केवल सरकारी उपयोग हेतु
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# जल गुणवत्ता वर्ष पुस्तिका

# WATER QUALITY YEAR BOOK

जून 2016- मई 2017 June 2016 - May 2017

# सोन बेसिन

# SONE BASIN

## जल विज्ञानीय प्रेक्षण परिमण्डल

**HYDROLOGICAL OBSERVATION CIRCLE**

## केन्द्रीय जल आयोग

**CENTRAL WATER COMMISSION**

## वाराणसी

**VARANASI**

# PREFACE

Water is a prime natural resource and basic human need. The National Water Policy lays stress on planning and development of water resources on a national perspective. The prime requisite of water resources planning is indeed an efficient information system on the quantity and quality of this time and space variable precious natural asset. In present times due to fast pace of development and increasing population the quality of waters in our river systems is under tremendous pressure, thereby posing a challenge to preserve the quality of waters and at the same time to clean up the already polluted rivers.

The Central Water Commission in its capacity as an apex technical organisation in the field of water resources development endeavours the gigantic task of collection and compilation of Water Quality data incorporating the quality and quantity of available waters in various basins of the country. The Water Quality Books of various river basins of the country are being published by Central Water Commission.

The present volume contains information and trend on various water quality parameters for the year 2016-2017 measured in Sone river basin, a tributary of Ganga river.

The valuable guidance and inspiration of Shri Pradeep Kumar, Member, RM, CWC, New Delhi and Shri S. K. Sibal, Chief Engineer, Upper Ganga Basin Organisation, CWC, Lucknow is gratefully acknowledged.

I would like to place on record the special contribution made by officers and staff of Hydrological Observation Circle, Varanasi and Middle Ganga Division-III, Varanasi in compilation of information and publication of the report in present form.

It is hoped that this publication will be found useful for the planners, managers and users in the field of water resources.

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HOC, CWC,VARANASI

September, 2017

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# 1. INTRODUCTION

## 1.1. Scope

Rapidly increasing population, rising standard of living, exponential growth of industrialized and urbanization have exposed the Water Resources in general and rivers in particular to various form of degradation. It is therefore necessary to keep vigilant watch of quality of available fresh waters whose major sources in our country are rivers.

## 1.2. Source of Information

Middle Ganga Division No. III, Varanasi under the Hydrological Observation Circle, Central Water Commission, Varanasi is conducting Water Quality observations at three sites in Sone sub-basin. The finalised data for the year 2016-2017 is presented in the book. The details of sites are given in Table 1 and same has been located in index map .

**T A B L E 1**

| Sl.No | Name of site | Station Code |
|---|---|---|
| **Middle Ganga Division No. III** | | |
| 1. | Kuldah Bridge at Sone | GGTOOT3 |
| 2. | Chopan at Sone | GGTOOL5 |
| 3. | Duddhi at Kanhar | GGT3OE8 |

## 1.3. Observation Technique

Water samples from all the Water Quality stations are collected on 1st working day of the month and transported to divisional laboratory where systematic analysis is conducted for the determination of constituents like pH, Specific Conductance, Potassium (as K), Sodium (as Na), Calcium (as Ca), Magnesium (as Mg), Iron (as Fe), Nitrogen Ammoniacal (as NH4-N), Carbonate (as CO3), Bicarbonate (as HCO3), Chloride (as Cl), Fluoride (as F), Sulphate (as SO4), Nitrate (as NO3), Nitrite (as NO2), Phosphate (as PO4 ), Silica (as SiO2) and Boron (as B).

pH and Specific Conductance are determined by digital pH meter and conductivity meter. Cl-, CO3--, HCO3- , Ca++ and Mg++ are estimated by titration method. SO4-- is estimated by turbidimetric method with the help of Nephelometer. Na+ and K+ estimation is done by the method of flame emission with the help of Flame

photometer and rest by the method of colorimetric estimation with the help of U-V Spectrophotometer.

In addition to the above, Dissolved Oxygen is also estimated. Biochemical Oxygen Demand, Chemical Oxygen Demand and Microbiological Parameters such as Total Coliform & Fecal Coliform are determined at selected sites.

# 2. WATER QUALITY DATA

## 2.1 Explanatory Notes

The explanatory notes, described hereunder, are designed to assist in the interpretation of various parameters contained in the data presented subsequently.

i) The river water samples are collected at a regular frequency of once in a month usually on the 1st working day from the main flowing portion of the stream as per uniform protocol.

ii) Well Water analysis is also carried out twice in a year i.e. 1$^{st}$ working day of November & May.

iii) Dissolved Oxygen is measured at the site laboratory within an hour of collection of samples.

iv) The other water quality parameters are analysed at the divisional laboratory, Varanasi/National River Water Quality laboratory,New Delhi.

v) Chemical Indices, namely, Hardness Number, Sodium Percentage, Sodium Adsorption Ratio and Residual Sodium Carbonate are calculated as follows :

a. Hardness Number (HAR) is calculated by adding the total $Ca^{++}$ and $Mg^{++}$ in the sample expressed as equivalent parts of $CaCO_3$.

$$H.N.=(Ca^{++}+Mg^{++}x50$$

Where Ionic concentrations being in m.e./litre.

b. Sodium Percentage (S.P.) is given by

$$S.P.= ( Na^{+} x100) / (Ca^{++} + Mg^{++} + Na^{+} + K^{+} )$$

c. Sodium Adsorption Ratio (S.A.R.) is given by

$$S.A.R. = Na^{+} / \{( Ca^{++} + Mg^{++} )/2\}^{½}$$

Where the ionic concentration being in m.e./litre.

d. Residual Sodium Carbonate (R.S.C.) is given by

$$R.S.C. = (CO_3^{--} +HCO_3^{-}) - (Ca^{++} + Mg^{++})$$

Where concentration of all the ions being in m.e./litre.

vi) Water year ranges from June 1st of one calendar year to May 31st of the next calendar year and covers one complete hydrological cycle.

vii) The gauging station code number is a unique seven column alpha-numeric reference number which facilitates storage and retrieval of water quality data in data banks. The first column is identifier of either an integral river basin or for convenience, a region having several contiguous river catchments. This is followed by a column which identifies an independent river system which either have one or more outlets to the sea or crosses international border to enter another country. The third, fourth and fifth column spaces denote first, second and third order tributaries respectively from the mouth upstream. The sixth and seventh column spaces indicate the location of the gauging station in one of the 225 slots earmarked on the river. The blank column spaces are filled by zero.

## 2.2 Method of Presentation

In the succeeding pages, stationwise water quality data and its trend is presented, comprising history sheet and water quality analysis tables.

History sheet gives concise description of the water quality observation station. The water quality analysis tables are given seasonwise (flood, winter, summer) for the river water and for well water during the month of November & May. The samples of water quality analysis are collected once a month as already mentioned in para 2.1 above.

# 3. WATER QUALITY TOLERANCE AND CLASSIFICATION

As per ISI-IS: 2296-1982, the tolerance limits of parameters are specified as per classified use of water ( Table 1,2,3,4,5 Annexed ) depending on various uses of water. The following classifications have been adopted in India.

| Classification | Type of use |
|---|---|
| Class A | Drinking water source without conventional treatment but After disinfection. |
| Class B | Outdoor bathing. |
| Class C | Drinking water source with conventional treatment followed by disinfection. |
| Class D | Fish culture and wild life propagation . |
| Class E | Irrigation , Industrial cooling or controlled waste disposal. |

# TABLE-1

## TOLERANCE LIMITS FOR INLAND SURFACE WATERS, CLASS – A

`

| S. No. | Characteristic | Tolerance |
|---|---|---|
| (i) | pH value | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l, ((Min)) | 6.0 |
| (iii) | Bio-chemical Oxygen Demand ((Max)) | 2.0 |
| (iv) | Total Coliform Organisms, MPN/100 ml,((Max)) | 50 |
| (v) | Colour, Hazen units, ((Max)) | 10 |
| (vi) | Odour | unobjectionable |
| (Vii) | Taste | Agreeable taste |
| (viii) | Total Dissolved Solids, mg/l, (Max) | 500 |
| (ix) | Total Hardness (as CaCO3), mg/l ,(Max) | 300 |
| (x) | Calcium Hardness (as CaCO3), mg/l, (Max) | 200 |
| (xi) | Magnesium (as CaCO3), mg/l,(Max) | 100 |
| (xii) | Copper (as Cu), mg/l, (Max) | 1.5 |
| (xiii) | Iron (as Fe), mg/l,(Max) | 0.3 |
| (xiv) | Manganese (as Mn), mg/l,(Max) | 0.5 |
| (xv) | Chlorides (as Cl), mg/l,(Max) | 250 |
| (xvi) | Sulphate (as SO4), mg/l ,(Max) | 400 |
| (xvii) | Nitrates (as NO2), mg/l,(Max) | 20 |
| (xviii) | Fluorides (as F,) mg/l,(Max) | 1.5 |
| (xix) | Phenolic compounds(as C6H5OH), mg/l,(Max) | 0.002 |
| (xx) | Mercury (as Hg), mg/l ,(Max) | 0.001 |
| (xxi) | Cadmium (as Cd), mg/l,(Max) | 0.01 |
| (xxii) | Selenium (as Se), mg/l ,(Max) | 0.01 |
| (xxiii) | Arsenic (as As), mg/l,(Max) | 0.05 |
| (xxiv) | Cyanides (as CN), mg/l, (Max) | 0.05 |
| (xxv) | Lead (as Pb), mg/l, (Max) | 0.1 |
| (xxvi) | Zinc (as Zn), mg/l, (Max) | 15 |
| (xxvii) | Chromium (asCr6+ ), mg/l,(Max) | 0.05 |
| (xxviii) | Anionic detergents, (as MBAS), mg/l ,(Max) . | 0.2 |
| (xxix) | Poly-nuclear aromatic hydrocarbons (PAH), | 0.2 |
| (xxx) | (Min)eral oil, mg/l ,(Max) | 0.01 |
| (xxxi) | Barium (as Ba), mg/l ,(Max) | 1.0 |
| (xxxii) | Silver (as Ag), mg/l (Max) | 0.05 |
| (xxxiii) | Pesticides | Absent |
| (xxxiv) | Alpha emitters, µc/ml, (Max) | $10^{-9}$ |
| (xxxv) | Beta emitters, µc/ml, (Max) | $10^{-8}$ |

# TABLE- 2

## TOLERANCE LIMITS FOR INLAND SURFACE WATERS, CLASS – B

| S. No. | Characteristic | Tolerance |
|---|---|---|
| (i) | pH Value | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l,(Min) | 5.0 |
| (iii) | Biochemical Oxygen Demand (5 days at 20 °C), (Max) | 3.0 |
| (iv) | Total Coliform Organisms, MPN/100 ml, (Max) | 500 |
| (v) | Fluorides (as F)<mg/l, (Max) | 1.5 |
| (vi) | Colour, Hazen units, (Max) | 300 |
| (vii) | Cyanides (as CN), mg/l, (Max) | 0.05 |
| (viii) | Arsenic (as As), mg/l, (Max) | 0.2 |
| (ix) | Phenolic Compounds (as C6H5OH) mg/l, (Max) | 0.005 |
| (x) | Chromium (as Cr6+), mg/l, (Max) | 1.0 |
| (xi) | Anionic detergents (as MBAS), mg/l, (Max) | 1.0 |
| (xii) | Alpha emitters, µc/ml, (Max) | $10^{-8}$ |

# TABLE- 3

## TOLERANCE LIMITS FOR INLAND SURFACE WATERS, CLASS – C

| S. No. | Characteristic | Tolerance |
|---|---|---|
| (i) | pH Value | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l (Min)imum | 4.0 |
| (iii) | Biochemical Oxygen Demand | 3.0 |
| (iv) | Total coliform organisms, MPN/100 ml, (Max) | 5000 |
| (v) | Colour, Hazen units, (Max) | 300 |
| (vi) | Fluorides (as F), mg/l ,(Max) | 1.5 |
| (vii) | Cadmium (as Cd), mg/l, (Max) | 0.01 |
| (viii) | Chlorides (as Cl), mg/l, (Max) | 600 |
| (ix) | Chromium (as Cr6+), mg/l, (Max) | 0.05 |
| (x) | Cyanides (as CN), mg/l, (Max) | 0.05 |
| (xi) | Total Dissolved Solids, mg/l, (Max) | 1500 |
| (xii) | Selenium (as Se), mg/l, (Max) | 0.05 |
| (xiii) | Sulphates (as SO4), mg/l, (Max) | 400 |
| (xiv) | Lead (as Pb), mg/l, (Max) | 0.1 |
| (xv) | Copper (as Cu),mg/l,(Max) | 1.5 |
| (xvi) | Arsenic (as As), mg/l, (Max) | 0.2 |
| (xvii) | Iron (as Fe), mg/l, (Max) | 50 |
| (xviii) | Phenolic compounds (as C6H5OH), mg/l, (Max) | 0.005 |
| (xix) | Zinc (as Zn), mg/l, (Max) | 15 |
| (xx) | Insecticides, mg/l, (Max) | Absent |
| (xxi) | Anionic detergents (as MBAS), mg/l, (Max) | 1.0 |
| (xxii) | Oils and grease, mg/l, (Max) | 0.1 |
| (xxiii) | Nitrates (as NO3), mg/l,(Max) | 50 |
| (xxiv) | Alpha emititers, µc/mg, (Max) | 10-9 |
| (xxv) | Beta emitters, µc/ml, (Max) | 10-8 |

# TABLE-4

## TOLERANCE LIMITS FOR INLAND SURFACE WATERS, CLASS -D

| S. No. | Characteristic | Tolerance |
|---|---|---|
| (i) | pH value | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l, (Min). | 4.0 |
| (iii) | Free Ammonia (as N), mg/l, (Max). | 1.2 |
| (iv) | Electrical Conductance at 25 °C, μ S, (Max) | 1000 |
| (v) | Free Carbon Dioxide (as C02),mg/l, (Max) | 6.0 |
| (vi) | Oils and Grease, mg/l, (Max) | 0.1 |
| (vii) | Alpha emitters, μ c/ml, (Max) | $10^{-9}$ |
| (viii) | Beta emitters, μ c/ml, (Max) | $10^{-8}$ |

# TABLE- 5

## TOLERANCE LIMITS FOR INLAND SURFACE WATERS,CLASS -E

| S. No. | Characteristic | Tolerance |
|---|---|---|
| (i) | pH value | 6.0 to 8.5 |
| (ii) | Electrical Conductance at 25°C, μ S, (Max) | 2250 |
| (iii) | Sodium Adsorption Ratio, (Max) | 26 |
| (iv) | Boron (as B), mg/l, (Max) | 2.0 |
| (v) | Total Dissolved Solids, (inorganic), mg/l, (Max) | 2100 |
| (vi) | Sulphates (as SO4), mg/l, (Max) | 1000 |
| (vii) | Chlorides (as Cl), Mg/l, (Max) | 600 |
| (viii) | Sodium Percentage, (Max) | 60 |
| (ix) | Alpha emitters, μ c/ml, (Max) | $10^{-9}$ |
| (x) | Beta emitters, μ c/ml, (Max) | $10^{-8}$ |

# 4. WATER QUALITY SCENARIO/TREND

Surface water quality trends assists resource managers in identifying nature and extent of emerging water-quality concerns, planning remedial measures, evaluating their effectiveness and prioritization of pollution control effects. This section presents the scenario of different water quality parameters based on the results of data analysis of the **Chopan** and **Kuldahbridge** stations on river Sone and **Duddhi** station on river Kanhar which confluences with river Sone downstream of Chopan.

## 4.1 W.Q. Network :

| S.No. | Name of Site | River | Class |
|---|---|---|---|
| 1 | Kuldahbridge | Sone | Trend |
| 2 | Chopan | Sone | Trend |
| 3 | Duddhi | Kanhar | Trend |

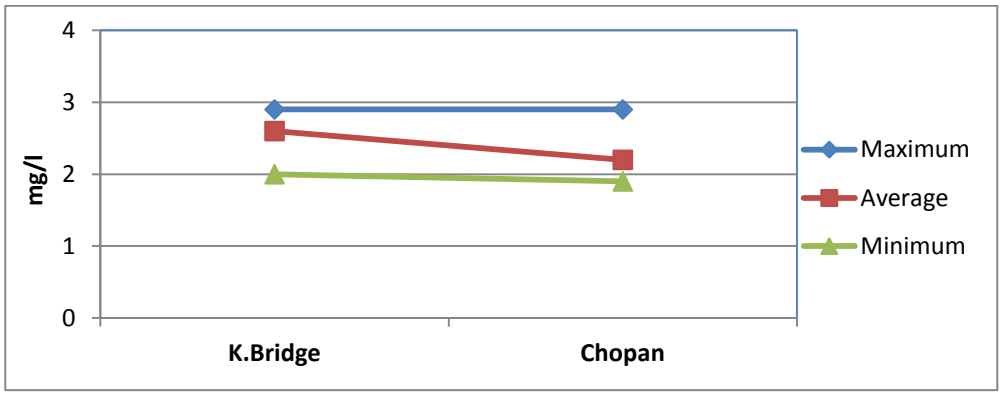
## 4.2. WATER QUALITY SCENARIO/TRENDS FOR RIVER SONE (MAIN STEM):

### 4.2.1 Biological Oxygen Demand (BOD) in mg/l

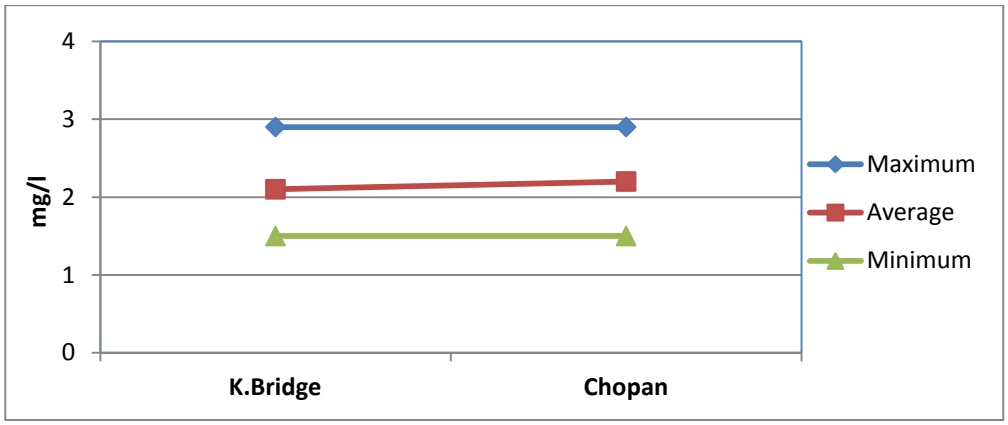
| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year |
| Kuldahbridge | - | 2.9 | 2.9 | - | 2.0 | 1.5 | - | 2.6 | 2.1 |
| Chopan | - | 2.9 | 2.9 | - | 1.9 | 1.5 | - | 2.2 | 2.2 |

*BOD started from June 2009.

**Parameter: BOD past 10 Year**



## Parameter: BOD current year

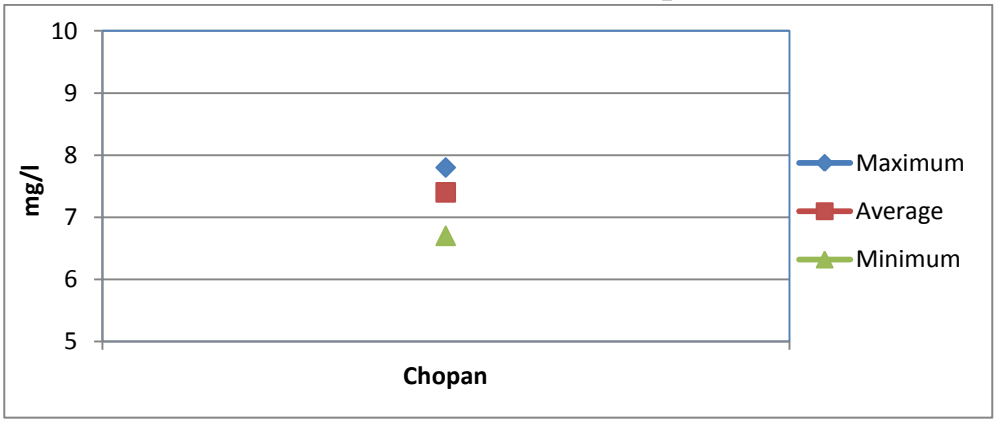



### 4.2.2 Dissolved Oxygen (DO) in mg/l

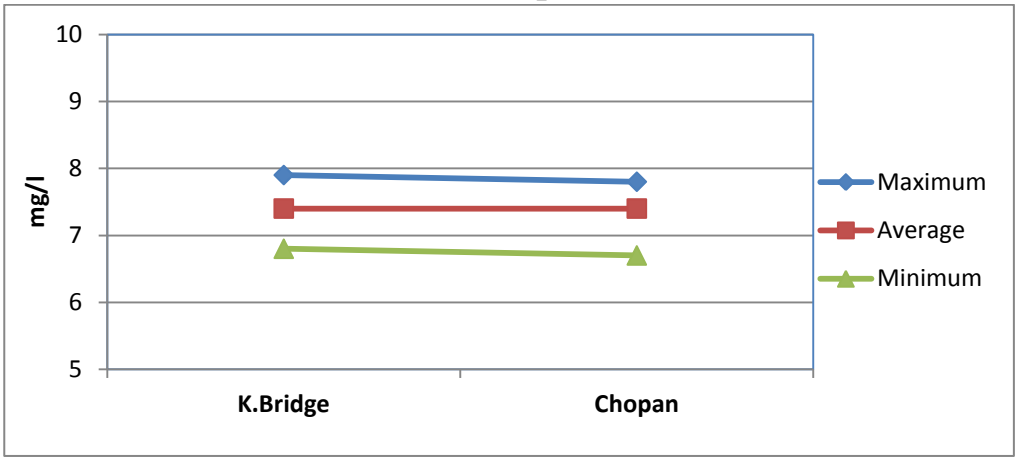
| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year |
| Kuldahbridge | - | 7.9 | 8.1 | - | 6.8 | 5.8 | - | 7.4 | 6.9 |
| Chopan | 7.9 | 7.8 | 8.1 | 6.7 | 6.7 | 6.1 | 7.4 | 7.4 | 7.2 |

*DO started from 2005 at Chopan , 2009 at Kuldahbridge.

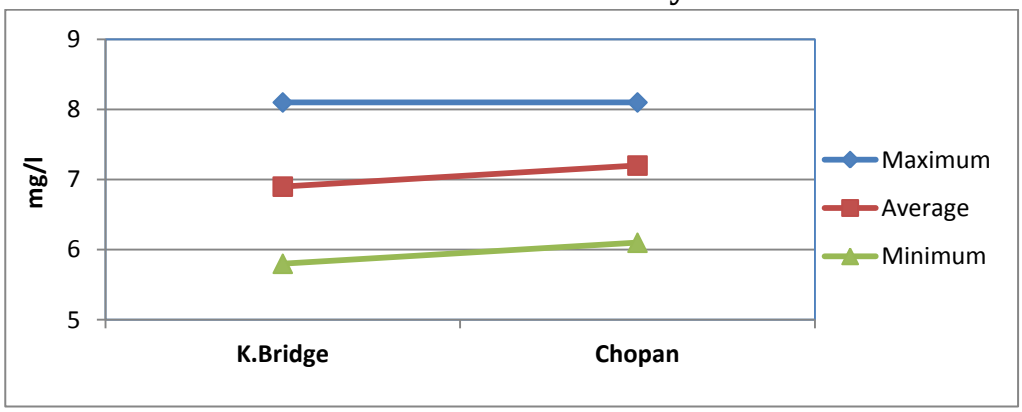
## Parameter: DO since inception



**Parameter: DO past 10 Year**



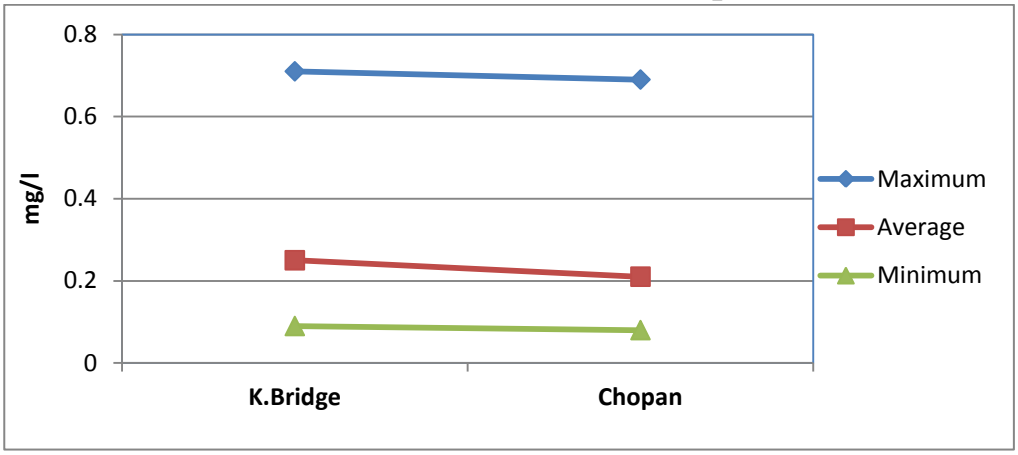

**Parameter: DO current year**



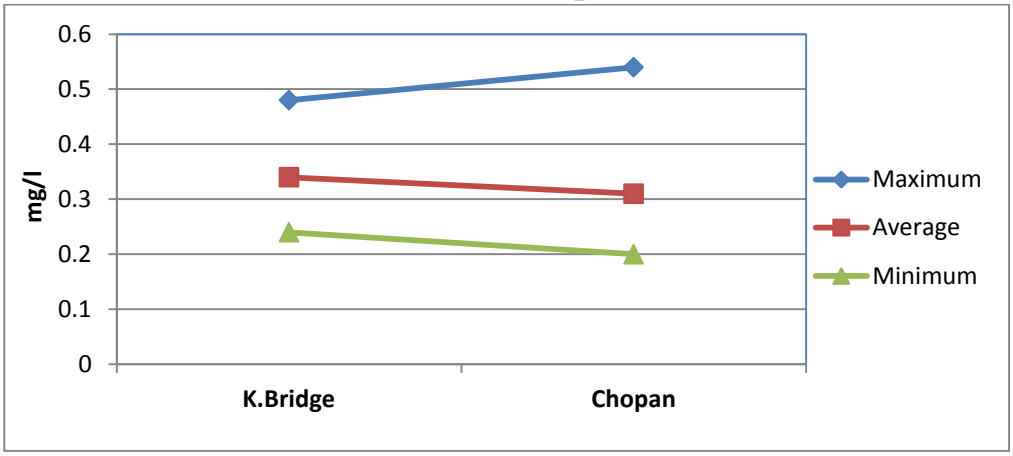

## 4.2.3 Fluoride in mg/l

| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year | Since inception from | 10 year | One year |
| Kuldahbridge | 0.71 | 0.48 | 0.28 | 0.09 | 0.24 | 0.24 | 0.25 | 0.34 | 0.26 |
| Chopan | 0.69 | 0.54 | 0.31 | 0.08 | 0.20 | 0.21 | 0.21 | 0.31 | 0.25 |

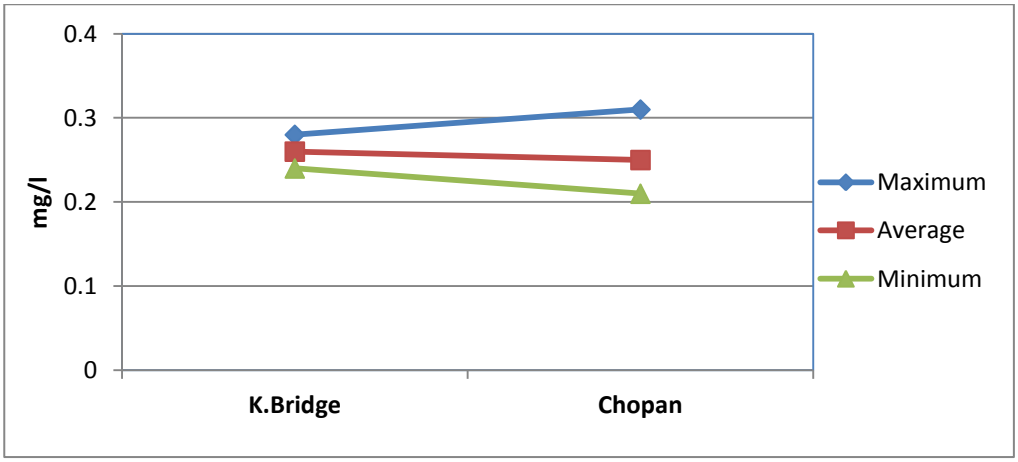
## Parameter: Fluoride since inception




## Parameter: Fluoride past 10 Year




## Parameter: Fluoride current Year

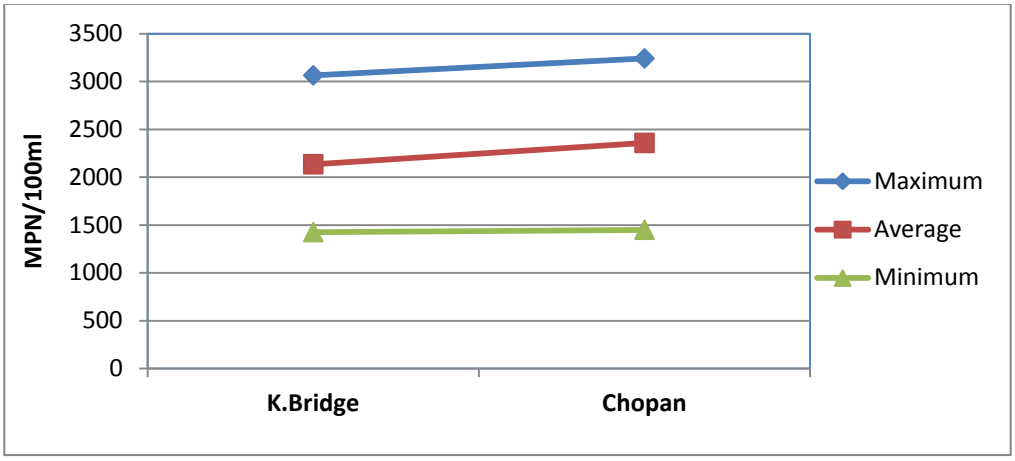


### 4.2.4 Total coliform in MPN/100ml

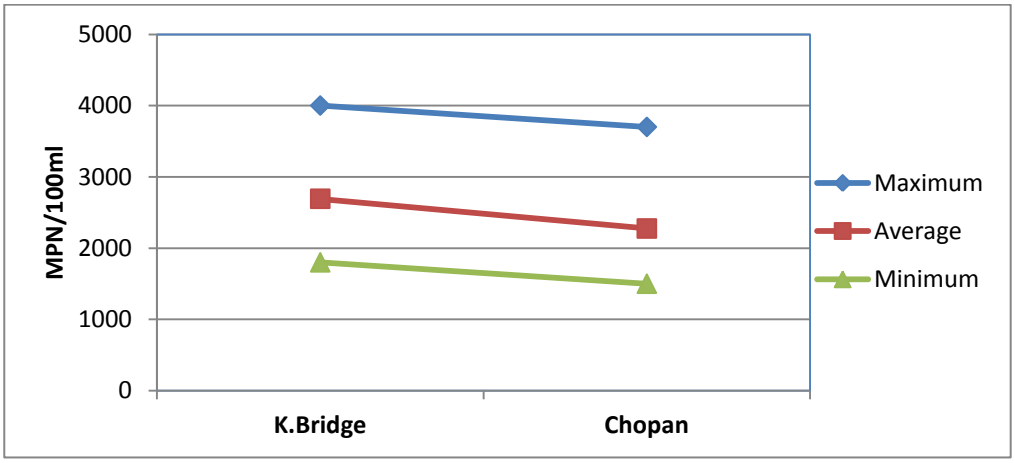
| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year |
| Kuldahbridge | - | 1130 | 2100 | - | 608 | 1100 | | 768 | 1450 |
| Chopan | - | 2200 | 3500 | - | 1200 | 2600 | - | 2119 | 3025 |

**Note :**Total coliform started from May 2007 at Kuldahbridge & Chopan.

**Parameter: Total coliform past 10 year**



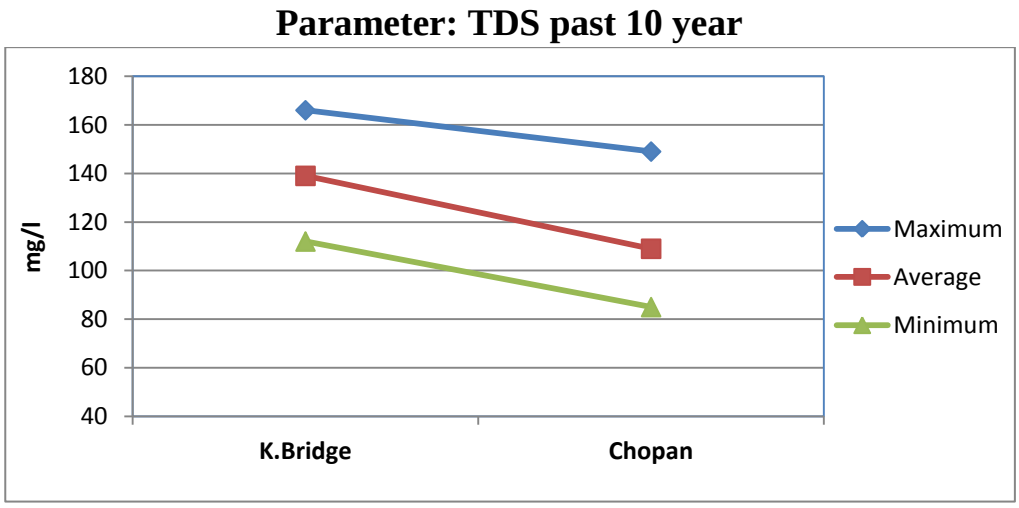

**Parameter: Total coliform current year**

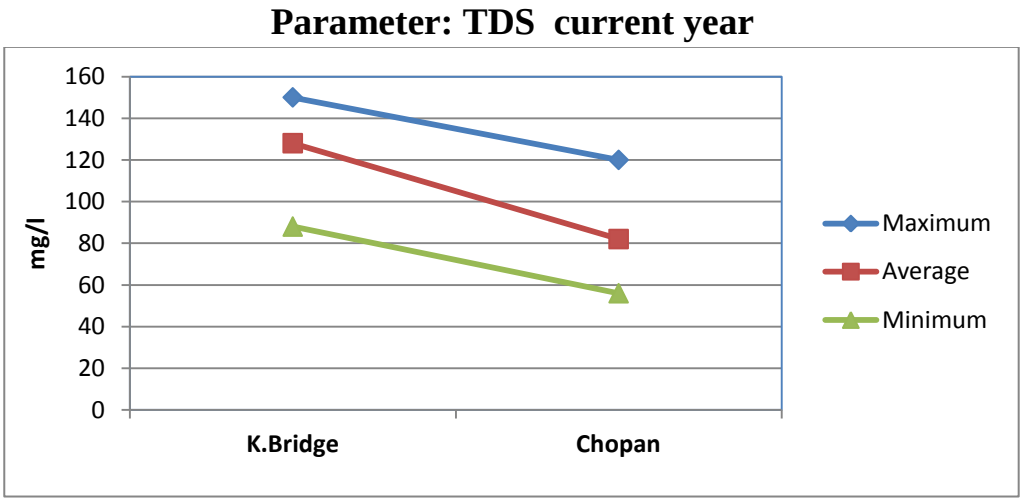


## 4.2.5 Total Dissolved Solids (TDS) in mg/l

| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year |
| Kuldahbridge | - | 166 | 150 | - | 112 | 88 | - | 139 | 128 |
| Chopan | - | 136 | 120 | - | 85 | 56 | - | 109 | 82 |

*TDS started from June 2009 at Kuldahbridge & Chopan.



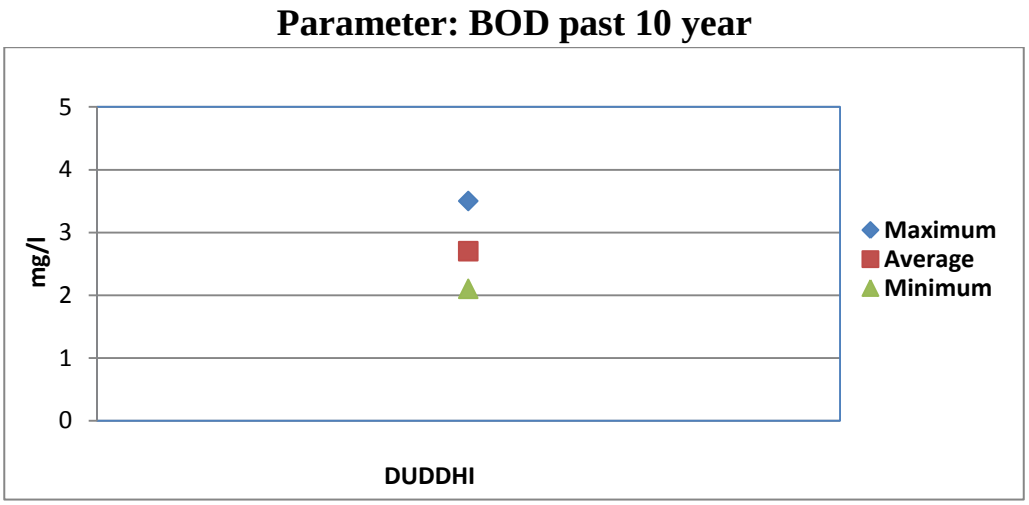



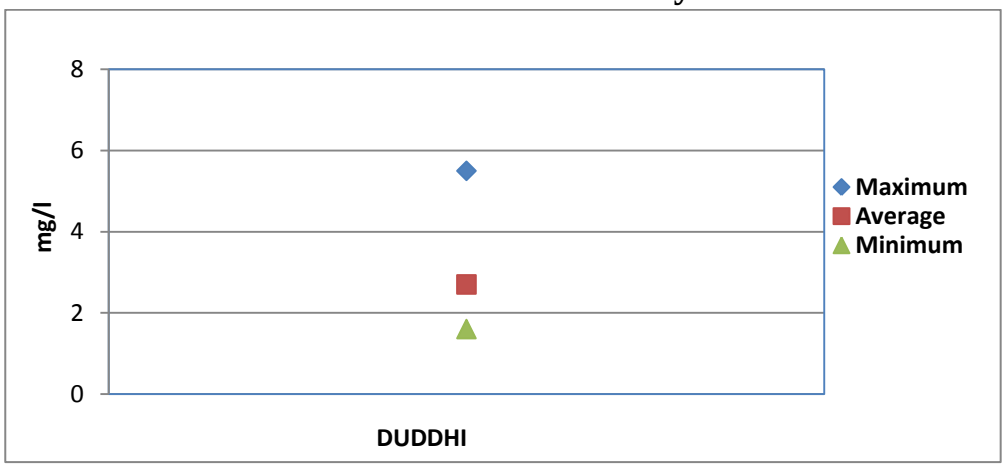
## 4.3. WATER QUALITY SCENARIO/TRENDS FOR RIVER KANHAR (SONE TRIBUTARY):

### 4.3.1 Biological Oxygen Demand (BOD) in mg/l

| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year |
| Duddhi | - | 3.5 | 5.5 | - | 2.1 | 1.6 | - | 2.7 | 2.7 |

*BOD started from June 2009.

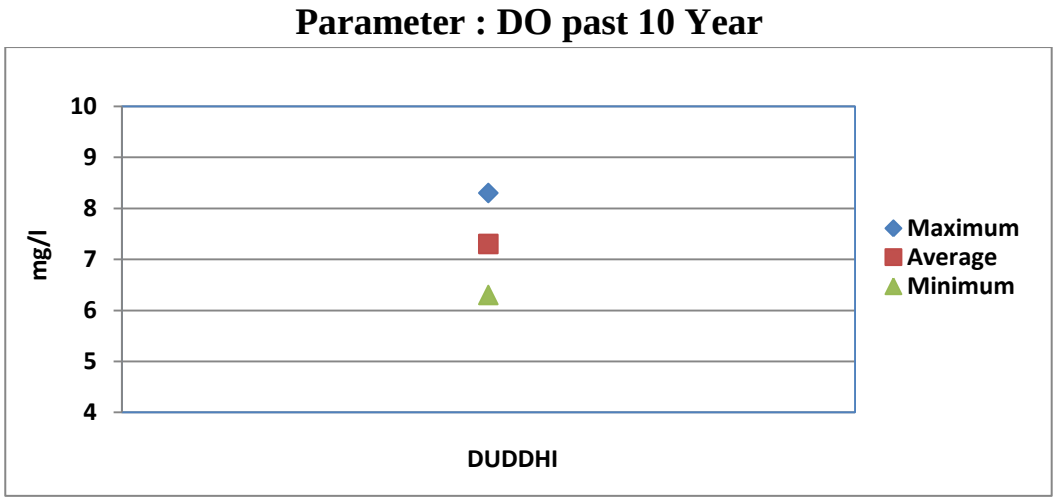


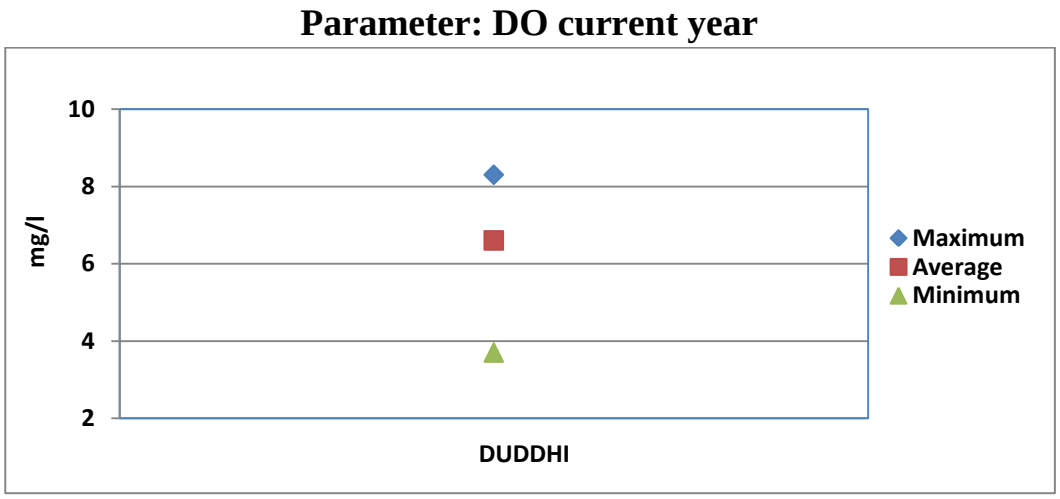



### 4.3.2 Dissolved Oxygen (DO) in mg/l

| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year |
| Duddhi | - | 8.3 | 8.3 | - | 6.3 | 3.7 | - | 7.3 | 6.6 |

*DO started from 2009 at Dudhhi.



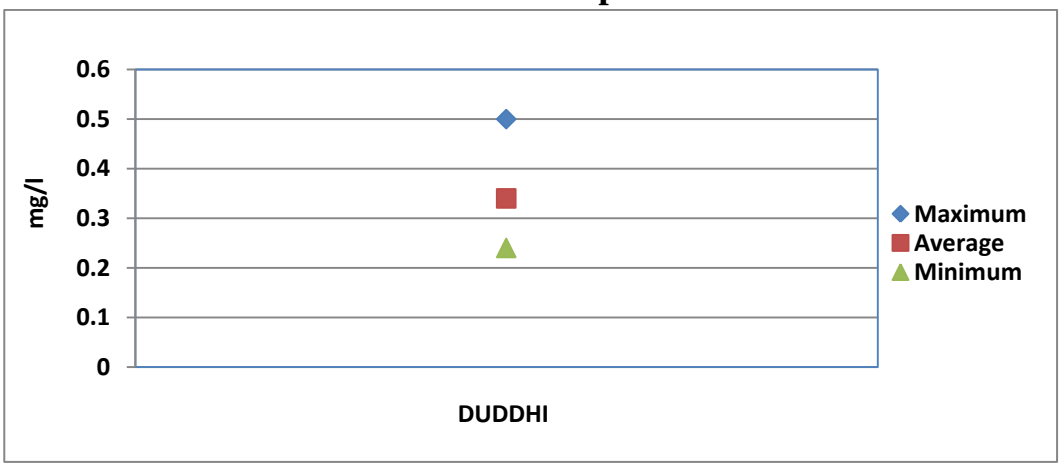




## 4.3.3 Fluoride in mg/l

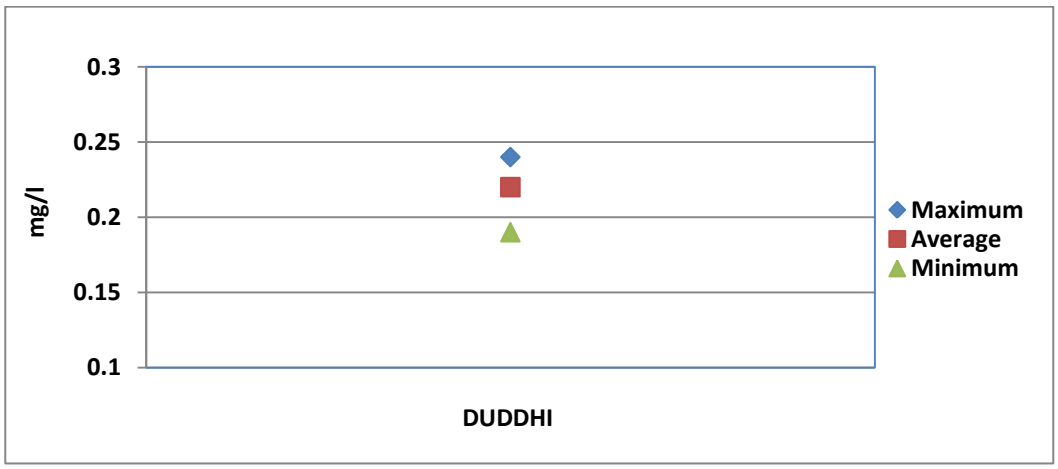
| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year | Since inception from | 10 year | One year |
| Duddhi | 0.48 | 0.50 | 0.24 | 0.20 | 0.24 | 0.19 | 0.29 | 0.34 | 0.22 |

## Parameter: Fluoride since inception


## Parameter: Fluoride past 10 Year




## Parameter: Fluoride current Year

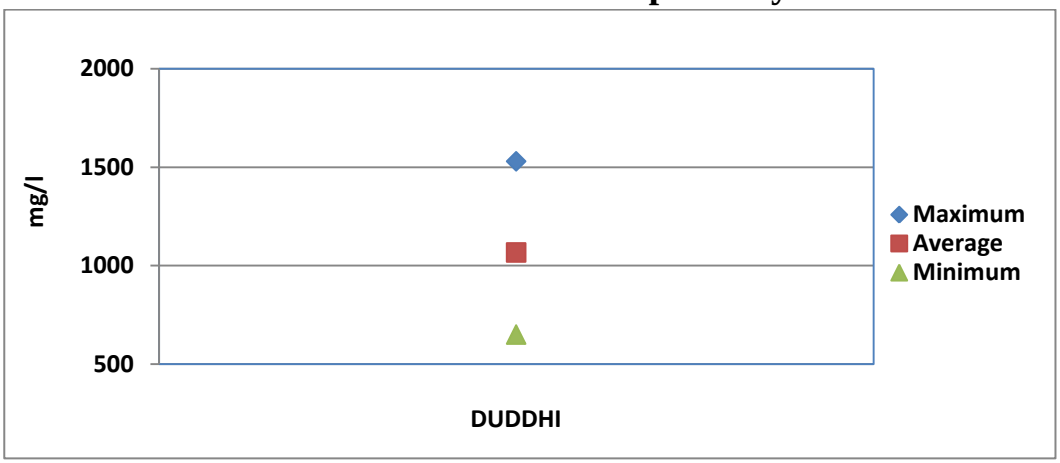


## 4.3.4 Total coliform in MPN/100ml

| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year | Since inception | Past 10 year | Current year |
| Duddhi | - | 1530 | 2500 | - | 650 | 1200 | - | 1067 | 1809 |

**Note :**Total coliform started from May 2007 at Duddhi.

**Parameter: Total coliform past 10 year**



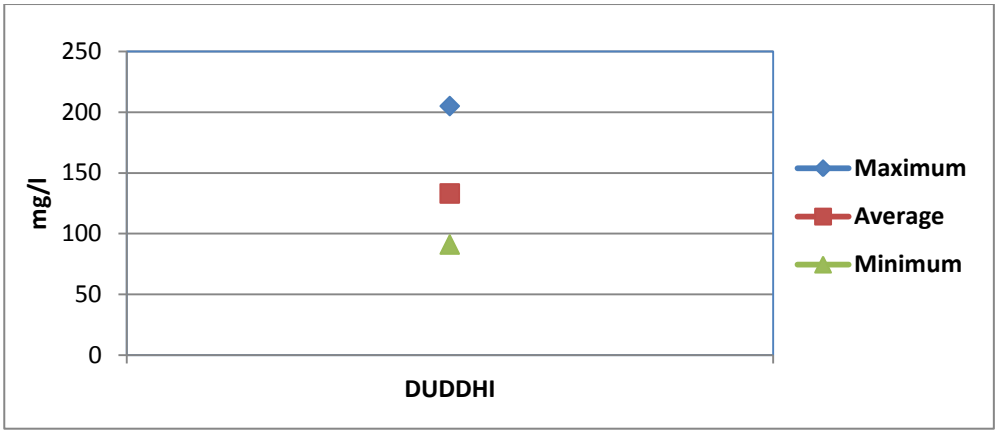

**Parameter: Total coliform current year**

## 4.3.5 Total Dissolved Solids (TDS) in mg/l

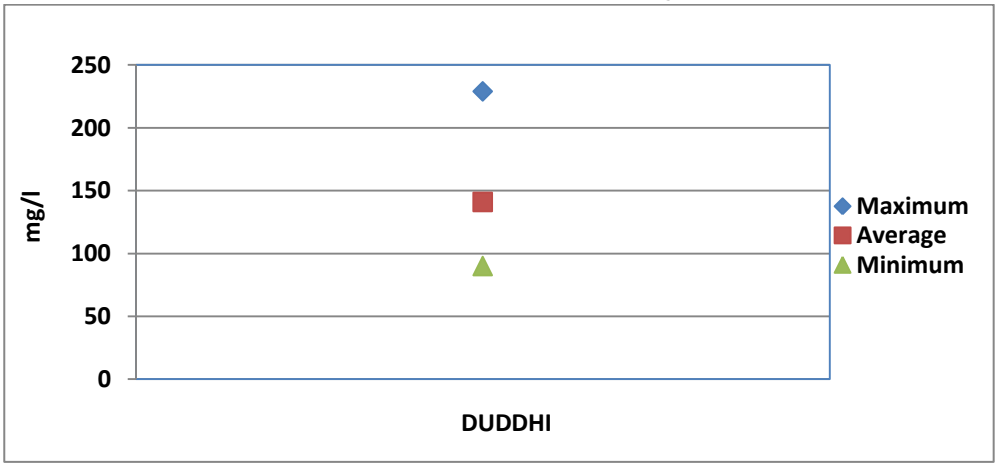
| Site Name (From U/S to D/S) | Avg. of Yearly Maximum | | | Avg. of Yearly Minimum | | | Annual Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year | Since inception | Past 10 year* | Current year |
| Duddhi | - | 205 | 229 | - | 91 | 90 | - | 133 | 141 |

*TDS started from June 2009 at Duddhi.

**Parameter: TDS past 10 year**

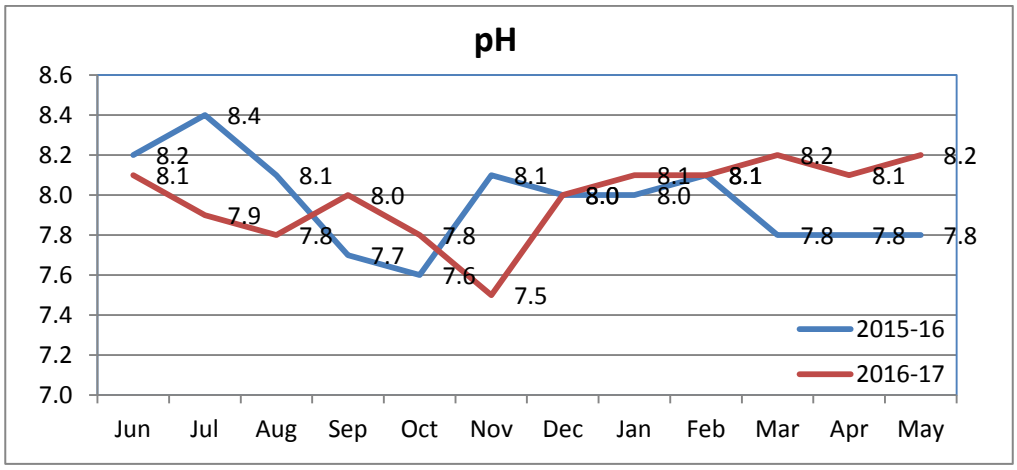


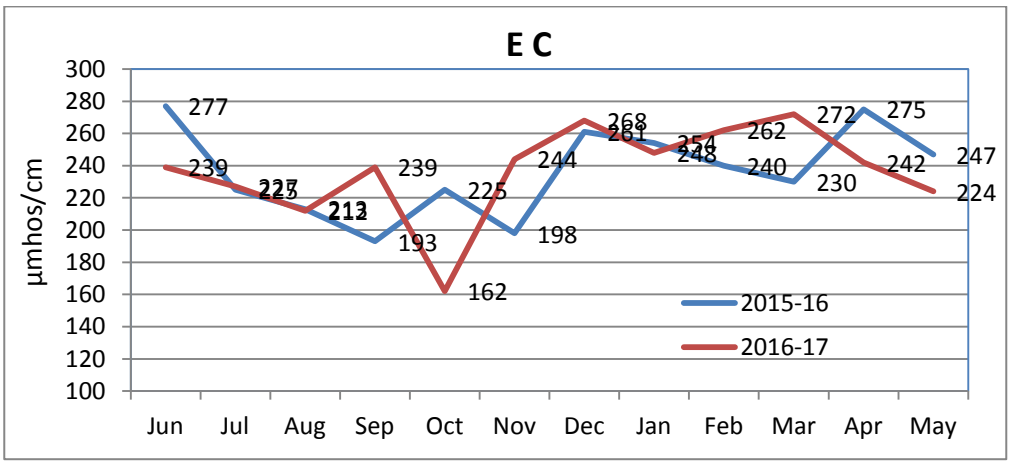

**Parameter: TDS current year**

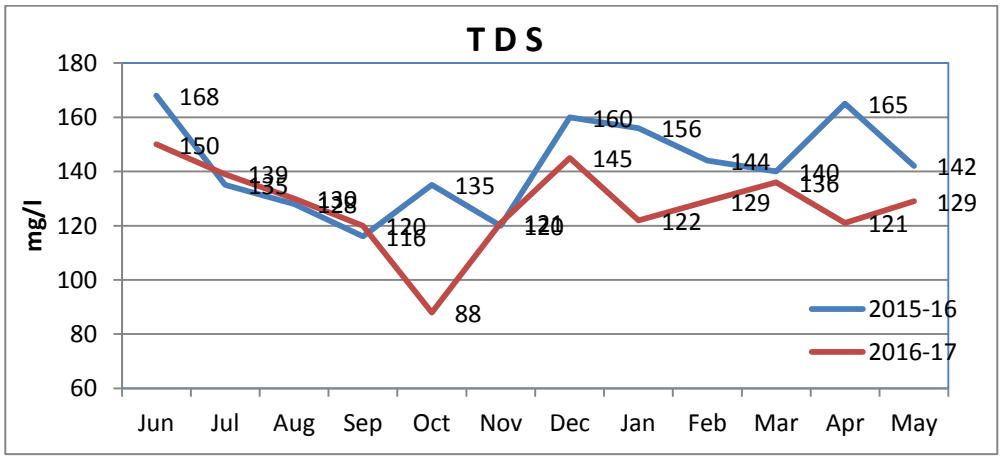


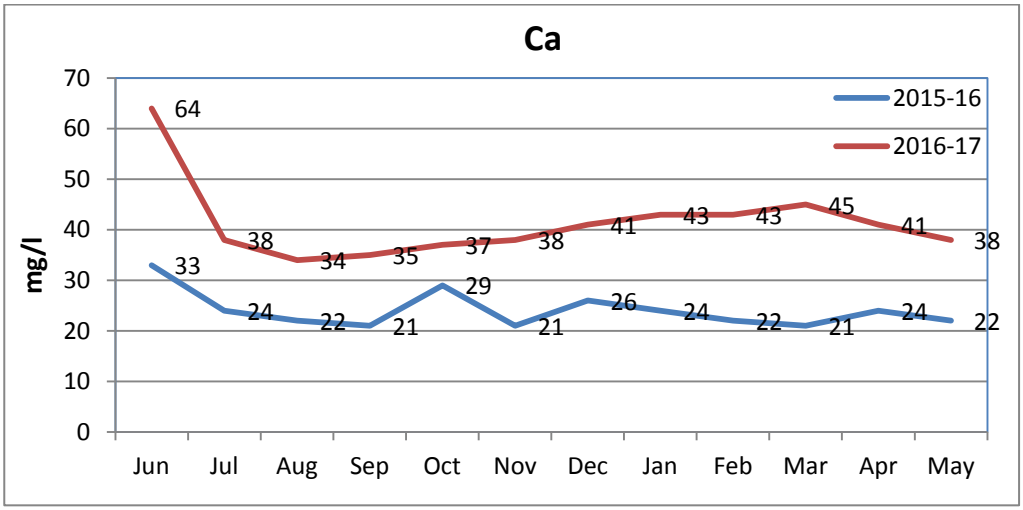
## 4.4. COMPARISION OF WATER QUALITY PARAMETERS DURING THE WATER YEAR 2014-2015 AND 2015 - 16:

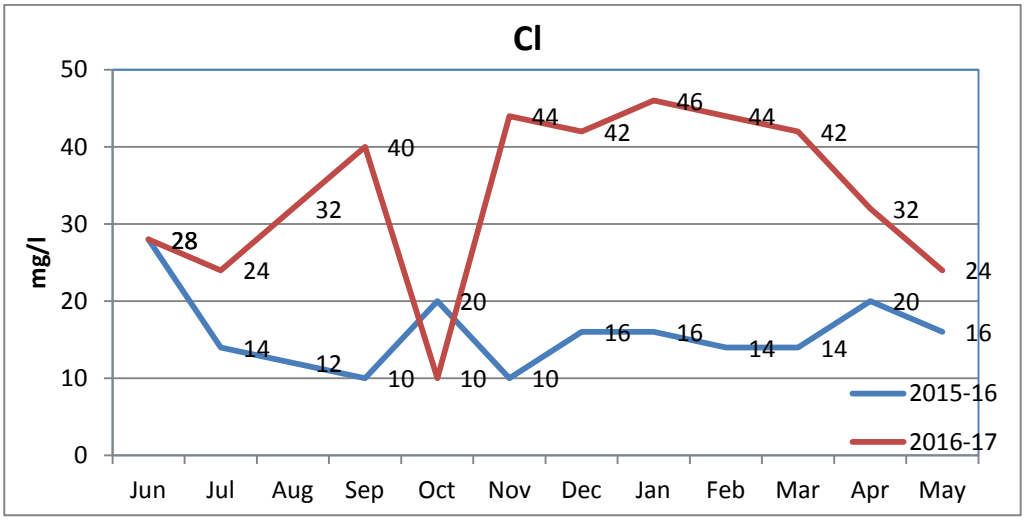
### 4.4.1 Kuldahbridge- River Sone

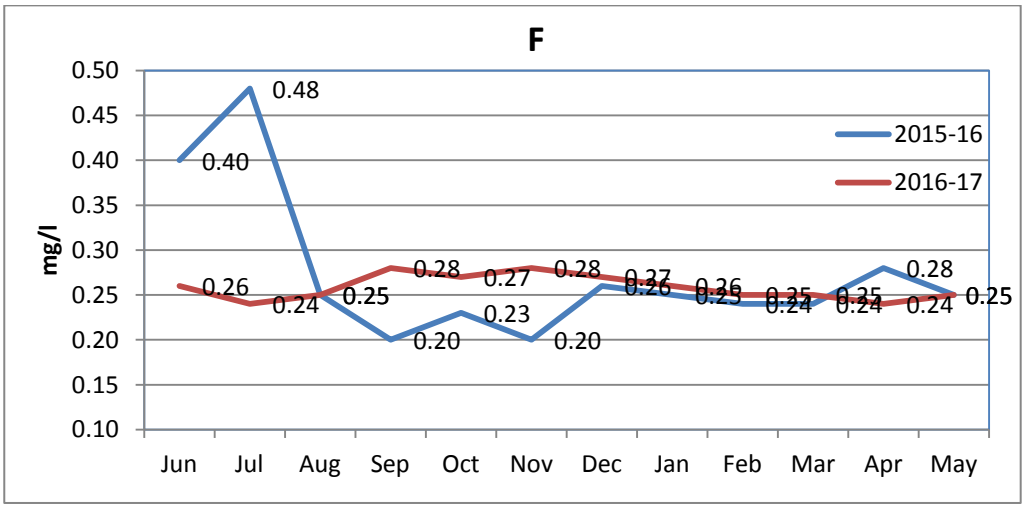


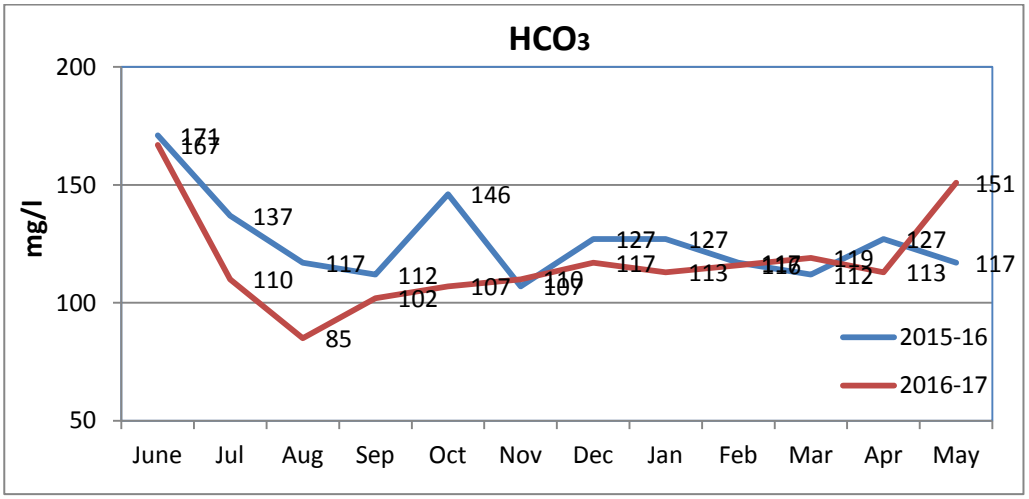



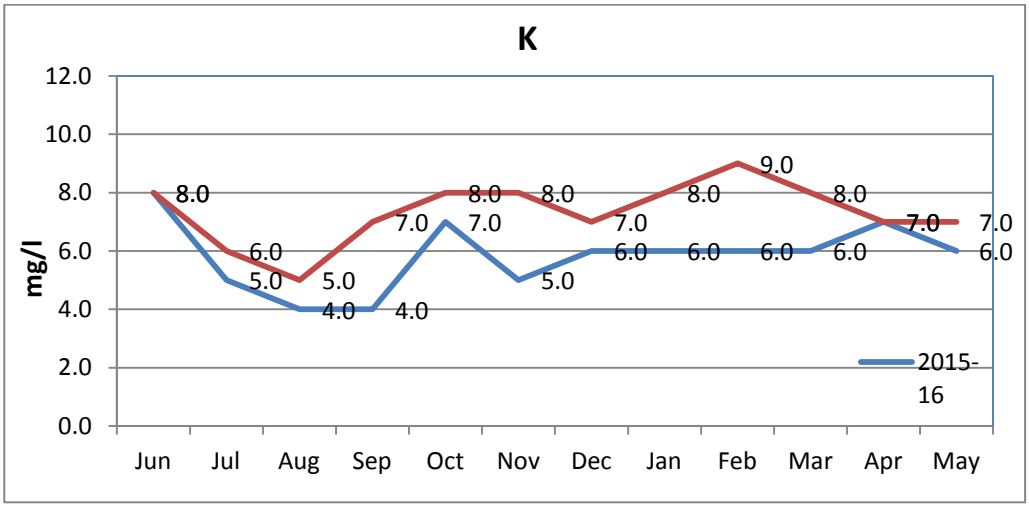



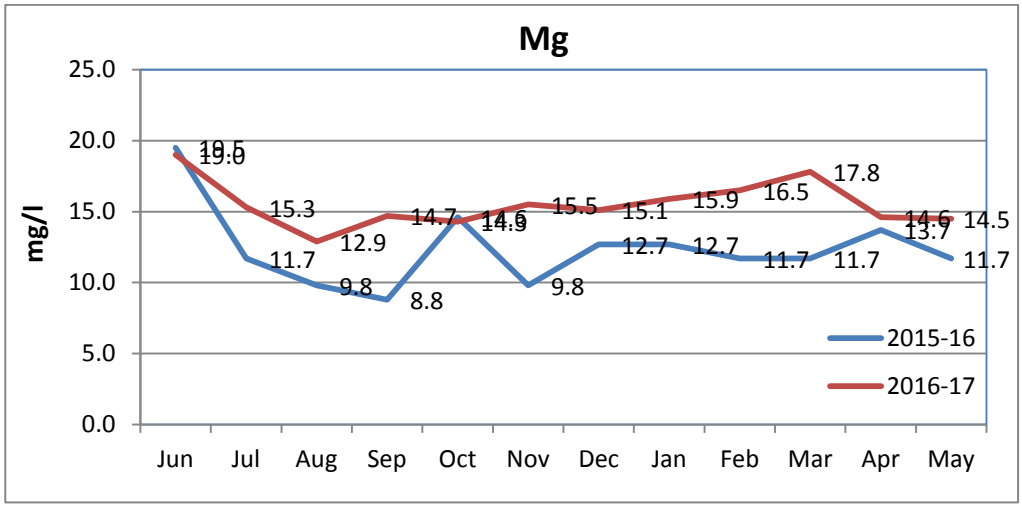

Ca
mg/l
70
60
50
40
30
20
10
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
64 38 34 35 37 38 41 43 43 45 41 38
33 24 22 21 29 21 26 24 22 21 24 22

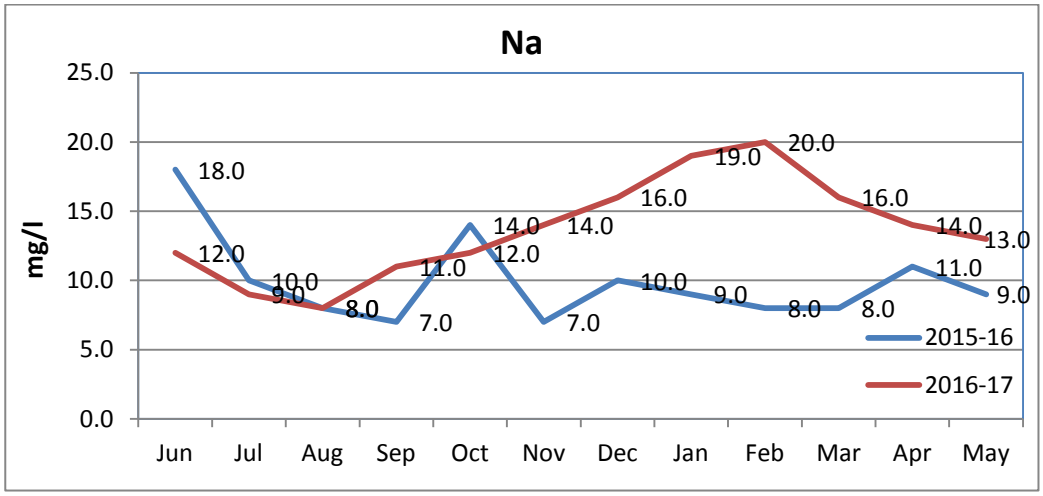

Cl
mg/l
50
40
30
20
10
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
28 24 32 40 10 44 42 46 44 42 32 24
28 14 12 10 20 10 16 16 14 14 20 16

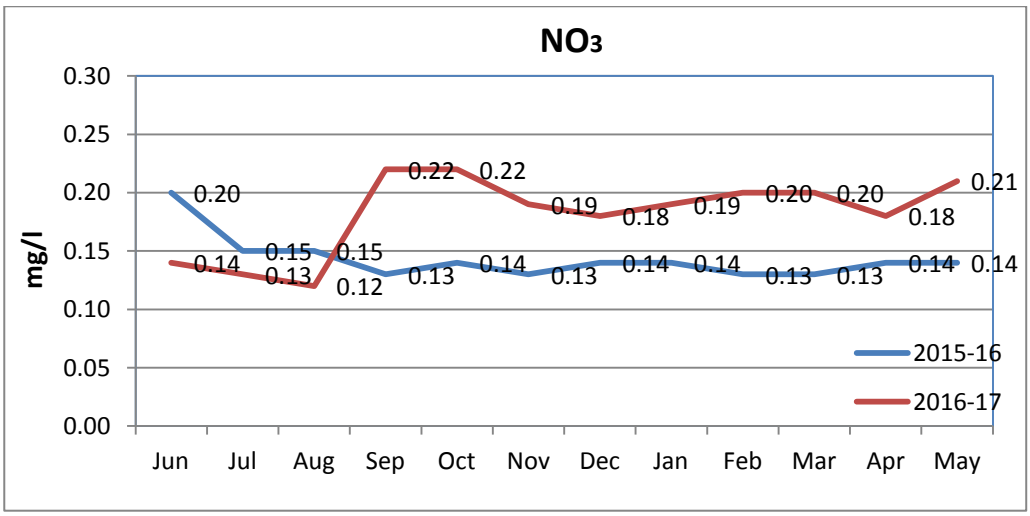

F
mg/l
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
0.40 0.48 0.25 0.20 0.23 0.20 0.26 0.25 0.24 0.24 0.28 0.25
0.26 0.24 0.25 0.28 0.27 0.28 0.27 0.26 0.25 0.24 0.24 0.24

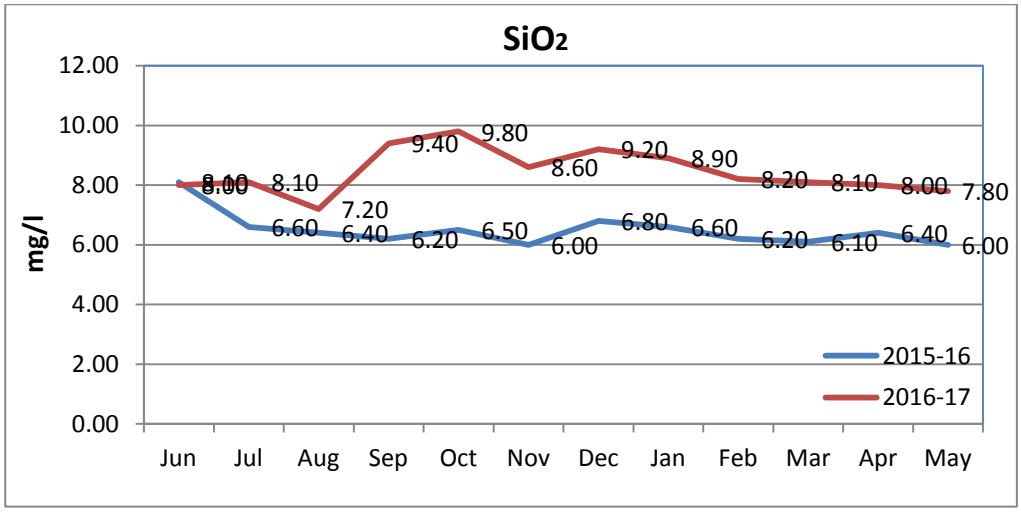

HCO3
200
150
100
50
mg/l
June
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2015-16
2016-17

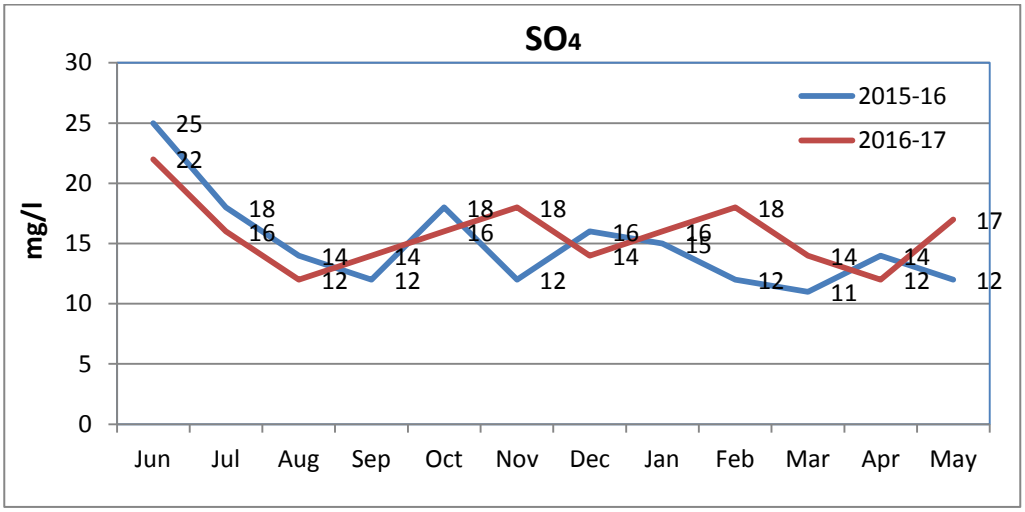

K
12.0
10.0
8.0
6.0
4.0
2.0
0.0
mg/l
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2015-16

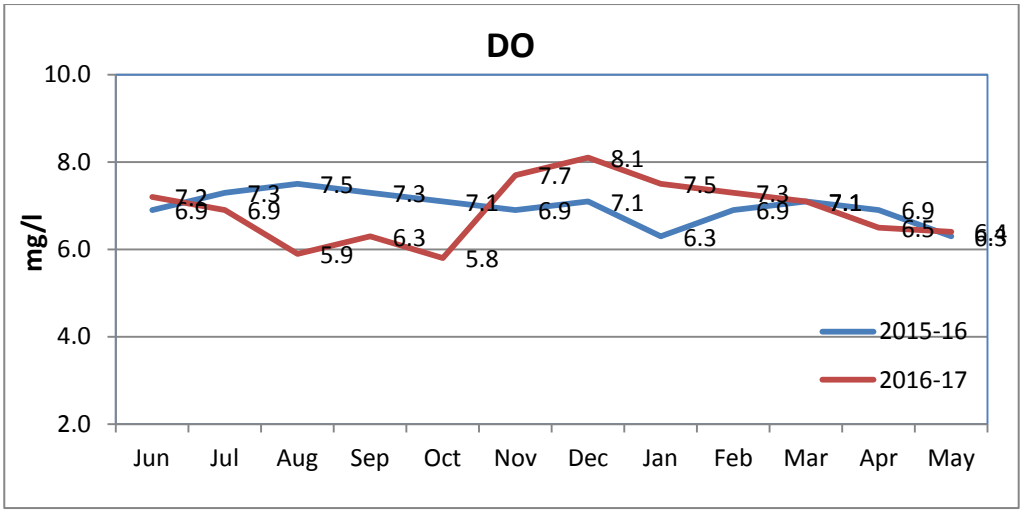

Mg
25.0
20.0
15.0
10.0
5.0
0.0
mg/l
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2015-16
2016-17

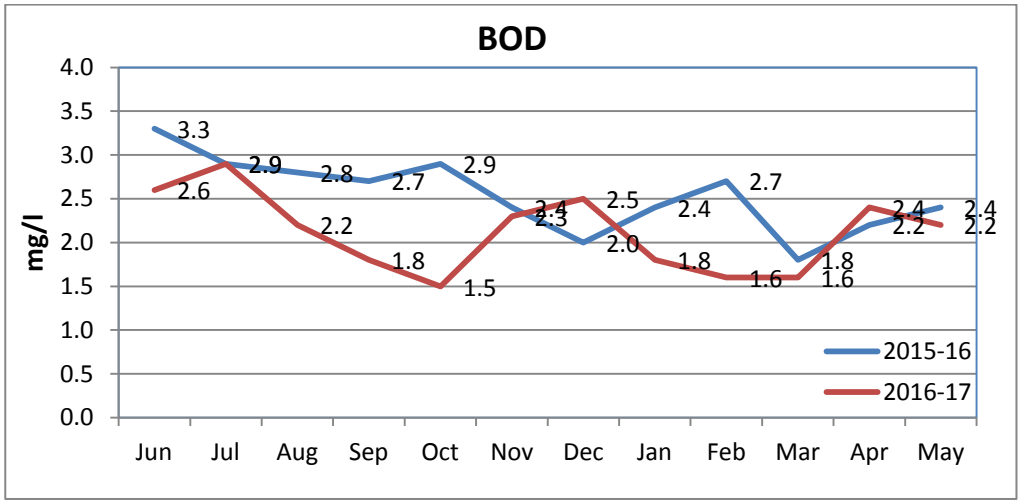

Na
mg/l
25.0
20.0
15.0
10.0
5.0
0.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
18.0 12.0 10.0 9.0 8.0 7.0 14.0 11.0 12.0 14.0 16.0 19.0 20.0 16.0 14.0 13.0
7.0 10.0 9.0 8.0 8.0 11.0 9.0
2015-16
2016-17

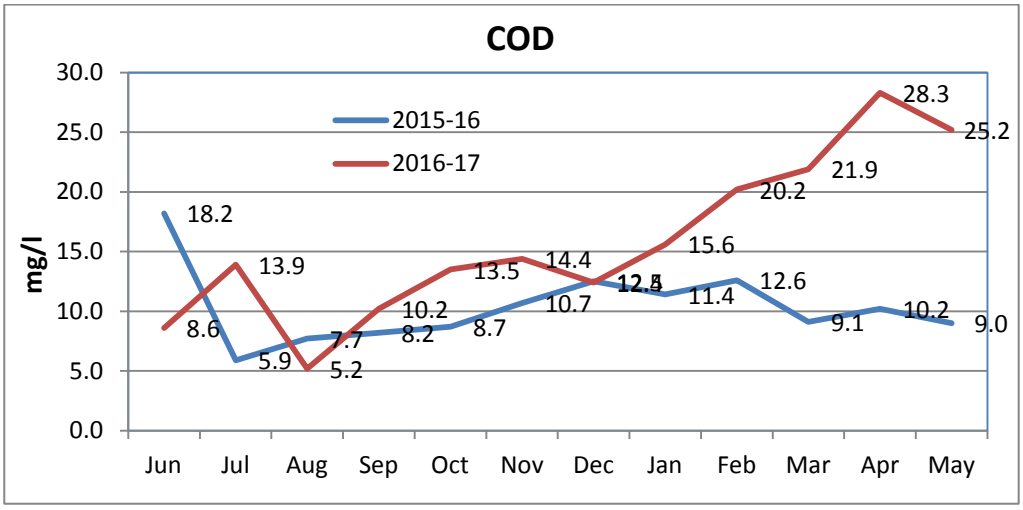

NO3
mg/l
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
0.20 0.14 0.15 0.13 0.15 0.12 0.22 0.13 0.22 0.14 0.19 0.13 0.18 0.14 0.19 0.14 0.20 0.14 0.20 0.13 0.18 0.13 0.21 0.14
2015-16
2016-17

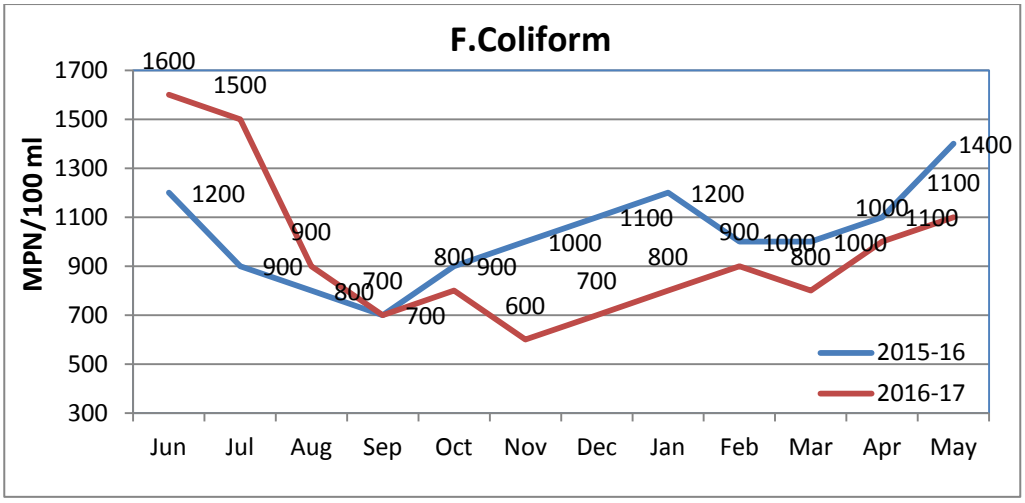

SiO2
mg/l
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
8.10 6.60 8.10 6.40 7.20 6.20 9.40 6.50 9.80 6.00 8.60 6.80 9.20 6.60 8.90 6.20 8.20 6.10 8.10 6.40 8.00 7.80 6.00
2015-16
2016-17

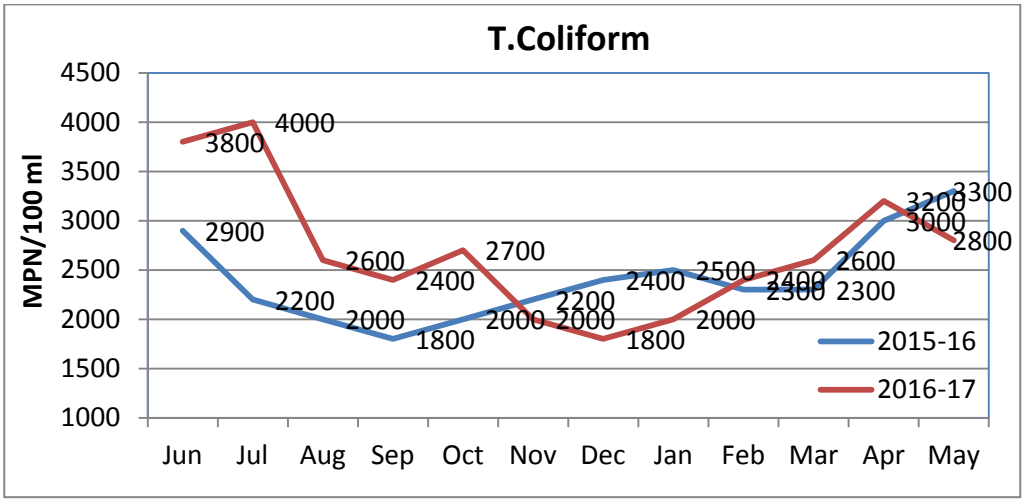

SO4
mg/l
30
25
20
15
10
5
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17

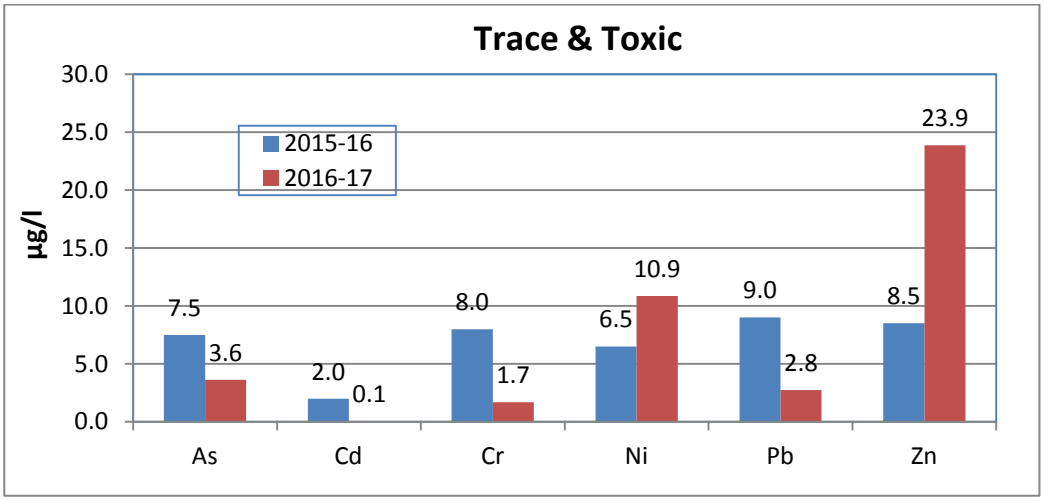

DO
mg/l
10.0
8.0
6.0
4.0
2.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17

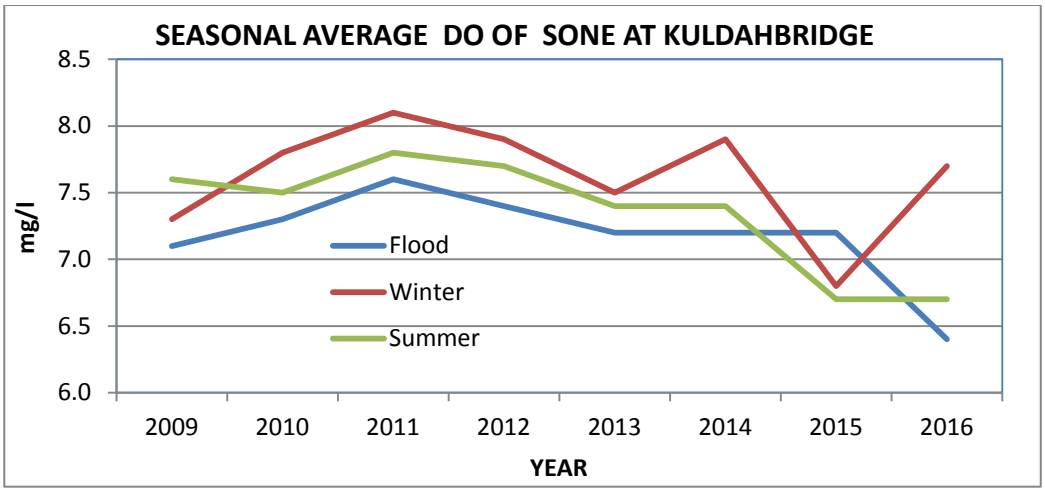

BOD
mg/l
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17

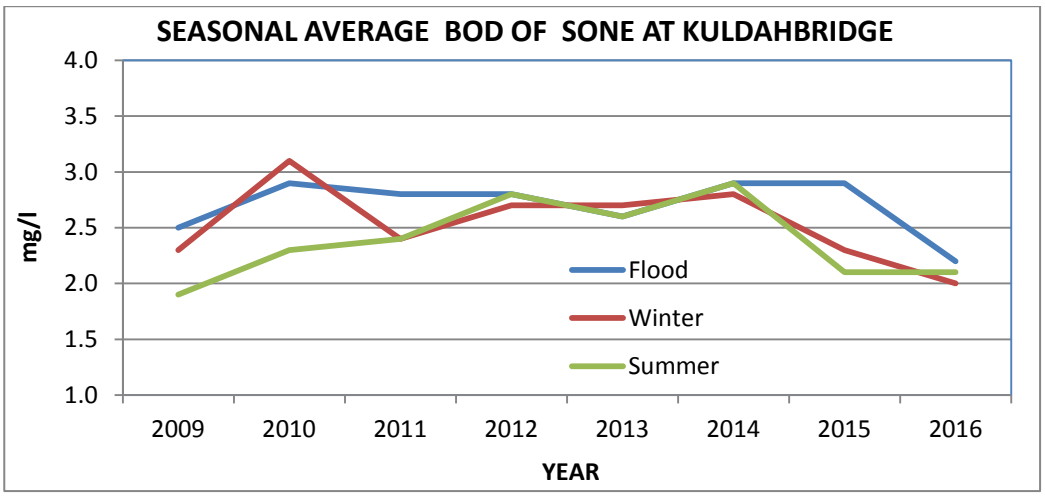

COD
mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2015-16
2016-17
18.2
8.6
13.9
5.9
7.7
5.2
10.2
8.2
13.5
8.7
14.4
10.7
12.5
11.4
15.6
12.6
20.2
9.1
21.9
10.2
28.3
9.0
25.2
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May


F.Coliform
MPN/100 ml
1700
1500
1300
1100
900
700
500
300
2015-16
2016-17
1600
1500
1200
900
800
700
800
900
1000
1100
1200
900
1000
800
1000
1100
1400
1100
700
600
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May

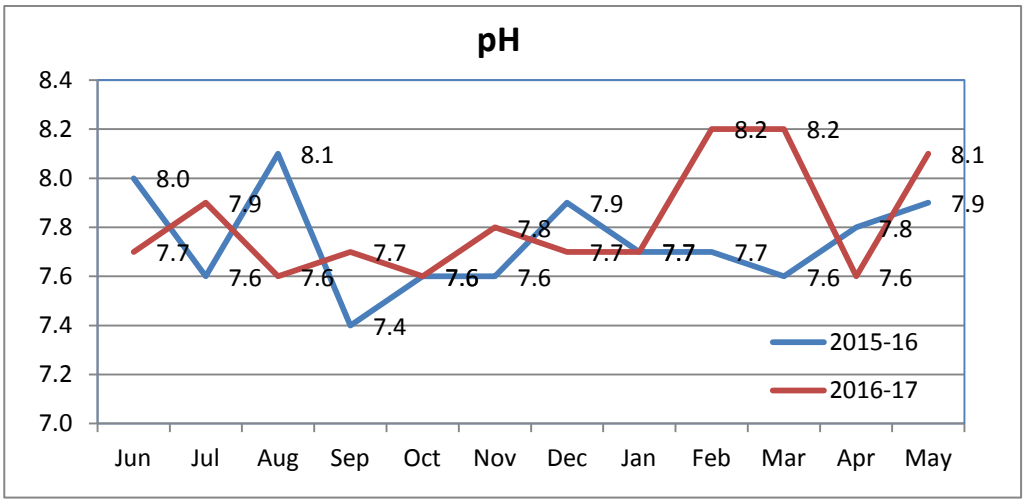

T.Coliform
MPN/100 ml
4500
4000
3500
3000
2500
2000
1500
1000
2015-16
2016-17
3800
4000
2900
2200
2600
2000
2400
1800
2700
2000
2200
2000
2400
1800
2500
2000
2400
2300
2600
2300
3200
3000
2300
2800
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May

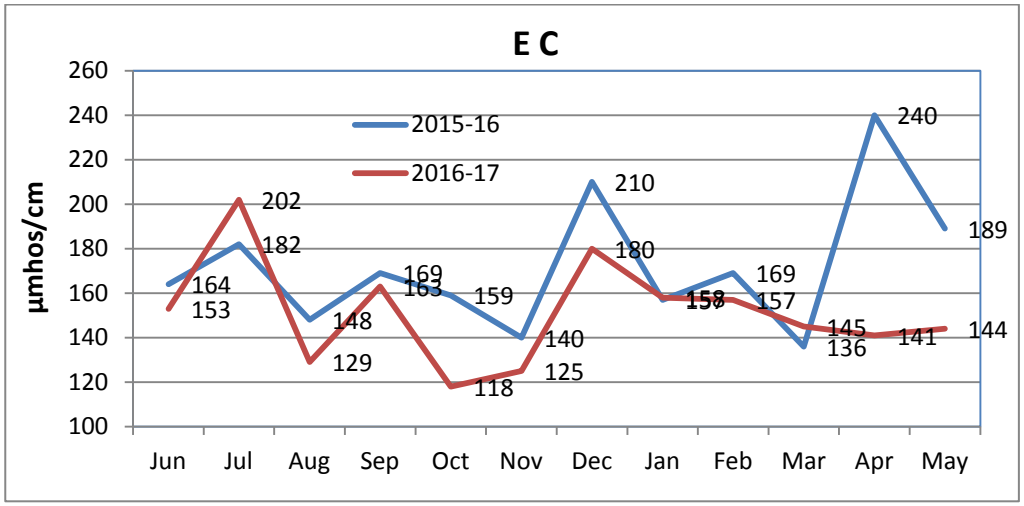

Trace & Toxic
µg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2015-16
2016-17
7.5
3.6
2.0
0.1
8.0
1.7
6.5
10.9
9.0
2.8
8.5
23.9
As
Cd
Cr
Ni
Pb
Zn

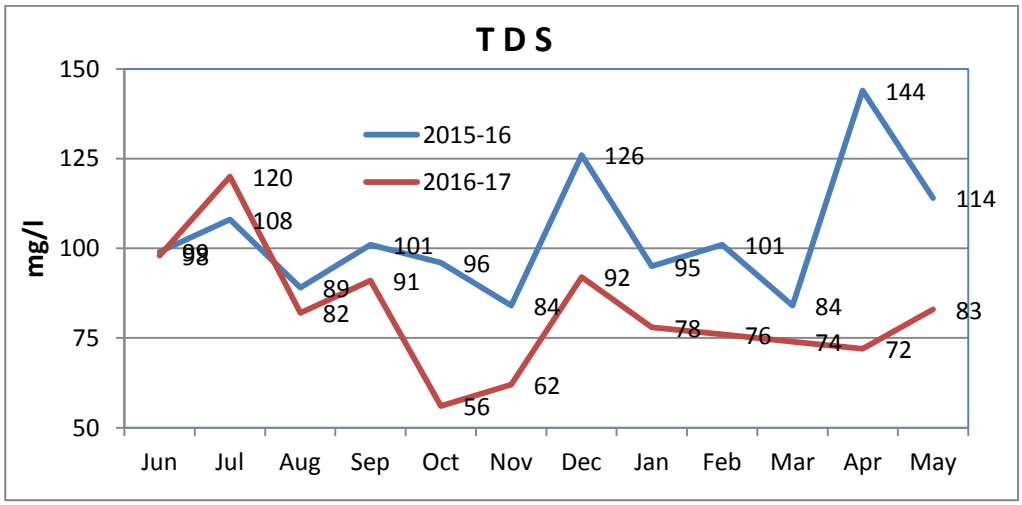

SEASONAL AVERAGE DO OF SONE AT KULDAHBRIDGE
mg/l
8.5
8.0
7.5
7.0
6.5
6.0
Flood
Winter
Summer
2009
2010
2011
2012
2013
2014
2015
2016
YEAR

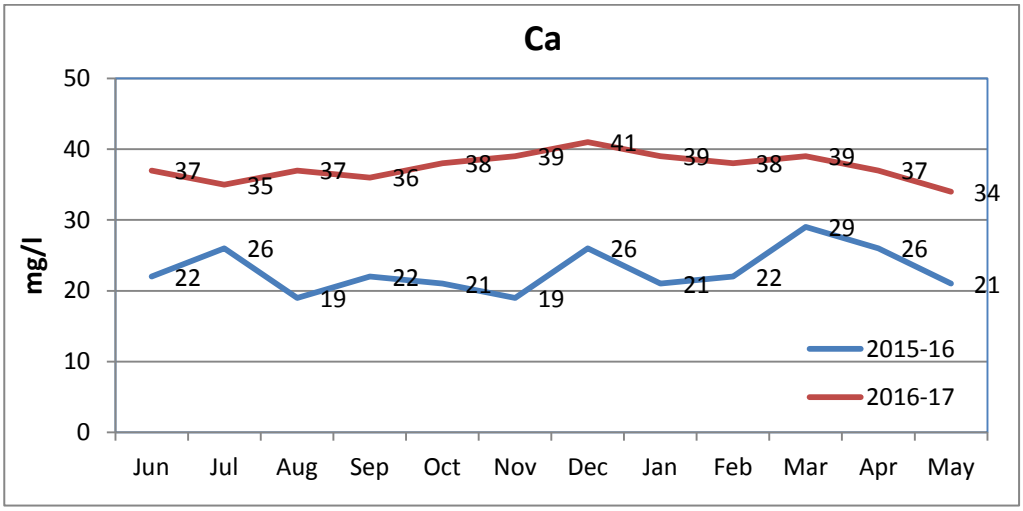

SEASONAL AVERAGE BOD OF SONE AT KULDAHBRIDGE
mg/l
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Flood
Winter
Summer
2009
2010
2011
2012
2013
2014
2015
2016
YEAR

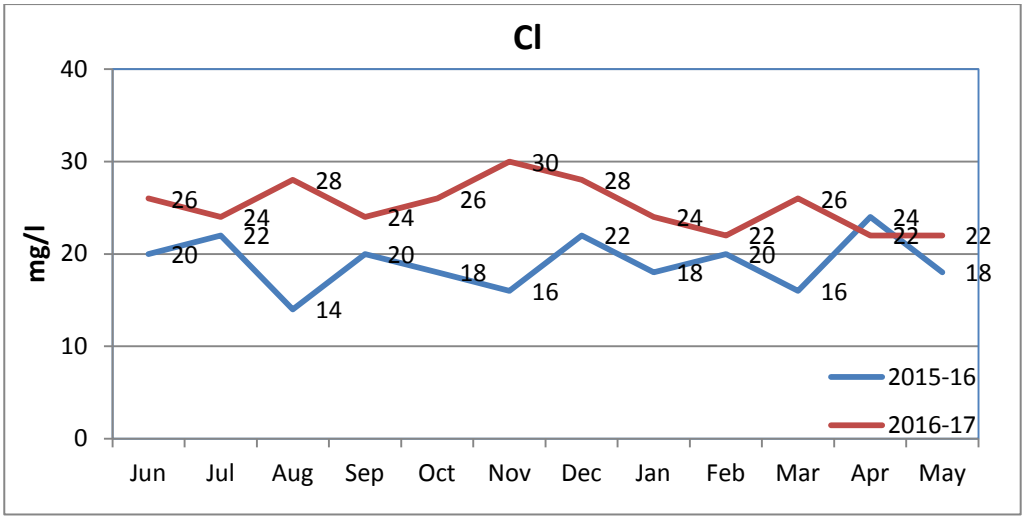
## 4.4.2 Chopan – River Sone

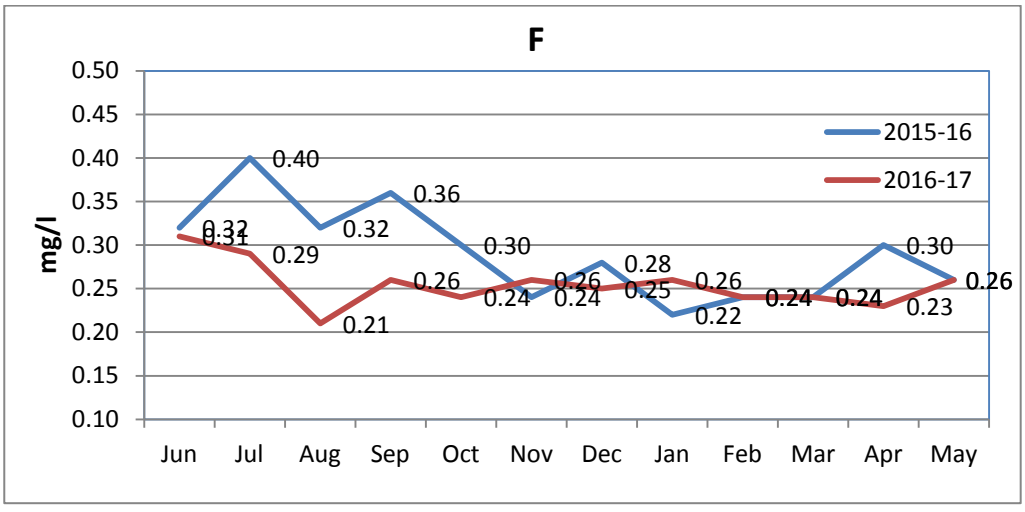


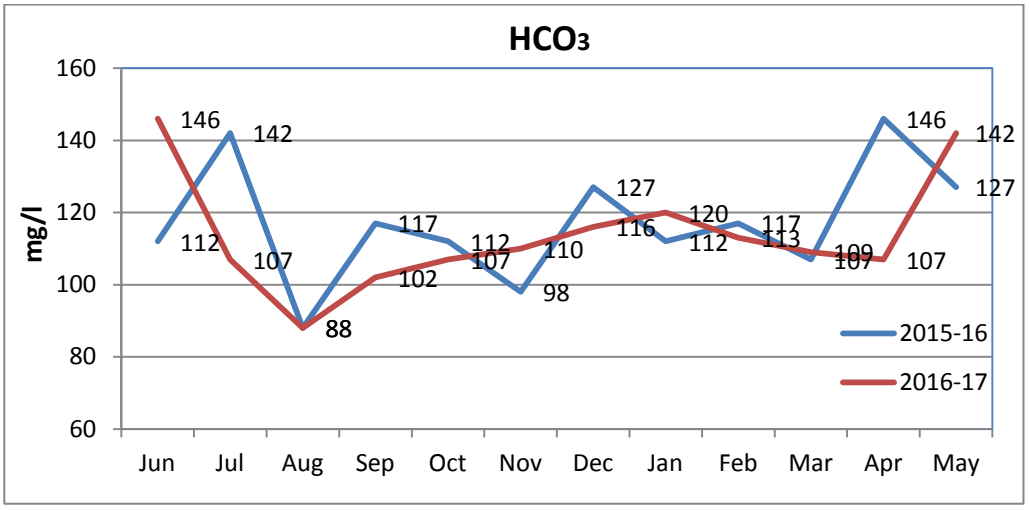



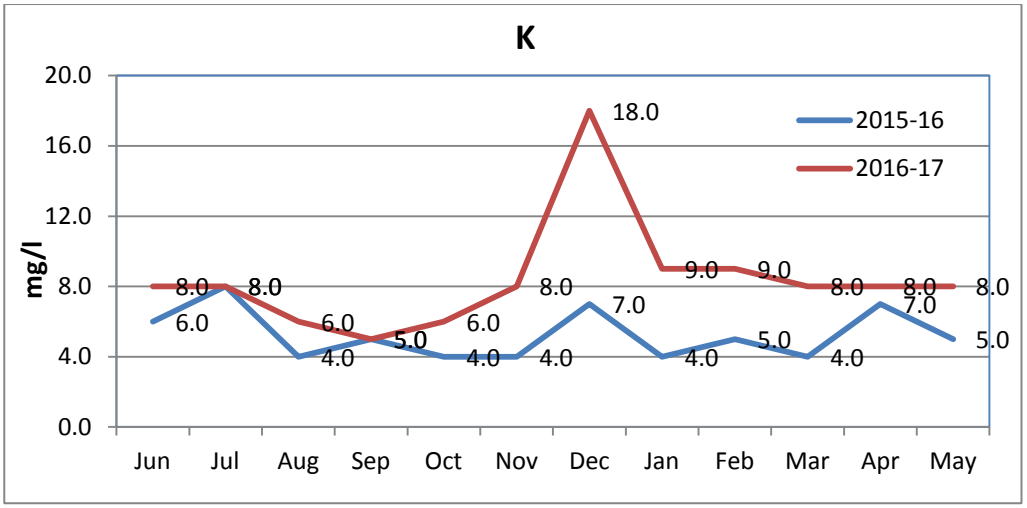



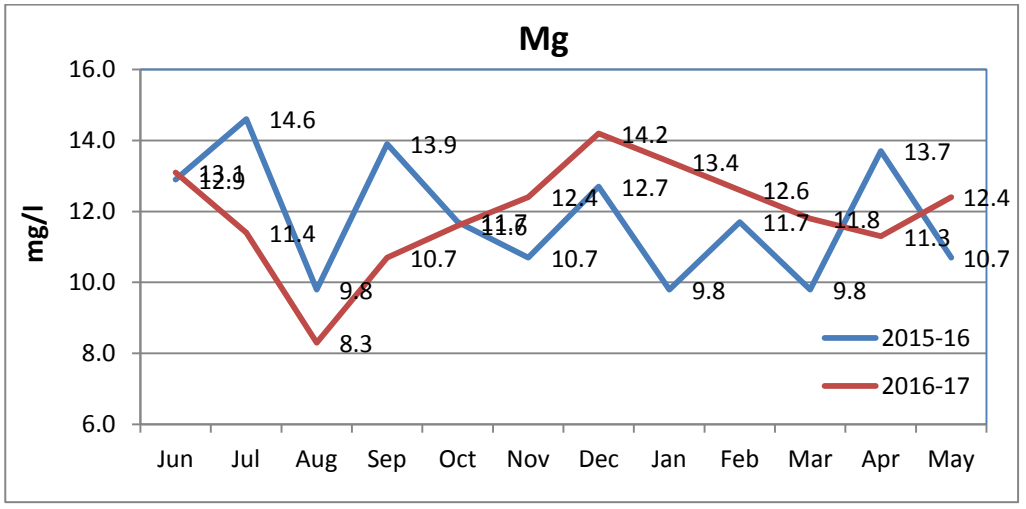

Ca
mg/l
50
40
30
20
10
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
37 35 37 36 38 39 41 39 38 39 37 34
22 26 19 22 21 19 26 21 22 29 26 21
2015-16
2016-17

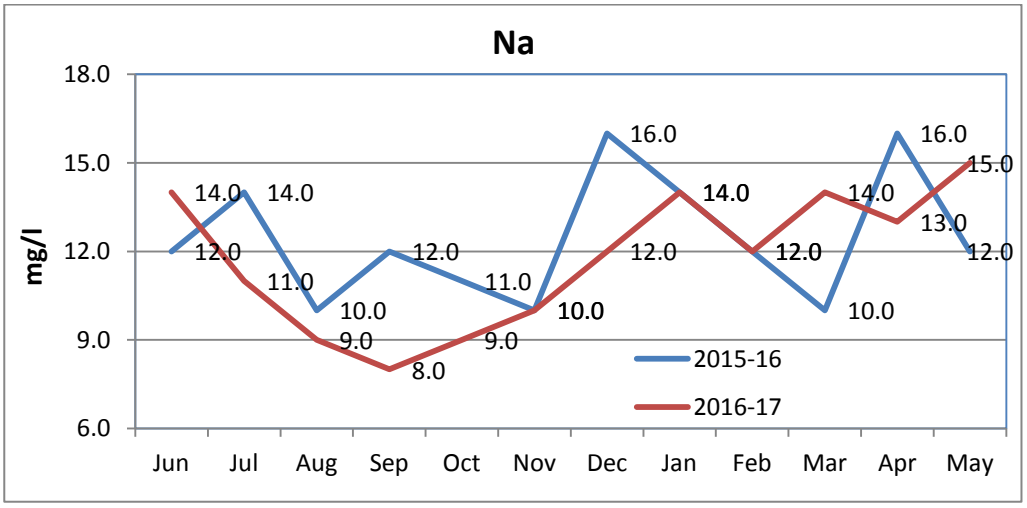

Cl
mg/l
40
30
20
10
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
26 24 28 24 26 30 28 24 22 26 22 22
20 22 14 20 18 16 22 18 20 16 24 18
2015-16
2016-17

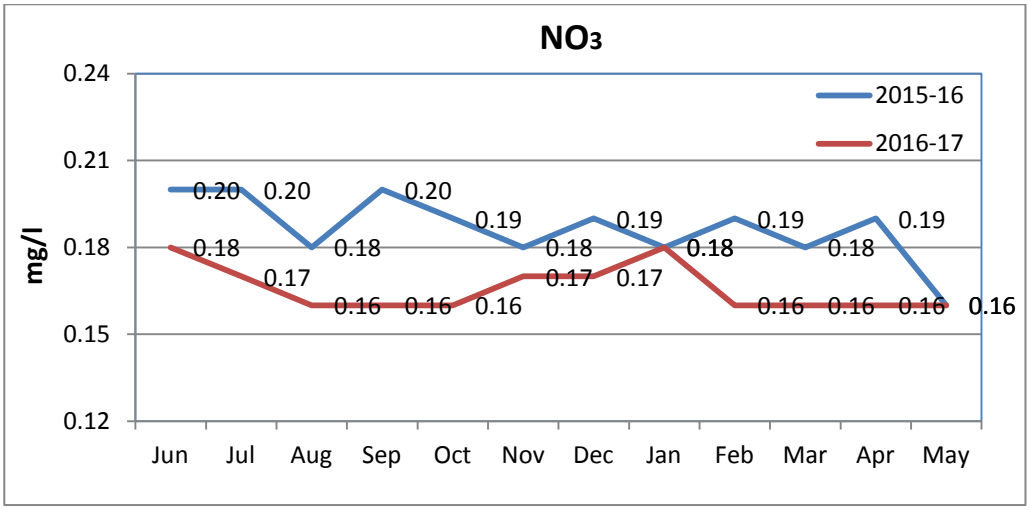

F
mg/l
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
0.31 0.29 0.21 0.26 0.24 0.26 0.25 0.26 0.24 0.24 0.23 0.26
0.32 0.40 0.32 0.36 0.30 0.24 0.28 0.22 0.24 0.24 0.30
2015-16
2016-17

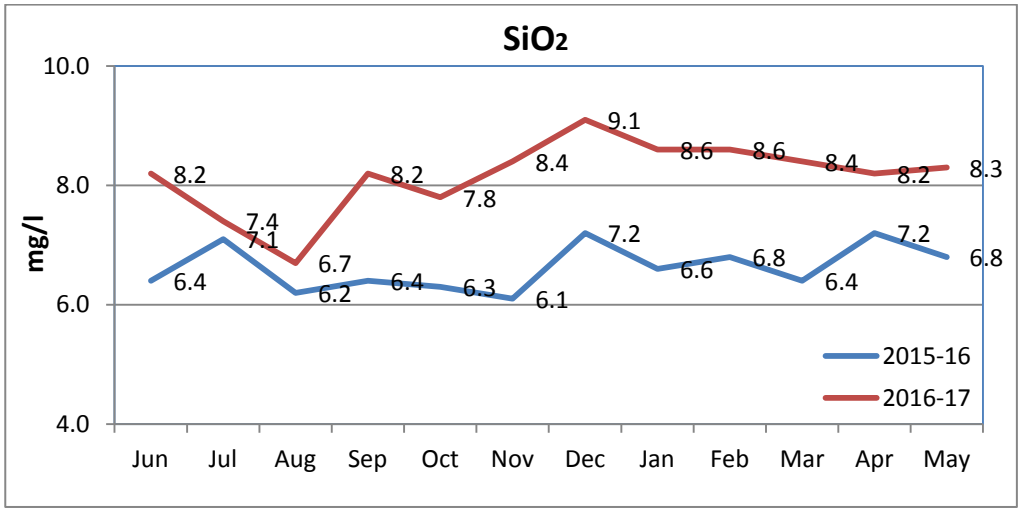

HCO3
mg/l
160
140
120
100
80
60
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
146 142 112 107 88 117 112 107 102 110 98 127 116 120 112 117 113 109 107 146 107 142 127
2015-16
2016-17

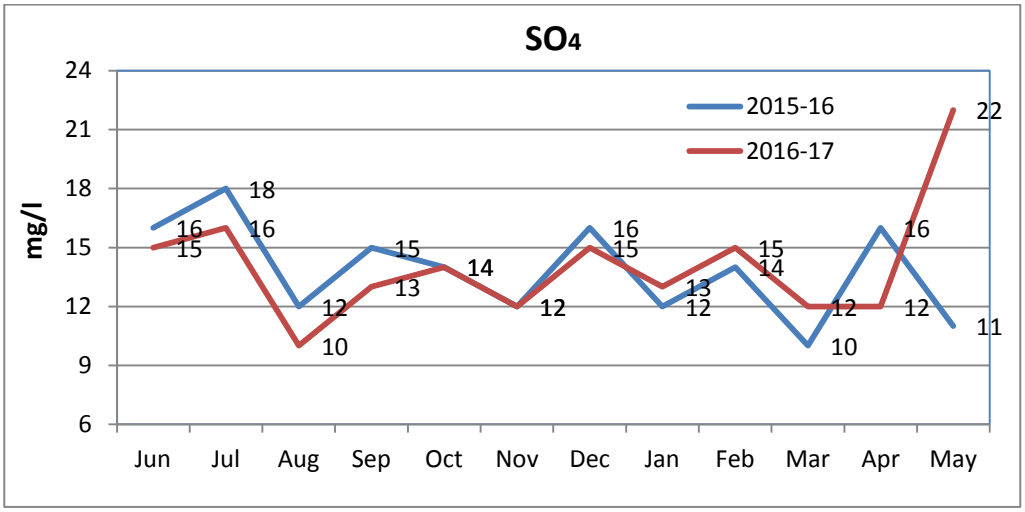

K
mg/l
20.0
16.0
12.0
8.0
4.0
0.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
8.0 8.0 6.0 4.0 6.0 5.0 6.0 4.0 8.0 4.0 18.0 7.0 9.0 4.0 9.0 5.0 8.0 4.0 8.0 7.0 8.0 5.0
2015-16
2016-17

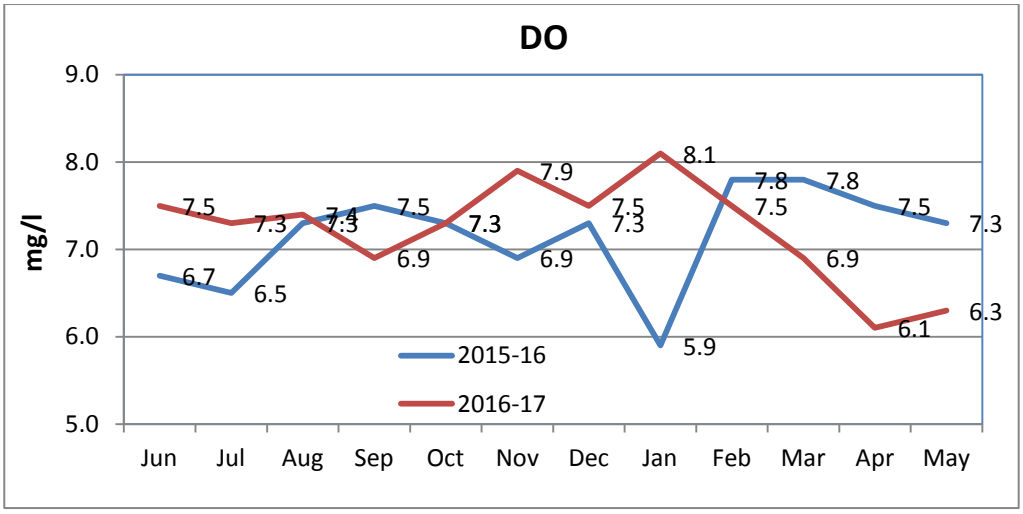

Mg
mg/l
16.0
14.0
12.0
10.0
8.0
6.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
13.1 12.9 14.6 11.4 9.8 13.9 10.7 11.7 11.6 10.7 12.4 12.7 9.8 14.2 13.4 12.6 11.7 9.8 11.8 13.7 11.3 12.4 10.7 8.3
2015-16
2016-17

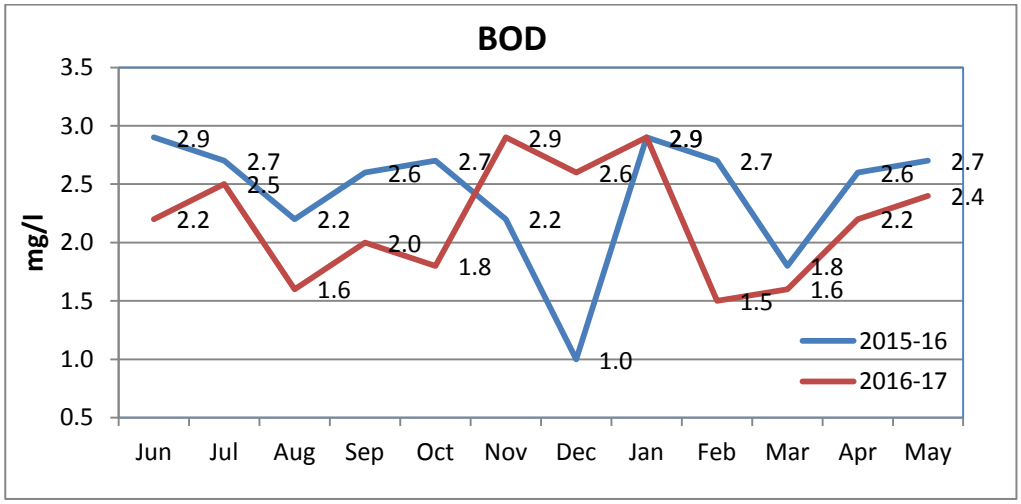

Na
mg/l
18.0
15.0
12.0
9.0
6.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
14.0 14.0 11.0 10.0 12.0 11.0 16.0 14.0 12.0 10.0 16.0 12.0
12.0 9.0 8.0 9.0 10.0 12.0 14.0 12.0 14.0 13.0 15.0
2015-16
2016-17

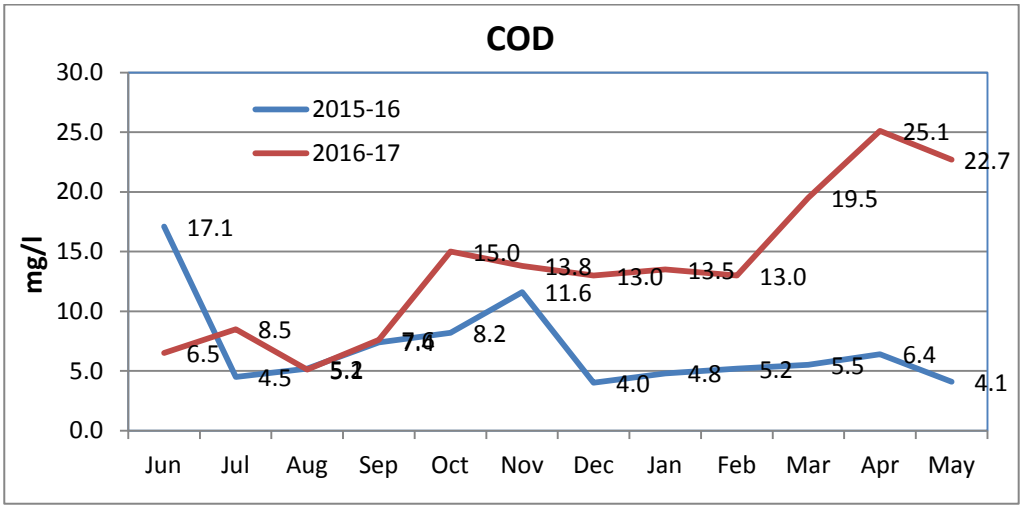

NO3
mg/l
0.24
0.21
0.18
0.15
0.12
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
0.20 0.20 0.18 0.20 0.19 0.18 0.19 0.18 0.19 0.18 0.19 0.16
0.18 0.17 0.16 0.16 0.16 0.17 0.17 0.18 0.16 0.16 0.16
2015-16
2016-17

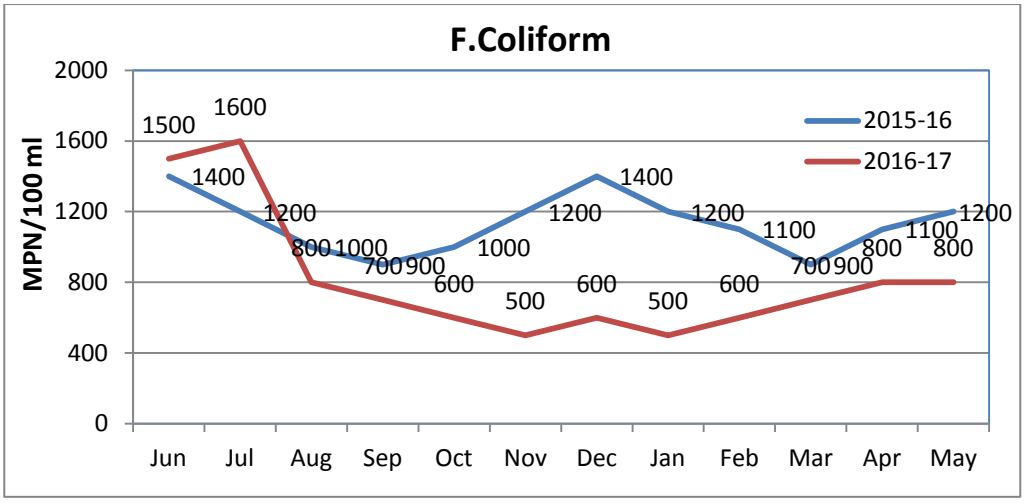

SiO2
mg/l
10.0
8.0
6.0
4.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
8.2 7.4 8.2 7.8 8.4 9.1 8.6 8.6 8.4 8.2 8.3
6.4 7.1 6.7 6.2 6.4 6.3 6.1 7.2 6.6 6.8 6.4 7.2 6.8
2015-16
2016-17

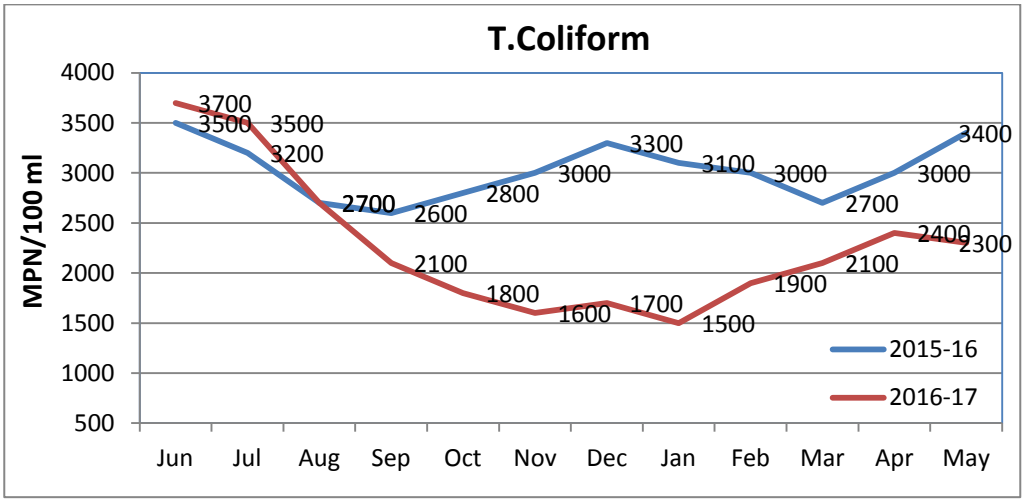

SO4
mg/l
24
21
18
15
12
9
6
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
16 18 12 15 14 12 16 12 14 10 16 11
15 16 10 13 14 12 15 13 15 12 12 22

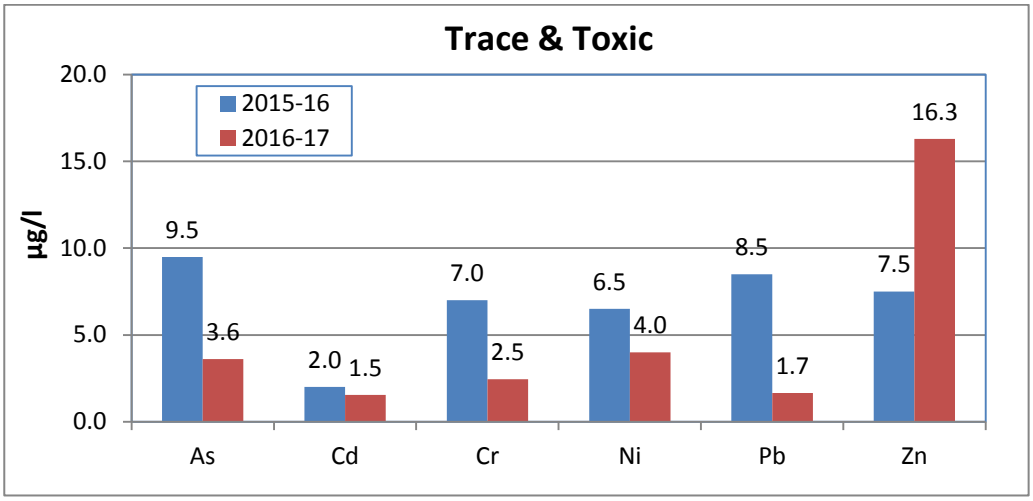

DO
mg/l
9.0
8.0
7.0
6.0
5.0
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
6.7 6.5 7.4 7.5 7.3 6.9 7.3 5.9 7.8 7.8 7.5 7.3
7.5 7.3 7.3 6.9 7.9 7.5 8.1 7.5 6.9 6.1 6.3

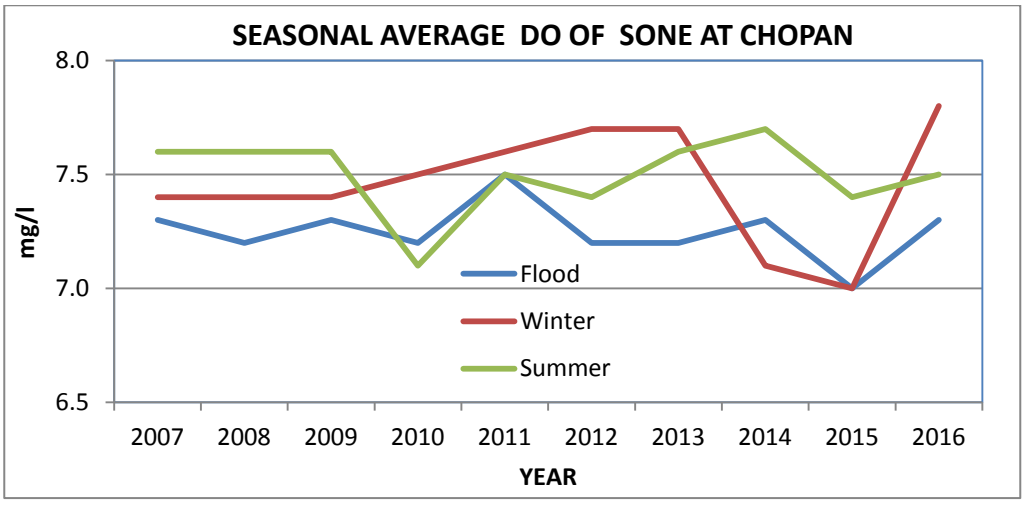

BOD
mg/l
3.5
3.0
2.5
2.0
1.5
1.0
0.5
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2.9 2.7 2.2 2.6 2.7 2.2 1.0 2.9 2.7 1.8 2.6 2.7
2.2 2.5 1.6 2.0 1.8 2.9 2.6 2.9 1.5 1.6 2.2 2.4

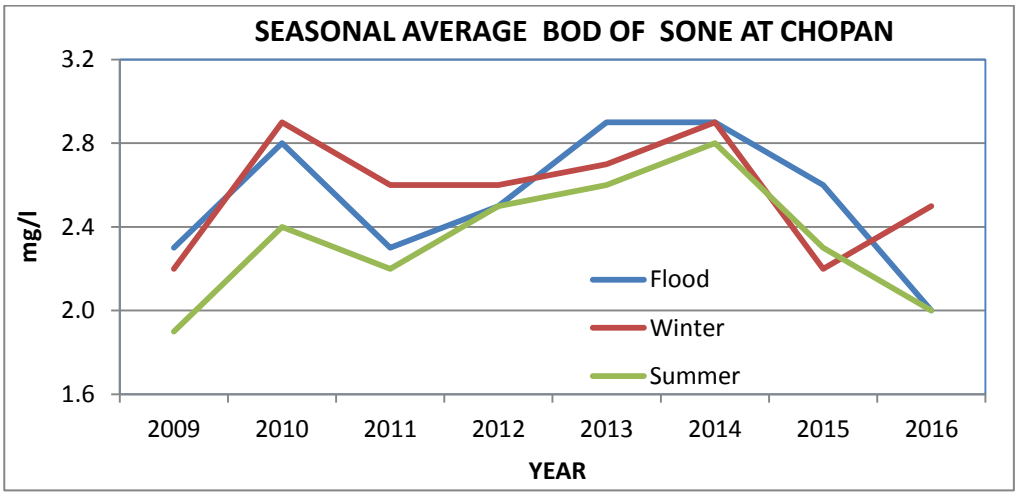

COD
mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
17.1 4.5 7.6 8.2 11.6 4.0 4.8 5.2 5.5 6.4 4.1
6.5 8.5 5.2 15.0 13.8 13.0 13.5 13.0 19.5 25.1 22.7


F.Coliform
MPN/100 ml
2000
1600
1200
800
400
0
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
1400 1200 800 700 1000 1400 1200 1100 700 1100 1200
1500 1600 1000 900 600 500 600 500 600 900 800 800

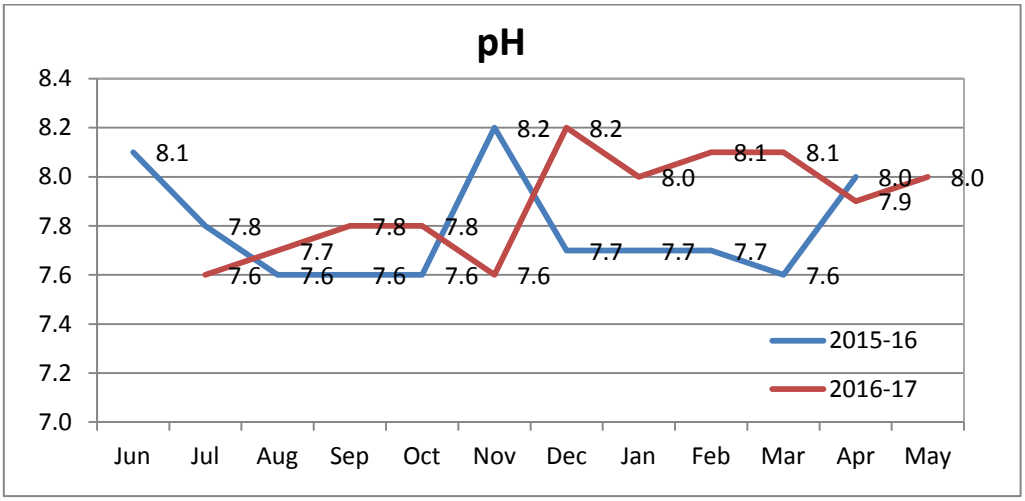

T.Coliform
MPN/100 ml
4000
3500
3000
2500
2000
1500
1000
500
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
3500 3200 2700 2600 2800 3000 3300 3100 3000 2700 3000 3400
3700 3500 2700 2100 1800 1600 1700 1500 1900 2100 2400 2300

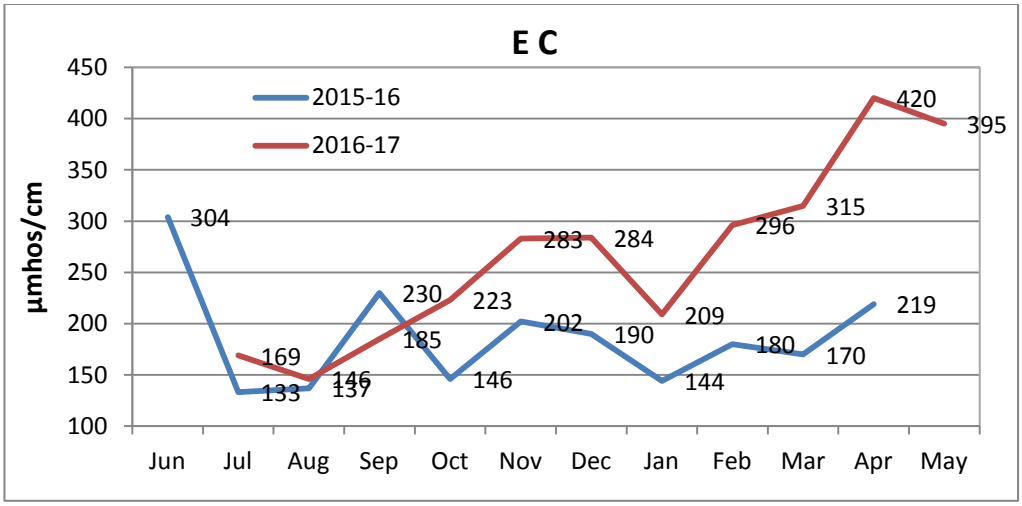

Trace & Toxic
20.0
15.0
10.0
5.0
0.0
µg/l
2015-16
2016-17
9.5
3.6
2.0
1.5
7.0
2.5
6.5
4.0
8.5
1.7
7.5
16.3
As
Cd
Cr
Ni
Pb
Zn

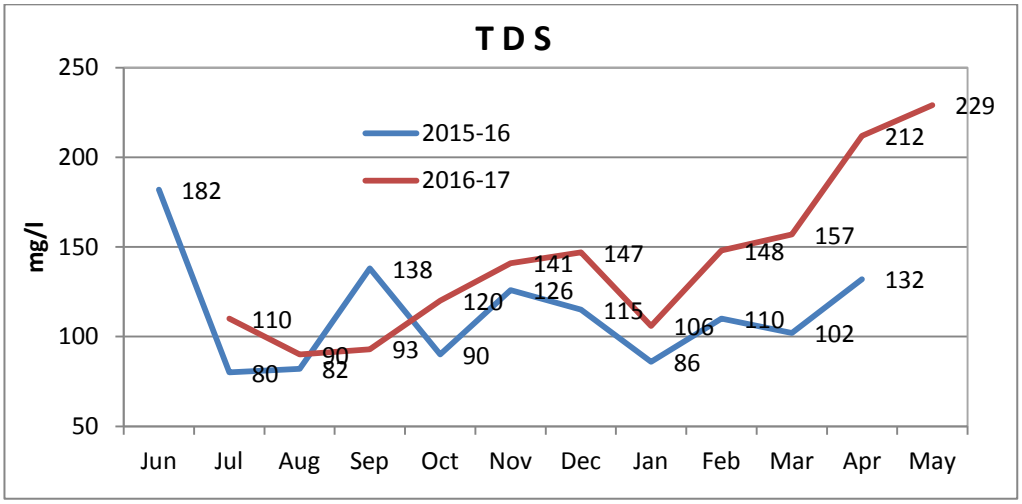

SEASONAL AVERAGE DO OF SONE AT CHOPAN
8.0
7.5
7.0
6.5
mg/l
Flood
Winter
Summer
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
YEAR

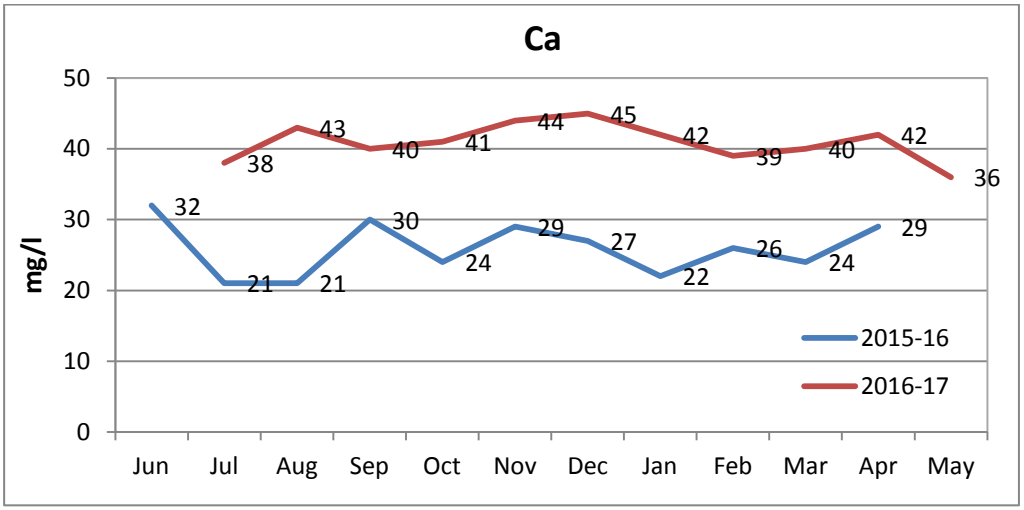

SEASONAL AVERAGE BOD OF SONE AT CHOPAN
3.2
2.8
2.4
2.0
1.6
mg/l
Flood
Winter
Summer
2009
2010
2011
2012
2013
2014
2015
2016
YEAR

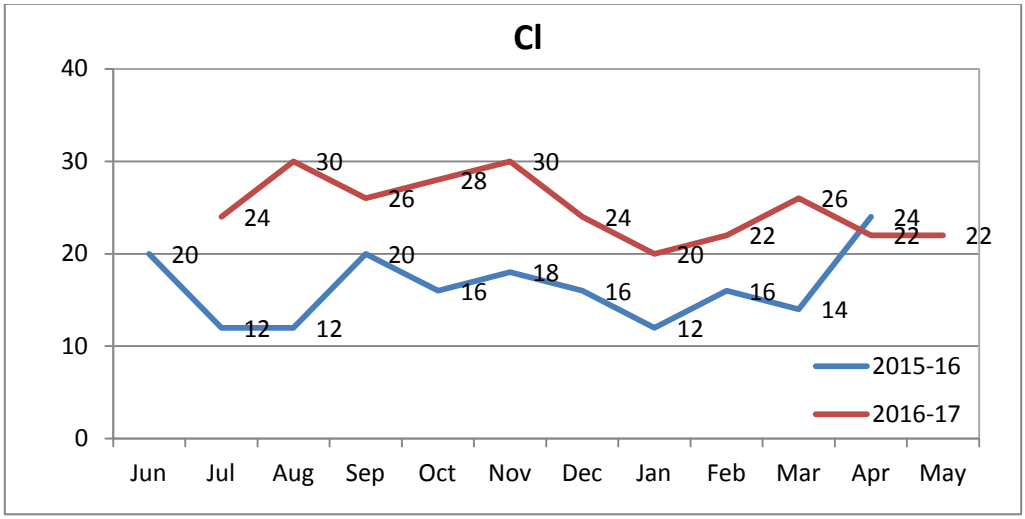
### 4.4.3 Duddhi – River Kanhar

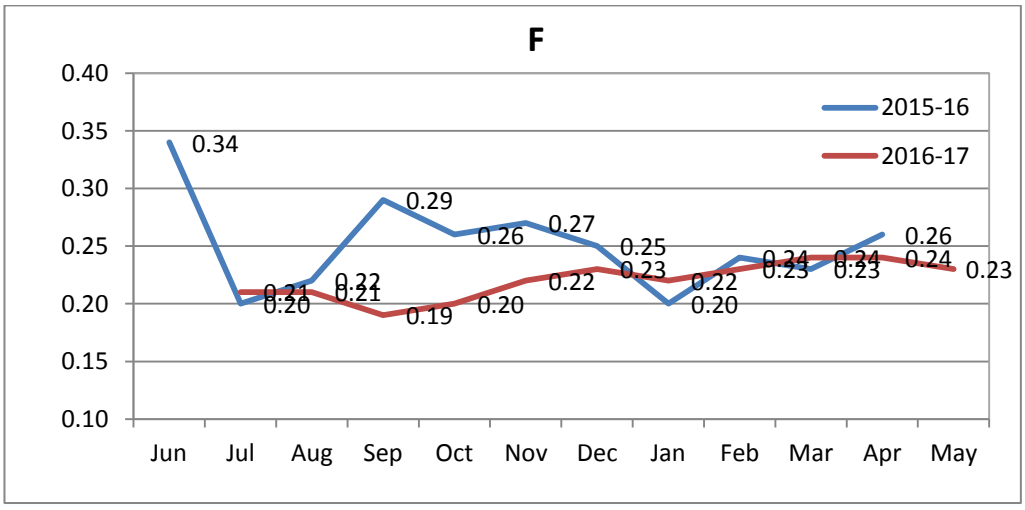


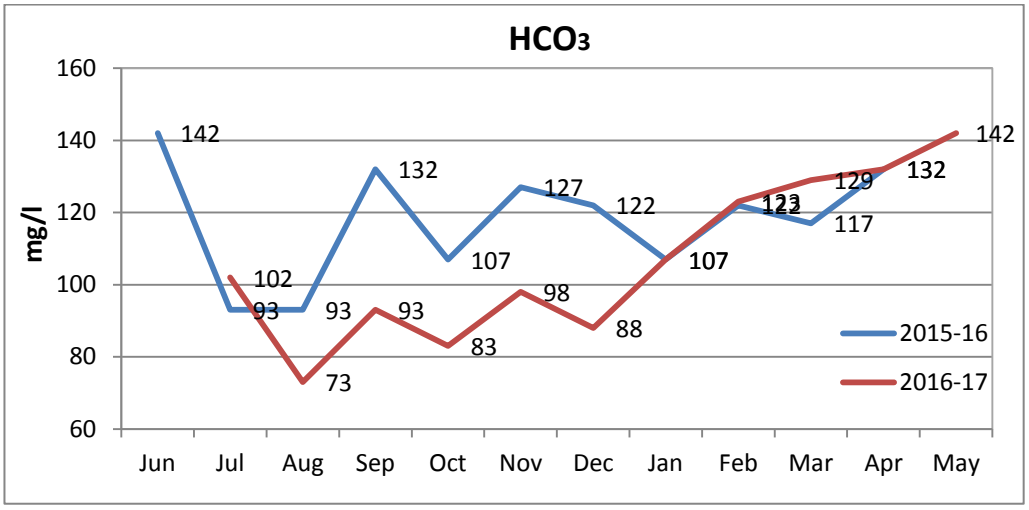



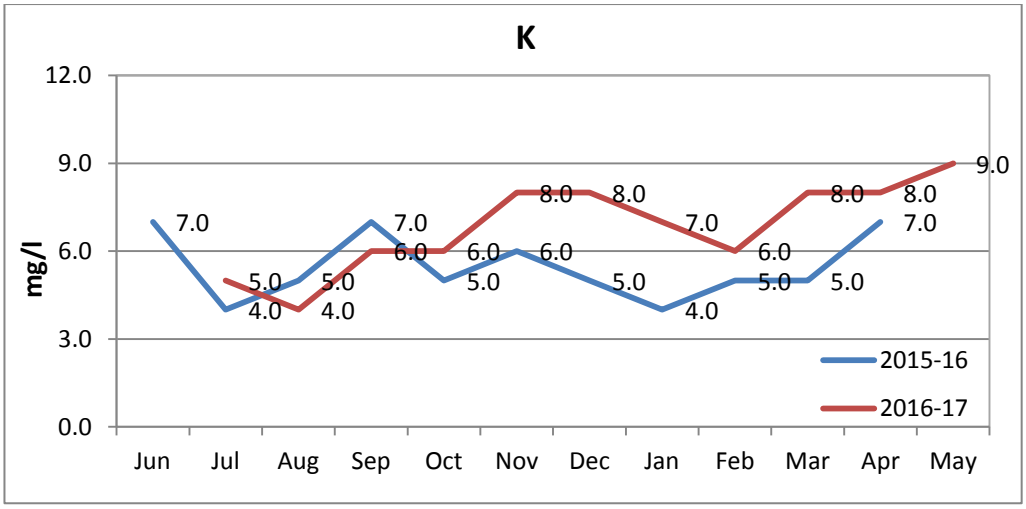



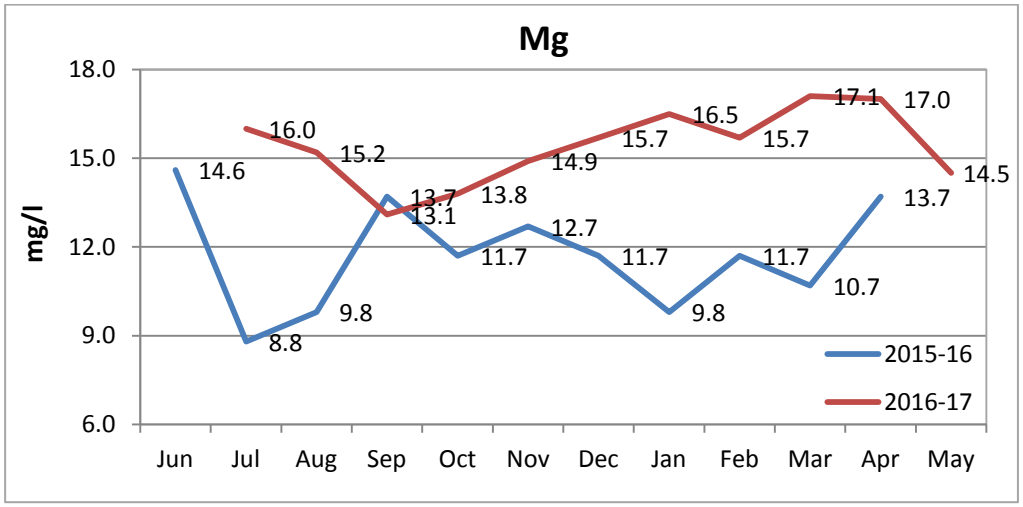

Ca
mg/l
50
40
30
20
10
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
32 21 21 30 24 29 27 22 26 24 29
38 43 40 41 44 45 42 39 40 42 36

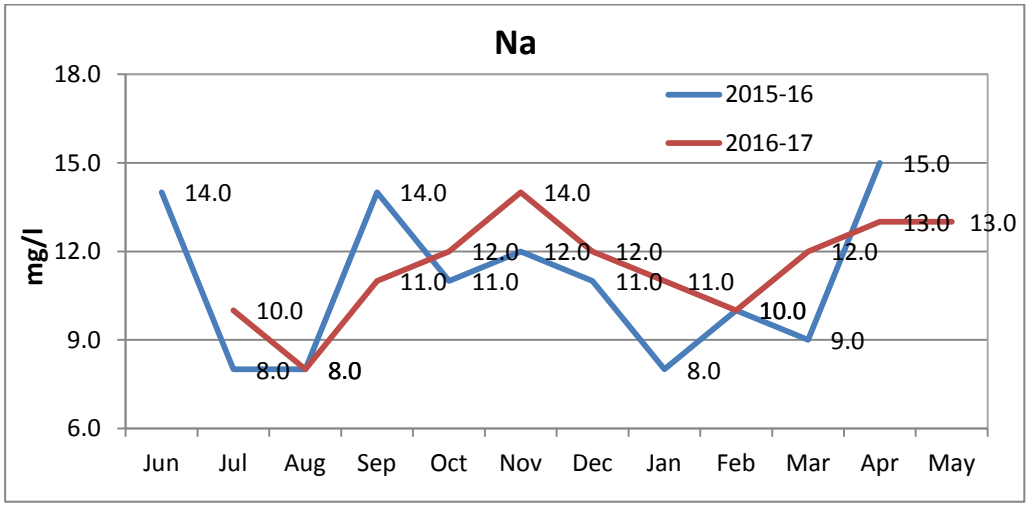

Cl
40
30
20
10
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
20 12 12 20 16 18 16 12 16 14 24
24 30 26 28 30 24 20 22 26 22 22

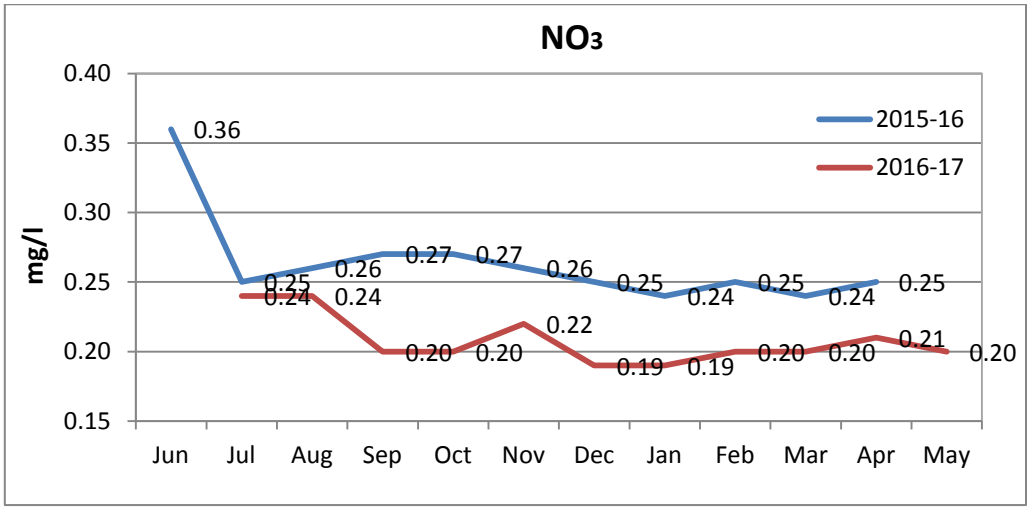

F
0.40
0.35
0.30
0.25
0.20
0.15
0.10
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
0.34 0.20 0.22 0.29 0.26 0.27 0.25 0.20 0.24 0.23 0.26
0.21 0.21 0.19 0.20 0.22 0.23 0.22 0.23 0.24 0.23

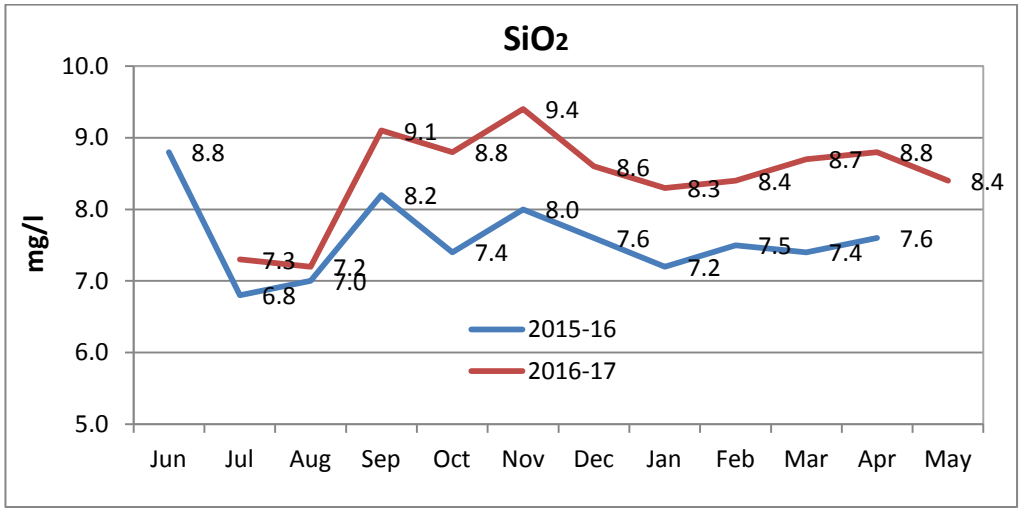

HCO3
mg/l
160
140
120
100
80
60
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
142 102 93 93 132 93 107 73 127 93 122 83 107 98 88 107 123 122 129 117 132 142
2015-16
2016-17

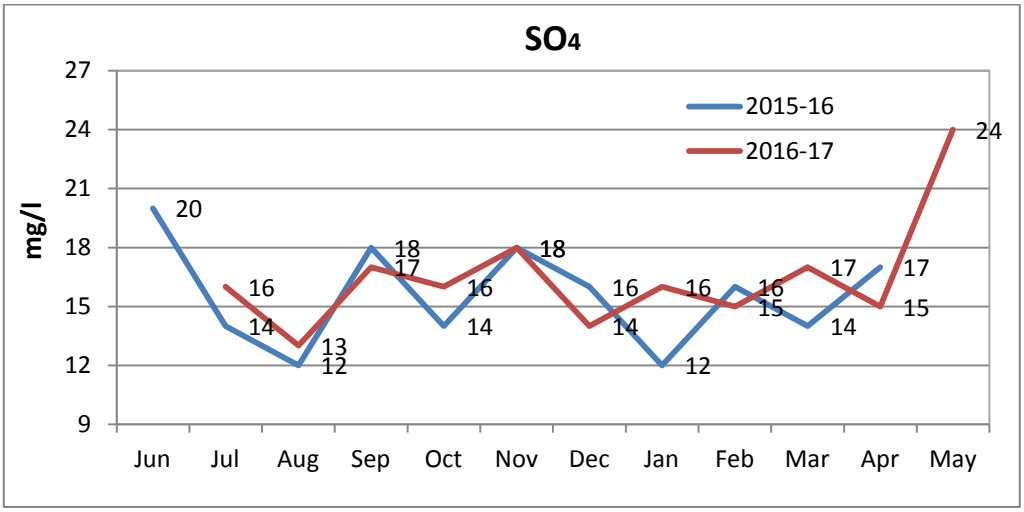

K
mg/l
12.0
9.0
6.0
3.0
0.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
7.0 5.0 4.0 5.0 7.0 6.0 6.0 5.0 6.0 5.0 8.0 6.0 8.0 5.0 8.0 4.0 7.0 6.0 8.0 5.0 8.0 5.0 9.0 7.0
2015-16
2016-17

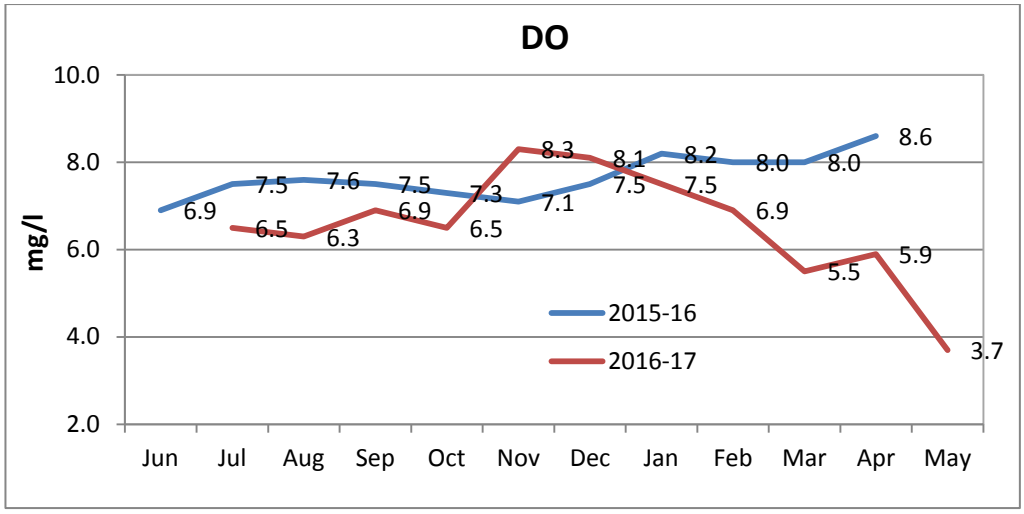

Mg
mg/l
18.0
15.0
12.0
9.0
6.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
14.6 16.0 8.8 15.2 9.8 13.7 13.1 13.8 11.7 14.9 12.7 15.7 11.7 16.5 9.8 15.7 11.7 17.1 10.7 17.0 13.7 14.5
2015-16
2016-17

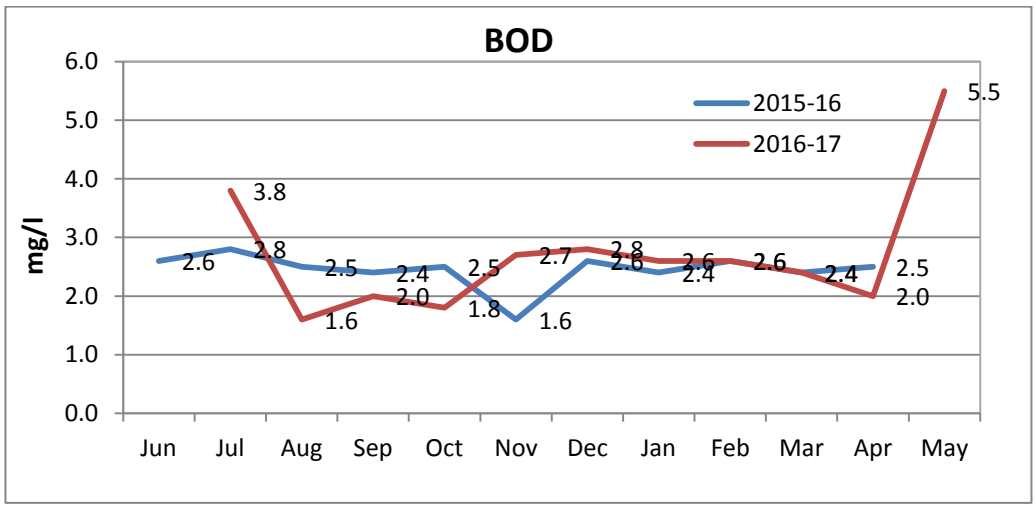

Na
mg/l
18.0
15.0
12.0
9.0
6.0
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
14.0 8.0 14.0 11.0 12.0 11.0 12.0 11.0 8.0 10.0 9.0 15.0
10.0 8.0 11.0 12.0 14.0 12.0 11.0 10.0 12.0 13.0 13.0

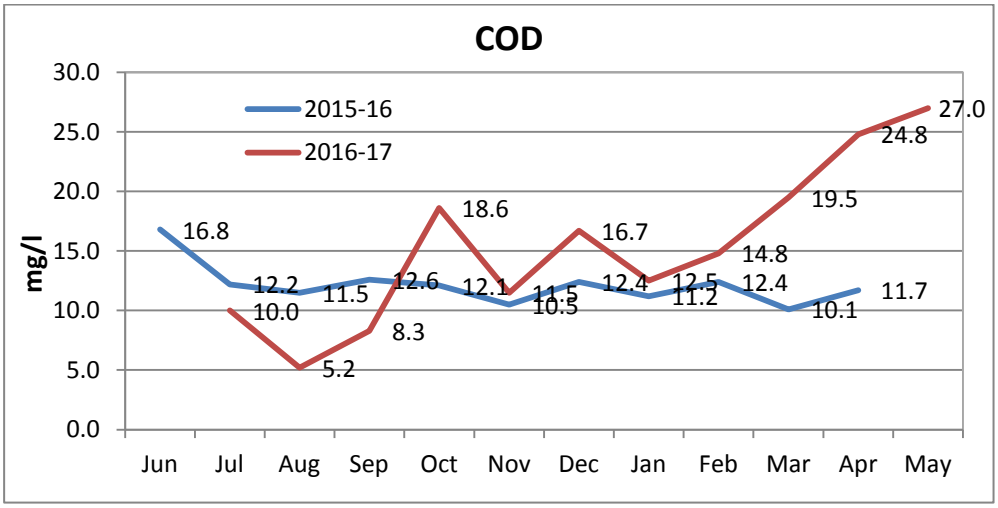

NO3
mg/l
0.40
0.35
0.30
0.25
0.20
0.15
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
0.36 0.25 0.26 0.27 0.27 0.26 0.25 0.24 0.25 0.24 0.25
0.24 0.24 0.20 0.20 0.22 0.19 0.19 0.20 0.20 0.21 0.20

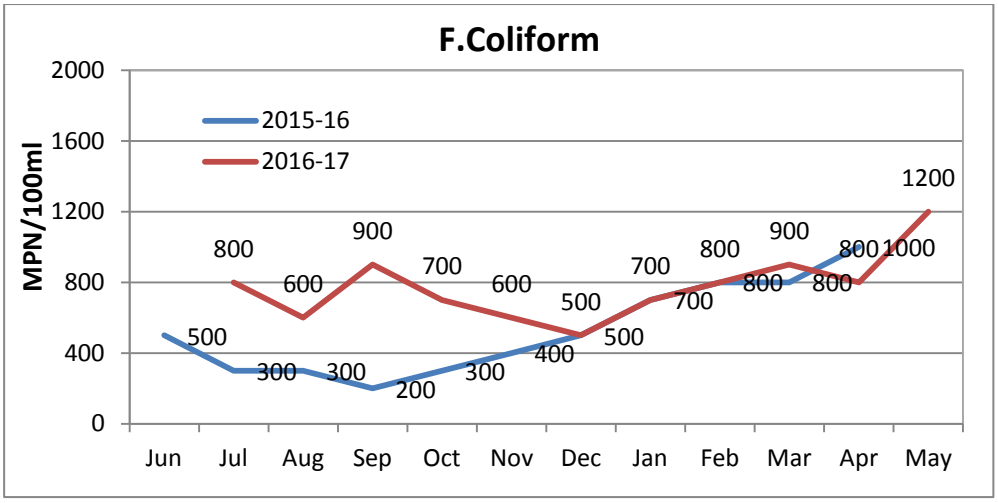

SiO2
mg/l
10.0
9.0
8.0
7.0
6.0
5.0
2015-16
2016-17
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
8.8 6.8 7.0 8.2 7.4 8.0 7.6 7.2 7.5 7.4 7.6
7.3 7.2 9.1 8.8 9.4 8.6 8.3 8.4 8.7 8.8 8.4

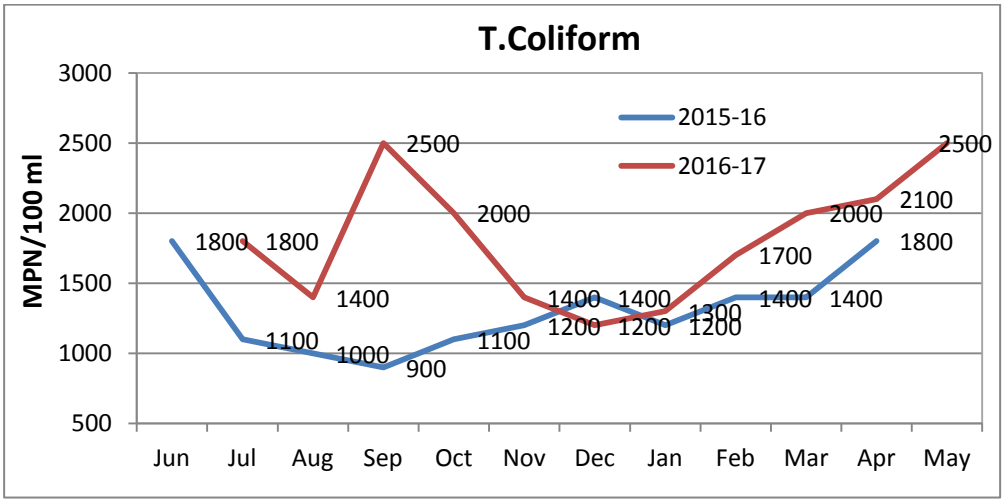

SO4
mg/l
27
24
21
18
15
12
9
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
20 14 12 18 14 18 16 12 16 15 14 17 15
16 14 13 17 16 18 14 16 16 16 17 15 24

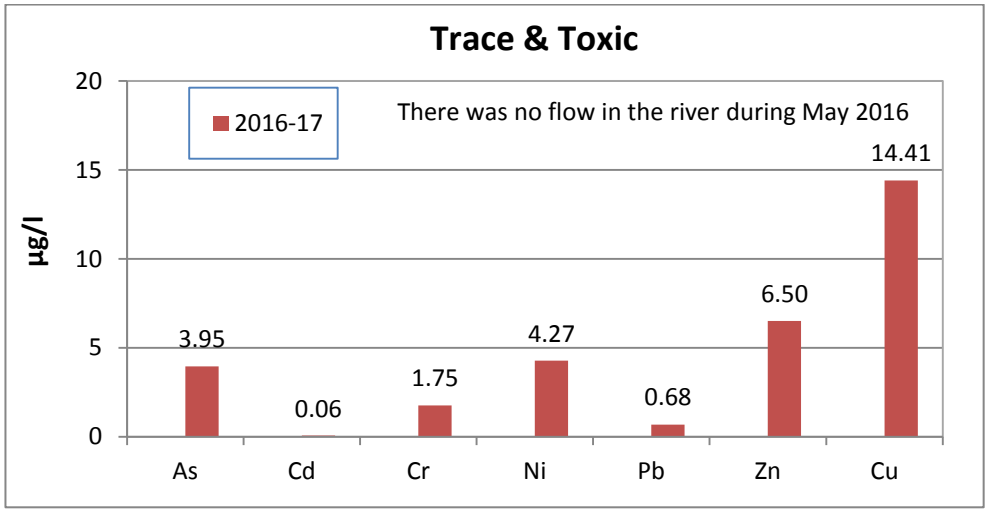

DO
mg/l
10.0
8.0
6.0
4.0
2.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
6.9 7.5 7.6 7.5 7.3 7.1 7.5 8.2 8.0 8.0 8.6
6.5 6.3 6.9 6.5 8.3 8.1 7.5 6.9 5.5 5.9 3.7

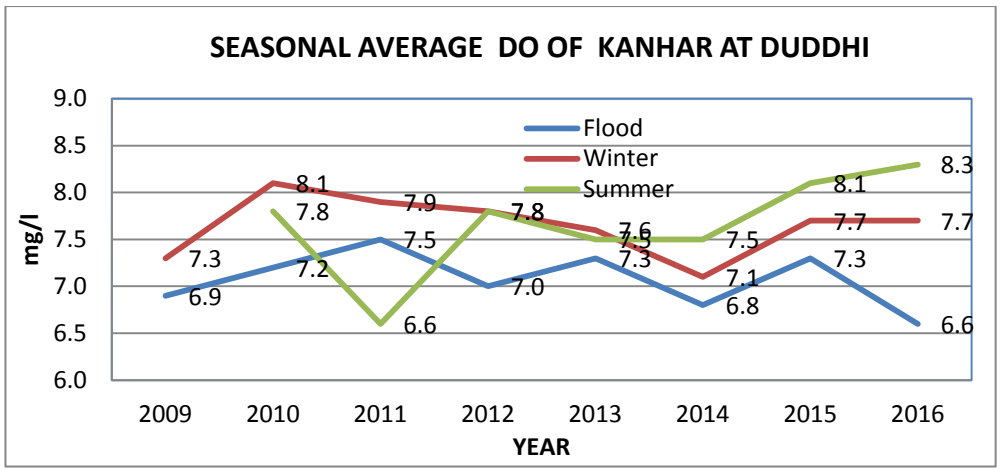

BOD
mg/l
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015-16
2016-17
2.6 2.8 2.5 2.4 2.5 1.6 2.6 2.4 2.6 2.4 2.5
3.8 1.6 2.0 1.8 2.7 2.8 2.6 2.6 2.4 2.0 5.5

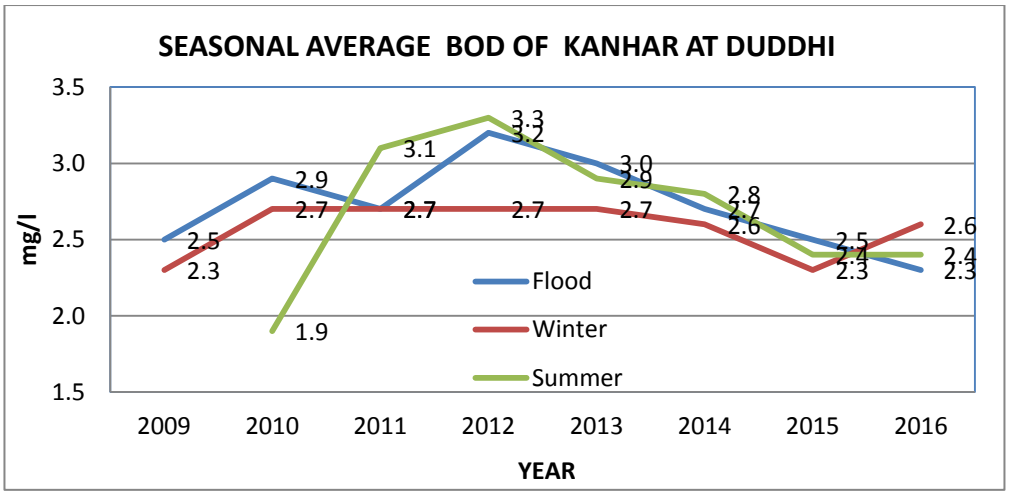

COD
mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2015-16
2016-17
16.8
12.2
11.5
12.6
12.1
11.5
12.4
12.5
12.4
11.7
10.0
5.2
8.3
18.6
10.5
16.7
11.2
14.8
19.5
24.8
27.0
10.1
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May


F.Coliform
MPN/100ml
2000
1600
1200
800
400
0
2015-16
2016-17
500
300
300
200
300
400
500
700
800
900
800
1000
800
600
900
700
600
500
700
800
800
800
1200
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May


T.Coliform
MPN/100 ml
3000
2500
2000
1500
1000
500
2015-16
2016-17
1800
1100
1000
900
1100
1200
1400
1300
1400
1400
1800
1800
1400
2500
2000
1200
1200
1200
1400
1700
2000
2100
2500
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May


Trace & Toxic
2016-17
There was no flow in the river during May 2016
µg/l
20
15
10
5
0
3.95
0.06
1.75
4.27
0.68
6.50
14.41
As
Cd
Cr
Ni
Pb
Zn
Cu


SEASONAL AVERAGE DO OF KANHAR AT DUDDHI
mg/l
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Flood
Winter
Summer
2009
2010
2011
2012
2013
2014
2015
2016
YEAR


SEASONAL AVERAGE BOD OF KANHAR AT DUDDHI
mg/l
3.5
3.0
2.5
2.0
1.5
Flood
Winter
Summer
2009
2010
2011
2012
2013
2014
2015
2016
YEAR

## 5. General Remark / Conclusion about W.Q. trend:

**Sone River:** Kuldahbridge and Chopan are water quality monitoring station on river Sone.

- During the year 2016-17 the maximum BOD observed was 2.9 mg/l. The dissolved oxygen(DO) content was in the range of 5.8 mg/l to 8.1 mg/l. The Faecal coliform range was 500-1600 MPN and Total Coliform fell in between 1500 to 4000 MPN. All other parameters including trace and toxic were within the permissible range.
- From the historical data it can be gathered that the values of BOD in all years was either equal to or less than 3.0 mg/l. The Dissolved oxygen average values have been above 7.4 mg/l. The Faecal and Total coliform values shows increasing trend is a matter of concern. The Coliform values during 2016-17 were on a lower side when compared to the year 2015-16, which may be due to very good rainfall during the year 2016-17. The quality of water at these stations is relatively Good except the presence of high Faecal and Total coliform values.

**River Kanhar:** This is the only water quality monitoring station on river Kanhar, tributary of Sone river

- In the year 2016-17, the maximum BOD values observed was 5.5 mg/l during summer season and minimum being 1.6 in flood season. The DO values ranged between 3.7 to 8.3 mg/l. The Faecal coliform range was 500-1200 MPN and Total Coliform fell in between 1200 to 2500 MPN. All other parameters including trace and toxic were within the permissible range.
- The water quality monitoring at this station started from 2004.In the month of June there is no flow condition and Due to negligible flow in summer season the BOD values are high in comparison to other month of year. The Faecal and Total Coliform values are above the permissible limits. Overall the water quality of the river is relatively good when compared to other rivers in Ganga basin.