ON THE DILUTION AND MITIGATION OF A SEWAGE DRAIN OF KASSABAN, AS IMPACTED BY THE WESTERN GANGA CANAL NEAR JWALAPUR, HARIDWAR

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This paper presents the results of a study to make assessment of dilution cum mitigating effects caused by a small city sewer drain on the physico-chemical qualities of a river like water body (western Ganga Canal in this case). There is vast difference in the average amount of water in the sewage (about 80.5 cusec/day) and that of canal water (about on an average 8016.8 cusec/day). The aim was to know that after about what distance having such difference in the quantity of the water, the pollutional characters are mitigated to near normal level that is compared to the pre-confluence zone of the river/canal. Results of this study show it was about 500 meters post confluence location and while there is no other source of pollution/any drain/source of contamination that water quality improves to potable status. The average annual values of the six parameters studied were: Temperature 17.35°C, 20.94°C, 19.15°C and 17.38°C TDS 156.66 mg/l, 401.25 mg/l, 273.12 mg/l and 163.12 mg/l, DO 8.51 mg/l, 1.99 mg/l, 4.50 mg/l, and 8.50 mg/l, BOD 1.90 mg/l, 60.21 mg/l, 38.79 mg/l and 1.99 mg/l, turbidity 103.91 NTU, 154.25 NTU, 135.87 NTU and 106.16 NTU and chloride 15.85 mg/l, 53.72 mg/l, 39.44 mg/l and 16.48 mg/l, respectively for the pre-confluence, sewage water, confluence and post confluence zone, respectively.

Material and Methods

Kassaban sewage drain a perennial sewage drain, having confluence with the canal, is domestic sewage in totality from colonies of Kassaban, colony and near by areas. In the present study water samples were taken from the Pre-confluence zone (which was about 100 meter before the confluence zone), Kassaban sewage drain (about 100 meters down from the confluence point), from the confluence zone and dilution zone (500 meters down from the confluence point). The monitoring of water quality was conducted during the month of November 2013 to October 2014 and sampling was done on fortnight. Some Physico-chemical parameters were analyzed on spot viz. temperature, turbidity, with the help of soil and water analysis kit Model no.191E, and some parameters like DO, BOD, TDS and chlorides were analyzed in the laboratory with

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RESULTS AND DISCUSSION

In the present study considerable differences were found in the water, quality of pre-confluence, sewage, confluence zone and dilution zone along the selected sites. Physico-chemical parameters are influenced by household yield, urban society, mismanagement of municipality, urbanization and other anthropogenic activities. The relative annual mean value and range value of physico-chemical parameters of sewer drain and that of canal water are given in Table-1 and Table-2.

**Temperature:** - The water temperature of Kassaban sewer drain was between 17.4 to 25.05 °C, at confluence zone it was between 15.75 - 23.1°C at pre-confluence, between 15.0 - 20.65°C and at dilution zone it ranged between 15.0 - 20.7 °C (Table- 1). The mean values were 17.35 ± 1.97, 20.94°C ± 2.97, 19.15°C ± 2.85 and 17.38°C ± 1.98 for pre-confluence, sewage, confluence and dilution zones respectively, during the study period.

**Total Dissolved Solids:** - TDS value of sewage drain was between 225.0 - 510.0 mg/l, at confluence it was between 185.0 - 415.0 mg/l, while in pre-confluence it was between 85.0 - 420.0 mg/l and at dilution zone, it ranged between 95.0 - 432.5 mg/l (Table- 1). The annual average values of this parameter were found 156.66 mg/l ± 93.06, 401.25 mg/l ± 88.19, 273.12 mg/l ± 62.67 and 163.12 mg/l ± 93.20 for pre-confluence, sewage, confluence and dilution zones respectively, for the study period.

**Turbidity:** - The turbidity is one of the most fluctuating parameter in all four zones. The turbidity value ranged between 82.0 - 400.0 NTU at sewage zone, while in confluence zone it ranged between 59.0 - 384.0 NTU. At pre-confluence values varies from 8.0 - 537.5 NTU and at dilution zone it ranged between 9.5 - 537.5 NTU (Table- 1). The annual average values were 103.91 NTU ± 170.24, 154.25 NTU ± 99.47, 135.87 NTU ± 116.64 and 106.16 NTU ± 171.15 for pre-confluence, sewage, confluence and dilution zones respectively during the study period.

**Dissolved Oxygen:** - In pre-confluence zone of western Ganga canal DO values varied from 8.04 to 9.02 mg/l, at dilution zone it was between 7.93 to 9.01 mg/l, while at confluence zone it ranged between 3.57 - 5.16 mg/l. On the other hand, the value of DO for sewage water ranged between 1.32 - 2.95 mg/l (Table-2). The annual mean values were 8.51 mg/l ± 0.36, 1.99 mg/l ± 0.54, 4.50 mg/l ± 0.42 and 8.50 mg/l ± 0.36 for pre-confluence, sewage, confluence and dilution zones respectively for the study period.

**BOD:** - Maximum value of BOD was found in the sewage water within a range of 45.75 - 81.83 mg/l in comparison to pre-confluence, confluence and dilution zones, where the values ranged between 1.42 - 2.23 mg/l, 25.0 - 59.11 mg/l and 1.62 - 2.26 mg/l, respectively. The annual average values were 1.90 ± 0.26, 60.21 mg/l ± 13.46, 38.79 mg/l ± 13.06 and 1.99 mg/l ± 0.18 for pre-confluence, sewage, confluence and dilution zones respectively during the study period.

**Chloride:** - The chloride content of sewage water ranged between 42.6 - 62.48 mg/l, at confluence zone it was between 29.82 - 56.8 mg/l. At pre-confluence it ranged between 11.36 - 19.88 mg/l, while at dilution, the values ranged between 12.78 - 20.59 mg/l (Table 2). The mean values were 15.85 mg/l ± 2.48, 53.72 mg/l ± 7.13, 39.44 mg/l ± 8.12 and 16.48 mg/l ± 2.47 for pre-confluence, sewage, confluence and dilution zones respectively, during the study period.

In like a natural event that any domestic or industrial sewer drain adds a variety of pollutants, causing deterioration in the quality of the river/ canal any where Therefore our study locations are not any exception to this phenomenon. At micro-niche level temperature is the first parameter which affects the whole process of any ecosystem, by impacting the inter-acting biological and abiological constituents, at their physical to intertnal physiological level.

Temperature plays the basic role in all physiological to physico-chemical reactions and self purification power of aquatic system. Our study shows that the temperature of sewage water was round the year higher (Table -1) as compared to confluence and dilution zones, as also reported earlier by Joshi and Bisht. The lower concentration of Dissolved Oxygen (DO) in sewage water was found during summer season, concomitant to relatively higher water temperature at all sampling sites. It is also due to higher amounts of raw and decomposing organic solid waste in the sewage, which leads to increase the temperature on account of microbial activities going within the decomposing matter, as also discussed earlier by Bhadula and Joshi, in relation to sewage effluents and Ganga river at Haridwar and described that the water quality of sewage (and the core point of the confluence zone), was very unsafe and unpotable for domestic use. In dilution zone of western Ganga canal, high value of DO was recorded during
Table 1: Physical Parameters of Kassaban Sewerage compared to Pre-confluence, Confluence and Dilution Zone of Western Ganga canal. Values are mean ± S.D. and range in parenthesis.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-confluence</th>
<th>Sewage</th>
<th>Confluence</th>
<th>Dilution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>28.0 ± 0.7</td>
<td>29.5 ± 0.5</td>
<td>28.9 ± 0.4</td>
<td>28.4 ± 0.3</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>105 ± 6.7</td>
<td>420 ± 98</td>
<td>280 ± 45</td>
<td>120 ± 30</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>150 ± 10</td>
<td>200 ± 15</td>
<td>120 ± 10</td>
<td>60 ± 5</td>
</tr>
</tbody>
</table>

Table 2: Chemical Parameters of Kassaban Sewerage compared to Pre-confluence, Confluence and Dilution Zone of Western Ganga canal. Values are mean ± S.D. and range in parenthesis.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-confluence</th>
<th>Sewage</th>
<th>Confluence</th>
<th>Dilution</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO (mg/l)</td>
<td>8.0 ± 0.8</td>
<td>5.0 ± 0.3</td>
<td>3.0 ± 0.2</td>
<td>1.0 ± 0.1</td>
</tr>
<tr>
<td>BOD (mg/l)</td>
<td>4.0 ± 0.2</td>
<td>3.0 ± 0.1</td>
<td>2.0 ± 0.1</td>
<td>1.0 ± 0.1</td>
</tr>
<tr>
<td>Chl-a (mg/l)</td>
<td>0.5 ± 0.1</td>
<td>0.3 ± 0.0</td>
<td>0.2 ± 0.0</td>
<td>0.1 ± 0.0</td>
</tr>
</tbody>
</table>

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Graphs A to F showing Monthly relative values of selected Parameters of Sewer Drain at Pre-Confluence Zone, Sewage, Confluence Zone and Dilution Zone.
winter and low during summer season (Table-2). Higher values of BOD shows higher amounts of organic matter in sewage water, when compared to pre-confluence, confluence and dilution zone of Ganga canal. At dilution zone, the maximum concentration of BOD was recorded in the month of May and minimum during the winter season, almost similar results are reported by Agrahari and Kushwaha\textsuperscript{15} in river Rapti at Gorakhpur. Total dissolved solids denote the existence of different solid material dissolved in the water. TDS value in sewage water remains higher compared to confluence and dilution zones. Joshi and Pathak\textsuperscript{11} mentioned that the municipal sewage water at Uttarkashi had a higher load of dissolved material, as compared to confluence and dilution zone of river Bhagirathi, obviously due to dilution - mitigation efforts / process of mixing waters. Turbidity is an indicator of the quantum of dissolved as well as material suspended in water. The sewage water obviously had higher turbidity in comparison to other three sampling spots. This is no exception as has been routinely reported by Joshi and Bisht\textsuperscript{6} for Ganga water at Haridwar and by Kushwah\textsuperscript{12} for waste water from a Sewage Treatment Plant, in Bhopal, and pointed out that the excessive turbidity in water can cause a problem with water purification processes which may increase treatment cost.

Chloride is one of the main inorganic anions in water and waste water, Chloride in sewage water was always higher, in comparison of all other sampling spots. This may be due to the impact of different types of domestic solid and liquid wastes being added and which churns up well during its flow even before confluence, while it is being generated from the various houses. Similarly Tripathi\textsuperscript{13} made such observations, with special reference to chloride contents of sewage at Varanasi in river Ganga. Discharge of human and animal waste not only contributes to the quality of water but also affects the health of the people. Similarly Srivastava and Srivastava\textsuperscript{14} studied the physico-chemical properties of sewage drains and river Gomti at Lucknow and suggested that the drains must be treated before merging into the river.

Now coming to the basic objective of this study, this study presents our one year monitoring (2013-14) of Ganga canal, to assess the impact of dilution vis a vis as impacted by the volume of river water on the amount of sewage water. In this case the annual average daily discharge of Kassaban drain was about 80.5 cusec. On the other hand annual average daily flow/discharge of Ganga canal was (as reported by NDGC Mayapur Haridwar) for the same period was 8016.8 cusec. That means the volume of sewage discharge was about 1% of the canal water. When we compare the TDS value of sewage water (about 100 meter upstream of confluence zone) being 401.25 mg/l with those of the Pre-confluence zone (which was about 100 meter before the confluence zone), confluence zone and 500 meter downstream of the confluence zone, were 156.66 mg/l, 273.12 mg/l and 163.12 mg/l were 156.19% higher compared to pre confluence zone, while for the confluence zone, the Kassaban sewage TDS was 46.91 % higher. Similarly for the dilution zone at 500 meter location, the TDS value of Kassaban sewage was 146.61% higher. In comparison of pre-confluence zone, the 500 meter location (dilution zone) TDS value was 3.85 % higher. The minimum mean value of DO (1.99 mg/l) was found for the sewage water at Kassaban, in comparison of pre and post confluence values it was 327.63% and 327.13% lower at five hundred meter location, respectively. The dilution zone value was 0.11 % lower compared to pre confluence zone. Taking up the most sensitive and important parameter that of the BOD value (60.21 mg/l), of Kassaban sewage was 3068.94 % higher as compared to pre-confluence zone and 2925.62 % higher to post-confluence zone at 500 meter post confluence site, the last point under our study area. In comparison of pre-confluence zone, the dilution zone BOD was only 4.73 % higher. The chloride content showed highest value for sewage water at Kassaban station, being 238.92 % to pre-confluence area and 225.97 % against the post confluence water at five hundred meter location. The dilution zone value was 3.97 % higher compared to pre confluence zone. Thus, from the present study it may be inferred that volume of sewage water discharged into Ganga canal is very low as compared to the large amount of water flowing in the Ganga canal. Hence this sewage gets diluted and its polluted components are widely mitigated, on account of the vast water volume of Ganga canal and the canal water quality is nearly restored, nearly to the pre-confluence level, by 500 m downstream, though not fully from confluence point.

This is on account of the massive difference in the volume of the sewage water and the canal water. It justifies three decade old saying that “Dilution is the solution of Pollution”. It suggest to note that a limited amount of moderate type of domestic sewerage when drains in any river having such vast ratio of sewage water Vs. river water (as in this case of 1:99 between
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Kassaban drain (Nala) and the western Ganga canal and sufficient space and time is given to a river, it can be fully mitigated / rejuvenated and its portability can be restored almost hundred percent, provided there is no addition to such polluting drains etc. between such a distance/space. Our studies are still in process where-in we are trying to assess that what happens when such drains are poured in any river like body regularly in terms of water volume in both (a drain and a river/stream), time and space. And we think this is important in water management under such conditions. We have just to keep away ourselves from a certain identified stretch of the river and follow the hygienic rules of health management.

ACKNOWLEDGEMENTS

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REFERENCES

Fig.-1. Location Map showing sampling site of sewage Drain (Kassaban nala) of Jawalapur and its confluence with river.

Fig.-2. Picture of Kassaban sewage Drain (Nala)  

Fig.-3. Confluence Point (C) of Kassaban drain with Western Ganga Canal, near Jwalapur.