CWC/2020/104

सत्यमेव जयते

Government of India

Ministry of Jal Shakti,

Department of Water Resources,
River Development and Ganga Rejuvenation

Water Quality Monitoring of Canals

August, 2020

Central Water Commission

Cover & Back page:

Indira Gandhi Main & Lift Canals

Photograph courtesy by Sh. Nitish Kumar Singh, SRA

Executive Summary

A meeting was held under the Chairmanship of Shri Gajendra Singh Shekhawat, Hon'ble Minister of Jal Shakti, Government of India through video-conferencing on 10th April, 2020 to review "Water Quality Activities of Central Water Commission". During the meeting, it was desired by the Hon'ble Minister that water quality of Sirhind Feeder Canal, Rajasthan Feeder Canal and Indira Gandhi Canal should be assessed by CWC at vulnerable places and at locations from which domestic water supply is being made to important cities of Rajasthan. In this regard, 25 probable locations on these Canals were identified.

The investigated water quality analysis results of these canals from 25 selected locations are compared with the BIS 10500:2012 standards and CPCB standards for Designated Best Use. Surface Water samples collected from all the Canals were found within acceptable limit with respect to most of the physical and chemical parameters (e.g. pH, EC, TDS, DO, Mg^{+2}, Ca^{+2}, Cl^{-}, F^{-}, NO_3^{-}, SO_4^{-2}). Water samples from these Canals were also found within acceptable limit with respect to all the heavy metals e.g. arsenic, chromium, cadmium, copper, iron, nickel, lead and zinc indicating the absence of industrial pollution in these canals. Also, the results of Pesticide analysis of the canal water samples were found to be Below Detection Limit.

However, Canal water samples were found beyond acceptable limit as per CPCB standards for Designated Best Use with respect to Total Coliform and Fecal Coliform which is an indication of presence of animal or human waste. Also, at 12 locations, BOD concentration was found to be beyond the acceptable limit as per CPCB standards for Class A, B & C.

CONTENTS

S.NO.	DESCRIPTION	PAGE NO.
1	INTRODUCTION	1
2	WATER QUALITY MONITORING OF INDIRA GANDHI CANAL, RAJASTHAN FEEDER AND SIRHIND FEEDER	4
3	WATER QUALITY STANDARDS	10
4	WATER QUALITY MONITORING	13
	- SAMPLING LOCATIONS	13
	- FIELD SURVEY	15
	- ANALYSIS AND OBSERVATIONS	19
5	CONCLUSIONS	30
6	ANNEXURE I	31
7	ANNEXURE II	32
8	ANNEXURE III	33

LIST OF TABLES

Table 1	Basin-wise water-quality stations monitored by CWC	2
Table 2	Designated Best Uses of Water by CPCB	11
Table 3	Drinking Water Quality Standards, BIS: 10500, 2012	12
Table 4	Locations identified for collecting samples from Canal system	14
Table 5	Heavy Metals concentration in Canal water samples	27
Table 6	Suitability of Canal Water as per CPCB standards for Designated Best Use and BIS: 10500: 2012.	29

LIST OF FIGURES

Figure 1	Water quality laboratories of CWC	3
Figure 2	Map showing Indira Gandhi Canal, Sirhind feeder and Rajasthan Feeder	5
Figure 3	Main Branches of Indira Gandhi Canal	6
Figure 4	Rajasthan and Sirhind Feeder run parallel with common bank	8
Figure 5	Sampling Locations (1-25) identified on the Indira Gandhi Canal, Rajasthan feeder and Sirhind Feeder	13
Figure 6	Laboratory analysis of samples received from Canals.	19
Figure 7	pH variation in Canal Water	20

Figure 8	Electrical Conductivity variation in Canal Water	21
Figure 9	Total Dissolved Solids (TDS) variation in Canal Water	21
Figure 10	Dissolved Oxygen (DO) variation in Canal Water	22
Figure 11	Bio-Chemical Oxygen Demand variation in Canal Water	23
Figure 12	Total Coliform variation in Canal Water	25
Figure 13	Fecal Coliform variation in Canal Water	25

Introduction

Water quality monitoring is one of the most important components in environmental management of aquatic ecosystems. Monitoring of water quality provides water managers with the necessary information for sustainable water resources management and provides insight into complex dynamic environmental processes as reliable, consistent, and appropriate information is necessary to understand the water resources. Due to the direct or indirect activities from natural and anthropogenic sources, water quality on earth's surface such as of lakes, rivers, canals and groundwater etc. are getting deteriorated day by day. In comparison to groundwater, the surface water gets polluted more easily as it is open to atmosphere and for which its quality monitoring is also a major concern.

Presently, Central Water Commission (CWC) is monitoring river water quality at its 634 key hydrological observation stations covering all the important river basins of India. Also, water quality samples are being collected from 33 water quality sampling stations. Further, CWC is planning to increase the water quality network on Indian rivers by considering future objectives and necessities, to cover each and every river in the country. The basin wise split of 667 WQ monitoring stations of CWC as on June 2020 are depicted in Table 1.

At present, CWC is maintaining a three tier laboratory system for analysis of the physio-chemical parameters of the water. The Level-I laboratories are located at 295 field water quality monitoring stations on major rivers of India where physical parameters such as temperature, colour, odour, specific conductivity, total dissolved solids, pH and dissolved oxygen of river water are observed. There are 18 Level–II laboratories located at selected division offices throughout India to analyses 25 no. of physio-chemical and bacteriological parameters of water. 5 Level-III laboratories are functioning at Varanasi, Delhi, Hyderabad, Coimbatore and Guwahati where 41 parameters including heavy metals / toxic parameters and pesticides are analysed. The list of 23 Level-II and Level-III laboratories

and parameters analysed in the laboratories given in Annexure-I and Annexure-II respectively.

Table 1: Basin-wise water-quality stations monitored by CWC

S.No.	Basin	GDQ	GDSQ	GQ	WQSS	Total
1	Brahmani-Baitarni Basin		11	1	14	26
2	Cauvery Basin	17	24			41
3	East Flowing rivers between Mahanadi and Pennar		5			5
4	East Flowing rivers between Pennar and Kanyakumari	10	8			18
5	Ganga/Brahmaputra/Meghna/Barak	76	162	96	5	339
6	Godavari Basin	13	32	4		49
7	Indus Basin	3	8			11
8	Krishna Basin	12	29	3		44
9	Mahanadi Basin	1	22		8	31
10	Mahi Basin	2	3			5
11	Minor Rivers Draining into Myanmar and Bangladesh		6			6
12	Narmada Basin	5	10	1		16
13	Pennar Basin	4	4			8
14	Sabarmati Basin	1	1		1	3
15	Subarnarekha Basin	1	6		5	12
16	Tapi Basin	1	3			4
17	West Flowing rivers from Tadri to Kanyakumari	9	26			35
18	West flowing rivers from Tapi to Tadri	4	5			9
19	West flowing rivers of Kutchh and Saurashtra including Luni	2	3			5
Total		**161**	**368**	**105**	**33**	**667**

Out of 23, 12 laboratories of CWC have got accreditation by National Accreditation Board for Testing and Calibration Laboratories (NABL) and 11 laboratories are under process of accreditation, details of which are given in figure 1.

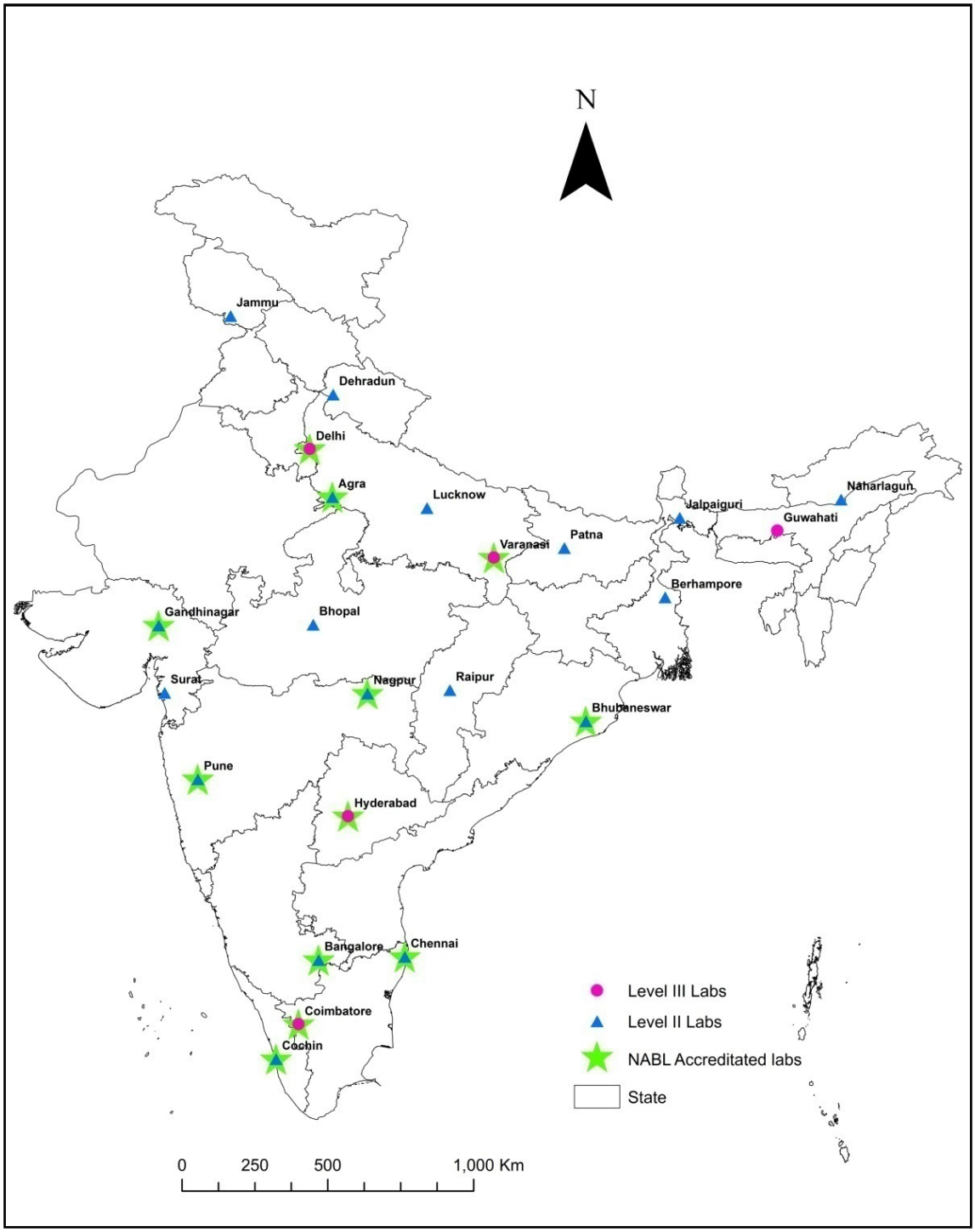

Figure 1: Water quality laboratories of CWC

Water Quality Monitoring of Indira Gandhi canal, Rajasthan Feeder and Sirhind Feeder

Canals are also an important part of Earth's water cycle. Canal provides a home, drinking water and a hunting ground for many organisms. Canal provides irrigation water, transportation, hydro-electrical power drainage, food and recreation opportunities. As water quality perturbations related to escalating human population growth and industry pressures continue to increase, effective water quality monitoring of canals has become critical for water resource management programs. Three important canals have been selected for water quality monitoring in Punjab and Rajasthan.

During the meeting held under the Chairmanship of Sh. Gajendra Singh Shekhawat, Hon'ble Minister of Jal Shakti, Government of India through video-conferencing on 10th April 2020 to review "Water Quality Activities of Central Water Commission", it was desired that Water Quality of Sirhind feeder, Rajasthan Feeder Canal and Indira Gandhi Canal Project should be assessed by CWC at vulnerable locations and at locations from which domestic water supply is being made to important cities of Rajasthan and the same should be taken up within a month of lifting of present lock-down.

In this regard, a desktop study was conducted and 25 probable sampling locations i.e 5 on the Sirhind Feeder & Rajastha feeder Canal and 20 on Indira Gandhi Canal Project were identified. 5 teams from CWC had taken 25 water samples from these canals during the 1st week of June 2020.

The collected canal water samples were analysed in the Water Quality Laboratories of CWC. Physio-Chemical and Biological WQ parameters analysis has been done at Chenab Division WQ Lab, IBO, Jammu and National River WQ Lab (NRWQL), YBO, New Delhi. Further, Trace & Toxic Metal analysis has been done at NRWQL, YBO, New Delhi and Pesticides analysis has been done at Lower Cauvery Water Quality Laboratory (LCWQL), CSRO, Coimbatore. The analysis of physio-chemical parameters and Trace & Toxic Metal were completed in the last week of June 2020. And, the analysis of Pesticides for canal water samples was completed in the first week of August, 2020.

Indira Gandhi Canal

It is the largest irrigation project of the world to provide irrigation to semi-arid and arid areas of Rajasthan and it has given a face lift to its economy and economic development. It is also known by the names 'Lifeline of Rajasthan' and 'Maruganga'. Its present name is Indira Gandhi Canal. The Indira Gandhi Canal is the longest canal of India. Kanwar Sen, the then irrigation engineer of Bikaner, had planned for this canal in 1948. Its construction started in the same year. The origin of this canal is from Harike barrage, a few kilometers below the confluence of the Sutlej and Beas rivers in Ferozepur district in Punjab and terminates in irrigation facilities in the Thar Desert in the north west of Rajasthan state (Figure 2). The Indira Gandhi Canal provides irrigation facilities over an area of 6,770 km^2 (1,670,000 acres) in Jaisalmer district and 37 km^2 (9,100 acres) in Barmer district. The canal has transformed the barren deserts of this district into fertile and good fields.

Besides providing water for agriculture, the canal supply drinking water to hundreds of people in far-flung areas.

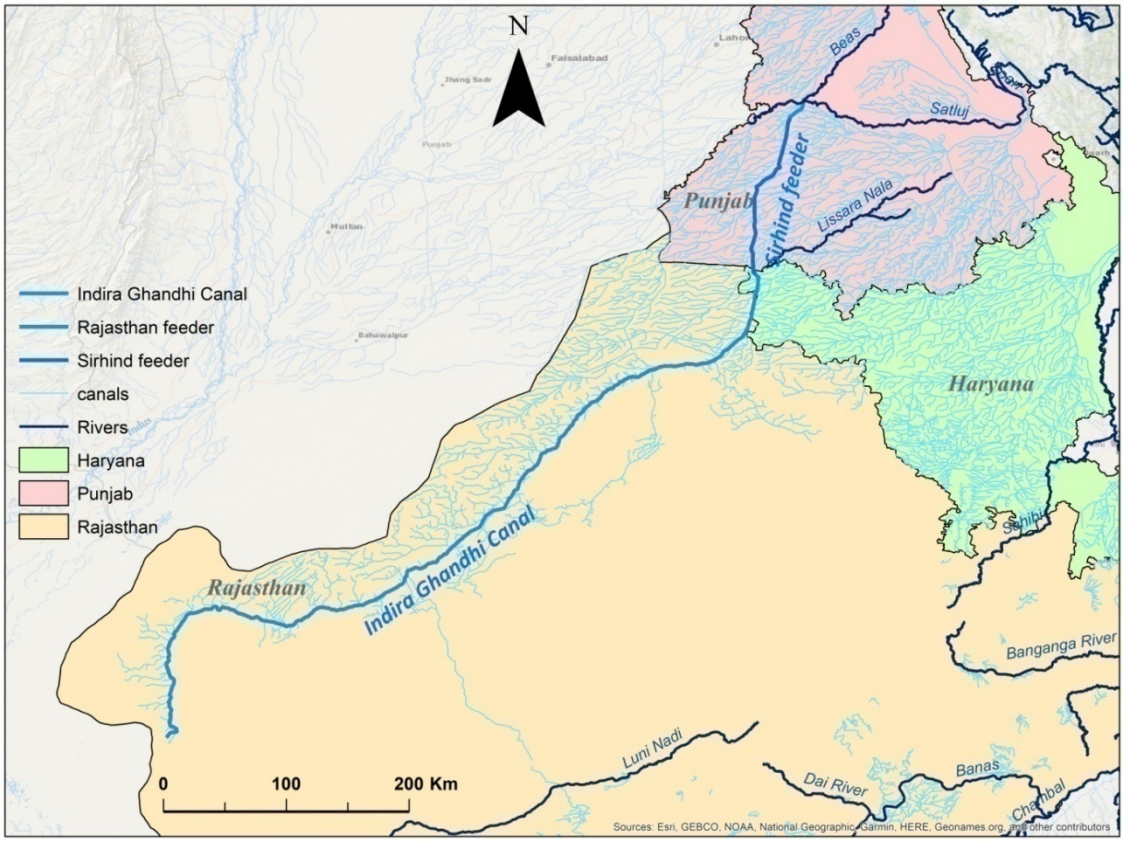

Figure 2: Map showing Indira Gandhi Canal, Sirhind feeder and Rajasthan Feeder.

The canal enters Haryana from Punjab near Lohgarh village then runs through the western part of the Sirsa district before entering Rajasthan near Kharakhera village in the Tibbi tehsil of the Hanumangarh district. The canal traverses seven districts of Rajasthan: Barmer, Bikaner, Churu, Hanumangarh, Jaisalmer, Jodhpur, and Sriganganagar. This canal supplies water to Sriganganagar, Hanumangarh, Bikaner, Jaisalmer, Barmer, Jodhpur, Churu and Nagaur districts. Total length of this canal is 649 Km, it is 40 m wide at the bottom and 6.4 m deep. The canal consists of the feeder canal and the main canal.

Main canal is 445 Km, which is entirely within Rajasthan and starts from the historically famous town Pugal in Bikaner also and it goes to Mohangarh in Jaisalmer which is nearest to Gadra road in Barmer. The length of its distributary canals are 5112 km. 30 % of area is irrigated through lift canals and remaining 70 per cent area by distributaries.

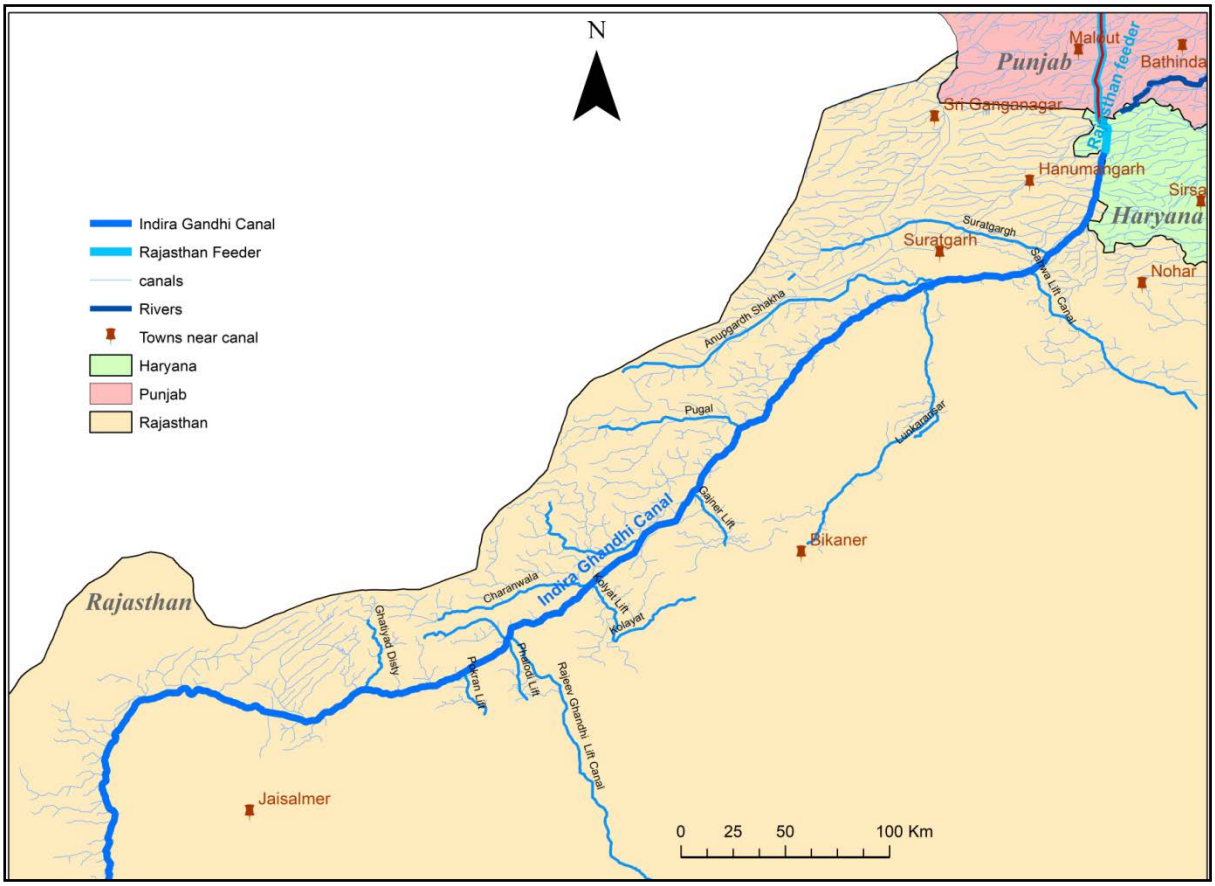

Figure 3: Main Branches of Indira Gandhi Canal.

Main branch canals

1. Rawatsar branch (Hanumangarh)
2. Suratgarh branch (Sriganganagar)
3. Anupgarh branch (Sriganganagar)
4. Pugal branch (Bikaner)
5. Charanwala branch (Bikaner)
6. Dantor branch (Bikaner)
7. Birsalpur branch (Bikaner)
8. Shahid Birbal branch (Jaisalmer)
9. Sagarmal Gopa branch (Jaisalmer)

Since the extension of the Thar Desert is towards the west, therefore, lift canals are also built to supply its water to the east of Rajasthan. Besides chief branch canals, lift canals are also made, which are:

Lift canal

1. Gandheli (Nohar) Sahwa lift canal (Hanumangarh)
2. Lunkaransar lift canal(Bikaner)
3. Gajner lift canal (Bikaner)
4. Bangrasar lift canal (Bikaner)
5. Kolayat lift canal (Bikaner)
6. Phalodi lift canal (Jodhpur)
7. Pokaran lift canal (Jaisalmer)

Rajasthan Feeder and Sirhind Feeder

Rajasthan Feeder and Sirhind Feeder run parallel with common bank. Rajasthan Feeder and Sirhind Feeder offtake from Harike Head Works constructed downstream of confluence of the Sutlej and Beas rivers (Figure 4).

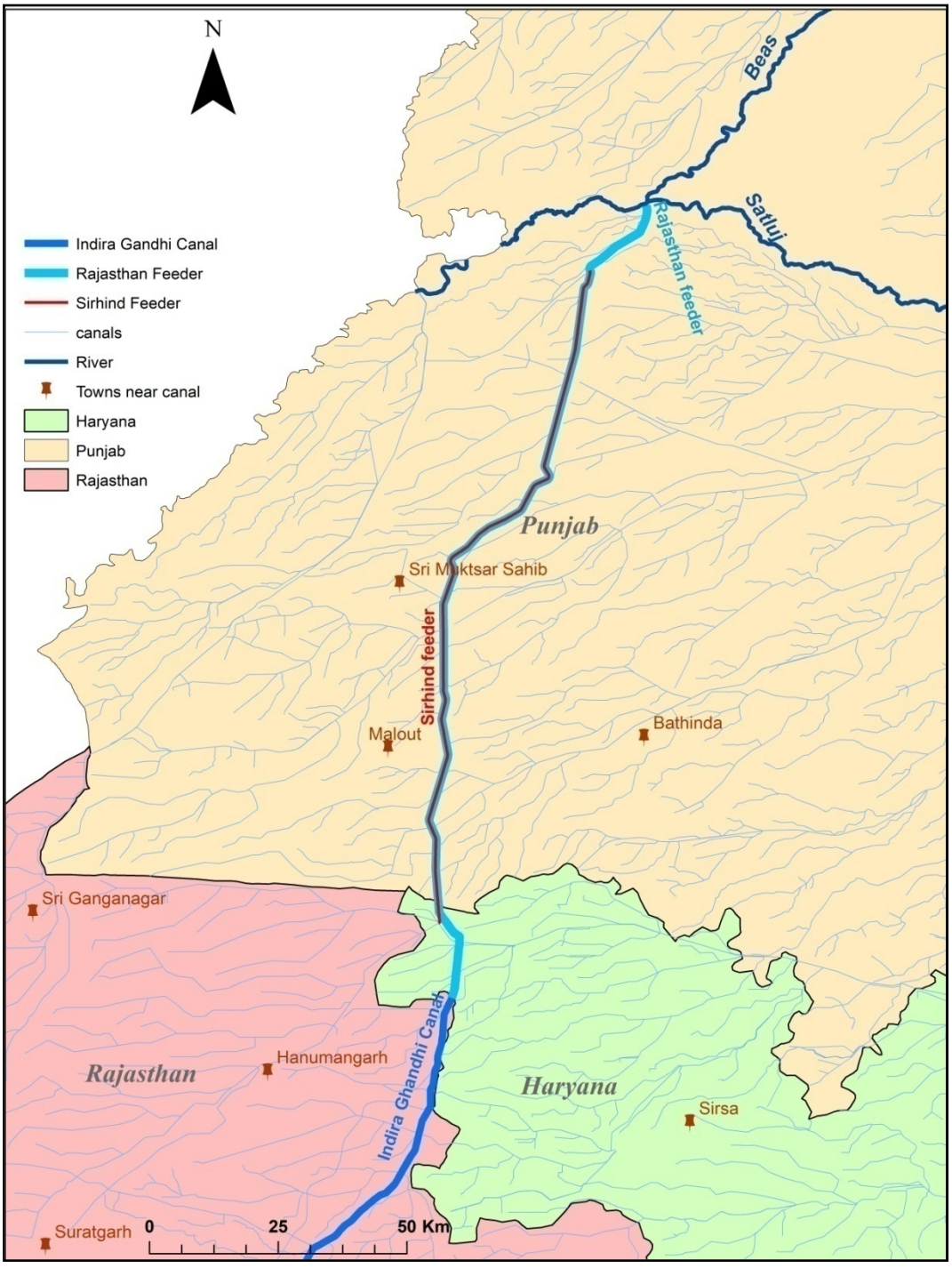

Figure 4: Rajasthan and Sirhind Feeder run parallel with common bank.

The Bhakra Dam on Satluj and Pong Dam on Beas are situated upstream of Harike Head works. Sirhind feeder is an important feeder canal off taking from Harike Headworks with 5264 cusecs capacity and having command area in Punjab. The Rajasthan Feeder which carries Ravi-Beas waters exclusively for Rajasthan off- takes from Harike Headworks. It has a capacity of 18500 cusecs. However, the head regulator of the canal has a capacity of 15000 cusecs which is sufficient for supplying allocated quantum of Ravi Beas waters to Rajasthan.

Rajasthan Feeder is exclusively meant for providing water to Indira Gandhi Nahar Project serving the command lying in the territory of Rajasthan State and is lifeline of Western Rajasthan. The feeder canal starts from Harike barrage to the head of Masitawali which is 204 km; first 167 Km lies in Punjab and Haryana state and a further 37 Km in Rajasthan. The canal which was constructed in the year 1958-1961, runs in a length of 149.53 Km in Ferozepur, Muktsar and Faridkot districts of Punjab. The canal enters Haryana from Punjab near Loh garh village then runs through the western part of the Sirsa district before entering Rajasthan. Seven districts of Western Rajasthan are totally dependent on it for drinking water. Major cities like Jodhpur, Bikaner, Jaisalmer, several towns & cities along with major army cantonments situated along the canal are dependent on it for drinking water. Besides it also supplies water to Power Plants at Surat garh, Ram garh etc.

Water Quality Standards

The physico - chemical parameters like pH, electrical conductance, Chloride, Fluoride, Nitrate, Sulphate, Boron, Total hardness, Dissolved Oxygen and Bio-chemical Oxygen demand are main constituents defining the quality of river water in surface water. Presence of these parameters in river water beyond the permissible limit is considered as polluted river water quality. CPCB has identified water quality requirements in terms of a few chemical characteristics, known as primary water quality criteria (Table 2).

Further, Bureau of Indian Standards (BIS) known as Indian Standard Institute (ISI) vide its document BIS 10500:2012 has recommended water quality standards for drinking water (Table 3).

Table 2: Designated Best Uses of Water by CPCB

Designated Best Use	Class	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1.Total Coliforms Organism MPN/100 mL shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6 mg/L or more 4. Biochemical Oxygen Demand 5 days 20 °C, 2 mg/L or less
Outdoor bathing (Organised)	B	1.Total Coliforms Organism MPN/100 mL shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5 mg/L or more 4. Biochemical Oxygen Demand 5 days 20 °C, 3 mg/L or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100 mL shall be 5000 or less 2. pH between 6 and 9 3. Dissolved Oxygen 4 mg/L or more 4. Biochemical Oxygen Demand 5 days 20 °C, 3 mg/L or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 and 8.5 2. Dissolved Oxygen 4 mg/L or more 3. Free Ammonia (as N) 1.2 mg/L or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 and 8.5 2. Electrical Conductivity at 25 °C micro mhos/cm, maximum 2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2 mg/L
	Below-E	Not meeting any of the A, B, C, D & E criteria

*Table 3: Drinking Water Quality Standards, BIS: 10500, 2012**

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible limit in the absence of Alternate source
Essential Characteristics			
1	Colour, Hazen units, Max	5	15
2	Odour	Agreeable	Agreeable
3	Taste	Agreeable	Agreeable
4	Turbidity NTU, Max	1	5
5	pH Value	6.5 -8.5	No relaxation
6	Total Hardness (as $CaCO_3$) mg/L, Max.	200	600
7	Iron (as Fe), mg/L, Max	0.3	No relaxation
8	Chlorides (as Cl), mg/L, Max	250	1000
9	Residual free chlorine, mg/L, Minimum	0.2	1.0
Desirable Characteristics			
10	Total Dissolved solids, mg/L, Max	500	2000
11	Calcium (as Ca) mg/L, Max.	75	200
12	Magnesium (as Mg) mg/L, Max	30	100
13	Copper (as Cu), mg/L, Max	0.05	1.5
14	Manganese (as Mn) mg/L, Max	0.1	0.3
15	Sulphates (as SO_4), mg/L, Max	200	400
16	Nitrate (as NO_3) mg/L, Max.	45	No relaxation
17	Fluorides (as F), mg/L, Max	1	1.5
18	Ammonia (as total ammonia-N) mg/L	0.5	No relaxation
19	Mercury (as Hg), mg/L, Max	0.001	No relaxation
20	Cadmium (as Cd), mg/L, Max	0.003	No relaxation
21	Selenium (as Se), mg/L, Max	0.01	No relaxation
22	Total Arsenic (as As), mg/L, Max	0.01	No relaxation
23	Cyanides (as CN), mg/L, Max	0.05	No relaxation
24	Lead (as Pb), mg/L, Max	0.01	No relaxation
25	Zinc (as Zn), mg/L, Max	5	15
26	Total Chromium (as Cr), mg/L, Max	0.05	No relaxation
27	Total Alkalinity mg/L, Max	200	600
28	Aluminum (as Al) mg/L, Max	0.03	0.2
29	Boron mg/L, Max	0.5	1.0
30	Mineral oil, mg/L, Max	0.5	
31	Poly Nuclear Aromatic Hydrocarbons, PAH's, mg/L, Max	0.0001	No relaxation
32	Anionic detergents (as MBAS), mg/L, Max	0.2	1
33	Total Coliform	Shall not be detected in any 100 of sample	
36	Phenolic Compounds, mg/L, Max	0.001	0.002

**** Limits have been given for specific parameters only as per Drinking Water Quality Standards, BIS: 10500, 2012.***

Water Quality Monitoring

Sampling Locations

Water quality monitoring is defined as the continued observation of the selected canal waters to determine spatial and temporal variability in water quality. Monitoring involves systematic, long-term data collection and analysis to measure the status of water quality and to detect changes over time. Water quality samples should be collected at appropriate locations that have been carefully selected in keeping with the criteria related to (i) longitudinal profile of canal to understand the long and short-term trends of spatial variations in water quality parameters, (ii) to identify the cause of pollutants on branches of canals (iii) for monitoring point pollution sources, such as industrial clusters or treatment facilities and lift branches and (iv) for monitoring non-point sources. According to the methodology adopted, samples were collected from the 25 most probable locations on these three canals (Figure 5 and Table 4).

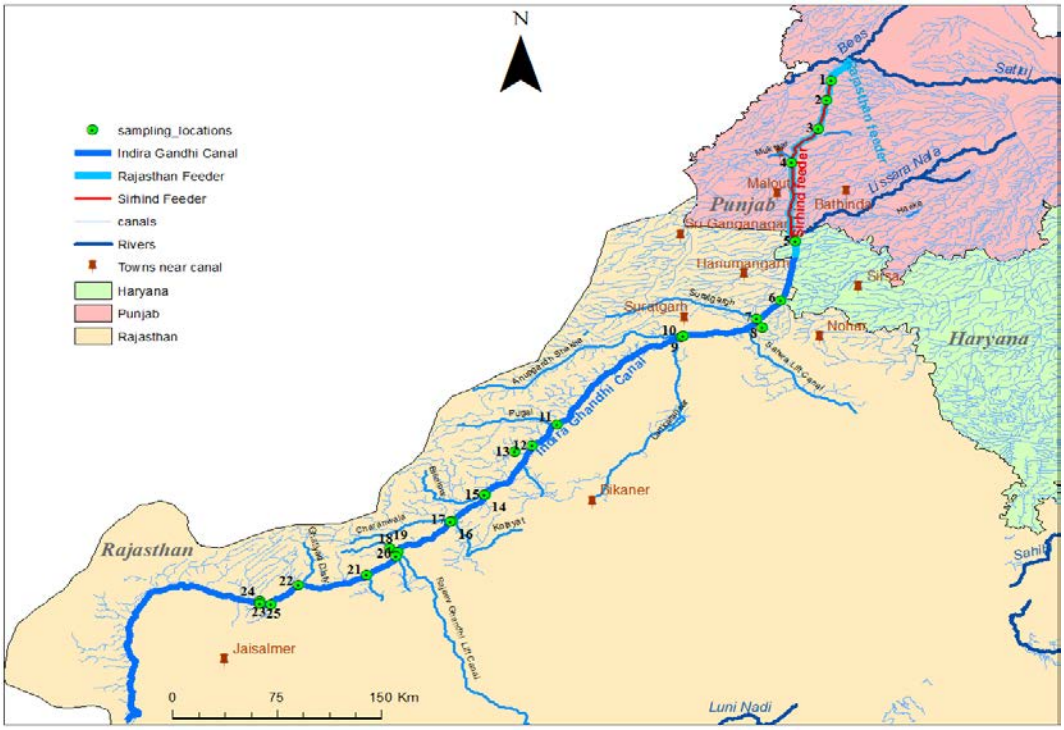

Figure 5: Sampling Locations (1-25) identified on the Indira Gandhi Canal, Rajasthan feeder and Sirhind Feeder.

Table 4: Locations identified for collecting samples from Canal system.

S. No	Sites	District	State	Longitude	Latitude	River Stream
1	Harike Barrage	Tarantaran	Punjab	74°51'00"E	31°00'00"N	Rajsthan Feeder &Sirhind Feeder
2	Ferozpur Canal(Ghall Khurd)	Ferozpur	Punjab	74°49'09"E	30°51'41"N	Rajsthan Feeder &Sirhind Feeder
3	Faridkot	Faridkot	Punjab	74°46'02"E	30°39'31"N	Rajsthan Feeder &Sirhind Feeder
4	Muktsar (Bhullar)	Muktsar	Punjab	74°35'41"E	30°25'14"N	Rajsthan Feeder &Sirhind Feeder
5	Lohagarh (Indira Gandhi Canal Bridge)	Sirsa	Haryana	74°37'08"E	29°52'00"N	Rajsthan Feeder &Sirhind Feeder
6	RawatsarBranch	Hanumangarh	Rajasthan	74°31'18"E	29°27'03"N	Indira Gandhi Canal
7	Suratgarh Branch	Sri Ganganagar	Rajasthan	74°22'14"E	29°19'14"N	Indira Gandhi Canal
8	Noharsahwa Lift Canal	Hanumangarh	Rajasthan	74°24'17"E	29°15'37"N	Indira Gandhi Canal
9	Lunkaransar Lift Canal	Bikaner	Rajasthan	73°53'24"E	29°11'54"N	Indira Gandhi Canal
10	Anupgarh Branch	Sri Ganganagar	Rajasthan	73°52'47"E	29°11'44"N	Indira Gandhi Canal
11	Pugal Branch	Bikaner	Rajasthan	73°04'40"E	28°34'18"N	Indira Gandhi Canal
12	Dantar Branch	Bikaner	Rajasthan	72°54'56"E	28°25'29"N	Indira Gandhi Canal
13	Gajner Lift Canal	Bikaner	Rajasthan	72°48'04"E	28°22'57"N	Indira Gandhi Canal
14	Birsalpur Branch	Bikaner	Rajasthan	72°36'39"E	28°04'58"N	Indira Gandhi Canal
15	Bangarsar Lift Canal	Bikaner	Rajasthan	72°36'28"E	28°04'50"N	Indira Gandhi Canal
16	Kolayat Lift Canal	Bikaner	Rajasthan	72°23'45"E	27°53'35"N	Indira Gandhi Canal
17	Charanwala Branch Canal	Bikaner	Rajasthan	72°23'02"E	27°53'20"N	Indira Gandhi Canal
18	Rajeev Gandhi Lift Canal (PHED)	Bikaner	Rajasthan	72°02'46"E	27°40'37"N	Indira Gandhi Canal
19	Nachna Main Disty	Bikaner	Rajasthan	71°59'36"E	27°42'09"N	Indira Gandhi Canal
20	Phalodi Lift Canal	Jodhpur	Rajasthan	72°02'06"E	27°38'53"N	Indira Gandhi Canal
21	Pokaran Lift Canal	Jaisalmer	Rajasthan	71°50'40"E	27°30'54"N	Indira Gandhi Canal
22	Ghantiyali Dist.	Jaisalmer	Rajasthan	71°24'22"E	27°26'41"N	Indira Gandhi Canal
23	Barmer Lift (PHED)	Jaisalmer	Rajasthan	71°13'28"E	27°18'13"N	Indira Gandhi Canal
24	SagarmalGopa Branch	Jaisalmer	Rajasthan	71°09'09"E	27°18'37"N	Indira Gandhi Canal
25	Shahid Birbal Branch	Jaisalmer	Rajasthan	71°09'19"E	27°19'54"N	Indira Gandhi Canal

Field Survey

1. Sample Collection and analysis at Harike Barrage, Tarantaran by IBO Team

2. Sample Collection at Indira Gandhi Canal Bridge, Abubshahar by IBO Team

3. Sample Collection and analysis at Rawatsar branch, Hanumangarh by YBO Team

4. Sample Collection and analysis at Charan wala Branch Canal, Bikaner by YBO Team

5. Sample Collection and analysis at Pugal and Dantor Branch, Bikaner by YBO Team

6. Sample Collection and analysis at Sahid Birbal Branch and Sagarmal Gopa Branch Canal, Jaisalmer by YBO Team

Analysis and Observations

Samples from Punjab were sent to Chenab Divisional Water Quality Laboratory, IBO, CWC, Jammu and from Rajasthan to National River Water Quality Laboratory, YBO, CWC, New Delhi as per standard guidelines given at http://cwc.gov.in/sites/default/files/water-quality-activities-cwc.pdf.

Figure 6: Laboratory analysis of samples received from Canals.

Detailed discussions on various parameters of water are given as under:

1. pH

pH measurement is the determination of the activity of hydrogen ions in aqueous solution. pH value in Canal varied between 7.43 and 8.29 during the study period. The average value of pH is 7.97. All values are found within the prescribed limit (6.5-8.5) given by CPCB standards for Designated Best Use (Figure 7).

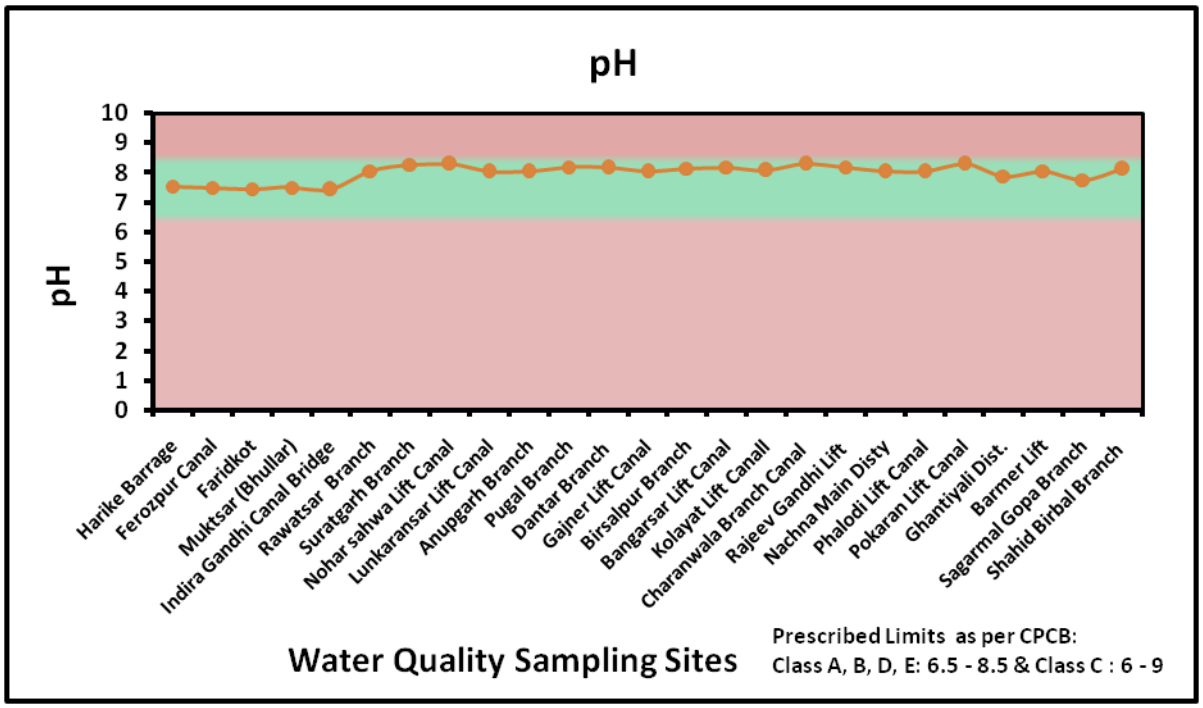

Figure 7: pH variation in Canal Water

2. ELECTRICAL CONDUCTIVITY (EC)

Electrical conductivity is the measure of the ability of a solution to conduct an electric current and is sometimes referred as “specific conductance”. This EC is due to the cations and anions in the solution. EC depends on the ionic strength of the water. As per CPCB standards for Designated Best Use, prescribed limit of conductivity is 2250 µS/cm for Class E - Irrigation/Agriculture purpose.

The Conductance varied from maximum 300.8 µS/cm at sampling station Barmer lift canal to minimum 217 µS/cm at sampling station Harike Barrage (Figure 8).

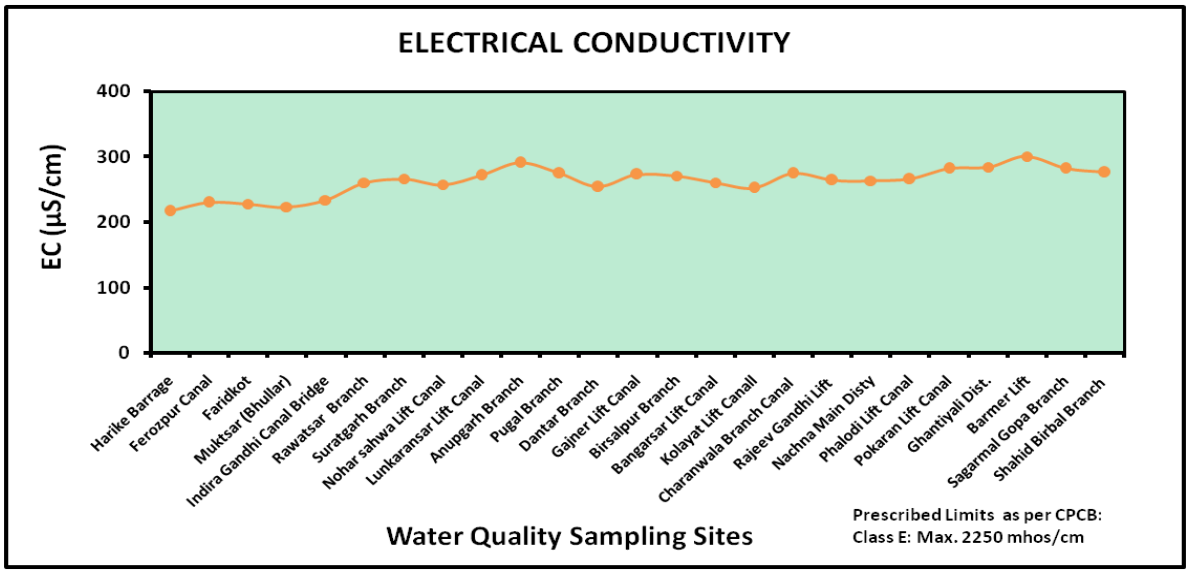

Figure 8: Electrical Conductivity variation in Canal Water

3. TOTAL DISSOLVED SOLIDS (TDS)

Sudden increase in the content of TDS can often indicate pollution by an extraneous source. Harmful hazardous and lethal heavy metals are also found in the form of dissolved solids. The Indian Standard standards i.e BIS 10500:2012 has recommended the TDS value for Drinking water as upto 500 mg/L.

During the period of the study, the average values of TDS observed within the permissible limits which are depicted in figure 9.

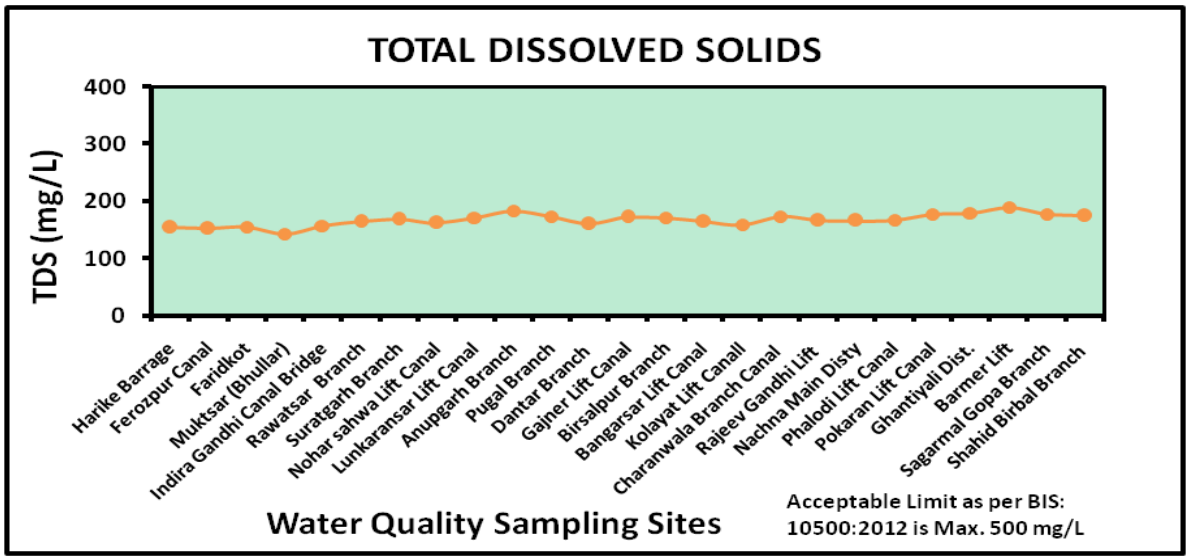

Figure 9: Total Dissolved Solids variation in Canal Water

4. DISSOLVED OXYGEN (DO)

The dissolved oxygen (DO) content plays an important role in supporting aquatic life in running water and is susceptible to environmental changes. The presence of DO is essential to maintain the higher forms of biological life and to keep proper balance of various populations thus making the water bodies healthy. As per the CPCB standards for Designated Best Use, the limit of DO for Class B – outdoor bathing is 5 mg/L. During the study period, the average value of DO was observed 6.54 mg/L and all the water samples of canal water are within the permissible limit (Figure 10).

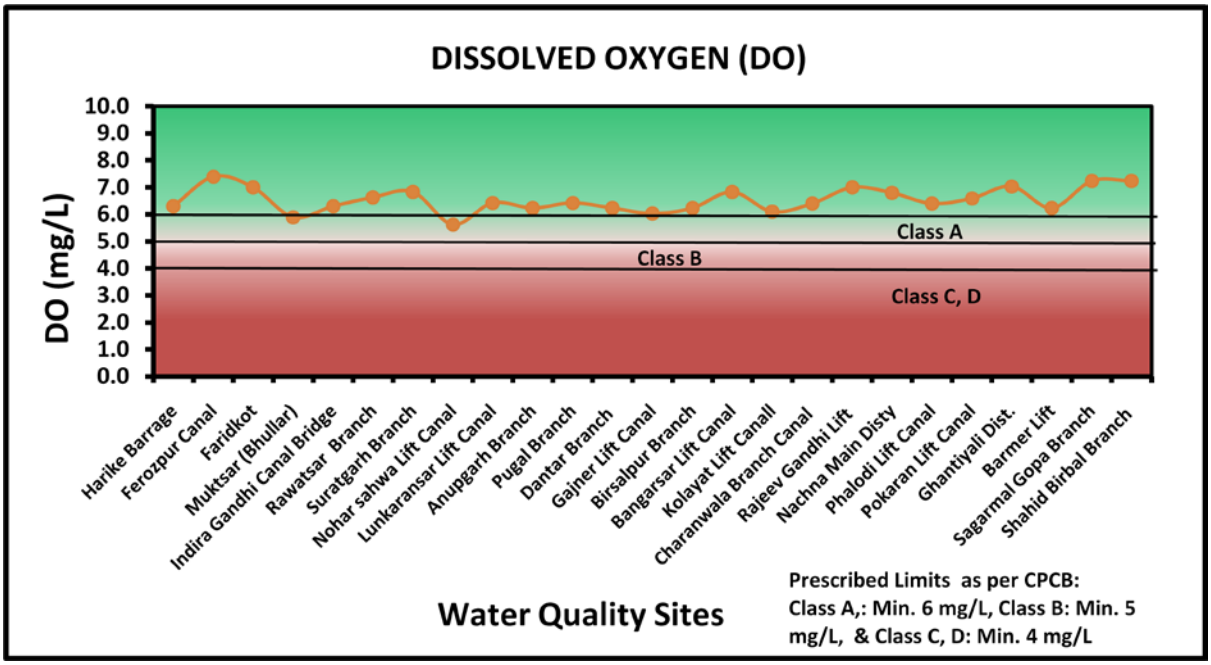

Figure 10: Dissolved Oxygen variation in Canal Water

5. BIO-CHEMICAL OXYGEN DEMAND (BOD)

BOD is an environmentally significant parameter. The measurement of BOD is done to assess pollution loads in aquatic environments. It indicates the strength of domestic and industrial contamination in an aquatic environment. As per CPCB standards for Designated Best Use, the limit of BOD for Class B– out door bathing is 3 mg/L. During the period of the study, the average value of BOD observed was 2.83 mg/L in the Canal Water. BOD has highest value of 3.82 mg/L at Pugal Branch of Indira Gandhi Canal and the lowest value at Indira Gandhi Canal Bridge (1.50 mg/L) (Figure 11).

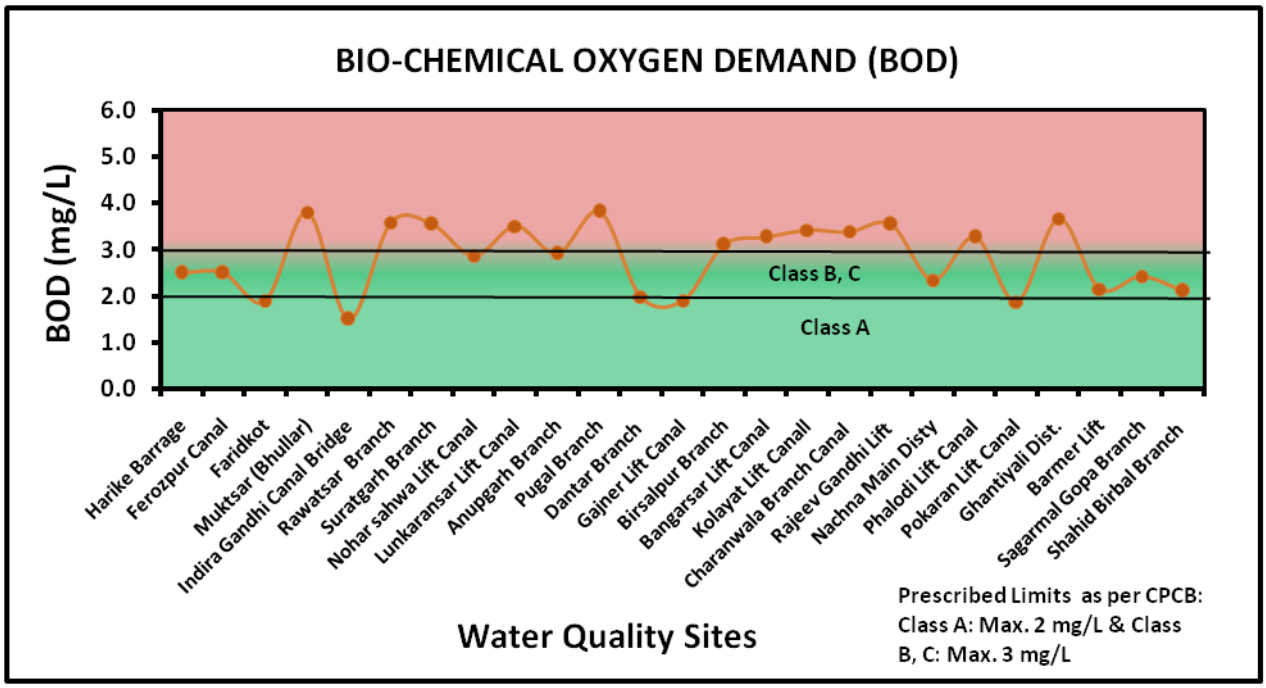

Figure 11: Bio-Chemical Oxygen Demand variation in Canal Water

6. MAJOR CATIONS & ANIONS

The most abundant cations present in water are calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^{+}), and potassium (K^{+}); the most abundant anions are bicarbonate (HCO_3^{-}), chloride (Cl^{-}), and sulfate (SO_4^{-2}). All the major cations and anions are within the permissible limit in Canal Water.

Major Cations:

- **Sodium** concentration in Canal Water varies from 2.90 mg/L to 11.10 mg/L, with an average value of 5.71 mg/L.
- **Potassium** concentration in Canal Water varies from 0.8 mg/L to 3.25 mg/L, with an average value of 1.88 mg/L.
- **Calcium** concentration in Canal Water varies from 15.05 mg/L to 32.85 mg/L, with an average value of 22.62 mg/L.
- **Magnesium** concentration in Canal Water varies from 3.06 mg/L to 24.05 mg/L, with an average value of 12.72 mg/L.

Major Anions:

- **Chloride** concentration in Canal Water varies from 3.58 mg/L to 18.05 mg/L, with an average value of 8.12 mg/L.
- The primary source of **carbonate** and **bicarbonate** ions water is the dissolved carbon dioxide in rainwater. Bicarbonate concentration in Canal Water varies from 63.00 mg/L to 145.27 mg/L, with an average value of 99.16 mg/L.
- **Sulphate** concentration in Canal Water varies from 23.63 mg/L to 50.94 mg/L, with an average value of 30.69 mg/L.
- **Fluoride** concentration in Canal Water varies from 0.09 mg/L to 0.29 mg/L, with an average value of 0.16 mg/L
- **Nitrate** concentration in Canal Water varies from 1.22 mg/L to 2.95 mg/L, with an average value of 1.9 mg/L
- The observed results of the nitrite, phosphate and Silicate at all sampling stations were well within the limit prescribed by BIS 10500:2012 for drinking water.

7. TOTAL COLIFORM AND FECAL COLIFORM

Microorganisms are a valuable parameter of water quality in relation to drinking water quality. Since most of the common disease, such as typhoid, cholera, dysentery, infectious hepatitis, etc., affect the gastrointestinal tract, faeces of the affected persons contain large number of the causative agents of the diseases. According to the CPCB standards for Designated Best Use, the limit of Total Coliform organisms for Class B – out door bathing is 500 MPN/100 mL. Total Coliform has highest value of 35000 MPN/100 mL at Birsalpur Branch of Indira Gandhi Canal and the lowest value at Nachna Main Disty (4600 MPN/100 mL). Average value of Total Coliform in canal waters is 13476 MPN/100 mL (Figure 12). Fecal Coliform has highest value of 4000 MPN/100 mL at Charanwala Branch and the lowest value of 450 MPN/100 mL at Sagarmal Gopal Branch of Indira Gandhi Canal (Figure 13). However, from bacteriological point of view as per BIS 10500:2012 for drinking water, coliform count should not be present in 100 mL and more importantly the absence of fecal coliform should be there.

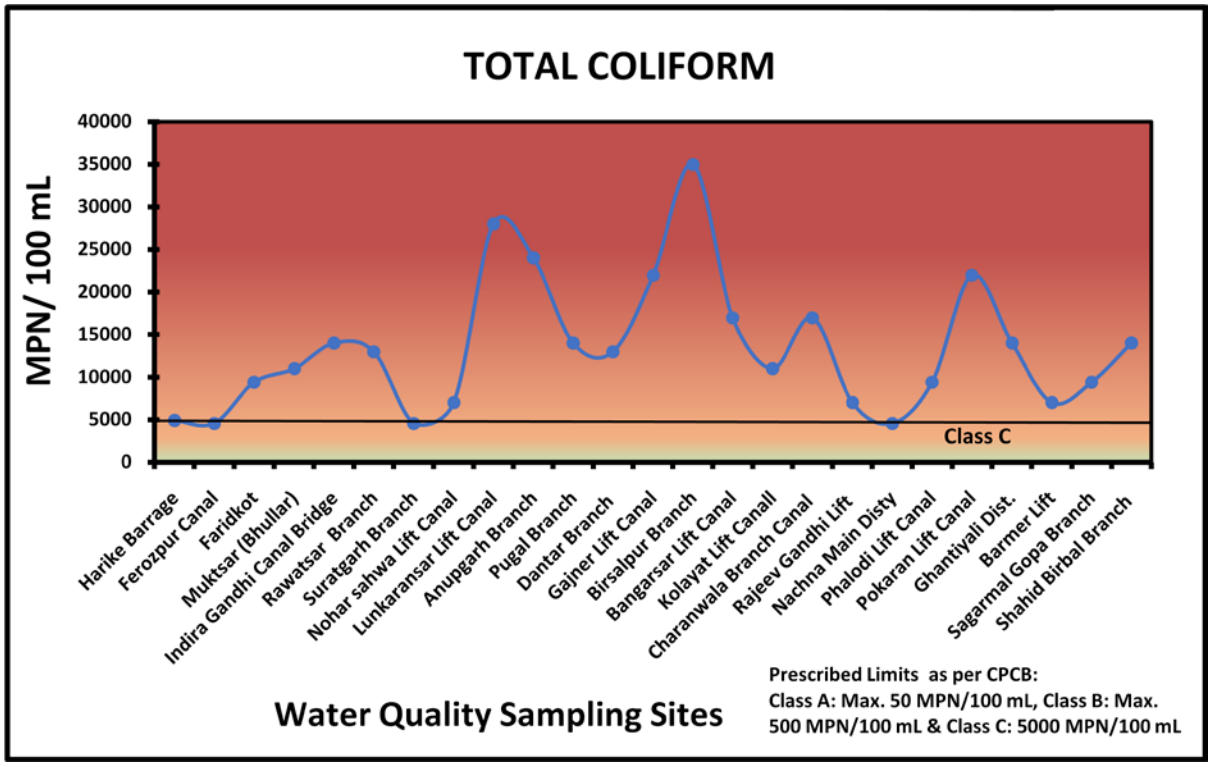

Figure 12: Total Coliform variation in Canal Water

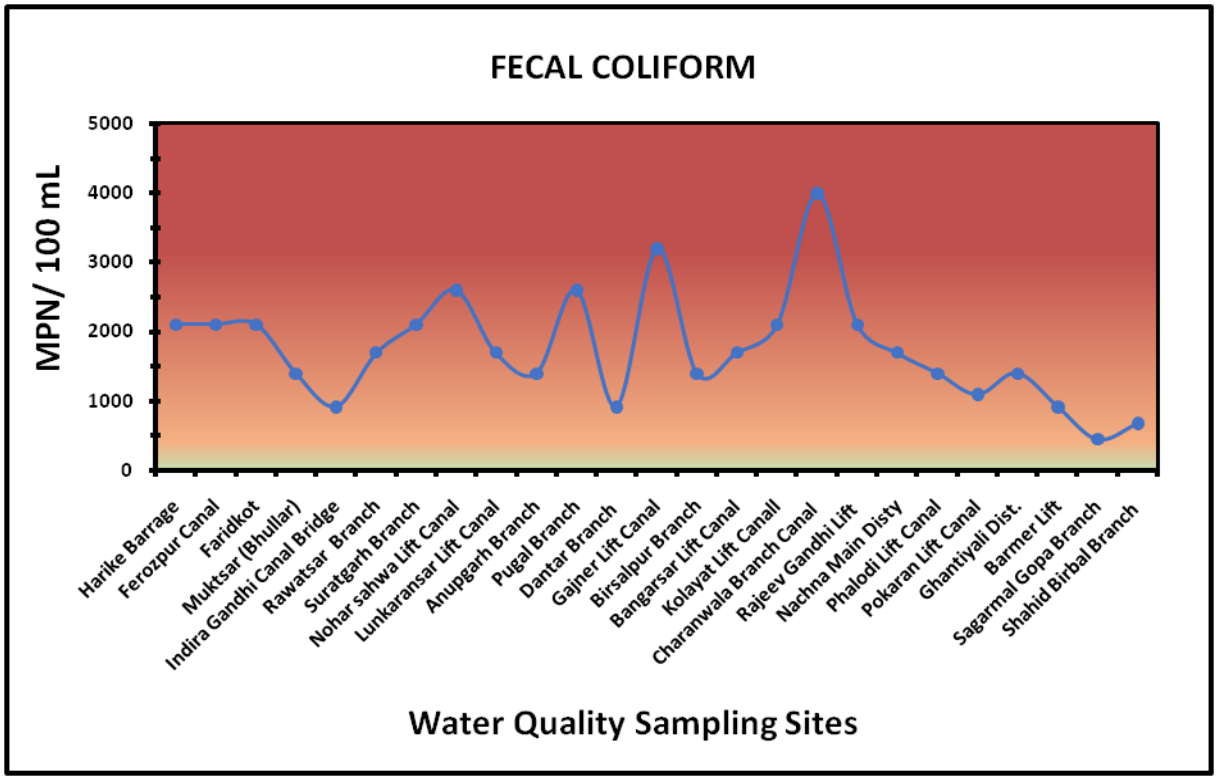

Figure 13: Fecal Coliform variation in Canal Water

8. HEAVY METALS

Aquatic ecosystem is the ultimate recipient of almost everything including heavy metals. Pollution of heavy metals in aquatic environment is a growing problem worldwide and currently it has reached an alarming rate. They are present at much lower concentrations in waters compared to major ions. Some heavy metals, such as Cu and Zn are necessary in trace amounts for the functioning of biological systems. Contamination of heavy metals in the environment is of high concern because of their toxicity and threat to human life and environment. All the metals (arsenic, chromium, cadmium, copper, iron, nickel, lead and zinc) concentrations were found within the permissible limit of BIS 10500: 2012 for the Canal water samples (Table 5).

Table 5: Heavy Metals concentration in Canal water samples

S.No.	Name of Site	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc
		µg/l							
		Water Quality Standards (BIS : 10500; 2012)							
		10	3	50	50	300	10	20	5000
1	Harike Barrage	BDL	0.038	5.89	3.98	16.57	2.49	7.11	6.254
2	Ferozpur Canal	0.08	0.024	3.87	6.14	23.64	1.35	4.69	3.654
3	Faridkot	0.21	0.024	2.68	0.88	36.49	0.89	3.54	12.598
4	Muktsar (Bhullar)	0.11	0.019	4.67	2.58	25.48	1.68	2.58	2.654
5	Indira Gandhi Canal Bridge	BDL	0.014	1.69	6.48	20.18	0.65	6.58	8.984
6	Rawatsar Branch	BDL	0.054	4.67	1.69	33.08	0.32	1.28	2.658
7	Suratgarh Branch	0.05	BDL	4.98	2.64	42.02	2.48	8.97	6.2987
8	Nohar sahwa Lift Canal	BDL	0.017	6.54	2.58	29.07	1.65	4.98	4.985
9	Lunkaransar Lift Canal	0.09	0.024	5.43	1.65	16.25	0.68	0.68	13.658
10	Anupgarh Branch	0.18	BDL	7.84	3.47	53.04	1.69	0.59	1.658
11	Pugal Branch	0.04	0.017	0.88	5.97	13.58	0.24	0.34	14.689
12	Dantar Branch	0.72	0.024	0.96	6.54	14.67	0.39	1.26	8.647
13	Gajner Lift Canal	BDL	0.036	2.79	2.89	19.54	0.27	5.24	2.689
14	Birsalpur Branch	BDL	0.018	1.68	6.78	16.58	0.66	3.24	3.698
15	Bangarsar Lift Canal	0.54	0.024	0.87	8.47	17.52	1.23	6.28	1.258
16	Kolayat Lift Canal	0.19	0.029	1.35	7.48	36.14	1.65	6.28	2.654
17	Charanwala Branch Canal	0.54	0.028	9.14	2.69	20.45	2.48	3.57	7.894
18	Rajeev Gandhi Lift Canal	0.68	0.058	3.64	2.54	39.87	0.57	0.68	6.148
19	Nachna Main Disty	0.24	0.021	2.87	4.65	8.04	0.98	1.29	7.148
20	Phalodi Lift Canal	0.37	0.064	9.47	1.64	14.25	0.64	6.54	12.579
21	Pokaran Lift Canal	0.27	0.027	2.64	7.98	10.32	2.65	5.39	8.145
22	Ghantiyali Dist.	BDL	0.057	1.58	0.52	8.67	1.25	3.25	3.258
23	Barmer Lift	BDL	BDL	1.69	4.98	16.54	0.65	1.65	12.569
24	Sagarmal Gopa Branch	BDL	0.082	0.98	5.87	9.68	5.64	1.36	3.654
25	Shahid Birbal Branch	0.12	BDL	0.58	3.98	10.54	3.84	0.64	7.984
Max		0.72	0.08	9.47	8.47	53.04	5.64	8.97	14.69
Min		0.04	0.01	0.58	0.52	8.04	0.24	0.34	1.26
Avg		0.28	0.03	3.58	4.20	22.09	1.48	3.52	6.66

9. PESTICIDES

25 nos. of collected water samples from canals were extracted into 10 mL size at National River Water Quality Laboratory (NRWQL), New Delhi and sent to Lower Cauvery Water Quality Laboratory (LCWQL), Southern Rivers Division, Coimbatore and get analyzed through Gas Chromatography technique.

From the Analysis results obtained for Samples of S. No. 1 to 12 as given in table 4, it was found that there are no considerable peaks for constituents of pesticides. Further, from the Analysis results obtained for Samples of S. No. 13 to 25, it was found that there are no prominent peaks detected for pesticides except for Endosulfan (Beta) which suggests that trace quantities of Endosulphan (Beta) may be present.

It is worth to note that, to confirm the results, sensitivity and correctness of the instrument on which the analysis is carried out, the analysis has been done also from the South India Textile Research Association (SITRA) chemical laboratory, Coimbatore, for the samples from S. No. 1 to 10. The results from SITRA Chemical Laboratory also confirmed that there was no presence of detectable pesticides.

From the analysis results of Pesticides for canal water samples, it has been observed that pesticide concentrations were found to be Below Detection Limit (BDL).

Table 6: Suitability of Canal Water as per CPCB standards for Designated Best Use and BIS: 10500: 2012.

S.No.	Name of Site	Suitability as per CPCB Standards for Designated Best Use					Suitability as per BIS: 10500 : 2012**
		Class-A	Class-B	Class-C	Class-D	Class-E	
1	Harike Barrage	✗	✗	✓	✓	✓	✗
2	Ferozpur Canal	✗	✗	✓	✓	✓	✗
3	Faridkot	✗	✗	✗	✓	✓	✗
4	Muktsar (Bhullar)	✗	✗	✗	✓	✓	✗
5	Indira Gandhi Canal Bridge	✗	✗	✗	✓	✓	✗
6	Rawatsar Branch	✗	✗	✗	✓	✓	✗
7	Suratgarh Branch	✗	✗	✓	✓	✓	✗
8	Nohar sahwa Lift Canal	✗	✗	✗	✓	✓	✗
9	Lunkaransar Lift Canal	✗	✗	✗	✓	✓	✗
10	Anupgarh Branch	✗	✗	✗	✓	✓	✗
11	Pugal Branch	✗	✗	✗	✓	✓	✗
12	Dantar Branch	✗	✗	✗	✓	✓	✗
13	Gajner Lift Canal	✗	✗	✗	✓	✓	✗
14	Birsalpur Branch	✗	✗	✗	✓	✓	✗
15	Bangarsar Lift Canal	✗	✗	✗	✓	✓	✗
16	Kolayat Lift Canal	✗	✗	✗	✓	✓	✗
17	Charanwala Branch Canal	✗	✗	✗	✓	✓	✗
18	Rajeev Gandhi Lift Canal	✗	✗	✗	✓	✓	✗
19	Nachna Main Disty	✗	✗	✓	✓	✓	✗
20	Phalodi Lift Canal	✗	✗	✗	✓	✓	✗
21	Pokaran Lift Canal	✗	✗	✗	✓	✓	✗
22	Ghantiyali Dist.	✗	✗	✗	✓	✓	✗
23	Barmer Lift	✗	✗	✗	✓	✓	✗
24	Sagarmal Gopal Branch	✗	✗	✗	✓	✓	✗
25	Shahid Birbal Branch	✗	✗	✗	✓	✓	✗

** Majorly, the unsuitability of canal water samples as per CPCB standards for Designated Best use is due to the presence of Total Coliform & BOD.*

*** The Canal Water Samples were analysed for physical and chemical parameters like pH, TDS, Major Cations, Major Anions etc. and bacteriological parameters like Coliform (Total Coliform ad Fecal Coliform). Majorly, the unsuitability of canal water samples as per Drinking Water Standards BIS: 10500:2012 is due to presence of Coliform.*

Conclusions

Total 25 water samples were collected and analysed from various sampling locations covering the entire Indira Gandhi, Rajasthan feeder and Sirhind feeder canals. Analysis results of these samples show that -

- Water samples from Canals were found within the acceptable limit with respect to almost all the water quality parameters e.g. pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Major Cations (Na^{+}, K^{+}, Mg^{+2}, Ca^{+2}) and Major Anions (Cl^{-}, F^{-}, NO_3^{-}, SO_4^{-2})
- Out of 25, for 12 samples, BOD was found to be beyond the limits for Class A, B & C. Out of remaining 13 samples, 5 samples were within limits for Class A also. CPCB limit for Designated Best Use with respect to BOD for Class A is 2 mg/L and for Class B & Class C is 3 mg/L. Maximum BOD observed was 3.82 mg/L and Minimum observed was 1.50 mg/L. The details thereof given at Annexure-III.
- CPCB limit for Designated Best Use with respect to Total Coliform for Class C is 5000 MPN/100 mL. Only 4 samples were found meeting this criterion. Presence of Total Coliform and Fecal Coliform in Canal water indicate the contamination from human & animal wastes from leaching animal manure, improperly treated septic and sewage discharge.
- Water samples from Canals were found within the acceptable limit with respect to all the heavy metals e.g. arsenic, chromium, cadmium, copper, iron, nickel, lead and zinc indicating the absence of industrial pollution in the canal system.
- The results of Pesticide analysis of the canal water samples were found to be Below Detection Limit.

Annexure-I

List of Water Quality Laboratories in CWC

S. No.	Location of laboratory	Level of Laboratory	Organization
1	National River Water Quality Laboratory, New Delhi	III	YBO, New Delhi
2	Lower Cauvery Water Quality Laboratory, Coimbatore	III	CSRO, Coimbatore
3	Upper and Middle Ganga Water Quality Laboratory, Varanasi	III	LGBO, Patna
4	Krishna and Godavari River Water Quality, Hyderabad	III	KGBO, Hyderabad
5	Upper Cauvery Water Quality Laboratory, Bangalore	II	MSO, Bangalore
6	South Western Flowing Rivers Water Quality Laboratory, Kochi	II	CSRO, Coimbatore
7	Upper Krishna Division Water Quality Laboratory, Pune	II	KGBO, Hyderabad
8	Mahi Division Water Quality Laboratory, Gandhinagar	II	MTBO, Gandhinagar
9	Lower Yamuna Water Quality Laboratory, Agra	II	YBO, New Delhi
10	Eastern Rivers Water Quality Laboratory, Bhubaneswar	II	MERO, Bhubaneswar
11	Hydrology Division, Chennai	II	CSRO, Coimbatore
12	Wainganga Division, Nagpur	II	MCO, Nagpur
13	Middle Brahmaputra Division, Guwahati	III	BBBO, Shillong
14	Lower Brahmaputra Division, Jalpaiguri	II	T&BDBO, Kolkata
15	Upper Brahmaputra Division, Dibrugarh	II	BBBO, Shillong
16	Chenab Division, Jammu	II	IBO, Chandigarh
17	Lower Ganga Division, Berhampore	II	T&BDBO, Kolkata
18	Middle Ganga Division -V, Patna	II	LGBO, Patna
19	Mahanadi Division, Raipur	II	MERO, Bhubaneswar
20	Narmada Division, Bhopal	II	NBO, Bhopal
21	Tapi Division, Surat	II	NTBO, Gangdinagar
22	Himalayan Ganga Division, Dehradun	II	UGBO, Lucknow
23	Middle Ganga Division -I, Lucknow	II	UGBO, Lucknow

Annexure-II

List of Water Quality parameters analysed by CWC in Level-I, II and III laboratories

S. No	Level-1	Level-II	Level-III
1	Temperature	Temperature	Temperature
2	Color	Color	Color
3	Odour	Odour	Odour
4	pH	pH	pH
5	Electrical Conductivity	Electrical Conductivity	Electrical Conductivity
6	Dissolved Oxygen	Dissolved Oxygen (DO)	Dissolved Oxygen (DO)
7		Turbidity	Turbidity
8		Biochemical Oxygen Demand (BOD)	Biochemical Oxygen Demand (BOD)
9		Chemical Oxygen Demand (COD)	Chemical Oxygen Demand (COD)
10		Total Dissolved Solids (TDS)	Total Dissolved Solids (TDS)
11		Sodium	Sodium
12		Calcium	Calcium
13		Magnesium	Magnesium
14		Potassium	Potassium
15		Carbonate	Carbonate
16		Bicarbonate	Bicarbonate
17		Chloride	Chloride
18		Sulphate	Sulphate
19		Fluoride	Fluoride
20		Boron	Boron
21		Ammonia (Nitrogen)	Ammonia (Nitrogen)
22		Nitrate + Nitrite	Nitrate + Nitrite
23		Phosphate	Phosphate
24		Total Coliform	Total Coliform
25		F. Coliform	F. Coliform
26			Arsenic
27			Cadmium
28			Chromium
29			Copper
30			Iron
31			Lead
32			Nickel
33			Mercury
34			Zinc
35			AlphaBenzenehexachloride(BHC), Beta BHC, Gama BHC (Lindane)
36			OP-Dichlorodiphenyltrichloroethane(OP DDT), PP-DDT
37			Alpha Endosulphan, Beta Endosulphan,
38			Aldrin, Dieldrin,
39			Carbaryl (Carbamate),
40			Malathian, Methyl Parathian,
41			Anilophos, Chloropyriphos

Annexure-III

BOD Analysis Results of Canal Water sampling locations as per CPCB standards for Designated Best Use

S. No	Sites	District	State	River_Stream	BOD	Within limits as per CPCB *
1	Harike Barrage	Tarantaran	Punjab	Rajsthan Feeder & Sirhind Feeder	2.50	Class B & C
2	Ferozpur Canal	Ferozpur	Punjab	Rajsthan Feeder & Sirhind Feeder	2.50	Class B & C
3	Faridkot	Faridkot	Punjab	Rajsthan Feeder & Sirhind Feeder	1.90	Class A, B & C
4	Muktsar (Bhullar)	Muktsar	Punjab	Rajsthan Feeder & Sirhind Feeder	3.80	**
5	Indira Gandhi Canal Bridge	Sirsa	Haryana	Rajsthan Feeder & Sirhind Feeder	1.50	Class A, B & C
6	Rawatsar Branch	Hanumangarh	Rajasthan	Indira Gandhi Canal	3.58	**
7	Suratgarh Branch	Sri Ganganagar	Rajasthan	Indira Gandhi Canal	3.54	**
8	Nohar sahwa Lift Canal	Hanumangarh	Rajasthan	Indira Gandhi Canal	2.87	Class B & C
9	Lunkaransar Lift Canal	Bikaner	Rajasthan	Indira Gandhi Canal	3.50	**
10	Anupgarh Branch	Sri Ganganagar	Rajasthan	Indira Gandhi Canal	2.91	Class B & C
11	Pugal Branch	Bikaner	Rajasthan	Indira Gandhi Canal	3.82	**
12	Dantar Branch	Bikaner	Rajasthan	Indira Gandhi Canal	1.99	Class A, B & C
13	Gajner Lift Canal	Bikaner	Rajasthan	Indira Gandhi Canal	1.91	Class A, B & C
14	Birsalpur Branch	Bikaner	Rajasthan	Indira Gandhi Canal	3.10	**
15	Bangarsar Lift Canal	Bikaner	Rajasthan	Indira Gandhi Canal	3.26	**
16	Kolayat Lift Canall	Bikaner	Rajasthan	Indira Gandhi Canal	3.42	**
17	Charanwala Branch Canal	Bikaner	Rajasthan	Indira Gandhi Canal	3.38	**
18	Rajeev Gandhi Lift Canal	Bikaner	Rajasthan	Indira Gandhi Canal	3.54	**
19	Nachna Main Disty	Bikaner	Rajasthan	Indira Gandhi Canal	2.35	Class B & C
20	Phalodi Lift Canal	Jodhpur	Rajasthan	Indira Gandhi Canal	3.26	**
21	Pokaran Lift Canal	Jaisalmer	Rajasthan	Indira Gandhi Canal	1.87	Class A, B & C
22	Ghantiyali Dist.	Jaisalmer	Rajasthan	Indira Gandhi Canal	3.66	**
23	Barmer Lift	Jaisalmer	Rajasthan	Indira Gandhi Canal	2.15	Class B & C
24	Sagarmal Gopal Branch	Jaisalmer	Rajasthan	Indira Gandhi Canal	2.43	Class B & C
25	Shahid Birbal Branch	Jaisalmer	Rajasthan	Indira Gandhi Canal	2.11	Class B & C

*** BOD Limits for Class A, B & C only specified in CPCB standards for Designated Best Use.**

**** For D and E class, there is no limit specified for BOD.**

CONTRIBUTION

Sampling and Field Survey

Sh Aditya Sarin, Assistant Research Officer, NRWQL, UYD, CWC, New Delhi

Sh Rajesh Kumar, Assistant Research Officer, NRWQL, UYD, CWC, New Delhi

Dr. Nirmal Kumar Bhuyan, Assistant Research Officer, IBRWQL, Chenab Division, CWC, Jammu

Sh Ashutosh Tripathi, Senior Research Assistant, NRWQL, UYD, CWC, New Delhi

Sh Nitish Kumar Singh, Senior Research Assistant, NRWQL, UYD, CWC, New Delhi

Sh Angad Kumar, Senior Research Assistant, IBRWQL, Chenab Division, CWC, Jammu

Sh Vivekanand Parasar, JE, CD, Jaipur

Sh Mahendra Meena, JE, CD, Jaipur

Sh Kuldeep Singh, JE, UYD New Delhi

Sh Sunil Negi, JE, UYD New Delhi

Sh Sajjan Singh, SWA, Chambal Division, Jaipur

Sh Munesh Meena, SWA, Chambal Division, Jaipur

Sh Shivcharan Meena, SWA, Chambal Division, Jaipur

Sh Chanda Ram, SWA, Chambal Division, Jaipur

Sh Kishori Lal, H'Dman, M&A Dte, CWC, Chandigarh

Sh Maghar Lal, WS-II, Chenab Division, CWC, Jammu

Analysis

Sh Aditya Sarin, Assistant Research Officer, NRWQL, UYD, CWC, New Delhi

Sh Rajesh Kumar, Assistant Research Officer, NRWQL, UYD, CWC, New Delhi

Dr. Nirmal Kumar Bhuyan, Assistant Research Officer, IBRWQL, Chenab Division, CWC, Jammu

Smt. L. Priyadharsini, Assistant Research Officer, LCWQL, SRD, CWC, Coimbatore

Sh Ashutosh Tripathi, Senior Research Assistant, NRWQL, UYD, CWC, New Delhi

Sh Nitish Kumar Singh, Senior Research Assistant, NRWQL, UYD, CWC, New Delhi

Sh Maneesh TP, Senior Research Assistant, LCWQL, SRD, CWC, Coimbatore

Sh Angad Kumar, Senior Research Assistant, IBRWQL, Chenab Division, CWC, Jammu

Sh Burri Jagadeesh Yadav, Senior Research Assistant, LCWQL, SRD, CWC, Coimbatore

Sh Srikanth Reddy Alla, Senior Research Assistant, LCWQL, SRD, CWC, Coimbatore

Smt Srujana Radha, Senior Research Assistant, LCWQL, SRD, CWC, Coimbatore

PREPARED BY

Dr. Sakshi Sharma, Senior Research Assistant, RDC-2 Directorate, CWC, New Delhi

GUIDANCE

Sh R.K. Jain, Chairman, CWC, New Delhi

Sh R.K. Sinha, Member (River Management), CWC, New Delhi

Sh Reading Shimray, Chief Engineer, Planning & Development, CWC, New Delhi

Sh Shivanandan Kumar, Chief Engineer, IBO, CWC, Chandigarh

Sh G. K. Aggarwal, Chief Engineer, YBO, CWC, New Delhi

Sh. N. M. Krishnaunni, Chief Engineer, CSRO, CWC, Coimbatore

Sh Vineet Gupta, Superintending Engineer (C), IBO, CWC, Chandigarh

Sh H. S. Senger, Superintending Engineer, HOC, Vaishali, YBO, CWC, New Delhi

Sh Amit Ranjan, Superintending Engineer (C), CSRO, Coimbatore

Sh Mohan Murali V, Superintending Engineer, CSRC, Bangaluru

Sh S. K. Sharma, Director M&A, CWC, Chandigarh

Sh S. D. Sharma, Director M&A, CWC, Jaipur

Sh Pankaj Kumar Sharma, Director RDC-2 Directorate, CWC, New Delhi

Sh Rakesh Kumar Gupta, Dy. Director, RDC-2 Directorate, CWC, New Delhi

Sh Satish Jain, Executive Engineer, Chenab Division, Jammu

Sh Shobhit Mishra, Executive Engineer, UYD, CWC, Delhi

Sh Ramdas Meena, Executive Engineer, Chabal division, CWC, Jaipur

Sh S. Rajendran, Executive Engineer, Southern Rivers Division, CWC, Coimbatore

Sh Vivek Kumar Singh, Dy. Director, M&A, CWC, Jaipur