The Confluence of Sewage and Stormwater in Sewage District C of Mysuru City - a case study

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Abstract - *The Karnataka State Pollution Control Board (KSPCB) is the regulatory body responsible for enforcing environmental laws and regulations in Karnataka. Various studies have been conducted to assess the amount of raw sewage entering the natural nalla/ lakes in Mysuru city. One such study was carried out under the guidance of KSPCB to examine confluence locations of sewage with stormwater valleys (also known as Raja Kaluve) in Sewage District 'C' of Mysuru City. The objective of the study was to identify the main areas where sewage and stormwater drains converge, to measure the amount of sewage flowing into the major stormwater drains that lead to the Sewage Treatment Plant (STP) and to evaluate the quality of wastewater that enters the natural nalla. Major confluence locations of sewage and stormwater drains (Raja Kaluve) were identified. Records were created to document the confluence locations and quantify the mixed flow of untreated sewage and treated effluent that enters the natural nallas/lakes. The study revealed that a significant volume of raw sewage from District 'C' was entering the natural nalla, which would subsequently travel and reach Paschim Vahini, posing a threat to the ecosystem. BOD and Total coliform levels of the water samples at the confluence locations exceeded the limits prescribed by CPCB.*

Key Words**: Confluence, Drains, Mysuru city, Raja Kaluve, Sewage.**

1. INTRODUCTION

Mysuru is a city located in the southern part of Karnataka. It is known for its palaces, rich culture, and peacefulness. The administrative seat of Mysuru District is one of the largest in Karnataka. It is 770 meters above mean sea level with geographical coordinates of 12.18° N 76.42° E. Currently, the city has a population of about 13,16,000 and a floating population of approximately 50,000 to 1,00,000 during Dasara Festival.

The city gets its surface water sources from the Kaveri and Kabini rivers. Newly developed and extended areas under Mysuru Urban Development Authority (MUDA) limits are supplied with Borewell (BW) water. The total water supply to the city from surface sources is about 214 Million Liters per day (MLD) (4 WTPs at Melapura, Hongalli, Belagola, and Rammanahalli), which is more than the minimum per capita rate supply of 135 litres, as per the Central Public Health and Environmental Engineering Organization (CPHEEO) norms.

Mysuru has an underground drainage (UGD) system that covers about 70% of the city's area. It comprises five major sewage Districts, A, B, C, D & E, within the Comprehensive Development Plan (CDP) boundary, and two Districts, G & F, outside the CDP boundary. The total length of the sewer line provided is about 1560 km, and the total installed capacity of Sewage Treatment Plants (STPs) in the city is about 172.5 MLD (3 nos. - 60 MLD, 67.5 MLD, 45 MLD). The total quantity of sewage collected is about 95 MLD, about 55% of the amount generated.

In the case of Sewage District 'C', it is observed that only a small amount of sewage is reaching the STP due to various issues. These include obstructions during solid waste dumping in the stormwater drains carrying untreated sewage, non-operation of interception and diversion works, ongoing pipeline works and repairs of aerators in the STP. The Kesare STP, which is of aerated lagoon type, has a designed capacity of 45 MLD. However, it can only treat a fraction of the total sewage generated, which reaches the STP through the underground drainage system. The untreated sewage flows into the stormwater drains and eventually reaches the natural nalla.

2. LITERATURE REVIEW

In Karnataka, two main types of sewage treatment plants are used to treat domestic sewage from small and medium towns. Waste stabilization ponds (WSP) and aerated lagoons were preferred for easy operation and maintenance. These technologies successfully treated sewage effluent with BOD (Biochemical Oxygen Demand) levels of 30 mg/l or lower. However, as the Central Pollution Control Board (CPCB) established stringent effluent parameters for treated effluent discharge to land or water bodies, with BOD levels of 10 mg/l or lower and COD (Chemical Oxygen Demand) levels of 50 mg/l or lower, some STPs have been upgraded.

In recent years, technologies like Sequential Bioreactors (SBR), Membrane Bioreactors (MBR), Moving Bed Bioreactors (MBBR), and Soil Biotechnology (SBT) have been constructed to treat domestic sewage.

The earlier WSPs / aerated lagoon-type STPs have proven effective in reducing some of the parameters but not all. Parameters like BOD and COD of treated effluent in Urban Wastewater (UWW) are within the permissible limits set by CPCB for disposing of UWW on land for irrigation. However, the continuous usage of this effluent for agricultural purposes may harm the soil. It has also been found that the aerated lagoon treatment is ineffective in treating or reducing coliform bacteria, which is used as a surrogate organism for microbial pathogens (Severni et al., 2019 [1]).

In some cases, sewage enters lakes directly without being treated. Jyotirmoy Sarma (2020 [2]) explains that entering wastewater into lakes from drains is a significant issue and proposes diversifying wastewater flows into urban lakes by constructing interception and diversion structures. If that is not possible, providing onsite wastewater treatment at their entry points to the lake is proposed.

When untreated municipal wastewater is suddenly discharged into river ecosystems, it has significant adverse environmental, economic, and social impacts. Parameters such as orthophosphates, nitrites, and nitrates intensify eutrophication (Michał Preisner, 2020 [3]).

Several existing urban lakes are infringed upon, followed by the dumping of solid waste into them. Manjunatha et al. (2022 [4]) have determined that lakes in Mysuru city are polluted and deteriorating due to urbanization pressures, illegal waste dumping, the inflow of sewage water and industrial effluents, and a variety of weeds infesting major portions of the lakes. A significant decrease in clean surface water bodies negatively impacts moisture content and groundwater.

Effective strategies for connecting all households to the sewage system must be undertaken for a healthy environment. Raising awareness and educating communities is crucial in promoting responsible waste management and encouraging community participation. Adequate infrastructure for collecting, treating, and disposing of solid waste and wastewater must be established (Zié Adama et al., 2023 [5]).

3. METHODOLOGY

The study was conducted over two months (from December 2023 to January 2024) to investigate the impact of sewage discharge on water bodies. The methodology consisted of 5 stages, as indicated in Figure 1. Primary data were collected for one month by visiting the site, conducting a reconnaissance survey, measuring the flow in major stormwater drains and analyzing the water samples collected at confluence locations. Supporting information was collected and collated from various sources such as the KSPCB, Karnataka Urban Water Supply and Drainage Board (KUWSDB), Mysuru City Corporation (MCC), research papers, etc.

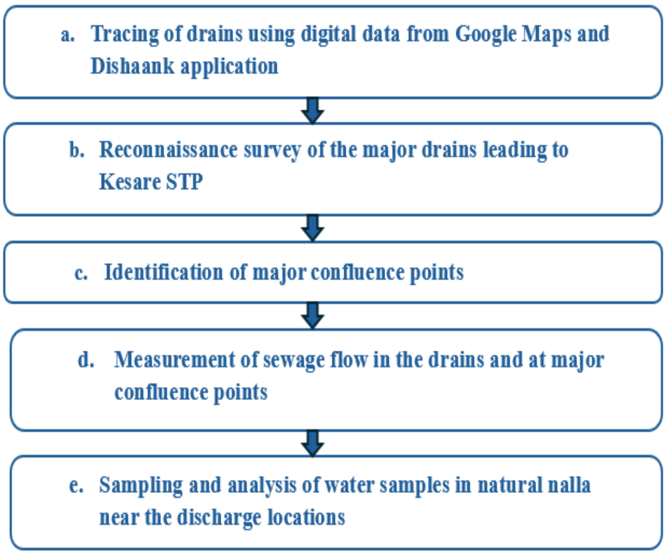

Fig -1: Study methodology

Primary data, namely photographs of the polluted locations and Sewage Treatment Plants, was obtained from the project sites. Supporting information was collected and collated from various sources such as the Karnataka State Pollution Control Board (KSPCB), Karnataka Urban Water Supply and Drainage Board (KUWSDB), KGIS website, Directorate of Municipal Administration website and research papers.

4. THE STUDY

In 2001, the Asian Development Bank financially assisted in installing an underground drainage system to serve District C, which is in the northern part of Mysuru city. This included a sewer network, trunk mains, outfall sewers, wet wells (3 in total), and a sewage treatment plant (aerated Lagoons) with a capacity of 30 MLD.

As part of the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) grants, KUWSDB recently made further improvements to the system in 2021. These included the construction of a common wet well cum pump house, additional pumping machinery and enhancement of the STP capacity from 30 MLD to 45 MLD. Interception and diversion work was also done to divert sewage from stormwater drains to the STP.

The various sewage Districts of Mysuru city and the location of Kesare STP are shown in Figure 2.

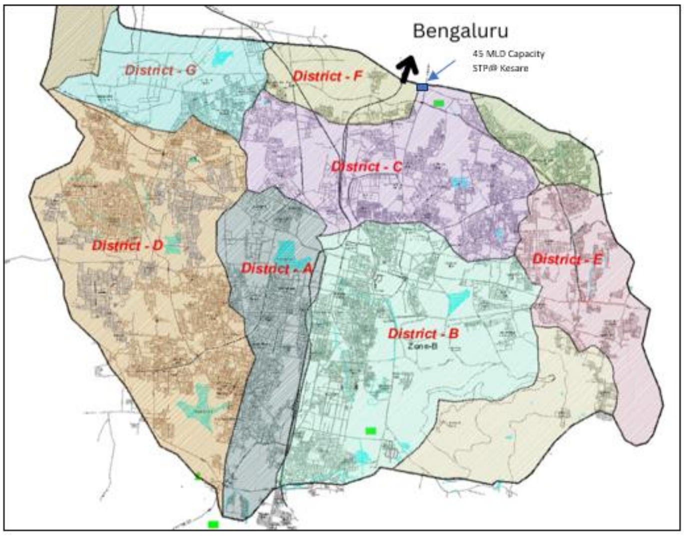

Fig -2: Sewage districts of Mysuru city

For the current study, Google Maps and Dishaank applications were utilized to track the major drains in District 'C' of Mysuru city. The details of the origination of stormwater drains and the confluence locations of sewage were also recorded.

A reconnaissance survey was conducted in the study area based on the traced information. Photographs and videos that included details of Global Positioning System (GPS) coordinates were taken. Locations of natural nallas, drains, and manholes, as well as details of the surrounding landmarks, roads, and areas, were obtained.

The float method was used to measure the liquid flow in a drain. This method is non-intrusive and involves timing how long it takes for a float to travel a certain distance in a straight section of the drain. Additionally, the width and depth of the flow were measured. The liquid flow was then calculated by multiplying the wetted cross-sectional area with the flow velocity. Since the depth of the drain is greater and velocity at higher depths will be less due to friction than the surface velocity, a correction factor of 0.80 was adopted. On each day of flow investigation, three sets of measurements were obtained during peak, average and lean periods. Three different periods were considered to determine the amount of flow per day. The first period is a peak flow period that lasts 4 hours, the second period is an average flow period that lasts 6 hours, and the third is a lean flow period that lasts 14 hours. Final values arrived with a tolerance of -5%, which accounts for any possible errors or approximations that may have occurred during the process.

The process for measuring flow depth and velocity is detailed in Plates 1, 2, and 3.

Plate - 1: Measurement of Depth of Flow

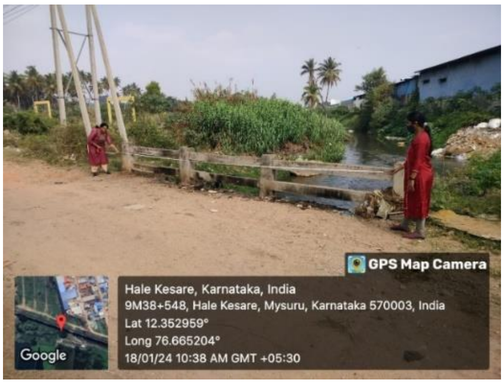

Plate - 2: Measurement of Width of Drain

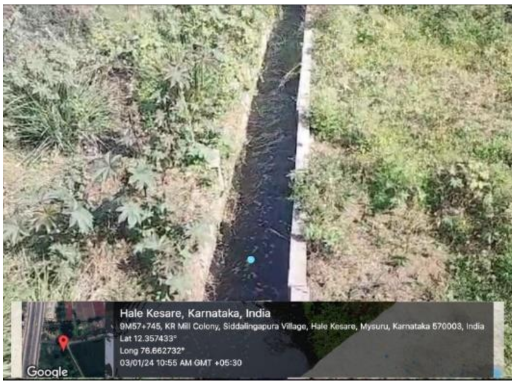

Plate - 3: Measurement of velocity using float

Samples of sewage and treated effluent from STP were collected using the grab sampling technique" at identified confluence points following prescribed standards. The entire sampling and analysis process was witnessed, and the results were interpreted.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 08 | Aug 2024 www.irjet.net p-ISSN: 2395-0072

5. RESULTS AND DISCUSSION

Sewage District 'C' is the most densely populated area of the city, with a current population of the sewage District of 3,90,000. Factoring in a floating population of approximately 30,000, the total sewage generated from domestic sources is approximately 43.5 MLD. The existing STP at Kesare is designed to handle a capacity of 45 MLD. Based on the study, it is observed that in some regions of the sewage District 'C', the sewer network's trunk mains have been connected to stormwater drains, resulting in sewage being discharged into them. Additionally, these stormwater drains are getting blocked due to the dumping of solid waste, including plastic bottles, bags, clothes, thermocols, cushions and more.

Due to ongoing work on the outfall sewer main along the Devanur Valley, sewage from two outfalls - Bannimantap and Belavatta - is being received at STP. As a result, a significant amount of sewage from the Devanur side is not reaching the STP and is bypassing the treatment plant. Additionally, the sewage flowing in Bannimantap and Belavatta stormwater drains does not enter the STP for treatment through interception and diversion works provided around the STP. Instead, the sewage directly flows into the natural nalla behind the STP. A satellite map of the Kesare STP and drains leading to the STP is shown in Plate 5.

Pate 5: Satellite image of Kesare STP indicating the major confluence locations

Based on the investigation, the cumulative flow beyond the STP during peak hours is 5.0 million liters (ML) per hour, the average flow is 4.0 ML per hour, and the lean flow is 1.0 ML per hour.

Therefore, considering 4 hours of peak flow, 6 hours of average flow, and 14 hours of lean flow, the total flow reaching the natural nalla, including the treated effluent, is approximately 54 MLD. The additional quantity of wastewater, beyond the domestic sewage quantity (about 9 MLD), is due to many establishments, institutions, industries, etc., that have borewells as water supply sources. Presently, only 7 MLD of sewage is being treated at STP, while the designed capacity is 45 MLD.

A statement of flow calculations is indicated in Table 1.

Table 1: Measurement of Flow in stormwater drains

Sl No.	Date of measurement	Avg. clear width of Flow (m)	Avg. Depth of Flow (m)			Length of Flow considered (m)	Time of travel (Sec) Peak	Time of travel (Sec) Avg	Time of travel (Sec) Lean	Flow Velocity (m/ sec) * 0.8			Flow in (m3/s) Peak	Flow in (m3/s) Avg	Flow in (m3/s) Lean	Flow in (ML/h) Peak (4 hrs)	Flow in (ML/h) Avg (6 hrs)	Flow in (ML/h) Lean (14 hrs)	Flow in (ML/D) (24 hours)
			Peak	Average	Lean					Peak	Average	Lean							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	From Devanuru Valley																		
	18.01.2024	1.9	0.3	0.3	0.1	9.5	9	10	12	0.85	0.76	0.32	0.46	0.42	0.08	1.66	1.51	0.29	19.73
	19.01.2024	1.9	0.3	0.3	0.1	9.5	9	11	12	0.90	0.69	0.32	0.51	0.38	0.08	1.84	1.37	0.29	19.58
	27.01.2024	1.9	0.3	0.3	0.1	9.5	9	10	11	0.90	0.76	0.35	0.48	0.41	0.09	1.73	1.48	0.32	20.30
	Check - 06.02.24	1.9	0.3	0.3	0.1	9.5	8	9	10	1.01	0.85	0.38	0.58	0.45	0.09	2.09	1.62	0.32	22.61
2	From Belavatta Valley																		
	18.01.2024	1.0	0.3	0.2	0.1	6.6	13	14	16	0.4	0.4	0.2	0.1	0.1	0.0	0.4	0.3	0.1	4.3
	19.01.2024	1.0	0.3	0.2	0.1	6.6	12	14	15	0.5	0.4	0.2	0.1	0.1	0.0	0.5	0.3	0.1	4.4
	27.01.2024	1.0	0.2	0.2	0.1	6.6	13	15	17	0.4	0.4	0.2	0.1	0.1	0.0	0.4	0.3	0.1	4.3
	Check - 06.02.24	1.0	0.3	0.2	0.1	6.6	13	14	16	0.4	0.4	0.2	0.1	0.1	0.0	0.4	0.3	0.1	4.7
3	From Bannimantapa Valley																		
	18.01.2024	2.2	0.4	0.4	0.1	6.0	6	9	10	0.8	0.5	0.2	0.7	0.5	0.1	2.5	1.6	0.3	23.3
	19.01.2024	2.2	0.4	0.4	0.1	6.0	6	7	8	0.9	0.7	0.3	0.7	0.5	0.1	2.6	1.9	0.2	25.1
	27.01.2024	2.2	0.4	0.4	0.1	6.0	6	7	9	0.9	0.7	0.3	0.8	0.6	0.1	2.7	2.0	0.2	26.1
	Check - 06.02.24	2.2	0.4	0.4	0.1	6.0	6	7	10	0.9	0.7	0.2	0.8	0.5	0.1	2.8	1.9	0.2	25.8
4	Combined Treated and untreated from Bannimantap & STP																		
	18.01.2024	3.2	0.4	0.3	0.1	5.0	5	6	7	0.8	0.7	0.3	0.9	0.6	0.1	3.2	2.1	0.3	30.2
	19.01.2024	3.2	0.4	0.3	0.1	5.0	5	6	9	0.9	0.7	0.2	1.0	0.7	0.1	3.4	2.4	0.3	32.7
	27.01.2024	3.2	0.4	0.4	0.1	5.0	5	7	8	0.9	0.6	0.3	1.0	0.7	0.1	3.7	2.3	0.3	33.4
	Check - 06.02.24	3.2	0.4	0.3	0.1	5.0	5	7	8	0.9	0.6	0.3	1.1	0.6	0.1	3.8	2.1	0.4	32.5
5	Effluent from STP																		
	18.01.2024															0.7	0.5	0.1	6.9
	19.01.2024															0.8	0.5	0.1	7.6
	27.01.2024															1.0	0.3	0.1	7.3
	Check - 06.02.24															0.9	0.1	0.1	6.6

Based on Present Population Dist C (2024)	390000	nos.
W/S to Household	42.12	lpcd
W/S at 55 lpcd to a floating population of 30000	55	lpcd
Sewage From Household	43.4	ML / D
From institutions / Hospitals/ Commercial	3	ML / D
From Industry	5	ML / D
Infilteration @5%	3	ML / D
	54	ML / D

Presently available capacity of STP is 45 MLD

		(ML/h)	(ML/h)	(ML/h)	(ML/D)
Devanuru	Average of 4 days	1.83	1.49	0.31	54.3
Belavatta		0.42	0.29	0.07	56.7
BNP		2.67	1.87	0.23	58.0
STP		0.86	0.36	0.11	59.8
Total		5.79	4.01	0.71	57.2
Considering 5% cushion towards limitations & errors		5	4	1	54

The samples collected from the confluence location were tested and analysed for critical parameters such as pH, BOD, COD, TSS, Ammoniacal Nitrogen, Total Nitrogen, and faecal coliforms. The samples' parameters were found to be beyond the limits prescribed by CPCB in the case of BOD, COD, faecal, and total coliforms, as shown in Table 2.

Table 2: Combined Raw Sewage & treated Sample Test Results

Sl No.	Parameter Description	Units	CPCB Standard for inland discharge	Results
1.	pH	pH unit	6.5-9.0	7.7
2.	BOD	mg/l	10	**18**
3.	COD	mg/l	50	**212**
4.	TSS	mg/l	20	10
5.	Ammoniacal Nitrogen	mg/l	5	3.36
6.	Total Nitrogen	mg/l	10	7.65
7.	Faecal coliforms	MPN/100 ml	100	**9300**
8.	Total coliforms	MPN/100 ml	5000	**47000**

6. CONCLUSIONS

A study of sewage District 'C' of Mysuru city involved a survey of various stormwater drains to which sewage was being discharged. Major confluence points of sewage with the main stormwater drain in sewage District 'C' of Mysuru city were identified and mapped. It was found that 87% of untreated wastewater and 13% of treated effluent were entering the natural nallas, which flowed through agricultural fields and eventually reached "Paschim Vahini", polluting the source of drinking water supply to

Srirangapatna. The discharge parameters of the combined flow exceeded the permissible levels prescribed by CPCB.

To prevent untreated sewage from mixing with the treated effluent, it is crucial that all the sewage from District 'C' reaches the Sewage Treatment Plant (STP) without any hindrance. STP should work efficiently to meet the discharge standards set by CPCB. Concerned authorities should promptly clear the accumulated solid waste in the stormwater drains, ensuring the smooth flow of sewage from the drains to the STP. They should also take necessary measures to prevent the dumping of solid waste into the stormwater drains. Installing Trash Screens/floating barriers at strategic locations in the stormwater drains can prevent solid waste from hindering the flow. Furthermore, an Online Continuous Effluent Monitoring System (OCEMS) and flow meters must be installed at the STP for efficient system monitoring.

The slope of the drains was not measured in the current study, which influences the quantum of flow in the drain. Continuous monitoring must be done 24x7 for at least one summer season using the required infrastructure/ equipment/ instruments for more accurate results.

ACKNOWLEDGEMENT

The first author would like to acknowledge Dr B.M. Krishna, Associate Professor at JSS STU, Mysuru, and Arun Kumar K., Associate Professor at Govt. Engineering College, K.R. Pete for their guidance; B.M. Prakash, Senior Environmental Officer at KSPCB, Mysuru; Asif Iqbal Khaleel, Executive Engineer at KUWSDB, Mysuru city division; and Nagaraje Gowda, Assistant Executive Engineer, Mysuru city corporation.

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