. Name of the Project : Water Quality Monitoring
3. Sample matrix : Water(Extracted Sample)
4. Date & time of sample collection : April 2014
5. Samples collected by : Rajasthan State Pollution Control Board,Kota
6. Date & time of sample receipt : 13/05/14
7. Date of sample analysis : July 2014
8. Sample registration no. & date : 11283/Inst-109/2K14
9. Sampling plan reference :
10. Test method reference : CB/CL/TM/5.4/C-54
11. Report sent to (Name & Address) : MS,Rajasthan State Pollution Control Board,Jaipur

S. No.	Sample code	Total BHC Ng/l	Aldrin ng/l	Total Endosulfan Ng/l	Dieldrin Ng/l	Total DDT Ng/l
1	PB	NT	NT	NT	NT	NT
2	P-1	NT	NT	NT	NT	129.56
3	P-2	NT	NT	NT	NT	31.44
4	P-3	NT	NT	NT	NT	18.64
5	P-4	NT	NT	NT	NT	20.84
6	P-5	NT	NT	NT	NT	37.60
7	P-6	NT	NT	NT	NT	NT
8	P-7	NT	NT	NT	NT	35.08
9	P-8	NT	NT	NT	NT	207.52
10	P-9	NT	NT	NT	NT	41.04

Statement:

1. The results relate only to the samples tested.
2. The report shall not be reproduced except in full, without the written approval of the laboratory

Analyst　　　　B.K.　Supervisor　　　　I/c NRTOL

	83	A-83, M-83 & P-83	2022	22/04/2014	HANDPUMP NEAR RANAPRATAP NAGAR RAILWAY STATION, UDAIPUR	HANDPUMP WATER
	84	A-84, M-84 & P-84	2023	22/04/2014	OPEN WELL HOTEL, ORIENTAL PALACE, SUBHASH NAGAR, UDAIPUR	OPEN WELL WATER
	85	A-85, M-85 & P-85	2940	21/04/2014	LAKE GAPE SAGAR, DUNGARPUR	LAKE GAPE SAGAR, DUNGARPUR
	86	A-86, M-86 & P-86	2941	21/04/2014	LAKE JAISAMAND, SALUMBER, UDAIPUR (POINT 1)	LAKE JAISAMAND, SALUMBER, UDAIPUR (POINT 1)
	87	A-87, M-87 & P-87	2942	21/04/2014	LAKE JAISAMAND, SALUMBER, UDAIPUR (POINT 2)	LAKE JAISAMAND, SALUMBER, UDAIPUR (POINT 2)
	88	A-88, M-88 & P-88	2938	23/04/2014	RAJSAMAND LAKE, RAJSAMAND	NEAR DWARIKADHISH TEMPLE (POINT 1)
	89	A-89, M-89 & P-89	2939	23/04/2014	RAJSAMAND LAKE, RAJSAMAND	NEAR P.H.E.D. PUMP HOUSE (POINT 2)
1	90	A-90, M-90 & P-90	1288	24/04/2014	RIVER CHAMBAL AT KOTA	AT AKELGARH U/S OF KOTA BARRAGE
	91	A-91, M-91 & P-91	2935	24/04/2014	JET SAGAR, BUNDI	AT NEAR PUMP HOUSE
2	92	A-92, M-92 & P-92	10030	24/04/2014	RIVER CHAMBAL KESHORAIPATAN DISTRICT-BUNDI	D/S OF KESHORAIPATAN NEAR AMBEDKAR NAGAR
3	93	A-93, M-93 & P-93	10029	24/04/2014	RIVER CHAMBAL KESHORAIPATAN DISTRICT-BUNDI	U/S OF KESHORAIPATAN NEAR SHRI RAJRAJESHWAR MAHADEV TEMPLE
4.	94	A-94, M-94 & P-94	1289	24/04/2014	RIVER CHAMBAL AT RANGPUR VILLAGE, KOTA	AT RANGPUR VILLAGE D/S OF KOTA BARRAGE
	95	A-95, M-95 & P-95	2933	23/04/2014	GANG CANAL AT KHAKKA HEAD NEAR HINDUMAL KOT, SHRI GANGANAGAR	GANG CANAL AT KHAKKA HEAD NEAR HINDUMAL KOT, SHRI GANGANAGAR
	96	A-96, M-96 & P-96	2934	24/04/2014	MASTIWALA HEAD, HANUMANGARH	MASTIWALA HEAD, HANUMANGARH
	97	A-97, M-97 & P-97	1717	23/04/2014	KODRA DAM, MOUNT ABU, DISTT-SIROHI	NEAR PHED INTAKE
	98	A-98, M-98 & P-98	1716	23/04/2014	NAKKI LAKE, MT. ABU	MIDDLE OF LAKE (NEAR PHED PUMPING STATION)
	99	A-99, M-99 & P-99	2950	23/04/2014	WEST BANAS DAM (DHANARI DAM) DISTT-SIROHI	NEAR DAM
	100	A-100, M-100 & P-100	2947	23/04/2014	JAWAI DAM, DISTT-PALI	BANK OF DAM

Regional Officer
R.S.P.C.B., Kota

	Sample code	Total BHC ng/l	Aldrin ng/l	Total Endosulfan ng/l	Dieldrin ng/l	Total DDT ng/l
65	P-64	NT	NT	NT	NT	NT
66	P-65	NT	NT	NT	NT	26.88
67	P-66	NT	NT	NT	NT	27.12
68	P-67	NT	NT	NT	NT	121 60
69	P-68	NT	NT	NT	NT	NT
70	P-69-	NT	NT	NT	NT	NT
71	P-70	NT	NT	NT	NT	NT
72	P-71	NT	NT	NT	NT	167.56
73	P-72	NT	NT	NT	NT	176.40
74	P-73	NT	NT	NT	NT	181.68
75	P-74	NT	NT	NT	NT	37.72
76	P-75	NT	NT	NT	NT	24 48
77	P-76	NT	NT	NT	NT	18.84
78	P-77	NT	NT	NT	NT	175.56
79	P-78	NT	NT	NT	NT	145.12
80	P-79	NT	NT	NT	NT	245.88
81	P-80	NT	NT	NT	NT	70.12
82	P-81	NT	NT	NT	NT	153 80
83	P-82	NT	NT	NT	NT	164 16
84	P-83	NT	NT	NT	NT	27.80
85	P-84	NT	NT	NT	NT	177 40
86	P-85	NT	NT	NT	NT	26.24
87	P-86	NT	NT	NT	NT	18.72
88	P-87	NT	NT	NT	NT	20.80
89	P-88	NT	NT	NT	NT	NT
90	P-89	NT	NT	NT	NT	93.76
91	P-90	NT	NT	NT	NT	168 96

1. **Statement:** The results relate only to the samples tested.
2. The report shall not be reproduced except in full, without the written approval of the laboratory.

Analyst Supervisor I/c NRTOL

S. No.	Sample code	Total BHC ng/l	Aldrin ng/l	Total Endosulfan ng/l	Dieldrin ng/l	Total DDT ng/l
~~92~~	~~P-91~~	~~NT~~	~~NT~~	~~NT~~	~~NT~~	~~215.88~~
2 93	P-92	NT	NT	NT	NT	90 16
3 94	P-93	NT	NT	NT	NT	276.76
4 95	P-94	NT	NT	NT	NT	282.68
96	P-95	NT	NT	NT	NT	124.88
97	P-96	NT	NT	NT	NT	136.80
98	P-97	NT	NT	NT	NT	33 36
99	P-98	NT	NT	NT	NT	164 24
100	P-99	NT	NT	NT	NT	277.04
101	P-100	NT	NT	NT	NT	109 44
102	P-101	NT	NT	NT	NT	113 96
103	P-102	NT	NT	NT	NT	237 04
104	P-103	NT	NT	NT	NT	126 40
105	P-104	NT	NT	NT	NT	429 20
106	P-105	NT	NT	NT	NT	139.00
107	P-106	NT	NT	NT	NT	313.36
108	P-107	NT	NT	NT	NT	[illegible]21 84
109	P-108	NT	NT	NT	NT	255 40

1. **Statement:** The results relate only to the samples tested.
2. The report shall not be reproduced except in full, without the written approval of the laboratory.

Note- Please see remark on reverse.

Analyst Supervisor I/c NRTOL

Appendix 4.1: City Sanitation Plan, Keshoraipatan, Ministry of Housing and Urban Affairs, Government of India

Dated : 16/11/2018

State : Rajasthan District : Bundi ULBName : Keshoraipatan (M)

Existing Situation Analysis

Statutory Town(Y/N)	Y	Total No. of Wards	20
Area of the City (Sq. Km)	26.000	No. of HouseHolds 2011 Census	4720
No. of Slums	5	Current City Population	26400
No. of wards with 100% D2D Collection	20	No. of wards with 100% Source Segregation	20
Waste Generated (Other than C&D) (in TPD)	0.000	C&D Waste Generated (in TPD)	8.030
Total Solid Waste Generated (in TPD)	8.030	Waste Transported (Other than C&D) (in TPD)	0.000
C&D Waste Transported (in TPD)	8.030	Total Waste Transported (in TPD)	8.030
Waste Treated (Other than C&D) (in TPD)	0.000	C&D Waste Treated (in TPD)	5.620
Total Waste Treated (in TPD)	5.620	Dry Waste Generated (in TPD)	1.920
Dry Waste Segregated (in TPD)	1.730	Bio Degradable Waste Segregated (in TPD)	0.000
Domestic Hazardous Waste Segregated (in TPD)	0.000	Domestic Hazardous Waste Generated (in TPD)	0.000
C&D Waste Segregated (in TPD)	0.000	Total Waste Segregated (in TPD)	0.000
Decentralized Processing Capacity (in TPD)	0.000	No. of Wards Covered under Decentralized Processing	0
Total Waste Collected (in TPD)	8.030		

Population	Year	Total Population	Slum Population	Floating Population
	2001	21163	1100	1060
	2011	24627	1800	1231
	2019 Projected	28250	2050	1412
	2025 Projected	30500	2300	1525

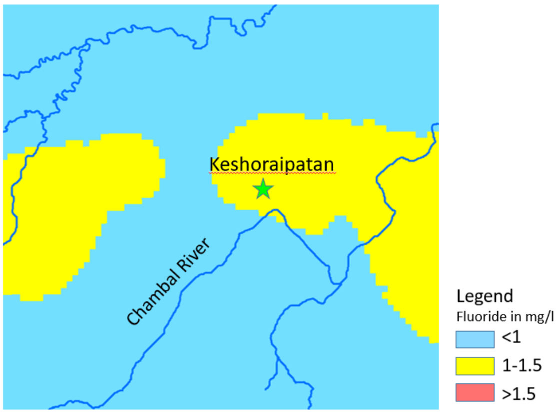
Assumption %age for floating population	5.00

	As per 2011 Census	Projected up to 2019	Justification for the Projection	Current Status
No. of Urban HHs resorting to Open Defecation	1539	100	NA	ODA : 1471
No. of Urban HHs having Pit latrines	0	0	NA	Pit : 0
No. of Urban HHs having Insanitary Latrines	711	0	NA	Insanitary : 0

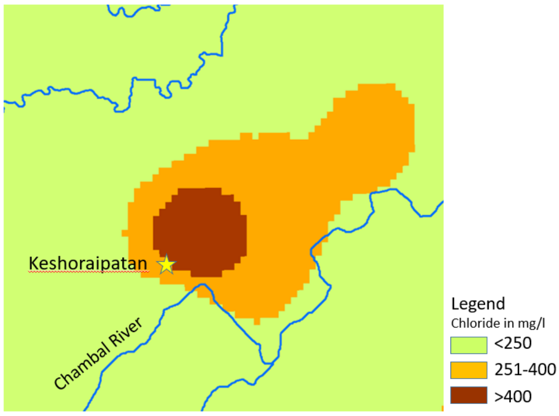
Is Anti Litering Law Incorporated by Law ? Yes/No	N	No. of spot fine made	0
Amount Generated(In Rupees)	0.00	Is User Fee Incorporated by Law ? Yes/No	N
Amount of user fee Generated Residential (In Rupees)	0.00	Amount of user fee Generated Commercial (In Rupees)	0.00
Capacity Building Current Status(Count)	0	Public Awareness IEC Status	15

Appendix 4.2: Groundwater quality maps of Keshoraipatan area (Source: data provided by CGWB and GWD, Jaipur)

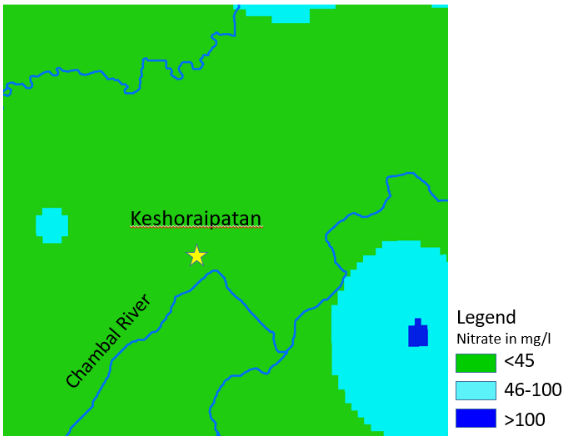
Fluoride (Keshoraipatan)



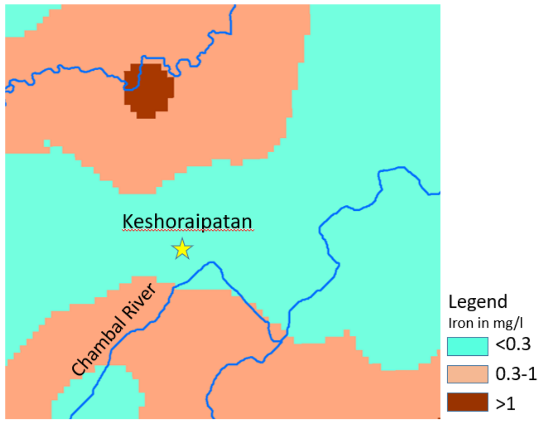
Chloride (Keshoraipatan)



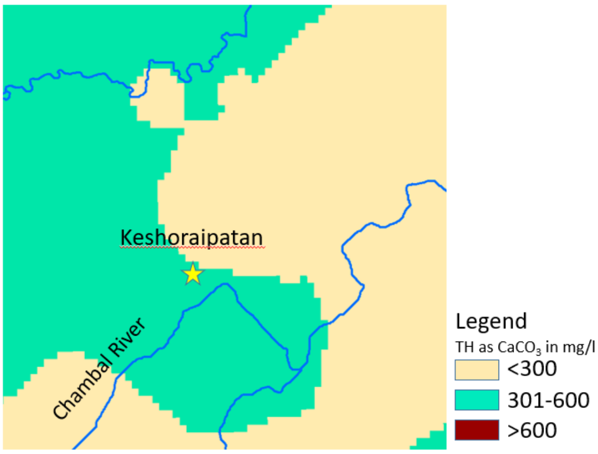
Nitrate (Keshoraipatan)



Iron (Keshoraipatan)



Total Hardness as $CaCO_3$ (Keshoraipatan)



Appendix 4.3: Photographs of Keshoraipatan area, from reports and taken during the field visit

Natural drain carrying domestic sewage (RUIDP)

Outfall 4 draining into Chambal river (RUIDP)

Ambedkar Nagar

Raj Rajeshwar Mahadev Temple

Keshav Nagar

Appendix 4.4: Water quality analysis report of waste water from different nallah

S. No.	Station	Phosphate as PO4 (mg/l)	pH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	Oil & Grease (mg/l)
1	Nallah Near Shamshan, Ward No. 7	2.2	7.48	59	55	29	1.4
2	Nallah Near Garhi Hanuman, Ward No. 7	1.7	7.95	2024	81	37	2
3	Nallah Near Jain Mandir, Ward No. 8	2.4	7.51	2241	72	38	1.8
4	Nallah Near Chipa Ghat, Ward No. 14	2.1	8.09	95	73	35	1.6
5	Nallah Near Bagichi, Ward No. 16	2.2	7.15	53	63	29	1.4
6	Nallah Near Ambedkar Colony, Ward No. 16	2.6	7.55	374	61	31	1.2

Source: RSPCB

Appendix 5.1: Excerpts from the report "Uncomfortable Nexus"

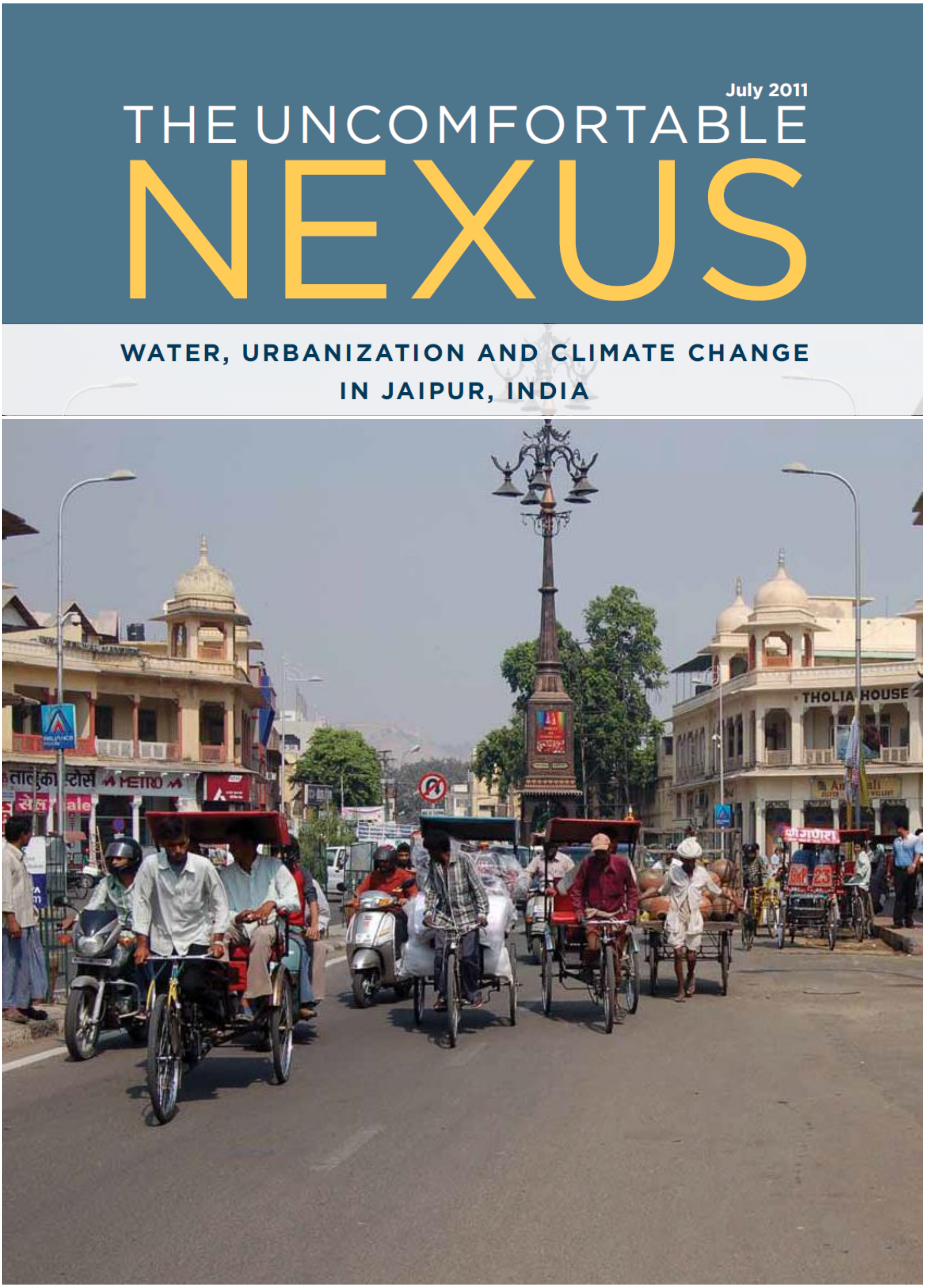


Figure 2.5:
Annual rainfall totals (mm) at select sites around Jaipur city.

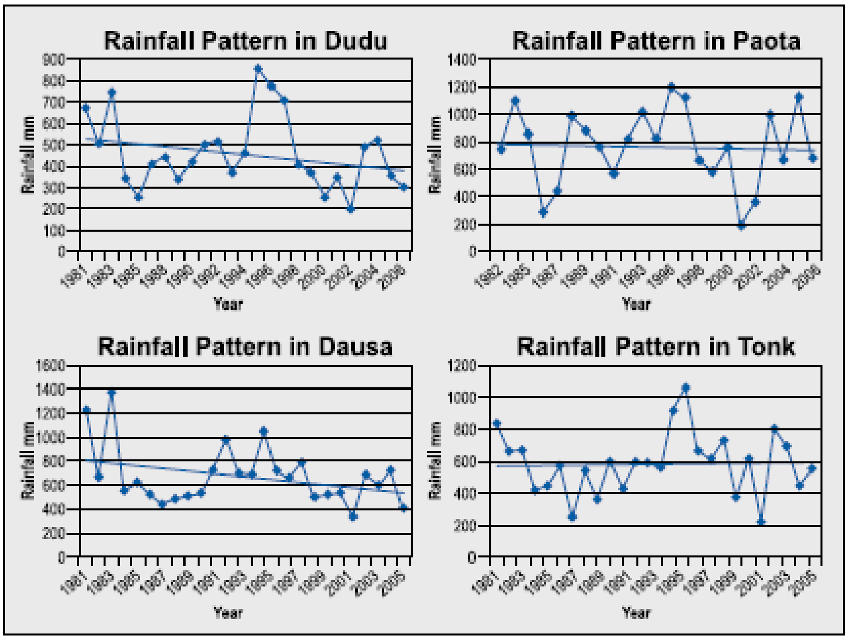
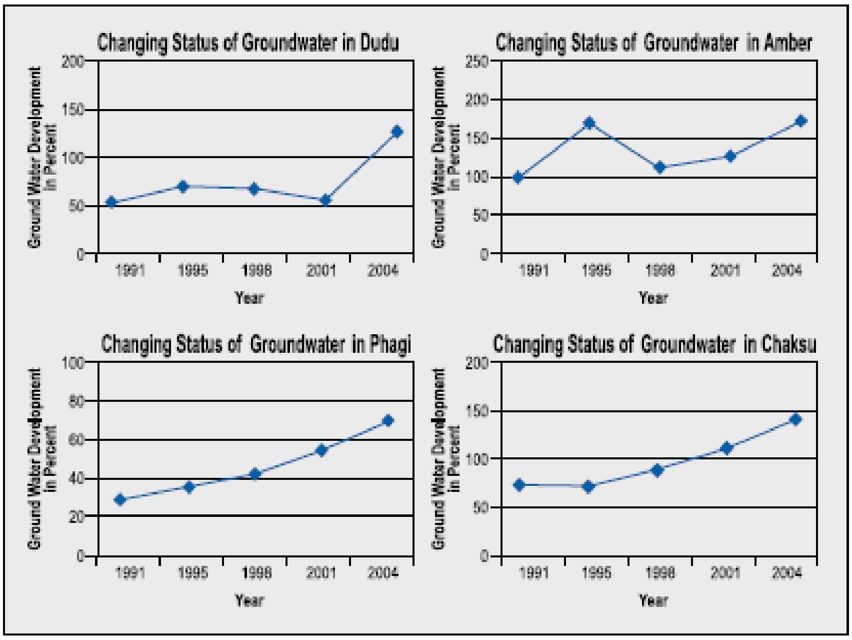


Figure 2.6:
Groundwater extraction rates over time in select sites around Jaipur city.



CHAPTER 4

RAINFALL, CLIMATE CHANGE AND WATER SUPPLY IN JAIPUR

INTRODUCTION

This chapter examines how rainfall patterns in the Banas River Basin might be altered in the near future (2010-2040) under various climate change scenarios and discusses the potential impacts of these changes on streamflow in the Banas River. Climate change scenarios on global and regional scales are generated by general circulation models (GCMs) and regional circulation models (RCMs). GCMs and RCMs are driven by different scenarios, known as the Special Report on Emissions Scenarios or SRES scenarios, of potential future greenhouse gas emissions based on population, energy choices and economic development. There are four primary SRES scenario families – A1, B1, A2 and B2 – developed by the Intergovernmental Panel on Climate Change (IPCC) that were each formulated from conditions in 2000 and then taken forward into the future under different growth pathways (Nakicenovic et al. 2000). Each SRES scenario is associated with varied levels of greenhouse gas emissions and rates of growth in those emissions through 2100. GCMs are driven by the scenarios in order to see how the planet's climate might be impacted if certain greenhouse gas emission levels, population, energy and economic choices are made. In the most recent IPCC assessment (2007), most of the GCMs were driven by the emissions scenarios B1, A1B and A2 as shown in Figure 4.1[1].

[1] The latest set of GCMs are being driven by new emissions scenarios, called Representative Concentration Pathways, that were developed with updated scientific knowledge, policy preferences and observations of human behavior over the past decade. The new climate change projections will be release in the Fifth IPCC Assessment in 2013.

- B1 assumes that the global population grows rapidly to approximately 9 billion until about 2050 where it begins to taper off. In addition, the global economy becomes more integrated and environmentally sustainable, relying less on fossil fuels.

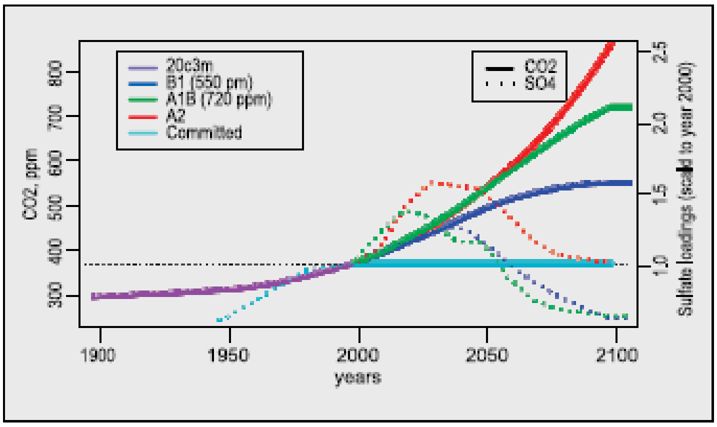
- A1B has similar population growth scenarios as B1, with the spread of efficient technologies and a balanced reliance on renewable and fossil fuel energy sources.

- A2 is one of the more pessimistic scenarios, with continuous population growth and fragmented economic, energy and technological growth, leading to higher emissions by the end of twenty-first century.

GCMs model the complex physical energy and water exchanges between the land, oceans and atmosphere on a global grid in which each grid space has a resolution of ~100 to 300 km, depending on the model. While GCMs are sufficient for investigating potential changes in climate patterns, such as winds or temperature at large scales, the spatial resolution of the models is too coarse to inform much about how rainfall might change in a small river basin or for a city. In order to examine potential local changes, it is necessary to downscale the climate change projections of GCMs to a smaller scale. With this, there are a number of various techniques for downscaling, each having different capabilities and limitations. RCMs are considered a downscaling technique, as they generate climate projections on a scale of ~25 to 50km. However, RCMs take significant time and computational resources to run, which were not available for this project. For a more detailed discussion of various downscaling techniques, which is beyond the scope of this chapter, the reader could refer to Wilby and Wigley (1997) or Wilby et al. (2004).

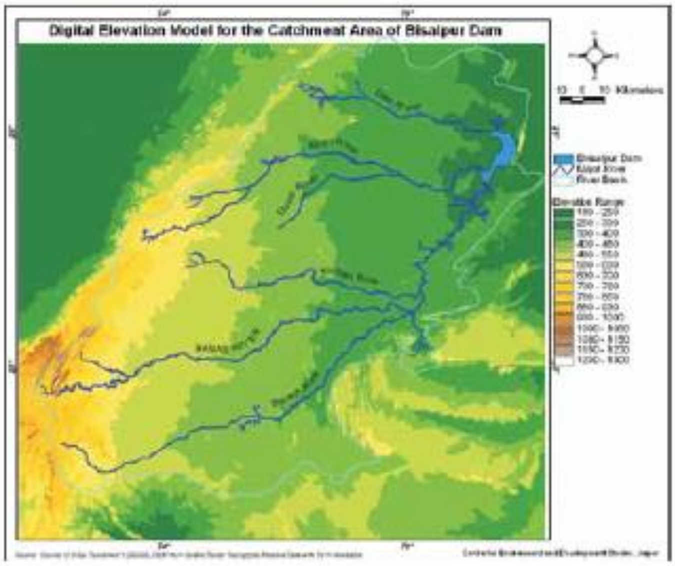
The selection of the downscaling technique is determined by a number of factors including: what climate change information is desired and the purpose of the study, the scale (weather station, river basin, region, etc.) being investigated, and the amount of time and computational resources the climate scientist has available to do the downscaling. For this study, we were interested in seeing how rainfall patterns might change in the Banas River catchment area of Bisalpur Reservoir under different SRES emission scenarios (A2 and A1B) according to different GCMs. In turn, we wanted to investigate how potential shifts in rainfall might impact streamflow in the catchment area, which when coupled with likely shifts in rural-to-urban migration and water demand, could provide insight into Jaipur's future water supply vulnerability. We then developed a simple rainfall-streamflow regression model to

Figure 4.1:
Common SRES emission scenarios (Source: Environment Canada 2011).



generate synthetic sequences of potential future streamflow, which were conditioned on the downscaled rainfall. The vulnerability of Jaipur's water supply was then investigated using the synthetic streamflow sequences, plausible scenarios of future migration and water demand through an integrated water planning tool known as the Water Evaluation and Planning (WEAP) software developed by the Stockholm Environment Institute (SEI). The WEAP models and their results are discussed in the next chapter.

Figure 4.2:
Catchment area of Bisalpur Reservoir.



CONCEPTS IN INTERPRETING CLIMATE SCENARIO INFORMATION

CLIMATE SCIENCE DEFINITIONS

Before delving into the actual downscaling methodology and rainfall projections for the basin, it is necessary for the reader to understand a few key concepts about interpreting climate change information.

A key challenge to communicating climate change science and translating information outputs is simply that the language used by climate scientists has very different meanings than the language used by non-climate scientists, even when they are the same word. Terms such as: *forecast, prediction, projection, scenario or uncertainty* have very different meanings to climatologists and meteorologists than they do to lay people. Furthermore, scientists from different disciplines may even use different definitions for the same words. These inconsistencies in language use and understanding between scientists muddle the field and add confusion for non-scientists (Bray and von Storch 2009; Opitz-Stapleton 2010; Klemens 2009; MacCracken 2001; Connolley 2007).[2]

Below are what we believe to be the clearest climate science definitions of the words that are commonly encountered in accessing climate information, as compiled from a variety of sources. These definitions are not written from the perspective of lay terminology, but rather from the perspective of climate scientists to provide a sense of what climate scientists generally mean when using these terms. However, it is important to remember that there remains significant confusion even among meteorologists and climatologists over this terminology, which underscores the importance of dialogue

[2] For different definitions of "predictions" versus "projections", refer to: http://sciencepolicy.colorado.edu/zine/archives/1-29/26/guest.html or http://scx.sagepub.com/content/30/4/534.short or http://scienceblogs.com/stoat/2007/08/projection_prediction.php or http://modelingwithdata.org/arch/00000024.htm

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