# Physico-Chemical Characterization of Three Selected Sewage Drains Discharged into Western Ganga Canal within Haridwar city, India

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**Abstract:** In the present investigation, three sewage drains viz. those at Rishikul, Govind Puri, and Kassaban, were monitored for few selected physico-chemical parameters (Temperature, Turbidity, Acidity, Alkalinity Dissolved Oxygen, BOD, Hardness and Chlorides.), round the year during 2015-16, before these drain have their confluence with river Ganga canal, within Haridwar city. It was found that the Kassaban sewage drain was the most polluting among the three selected drains, which may be due to disposal of domestic waste - related to their specific life styles and comparatively poor socio-economic conditions of the people living in this area, as compared to other two locations. The DO value is recorded for this sewage drain is 16.83% and 25.24% lower in comparison to Rishikul and Govindpuri sewage drain respectively. Similarly chloride values were observed for sewage water at Kassaban was 11.09% and 24.35% higher in comparison to Rishikul and Govindpuri sewage values. Taking up the most sensitive and important parameter i.e. BOD of Kassaban sewage drain was found 6.40% higher as compared to Rishikul sewage drain and 16.38 % higher to Govindpuri sewage drain. Hence, it may be concluded from the present study that the high values of pollutants in sewage water makes it unfit, unsafe and not good enough for any purposes in Haridwar city.

[B.D. Joshi, D.S.Malik, Sandeep Singh Rawat. **Physico-Chemical Characterization of Three Selected Sewage Drains Discharged into Western Ganga Canal within Haridwar city, India.** *Nat Sci* 2017;15(11):54-61]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 7. doi:10.7537/marsnsj151117.07.

**Keywords:** Sewage drains, Pollution, Socio-economic and Kassaban.

## 1. Introduction

The disposal of sewage is one of major concern in most of the urban areas of India. Almost 70% of water in India has become polluted due to discharge of domestic sewage, municipal waste drains, urban agricultural waste and large scale of industrial effluents **(Sangu and Sharma, 1987).** However, sewage drains are the main source of water pollution mainly for rivers and lead to creation of health issue as well as environmental pollution in India and most of the developing countries **(Shivaraju, 2011).** Sewage water mainly consists of both solid and liquid wastes generated by various domestic activities. At Haridwar, the Hari Ki Pauri is located at the bank of western Ganga canal- and interestingly most of the people visiting Hardwar revere this canal as the major branch of the main river ganga- which in fact flows about half an kilometer east of this canal. This canal irrigates millions of hectares of agricultural land right from Haridwar to the end of Agra division of Uttar Pradesh. **(Joshi et al., 2016)**. On the other hand passing from the holiest place of Har Ki Pauri, the canal is regarded as one of the holiest stream within the boundaries of Haridwar district. But gradually the qualitative status of this holiest stream is turning in to a polluted aquatic system, as there are more than a dozen sewer points of municipality being discharged in it. Few of these bring a huge load of city sewage from various regions of the townships, colonies and areas associated partially with industrial zones. These sewage drains remain a source of unending controversies for last three decades of Ganga Action Plan, **(Joshi & Bisht 1993),** and are regarded as the only source of pollution of river Ganga Canal. It is also realized through our routine monitoring that the much hyped Ganga Action Plan (GAP) has in no way improved the quality of the Ganges canal or Ganga river water, still the problem remains same. This paper presents how the three selected sewage drains of Haridwar city falling in Ganga canal between a stretch of about 6-7 Km. affect the water parameters, with specific emphasis on sewage drain of **Kassaban** where untreated domestic waste originates, from rapidly growing urban areas in ambience.

## 2. Material and Methods

Water samples were taken from three selected sewage drains within Haridwar city along a stretch of about six kilometers. The monitoring of water quality was conducted from January 2015 to December 2016, and three consecutive samples were taken during sampling period. Some parameters were analyzed on spot viz. temperature and turbidity, with the help of soil and water analysis kit Model no.191E, and other parameters were analyzed in the laboratory by following standard methods of **APHA (1995)** and **Trivedi and Goel (1986).** The selected sewer drains are:

**Rishikul Sewer Drain**- It receives the sewage from about 250 houses; typically having a rural life style.

**Govind Puri Sewer Drain:** It is situated 1km downwards from Rishikul sewer drain. It receives sewage from different colonies (Tibadi, Govindpuri, New Haridwar, Ranipur area) with morethan 3500 houses located in the area. This catchment area consists of developing urbanized community.

**Kassaban Sewer Drain**-It is situated 3km downwards from Govindpuri sewer drain and is a perennial sewage drain, having confluence with canal, is full of domestic sewage from different colonies of Kassaban, Kasaiyon ka mohalla, and unchisadak, spread in about 4000 houses..

## 3. Results

The relative annual mean value and range value of physico-chemical parameters of sewer drain are given in Table-1 and Table-2.

**Temperature:-**The mean values of temperature ranged between 20.93°C- 21.31°C (Table-1) for the present study period. The temperature of different sites ranges between 20.93°C – 21.31°C. The maximum value of temperature (25.03°C) was recorded at Kassaban sewer drain in the month of September and minimum value (17.1°C) of temperature at Govindpuri sewer drain in the month of January.

**Turbidity:** -The maximum value of turbidity (405.0 NTU) was recorded at Rishikul sewer drain in the month of August and the minimum mean value (78.0 NTU) (Table 1) was at Govindpuri sewer drain in the month of May. The average values of turbidity ranged between 143.88 – 153.19 NTU (Table-1) during the study period.

**Dissolved oxygen:** - The average value of dissolved oxygen content in sewage water ranged between 2.02-2.53 mg/l (Table- 2). It was found maximum (3.03 mg/l) at Govindpuri sewer drain and minimum (1.32mg/l) at Kassaban sewer drain in the month of January and May, respectively.

**Acidity:** - The average value of total acidity in sewage water ranged between 96.24- 110.06mg/l (Table- 1). The maximum mean value of acidity (175.83 mg/l) was observed at Kassaban and minimum (43.33 mg/l) at Govindpuri sewage drain. The maximum value was recorded in the month of September and minimum value in the month of July.

**Alkalinity:** - The alkalinity of sewage water of different sites was high around the year. The average value varied between 261.80 - 320.27 mg/l (Table- 1). The maximum mean value (408.33 mg/l) of alkalinity was recordedat Kassaban sewer drain in the month of January and minimum value (198.33 mg/l) was at Govindpuri sewage drain in the month of March.

**Total Hardness:** - The value of total hardness was maximum (328.66 mg/l) in the month of February at sewage zone at Rishikul and minimum (173.33 mg/l) in the month of December was at Govindpuri sewage drain. The average value of total hardness in sewage water ranged between 220.0 – 265.49 mg/l (Table -2).

**Chloride:** -The maximum mean value of chloride at Kassaban sewage zone was recorded 59.64 mg/l the month of June and minimum was 30.76 mg/l was at Govindpuri sewer drain in the month of November. The average value of chloride in sewage water ranged between 41.96 – 52.18 mg/l (Table-2) during the study period.

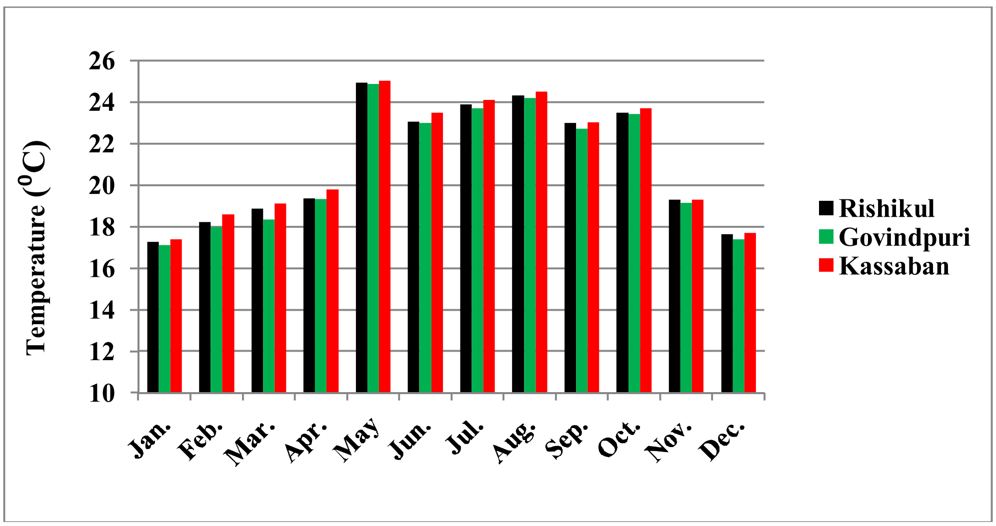
**BOD:** -The maximum mean value of BOD at Kassaban sewage drain was 81.83 mg/l in the month of May and minimum 37.73 mg/l was at Govindpuri sewage drain in the month of January. The average value of BOD in sewage water ranged between 54.92 -63.29 mg/l (Table-2) during the study period.

**Table 1-Physico-chemical Parameters of three sewer drains within Haridwar city during 2015-16. Values are mean ± S.D. and range in parenthesis.**

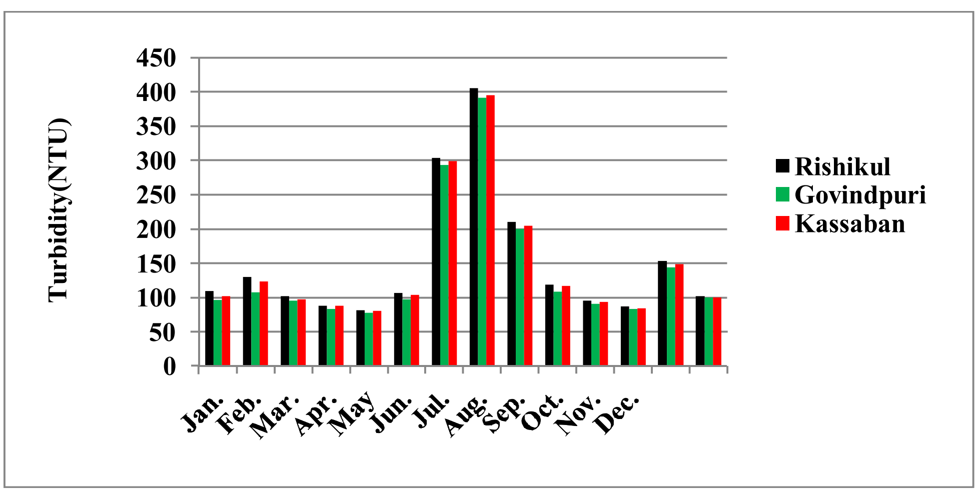
| Par./Mon. | TEMPERATURE (ºC) | | | TURBIDITY (NTU) | | | Acidity (mg/l) | | | Alkalinity (mg/l) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rishikul Sewer Drain | Govindpuri Sewer Drain | Kassaban Sewer Drain | Rishikul Sewer Drain | Govindpuri Sewer Drain | Kassaban Sewer Drain | Rishikul Sewer Drain | Govindpuri Sewer Drain | Kassaban Sewer Drain | Rishikul Sewer Drain | Govindpuri Sewer Drain | Kassaban Sewer Drain |
| Jan. | 17.26 ± 0.05 (17.2-17.3) | 17.1 ± 0.1 (17.0-17.1) | 17.4± 0.1 (17.3-17.5) | 110.0± 1.0 (109-111.0) | 96.33±2.08 (94.0-98.0) | 102.0±3.0 (99.0-105.0) | 115.83 ±3.81 (112.5-120.0 | 105.0±2.5 (102.5-107.5) | 117.5±15.20 (100.0-127.5) | 378.33±15.27 (365.0-395.0) | 356.66±2.88 (355.0-360.0) | 408.33±2.88 (405.0-410.0) |
| Feb. | 18.23 ± 0.05 (18.2-18.3) | 17.96 ± 0.15 (17.8-18.1) | 18.6 ± 0.2 (18.4-18.8) | 129.66±10.78 (122.0-142.0) | 108.0±2.64 (105.0-110.0) | 123.33± 5.77 (120.0-130.0) | 95.0± 2.5 (92.5-97.5) | 85.83± 5.20 (80.0-90.0) | 100.83± 9.46 (90.0-107.5) | 360.0±5.0 (355.0-365.0) | 333.33±7.63 (325.0-340.0 | 415.0±5.0 (410.0-420.0) |
| Mar. | 18.86 ±0.05 (18.8-18.9) | 18.33 ± 0.37 (17.9-18.6) | 19.1± 0.45 (18.6-19.5) | 102.33±7.50 (95.0-110.0) | 96.0± 1.73 (95.0-98.0) | 97.33± 8.02 (89.0-105.0) | 75.83±5.20 (70.0-80.0) | 62.5 ±2.5 (60.0-65.0) | 80.0±2.5 (77.5-82.5) | 218.33±7.63 (210.0-225.0) | 198.33±7.63 (190.0-205.0) | 276.66±27.5 (245.0-295.0) |
| Apr. | 19.36 ± 0.15 (19.2-19.5) | 19.33 ± 0.20 (19.1-19.5) | 19.78 ± 0.63 (19.05-20.2) | 88.0±2.64 (85.0-90.0) | 83.0±5.56 (78.0-89.0) | 88.33±6.50 (82.0-95.0) | 89.16±3.81 (85.0-92.5) | 85.0±6.61 (77.5-90.0) | 103.33±39.71 (57.5-127.5) | 231.66±7.63 (225.0-240.0) | 203.33±7.63 (195.0-210.0) | 266.66±18.92 (245.0-280.0) |
| May | 24.93 ± 0.05 (24.9-25.0) | 24.86 ± 0.05 (24.8-24.9) | 25.03 ±0.15 (24.9-25.2) | 82.0±2.0 (80.0-84.0) | 78.0±4.0 (74.0-82.0) | 81.0±7.0 (76.0-89.0) | 58.33±3.81 (55.0-62.5) | 56.66±3.81 (52.5-60.0) | 89.16±16.64 (70.0-100.0) | 253.33±7.63 (245.0-260.0) | 228.33±7.63 (220.0-235.0) | 326.66±28.43 (295.0-350.0) |
| Jun. | 23.06 ± 0.15 (22.9-23.2) | 23.0 ± 0.1 (22.9-23.1) | 23.5 ± 1.12 (22.2-24.2) | 106.33±2.08 (104.0-108.0) | 97.0±2.64 (94.0-99.0) | 104.33±2.51 (102.0-107.0) | 53.33±2.88 (50.0-55.0) | 45.0±2.5 (42.5-47.5) | 92.5±28.39 (60.0-112.5) | 305.0±5.0 (305.0-310.0) | 233.33±7.63 (225.0-240.0) | 335.0±66.14 (285.0-410.0) |
| Jul. | 23.9 ±0.1 (23.8-24.0) | 23.7 ± 0.2 (23.5-23.9) | 24.1 ±0.1 (24.0-24.2) | 303.66±5.13 (298.0-308.0) | 293.33±6.11 (288.0-300.0) | 299.0±7.93 (290.0-305.0) | 56.66±3.81 (52.5-60.0) | 43.33±3.81 (40.0-47.5) | 68.33±3.81 (65.0-72.5) | 268.33±7.63 (260.0-275.0) | 253.33±7.63 (245.0-260.0) | 291.66±17.55 (275.0-310.0) |
| Aug. | 24.33 ± 0.15 (24.2-24.5) | 24.2 ± 0.2 (24.0-24.4) | 24.5 ± 0.2 (24.3-24.7) | 405.0±21.79 (380.0-420.0) | 391.66±14.57 (375.0-402.0) | 395.0±18.02 (375.0-410.0) | 72.5±5.0 (67.5-77.5) | 65.83±3.81 (65.0-70.0) | 83.33±3.81 (80.0-87.5) | 253.33±7.63 (245.0-260.0) | 218.33±7.63 (210.0-225.0) | 268.33±10.40 (260.0-280.0) |
| Sep. | 23.0 ± 0.1 (22.9-23.1) | 22.73 ± 0.30 (22.4-23.0) | 23.03 ± 0.15 (22.9-23.2) | 210.0±5.0 (205.0-215.0) | 199.66±1.52 (198.0-201.0) | 204.66±3.51 (201.0-208.0) | 164.16±5.20 (160.0-170.0) | 155.0±2.5 (152.5-157.5) | 175.83±3.81 (172.5-180.0 | 281.66±7.63 (275.0-290.0 | 260.0±5.0 (255.0-265.0) | 305.0±5.0 (300.0-310.0) |
| Oct. | 23.5 ± 0.1 (23.4-23.6) | 23.43 ± 0.05 (23.4-23.5) | 23.7 ± 0.43 (23.4-24.2) | 118.66±8.08 (110.0-126.0) | 109.0±9.64 (102.0-120.0) | 117.33±6.42 (110.0-122.0) | 148.33±3.81 (145.0-152.5) | 136.66±5.20 (132.5-142.5) | 162.5±5.0 (157.5-167.5) | 288.33±7.63 (280.0-290.0) | 268.33±7.63 (260.0-275.0) | 306.66±2.88 (305.0-310.0) |
| Nov. | 19.3 ± 0.1 (19.2-19.4) | 19.16 ± 0.11 (19.1-19.3) | 19.3 ± 0.3 (19.0-19.6) | 95.33±1.52 (95.0-97.0) | 91.33±3.21 (89.0-95.0) | 93.66±1.52 (92.0-95.0) | 116.66±3.81 (112.5-120.0) | 108.33±3.81 (105.0-112.5) | 123.33±6.29 (117.5-130.0) | 316.66±10.40 (305.0-325.0) | 293.33±7.63 (285.0-300.0) | 330.0±8.66 (325.0-340.0) |
| Dec. | 17.63 ± 0.15 (17.5-17.8) | 17.4 ± 0.1 (17.3-17.5) | 17.7 ± 0.2 (17.5-17.9) | 87.33±2.51 (85.0-90.0) | 83.33±5.13 (79.0-89.0) | 84.0±5.29 (80.0-90.0) | 109.16±5.20 (105.0-115.0) | 100.83±5.20 (95.0-105.0) | 117.5±2.5 (115.0-120.0) | 311.66±7.63 (305.0-320.0) | 295.0±10.0 (285.0-305.0) | 313.33±7.63 (305.0-320.0) |
| Avg. ±SD | 21.11 ± 2.89 | 20.93±2.95 | 21.31±2.89 | 153.19 ± 102.10 | 143.88±100.25 | 149.16±100.11 | 96.24±35.89 | 100.83 ± 35.23 | 110.06±30.98 | 288.88±48.48 | 261.80±50.08 | 320.27±48.46 |

**Table 2-Physico-chemical Parameters of three sewer drains within Haridwar city during 2015-16.Values are mean ± S.D. and range in parenthesis.**

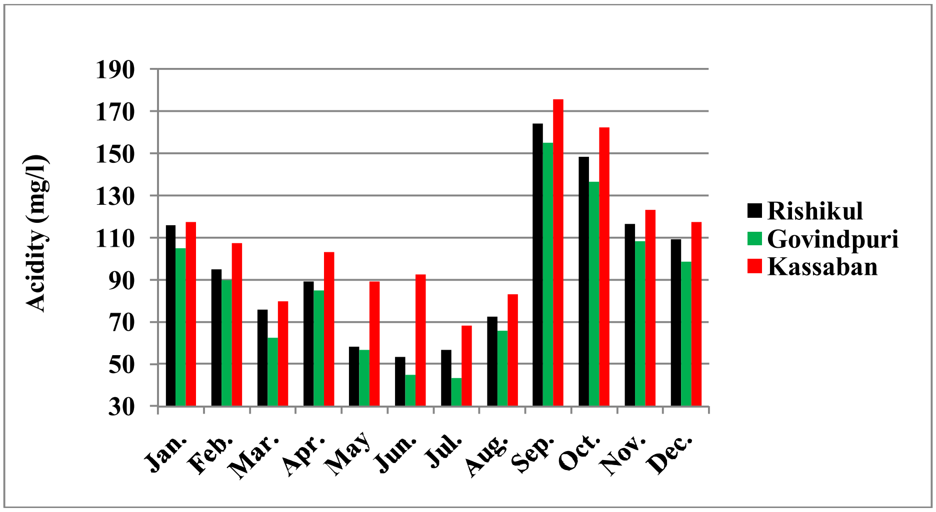
| Par./Mon. | DO (mg/l) | | | BOD (mg/l) | | | Hardness (mg/l) | | | Chloride (mg/l) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rishikul Drain | Govindpuri Sewer Drain | Kassaban Drain | Rishikul Drain | Govindpuri Drain | Kassaban Drain | Rishikul Drain | Govindpuri Drain | Kassaban Drain | Rishikul Drain | Govindpuri Drain | Kassaban Drain |
| Jan. | 2.93 ± 0.10 (2.83-3.04) | 3.03 ± 0.20 (2.83-3.24) | 2.91 ±0.47 (2.49-3.42) | 40.46 ± 14.72 (28.2-56.8) | 37.73 ± 14.16 (24.4-52.6) | 49.43 ±16.53 (30.5-61.0) | 306.66 ±41.0 (282.0-354.0) | 232.66 ±7.57 (224.0-238.0) | 261.33 ±3.05 (258.0-264.0) | 51.59 ± 2.16 (49.7-53.96) | 43.54 ±2.16 (41.18-45.44) | 57.27 ±7.14 (49.7-63.9) |
| Feb. | 2.58 ± 0.08 (2.49-2.63) | 2.86 ± 0.05 (2.83-2.93) | 2.24±0.37 (1.82-2.49) | 47.33 ± 8.43 (40.6-56.8) | 45.88 ± 6.28 (40.2-52.6) | 45.86 ± 5.60 (41.0-52.0) | 328.66 ±4.16 (324.0-332.0) | 256.66 ±6.11 (250.0-262.0) | 271.66±4.72 (268.0-277.0) | 57.74 ± 2.16 (55.38-59.64) | 53.96 ± 2.45 (51.12-55.38) | 59.16 ± 4.33 (55.38-63.9) |
| Mar. | 2.78 ± 0.08 (2.69-2.83) | 2.89 ± 0.06 (2.83-2.95) | 2.07 ± 0.38 (1.72-2.49) | 56.73 ± 4.0 (52.8-60.8) | 55.40 ± 6.21 (48.6-60.8) | 60.67 ± 2.39 (58.22-63.0) | 230.66 ± 26.63 (200.0-248.0) | 176.66 ± 6.11 (170.0-182.0) | 185.33 ± 3.05 (182.0-188.0) | 37.39 ±2.16 (35.5-39.76) | 35.02 ± 3.57 (31.24-38.34) | 44.02 ± 1.42 (42.6-45.44) |
| Apr. | 2.67 ± 0.14 (2.55-2.83) | 2.83 ± 0.12 (2.69-2.93) | 1.70 ± 0.34 (1.41-2.08) | 60.73± 4.10 (56.6-64.8) | 57.93 ± 8.51 (48.4-64.4) | 66.26 ±4.19 (63.0-71.0) | 260.66 ± 33.54 (222.0-282.0) | 202.0 ± 4.0 (198.0-206.0) | 213.33 ± 5.03 (208.0-218.0) | 41.65 ± 2.95 (38.34-44.02) | 40.7 ± 2.16 (38.34-42.6) | 50.17 ± 2.95 (46.86-52.54) |
| May | 1.64 ± 0.03 (1.62-1.68) | 1.91 ± 0.34 (1.62-2.29) | 1.32 ± 0.35 (0.93-1.62) | 77.33 ±5.92 (70.5-81.0) | 70.83 ±10.25 (60.5-81.0) | 81.83 ±11.27 (71.0-93.5) | 295.33 ± 12.05 (284.0-308.0) | 244.0 ± 2.0 (242.0-246.0) | 247.33 ± 3.05 (244.0-250.0) | 47.33 ± 2.16 (45.44-49.7) | 43.07 ± 2.95 (39.76-45.44) | 55.38 ± 2.45 (52.54-56.8) |
| Jun. | 1.96 ± 0.04 (1.94-2.02) | 2.19 ± 0.19 (2.08-2.42) | 1.62± 0.29 (1.33-1.92) | 70.50 ±10.0 (60.5-80.5) | 67.16 ± 5.77 (60.5-70.5) | 73.83 ±11.98 (60.0-81.0) | 294.0 ±51.06 (250.0-350.0 | 195.33 ± 3.05 (192.0-198.0) | 246.66 ±3.05 (244.0-250.0) | 46.86 ± 1.42 (45.44-48.28) | 44.96 ± 2.16 (42.6-46.86) | 59.64 ± 12.37 (51.12-73.84) |
| Jul. | 2.83 ± 0.35 (2.83-3.04) | 2.90 ± 0.42 (2.43-3.24) | 2.78± 0.13 (2.63-2.89) | 55.26 ± 12.35 (44.6-68.8) | 48.40 ± 4.0 (44.4-52.4) | 56.73 ± 12.10 (44.6-68.8) | 258.66 ± 7.57 (250.0-264.0) | 231.33 ± 6.11 (226.0-238.0) | 237.33 ± 3.05 (234.0-240.0 | 43.54 ± 2.16 (41.18-45.44) | 39.28 ± 2.16 (36.92-41.18) | 47.8 ±1.63 (46.86-49.7) |
| Aug. | 2.85 ± 0.03 (2.83-2.89) | 2.92 ± 0.25 (263-3.10) | 2.47±0.14 (2.35-2.63) | 44.40 ± 4.0 (40.4-48.4) | 40.46 ±4.10 (36.4-44.6) | 44.8 ±2.40 (42.5-47.3) | 249.33 ± 7.57 (244.0-258.0) | 229.33 ± 3.05 (226.0-232.0) | 240.66 ±4.16 (236.0-244.0) | 37.39 ± 2.16 (35.5-39.76) | 30.76 ± 2.16 (28.4-32.66) | 43.54 ± 2.16 (41.18-45.44) |
| Sep. | 2.40 ± 0.04 (2.35-2.43) | 2.47 ± 0.03 (2.43-2.49) | 2.28± 0.24 (2.02-2.49) | 64.33 ± 5.77 (61.0-71.0) | 60.66 ±0.28 (60.5-61.0) | 70.83 ±9.47 (60.5-79.1) | 278.0 ±2.0 (276.0-280.0) | 260.66 ± 4.16 (256.0-264.0) | 268.0 ± 5.29 (264.0-274.0) | 51.12 ± 2.84 (48.28-53.96) | 44.02 ± 2.45 (41.18-45.44) | 53.96 ± 1.42 (52.54-55.38) |
| Oct. | 1.94 ± 0.21 (1.82-2.2) | 2.49 ± 0.11 (2.43-2.63) | 1.49 ± 0.33 (1.11-1.74) | 68.80 ± 4.2 (64.6-73.0) | 59.53 ± 6.0 (52.6-63.0) | 74.33 ± 2.30 (73.0-77.0) | 272.66 ± 3.05 (270.0-276.0) | 247.33 ± 3.05 (244.0-250.0) | 258.0 ± 4.0 (254.0-262.0) | 49.23 ± 2.15 (46.88-51.12) | 41.64 ± 2.15 (39.76-44.0) | 51.12 ± 1.42 (49.7-52.54) |
| Nov. | 1.92 ± 0.08 (1.88-2.02) | 1.95 ± 0.11 (1.82-2.02) | 1.58 ± 0.20 (1.47-1.82) | 70.26 ± 4.73 (64.8-73.0) | 60.43 ±7.56 (51.7-64.8) | 73.0 ±4.0 (69.0-77.0) | 219.33 ±4.16 (218.0-224.0) | 194.0 ± 4.0 (190.0-198.0) | 206.66 ± 4.16 (202.0-210.0) | 44.02 ± 2.84 (41.18-46.86) | 35.02 ± 2.16 (32.66-36.92) | 47.8 ± 2.16 (45.44-49.7) |
| Dec. | 1.90 ± 0.03 (1.88-1.94) | 1.99 ± 0.04 (1.94-2.02) | 1.86 ± 0.03 (1.82-1.88) | 64.8 ± 4.2 (60.6-69.0) | 54.66 ± 5.13 (51.7-60.6) | 62.0 ± 2.42 (60.6-64.8) | 186.0 ± 10.39 (180.0-198.0) | 173.33 ± 5.03 (168.0-178.0) | 180.66 ± 4.16 (176.0-184.0) | 55.85 ± 2.16 (53.96-58.22) | 51.59 ± 2.95 (48.28-53.96) | 56.32 ± 2.95 (53.96-59.64) |
| Mean ±SD | 2.36±0.46 | 2.53±0.42 | 2.02±0.51 | 60.07±11.49 | 54.92±10.11 | 63.29±12.15 | 264.99±39.98 | 220.27±30.68 | 234.74±31.14 | 46.97±6.54 | 41.96±6.63 | 52.18±5.60 |



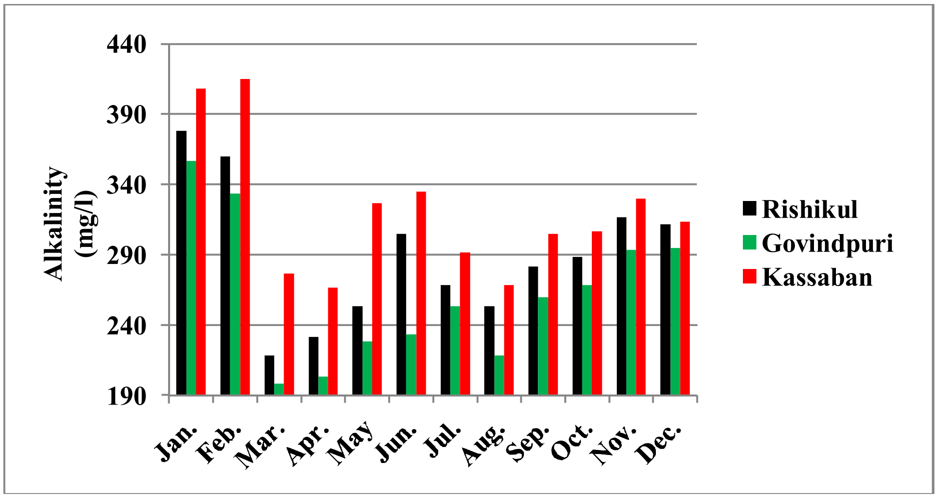

(A)



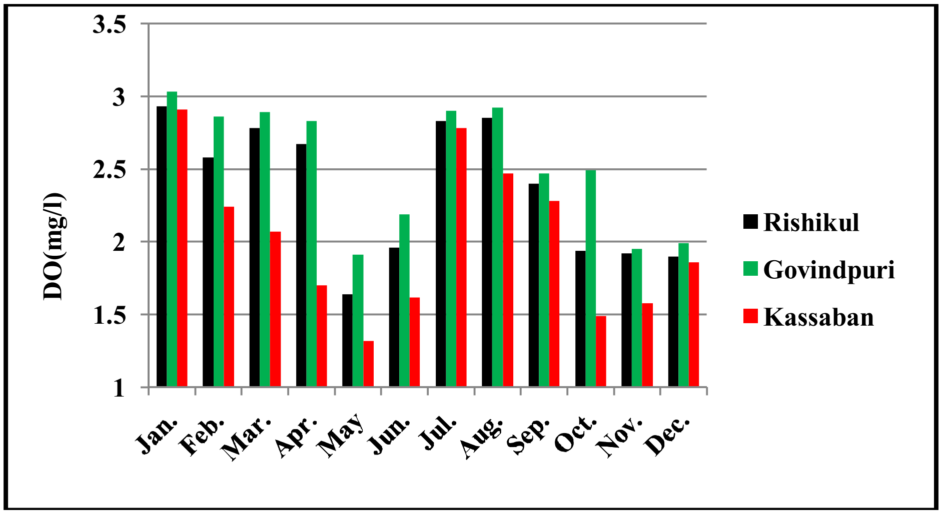

(B)


Acidity (mg/l)
190
170
150
130
110
90
70
50
30
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Rishikul
Govindpuri
Kassaban

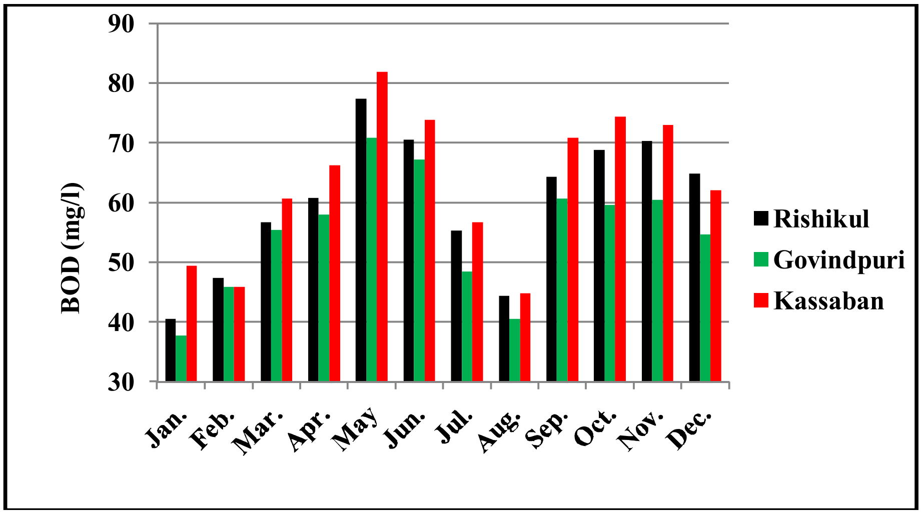
(C)


Alkalinity (mg/l)
440
390
340
290
240
190
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Rishikul
Govindpuri
Kassaban

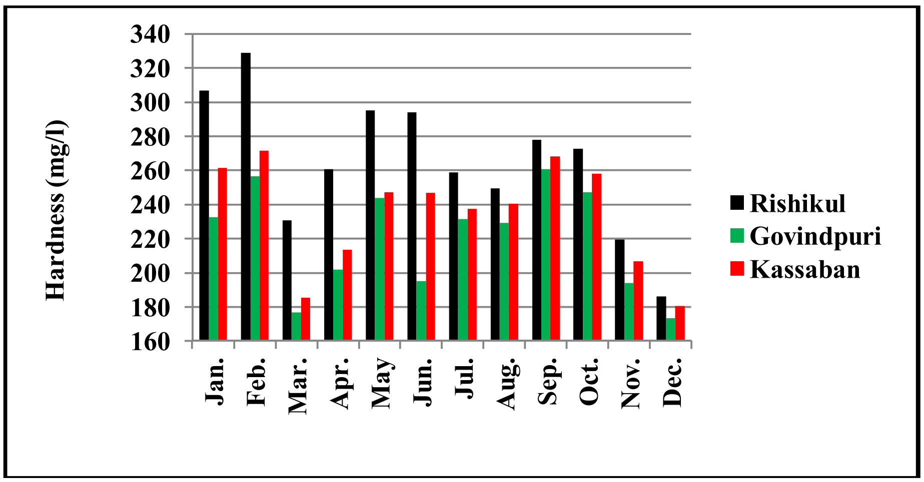
(D)


DO(mg/l)
3.5
3
2.5
2
1.5
1
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Rishikul
Govindpuri
Kassaban

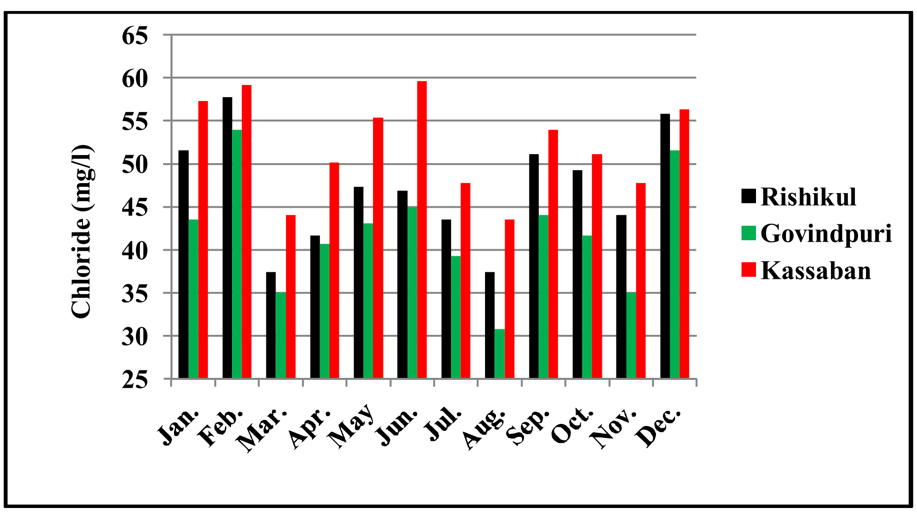
(E)




(F)




(G)




(H)

**Graphs A to H showing monthly relative values of selected parameters of Three Sewer Drains within Haridwar City.**

## 4. Discussions

In the present study we have examined certain parameters in order to evaluate the water quality of three sewage drain. The study shows that domestic sewer drains conspicuously adds to the level of pollution causing constituents of Ganga river canal with in Haridwar city. Among all the three selected drains, the Kassaban sewage drain was found most polluted (Table -1 and 2).

Temperature is one of the most important parameter in the aquatic system. The sewage temperature is frequently regulated by the ambient temperature. Our study shows that temperature of Kassaban sewage drain was higher as compared to all other sewage drain. This situation has become further complicated on account of growing urbanization & industrialization of Haridwar **(Trivedi 2010).** Recently **Bhadula & Joshi (2012)** reported that a careless way of living style of the people along these sewage feeder areas, which are almost as good as that may be of any rural community, besides the careless municipal working and contributions of pilgrims are the main causative for pollution and degradation of Ganga water quality. The temperature values were higher during summer and rainy season and lower during winter season. This study shows similarity with the findings of **Joshi & Bisht (1991)** they too pointed out that sewer drain of Jwalapur degraded the water quality of river Ganga. The concentration of Dissolved Oxygen in Kassaban sewage water was found lower as compared to rest of the two sampling spots. It is obviously due to higher amounts of raw and decomposing organic solid waste in the sewage which may refer to high pollution load. It is already proved that a high pollution load reduces the DO to an extensive level. **Bhadula and Joshi (2012)**, also studied the impact of sewer drains on Ganga river at Haridwar, study revealed that the water quality of sewage and confluence zone was very unsafe and not usable for any purpose. Hence this study provides solid evidence in favor of our results which also shows the same pattern. BOD is of great significance in evaluation of water quality, the seasonal variation in the values of BOD appears to be change in the degree of dilution, quality of organic matter and activities of microorganisms. Kassaban sewage water shows higher values of BOD in comparison of two other drains. This is due to higher amounts of organic matter in sewage water. Usually higher values were recorded in summer and lower in winter season. Similar results were also reported by **Dubey *et al.,* (2012)** in sewage drains of Yamuna river at Delhi and **Joshi and Pathak (1991)** in sewage water at Uttarkashi.

Turbidity is an indicator of the quantity of material suspended in water. Rishikul sewage water shows higher turbidity in comparison of other sewage drains. A Similar trend of turbidity in sewage water was also observed by **Joshi *et al.,* (2016)** at Haridwar**.** Like most of the parameters mentioned above, Alkalinity and chloride too were following the same pattern i.e. values of alkalinity & chloride in Kassaban sewage water was found higher, in comparison to other sewage drains. This may be due to the impact of different types of domestic solid and liquid wastes being added to the sewage contents, which is generated from various households, similar trend of alkalinity and chloride in sewage was also observed by **Tripathi *et al.,* (1991)** in river Gangaat Varanasi. Acidity of water is capability to react with a strong base to fix pH. Acidity in Kassaban sewage water was always higher, in comparison of all other sewage drains. This may be due to the discharge of various acidic substances in sewage water. Similar trend of results were observed by **Bhutiani*et al.,* (2016)** in Sewage treatment plant of Jagjeetpur, Haridwar. Total hardness is the amount of dissolved calcium and magnesium salts in the water and influences its solubility and portability. Similarly **Igbinosa *et al.,* (2009)** studied the impact of waste water effluents on the physico-chemical character of watershed in a rural community and reported that the effluent could cause considerable health and environmental risk to rural communities. The impacts of sewage are not only harmful to human health but also to whole ecosystem of water bodies and even sometimes to the riparian ecosystems in general. Depending on the status and degree of pollution, polluted water is not suitable for drinking, agricultural and even for industrial purposes. It reduces the usable qualities of water bodies. Similarly **Tewari *et al.,* (2011)** studied the physico-chemical properties of sewage drains in relation to river Arpa at Bilaspur and concluded that the water of river Arpa is highly polluted due to domestic sewage and is affecting the health of the people of downstream at Bilaspur, since water isbeing used for several domestic and agricultural purposes like bathing, washing and irrigation etc. Value of total hardness in Rishikul sewage water remains higher as compared to all other sewage drain, showing that there is certainly some difference in the utility of water in the feeder area which is impacting its hardness. Similar trends of total hardness were also observed by **Rai *et al.,* (2012)** who studied the sewage disposal on water quality of Harmu River at Ranchi.

Recently **Joshi *et al.* (2016)** studied the dilution & mitigation of sewage drain by Ganga canal water and reported that pollution characters were mitigated at five hundred meters down from the confluence point. Similarly when we compare the present values obtained for the sewage water with post confluence zone, we found that mean DO value (2.02 mg/l) of Kassaban sewage water was 320.79% lower in comparison to post confluence value at five hundred meter location in downstream. Likewise for Rishikul and Govindipuri drains, mean values of DO were 260.16% and 235.96% lower at five hundred meter location, downstream again, respectively. Taking up the another important parameter i.e. BOD, mean value (63.29 mg/l) of Kassaban sewage was 3080.40% higher as compared to post-confluence value while that of Rishikul sewage water BOD was 2918.59% higher, followed by Govindpuri sewage water, where it was 2659.79%, higher. The chloride value was highest for sewage water at Kassaban station, being 216.62% higher against the post confluence values at 500m location, downstream. For Rishikul and Govindpuri sewage drain chloride values were 185.01% and154.61% higher, respectively in comparison to post-confluence value. The maximum mean value of turbidity 153.19 NTU, was found for the sewage water of Rishikul drain, which was 44.30% higher when compared to post-confluence value at five hundred meter location. Similarly for Govindpuri and Kassaban drain the turbidity value were 35.53% and 40.50 % higher at five hundred meter location, respectively.

**Conclusion and Recommendations**

The present study revealed that among the three drains, the Kassaban sewage drain is most polluted among all, which may be due to disposal of domestic waste - related to their specific life styles and relatively poor socio-economic conditions of the people living in this area, as compared to other two locations. It is further noted that the Haridwar city sewage, almost at all locations, is more or less comprised of organic solid waste and synthetic materials, on account of a massive influx of pilgrims, who contribute a lot of, rather major part of solid waste, littering it throughout the city.. The higher values of physico-chemical parameters of sewage is indeed very poor, unsafe and not good enough for any purposes, without proper treatment and purification. However, it also permits us to share and infer that if there occurs more than thousands times of dilution **(vide Joshi *et al.*, 2016)** of this sewage water and there is no discharge of sewage drains at least before 1000 meter downstream, of the observed volume (as in this case), then the pollution impacts are mitigated top greater extent.

**Acknowledgements:**

Authors extend their thanks to the Head of the Department of Zoology and Environmental Sciences, of G. K.V. for providing routine facilities of work in the departmental laboratory.

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10/8/2017