# Anthropogenic Pressures on Water Quality of Devika Stream in Udhampur City, J&K

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**Abstract**—*Devika stream is an important sacred stream flowing through the heart of the Udhampur city. This stream also known as 'Gupt Ganga' has religious importance and is considered elder sister of 'River Ganges'. People after burning the dead bodies at cremation ground located at the bank of stream immerse ashes directly into the stream water. During baisakhi and navratri festival, people from far flung areas visit this place to take holy dip in this stream. The water of this stream is considered holy and people drink it and carry it for use during worshipping and other religious occasions. There is general practice of immersion of flowers, garlands and other worship waste materials into this stream. A large number of people visit this stream as a very ancient Shiv temple is located at its banks. The stream once known for its quality water due to entry of large number of springs along its course has now become nothing less than a sewage sink. Rapid expansion of Udhampur city has put pressure on its catchment and massive deforestation for road widening and construction of buildings has caused reduced rain water infiltration and spring water discharge into the stream. This has also led to water quality deterioration. Other anthropogenic pressures include entry of the untreated sewage drains including biomedical waste from three hospitals and disposal of city's solid waste into the stream. In the present study, an attempt has been made to determine the water quality of this stream. The study has indicated that most of the parameters have exceeded the desirable limits set by BIS (1991), WHO (2008) and CPCB standards and may exceed the permissible limits in future if proper precautions are not taken.*

## 1. INTRODUCTION

Rapid industrialization and subsequent urbanization has led to wanton destruction and deterioration of various environment segments. Water is considered 'Elixir of life' and is an important resource for sustenance of life on Earth. Fresh water is abundant but there is lack of potable water due to indiscriminate pollution caused by various anthropogenic activities. Rivers are generally considered lifelines of any nation and help in development by providing water for domestic, industrial and agricultural purposes. Water quality in rivers and streams is generally affected naturally by geological formations and by various anthropogenic pressures in the form of direct disposal of sewage, industrial waste, domestic waste, agricultural runoff and indirectly by the deposition of nutrients or contaminants in the drainage basin. Land use changes, construction works in guise of modernization and pollution are some other factors that have led to the deterioration of water quality in rivers. There is an extensive literature on the physicochemical and microbial variations affecting water quality of rivers from both within and outside the country [1-7].

## 2. STUDY AREA

Udhampur district popularly known as 'the land of Devika' lies within 32° 34′ to 39° 30′ N latitude and 74° 16′ to 75° 38′ E longitude. Devika stream, the area of present study has its origin from Nadda Gali spring and joins Chowka nullah, at Beni sang, Chenani, Udhampur before entering river Tawi [6,8]. The study area selected for the present study is located within the Udhampur City.

## 3. METHODOLOGY

For present study of water quality of Devika stream, monthly water samples were collected from the three sites located upstream, within Udhampur city and downstream and analysed for various water quality characteristics for a period of twelve months extending from March, 2013 to February, 2014.

### 3.1 Physicochemical analysis

Water samples were collected for physico-chemical analysis in pre-cleaned, poly-propylene plastic bottles of 2L capacity. Before the collection of water sample, temperature (both air and water) was recorded at all study sites. The collected samples were analyzed in chemical laboratory within four hours of their collection. Air and water temperature was measured by mercury bulb thermometer ($^0$C); electrical conductivity, TDS, salinity, pH were measured by Century water/ soil analyser kit (model CMK 731); free carbon dioxide and bicarbonate, DO, chloride, calcium, magnesium by titration methods; sodium and potassium by flame photometry and phosphate, silicate, sulphate and nitrate by double beam spectrophotometer. For analysis standard techniques as mentioned in APHA[9] were used. The types of analysis varied from simple field testing for a single analyte to

laboratory based multi-component instrumental analysis. Statistical analysis of the data was also conducted.

### 3.2 Microbial analysis

For bacteriological analysis, water samples were collected in sterilized wide mouth BOD bottles by plunging its neck downward below the surface that was later tilted upwards. The bottle was closed using stopper and was taken to lab for analysis. Microbial analysis of water was done using Multiple tube technique[9,10]. MPN/100ml was calculated for both total and feacal coliforms.

## 4. RESULTS AND DISCUSSION

### 4.1 Physicochemical analysis

The analytical results of mean monthly variations in various physico-chemical parameters of Devika stream have been tabulated in Table 1. The findings have clearly indicated that the stream water quality is influenced by various anthropogenic and environmental factors. Water temperature showed mean annual variation of $14^0$C to $31.67^0$C and air temperature ranged between $16.75^0$C - $39.67^0$C. Water temperature closely followed atmospheric temperature during most part of the year and observed summer increase and winter decline. Electrical conductivity and total dissolved solids showed a direct relationship in the present study and showed increase during summer(0.54mS/cm and 252.33ppm) and post-monsoon season(0.57mS/cm and 282.67ppm) and decline during winter(0.43mS/cm and 208.70ppm). Direct relationship between EC and TDS is already on record[11] and is further supported by their strong positive correlation($r=.878$; $p<0.01$) in the present study(Table 2). Summer increase in electrical conductivity may be attributed to increased decomposition rate which is further aggravated by exposure of organic matter rich bottom sediments caused by high evaporation rate. pH of the stream varied between 6.20 to 7.26 and was observed to be more towards acidic side. This may be attributed to absence of carbonate and high free $CO_2$ content in the stream water ranging between 14.09 to 47.15 mg/l. Comparatively, high free $CO_2$ concentration in Devika stream is due to addition of $CO_2$ rich water from various springs along its course. However, free $CO_2$ concentration further increases due to entry of various sewage drains and disposal of city's solid waste into the stream. Seasonally, pH observed strong inverse relationship with free $CO_2$ and increased during winter(January-February) with summer(May-June) decline. An inverse relationship between pH and free $CO_2$ has also been reported by earlier workers like [11-13]. This is supported by strong negative correlation($r=-.884$;$p<0.01$) between pH and free $CO_2$ in Devika stream water. Summer decline in pH may be attributed to increased decomposition of organic matter at high temperature, thereby, increasing free $CO_2$ content. Winter decline in free $CO_2$ may be due to its low solubility at low temperature. Seasonally, carbon dioxide showed increase during monsoon and winters. Significant correlation of carbon dioxide was observed with bicarbonates and chlorides. Salinity observed annual variation from 0.2 to 0.53 ppt. Seasonally, salinity observed highest record during summer(0.53ppt). Dissolved oxygen in Devika stream varied between 1.79-8.09mg/l. Seasonally, dissolved oxygen showed high values during winter(December-February) with decline during summer(April-June). Winter high record of DO may be attributed to its increased solubility at low temperature. A strong negative correlation($r= -0.845$; $P<0.01$) has been observed in Devika Stream (Table 2). Also, reduced microbial activity during winter may also explain December and January rise in DO and low observation of free $CO_2$. DO and free $CO_2$ concentration has observed well marked inverse relationship in Devika stream. The tolerance limit for dissolved oxygen(DO) for inland surface waters used as raw water and bathing ghat is 3 mg/l, for sustaining aquatic life is 4 mg/L whereas for drinking purposes it is 6 mg/L[14]. However, in the present study it has been observed that the DO value of Devika stream water for most of the seasons has shown low concentration as compared to the prescribed limits. Therefore, the water is put under the category of unfit for domestic use and drinking purposes during most of the seasons.

The cationic composition of Devika stream is dominated by calcium (43.30-73.59 mg/l) followed by sodium(18.33-45.80mg/l), magnesium(12.17-28.06mg/l) and potassium(3.15-9.45mg/l). Calcium, magnesium and total hardness have shown irregular variations during most part of the year and almost paralleled in their seasonal pattern of increase and decrease during different seasons. Stream water remained moderately hard throughout the year (TH: 179.95-299.92 mg/l). Seasonally, sodium showed increase during summer(May-June) and monsoon(July-August) whereas potassium showed increase during monsoon(July-August) and post monsoon(September-October) with decline during winter(December-February). A strong positive correlation was observed between sodium and potassium($r=0.753$; $p<0.01$). Anionic spectrum of the stream water showed dominance of various anions in the order of bicarbonate (195.61-344.99mg/l) followed by chloride (21.67-44mg/l), silicate (11.40-22.47mg/l), nitrate (0.62-12.87mg/l), sulphate (2.63-9.40mg/l) and phosphate (0.15-0.91mg/l). Anionic composition has shown bicarbonate as dominant anion in stream water which observed increase during summer (May-June) and post-monsoon(October-November) with monsoon(July) and winter(January) decline. Bicarbonate showed significant correlation with chloride. Chloride observed summer(May-June) and post monsoon(October-November) high record. Similar results have been obtained by Yadav and Srivastava [15] from River Ganga at Ghazipur, India. Chloride showed significant correlation with sodium. Cationic and anionic concentration in the stream water observed irregular pattern of distribution during different seasons and their increase mostly corresponded to increase in various anthropogenic pressures on the stream in the form of

**Table 1: Mean monthly variations in physico-chemical characteristics of Devika stream water in Udhampur ( March, 2013-February, 2014).**

| | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec | Jan | Feb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A.T. (0C) | 25.17 | 36.17 | 39.67 | 37.17 | 35.33 | 36.17 | 27.33 | 22.00 | 23.67 | 16.75 | 19.17 | 21.00 |
| W.T. (0C) | 21.50 | 29.17 | 31.67 | 30.00 | 30.67 | 29.50 | 25.50 | 19.17 | 18.30 | 14.00 | 14.50 | 16.17 |
| E.C. (mS/cm) | 0.49 | 0.52 | 0.53 | 0.54 | 0.47 | 0.49 | 0.49 | 0.57 | 0.51 | 0.46 | 0.43 | 0.48 |
| TDS (ppm) | 249.43 | 246.67 | 252.33 | 235.50 | 229.83 | 234.77 | 242.67 | 282.67 | 258.33 | 209.00 | 208.70 | 242.67 |
| Sal (ppt) | 0.20 | 0.33 | 0.53 | 0.40 | 0.20 | 0.27 | 0.27 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| pH | 7.15 | 7.00 | 6.20 | 6.44 | 7.16 | 6.89 | 6.70 | 6.66 | 6.82 | 7.00 | 7.24 | 7.26 |
| FCO2(mg/l) | 37.06 | 37.81 | 47.15 | 42.30 | 15.42 | 19.99 | 40.41 | 41.74 | 32.04 | 34.25 | 24.19 | 14.09 |
| DO(mg/l) | 5.98 | 3.59 | 2.67 | 1.79 | 4.54 | 3.76 | 3.51 | 4.91 | 3.13 | 8.09 | 5.59 | 7.73 |
| HCO3-(mg/l) | 246.39 | 267.95 | 295.99 | 344.99 | 195.61 | 243.87 | 249.02 | 324.30 | 252.88 | 232.68 | 216.20 | 248.37 |
| Cl-(mg/l) | 24.12 | 44.06 | 43.96 | 45.00 | 26.01 | 29.47 | 29.61 | 34.23 | 41.16 | 33.85 | 25.28 | 21.67 |
| Ca2+(mg/l) | 52.40 | 44.87 | 43.30 | 55.13 | 50.21 | 57.20 | 48.98 | 60.99 | 73.59 | 50.24 | 67.92 | 59.86 |
| Mg2+ (mg/l) | 13.31 | 14.64 | 24.53 | 15.11 | 12.17 | 21.64 | 24.51 | 14.36 | 28.06 | 23.90 | 22.36 | 14.47 |
| TH(mg/l) | 185.57 | 179.95 | 206.61 | 214.62 | 181.59 | 231.70 | 203.71 | 222.26 | 299.92 | 221.54 | 261.48 | 259.36 |
| Na+ (mg/l) | 23.47 | 29.87 | 45.80 | 40.40 | 36.60 | 33.37 | 32.43 | 32.67 | 29.73 | 23.35 | 18.33 | 18.77 |
| K+ (mg/l) | 3.68 | 5.71 | 7.19 | 8.24 | 8.33 | 9.21 | 9.45 | 8.85 | 5.51 | 5.60 | 3.15 | 3.59 |
| SiO2-(mg/l) | 12.17 | 19.48 | 13.50 | 11.40 | 13.42 | 15.67 | 16.27 | 18.18 | 13.07 | 12.65 | 15.87 | 22.47 |
| NO3 -(mg/l) | 12.87 | 0.62 | 3.63 | 4.40 | 5.75 | 0.72 | 3.43 | 3.31 | 2.33 | 1.35 | 1.91 | 0.96 |
| SO4 2-(mg/l) | 5.38 | 2.63 | 5.43 | 4.70 | 9.40 | 7.87 | 3.88 | 4.13 | 5.08 | 6.65 | 5.07 | 3.65 |
| PO4 3- (mg/l) | 0.84 | 0.91 | 0.16 | 0.68 | 0.34 | 0.77 | 0.40 | 0.33 | 0.23 | 0.15 | 0.19 | 3.53 |

**Table 2: Coefficient of correlation(r ) among various physico-chemical parameters of Devika Stream .**

| | W.T | EC | TDS | SAL | pH | FCO2 | HCO3- | DO | Cl- | Ca2+ | Mg2+ | TH | Na+ | K+ | PO43- | NO3- | SiO4 | SO42- |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W.T | 1 | | | | | | | | | | | | | | | | | |
| EC | .223 | 1 | | | | | | | | | | | | | | | | |
| TDS | .181 | .878** | 1 | | | | | | | | | | | | | | | |
| Sal | .682* | .340 | .148 | 1 | | | | | | | | | | | | | | |
| pH | -.302 | -.615* | -.293 | -.734** | 1 | | | | | | | | | | | | | |
| FCO2 | .131 | .663* | .347 | .600* | -.884** | 1 | | | | | | | | | | | | |
| HCO3- | .157 | .793** | .630* | .187 | -.559 | .489 | 1 | | | | | | | | | | | |
| DO | -.845** | -.139 | -.113 | -.601* | .382 | -.176 | -.028 | 1 | | | | | | | | | | |
| Cl- | .660* | .458 | .266 | .810** | -.641* | .591* | .302 | -.602* | 1 | | | | | | | | | |
| Ca2+ | -.653* | -.315 | -.112 | -.531 | .321 | -.449 | -.038 | .498 | -.510 | 1 | | | | | | | | |
| Mg2+ | -.129 | -.304 | -.353 | -.103 | .055 | .046 | -.506 | -.227 | -.101 | -.281 | 1 | | | | | | | |
| TH | -.587* | -.497 | -.372 | -.512 | .351 | -.303 | -.522 | .164 | -.395 | .452 | .708** | 1 | | | | | | |
| Na+ | .800** | .437 | .263 | .693* | -.704* | .487 | .391 | -.820** | .707* | -.513 | -.091 | -.485 | 1 | | | | | |
| K + | .675* | .384 | .296 | .244 | -.317 | .150 | .457 | -.674* | .396 | -.507 | .073 | -.314 | .741** | 1 | | | | |
| PO43- | .453 | .274 | .358 | .250 | .084 | -.020 | .302 | -.224 | .468 | -.313 | -.142 | -.266 | .077 | .330 | 1 | | | |
| NO3- | -.220 | -.007 | .167 | -.091 | .249 | -.020 | -.002 | .449 | -.351 | .095 | -.401 | -.318 | -.439 | -.500 | .060 | 1 | | |
| SiO4 | .226 | .070 | .195 | -.018 | .284 | -.227 | -.147 | -.120 | .258 | -.253 | .262 | .172 | -.058 | .198 | .626* | -.359 | 1 | |
| SO42- | .156 | -.587* | -.523 | -.201 | .329 | -.375 | -.425 | -.186 | -.448 | -.075 | .223 | .076 | .013 | -.003 | -.356 | .133 | -.253 | 1 |

**significant at 0.05 level*
***significant at 0.01 level*

religious ceremonies, festivals, fairs and cremations of bodies etc. However, cationic dominance of calcium and anionic dominance of bicarbonate in the present study is similar to their dominance in other freshwater streams and rivers of the area.

### 4.2 Microbial analysis(MPN/100 ml for total coliforms and feacal Coliforms)

Most probable number of total coliforms and feacal coliforms was observed to be more than 240/100ml of water throughout the year and indicated their perennial presence in the stream.

Present findings are in accordance with the findings of Dutta[6] from same stream during the year 2010-2011. Total coliform and feacal coliform in stream water throughout the study period confirms severe contamination due to sewage and feacal matter and indicates that the stream is grossly polluted. This may be due to the open defecation, discharge of drains carrying feacal matter from households and high amount of raw sewage into the stream[16].

### 4.3 Comparison with national and international standards

Comparison of mean monthly variations of various physico-chemical and microbial characteristics of Devika Stream with various National and International standards reveals that most of the parameters like bicarbonate, calcium, magnesium, total hardness have either crossed desirable limits or are nearing these limits and would cross these if proper preventive measures are not taken well in time (Table 3). Parameters like pH, DO and phosphate have already crossed the permissible limits given by BIS[17], CPCB[18] and WHO[19] standards and use of such water by inhabitants for domestic and drinking purposes can be detrimental to the health of people. The present study recommends the use of stream water only after proper treatment.

**Table 3: Comparison of physico-chemical parameters of Devika stream with various national and international standards.**

| | Min | Max | WHO(2008) Desirable | WHO(2008) Permissible | BIS(1991) Desirable | BIS(1991) Permissible |
|---|---|---|---|---|---|---|
| A.T. (0C) | 16.75 | 39.67 | | | | |
| W.T. (0C) | 14 | 31.67 | | | | |
| E.C.(mS/cm) | 0.43 | 0.57 | | 1500* | | 3000 |
| TDS (ppm) | 208.70 | 288.67 | 600 | 1000 | 500 | 2000 |
| Salinity(ppt) | 0.2 | 0.53 | | | | |
| pH | 6.20 | 7.26 | 6.5-8.5 | No relaxation | 6.5-8.5 | No relaxation |
| CO2(mg/l) | 14.09 | 47.15 | | | | |
| HCO3- (mg/l) | 195.61 | 344.99 | 300* | 600* | 300 | 600 |
| DO(mg/l) | 1.79 | 8.09 | | 5-7** | | |
| Cl-(mg/l) | 21.67 | 45 | 250 | 600 | 250 | 1000 |
| Ca2+(mg/l) | 43.30 | 73.59 | 100 | 300 | 75 | 200 |
| Mg2+ (mg/l) | 12.17 | 23.06 | 30* | 150* | 30 | 100 |
| TH(mg/l) | 179.95 | 299.92 | 100 | 500 | 300 | 600 |
| Na+ (mg/l) | 18.32 | 45.80 | 50 | 200 | | |
| K+ (mg/l) | 3.15 | 9.45 | 10* | 12* | | |
| PO4 3- (mg/l) | 0.15 | 3.53 | | 0.1** | | |
| NO3- (mg/l) | 0.62 | 12.87 | 50 | | 45 | 100 |
| SiO2 (mg/l) | 11.40 | 22.47 | | | | |
| SO4 2- (mg/l) | 2.63 | 9.40 | 250 | 400 | 250 | 400 |

* WHO(1997)

**WHO(1993)

MPN/100ml of total coliforms recorded in the present study was more than 240 throughout the year which is beyond the acceptable limit of 10/100 ml as per BIS[17] and WHO[19] drinking water standards. According to CPCB [20], the total Coliform level should not exceed 50 MPN/100ml to recommend the water as potable without conventional treatment but after disinfection and the class of water is "A". MPN/100ml for feacal coliform should be nil for drinking water. The present water quality study of Devika stream both in terms of physico-chemical and microbial analysis has indicated that stream water is unfit for drinking and also for other domestic uses without conventional treatment.

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