Estimation of Water Quality of Chhoyia River using the Streeter-Phelps Equation

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Abstract
This study investigates the impact of industrial wastewater discharges on the water quality of rivers and drains that are tributaries of the Ganga and Ramganga rivers, with a focus on areas in Bijnor, Uttar Pradesh, India. The research assesses industrial wastewater characteristics and evaluates its influence on key water quality parameters, including temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), chloride, nitrate, and ammoniacal nitrogen. The study incorporates monthly data from September 2020 to March 2021 collected at multiple locations along these river systems, including upstream and downstream of industrial discharge points.This study applies mathematical modelling using the Streeter-Phelps equation to assess the impact of industrial wastewater discharges on the dissolved oxygen (DO) levels and self-purification capacity of Chhoiya Drain which is tributary of the Ganga.The Chhoiya Drain, which receives effluents from multiple industries, showed a consistent decline in DO levels from 6.3 mg/L upstream to 2.7 mg/L downstream. The Streeter-Phelps model for this drain indicated a high oxygen demand due to the presence of organic and chemical pollutants, with the BOD peaking at 28 mg/L downstream. The model predicts that unless effluent treatment is improved, the drain's self-purification capacity will remain severely limited, affecting aquatic life and the overall riverine ecosystem.
Keywords: Surface water quality, Streeter-Phelps Equation, Chhoyia River,Ganga.

1. Introduction

The quality of river water is a critical concern as it directly affects the health and well-being of communities that rely on it for various purposes, including drinking, irrigation, and industrial use. The Streeter-Phelps equation is a widely used mathematical model that can be employed to estimate the dissolved oxygen levels in a river, which is a key indicator of water quality. This study aims to apply the Streeter-Phelps equation to assess the water quality of the Chhoyia River, a vital water resource in the region.

Chhoiya Drain is a small district located in the Bijnor district of Uttar Pradesh, India.Chhoiya Drain gets its name from a local water body, a drain or canal that serves as an important irrigation source for the region. The surrounding landscape is primarily flat and fertile, benefiting from the rich alluvial soil of the Ganges basin. The drainage system plays a crucial role in supporting local agriculture, particularly the cultivation of sugarcane, wheat, and paddy, which are staple crops in the area.The fig. 1.1 shows a Google Maps view of the Chhoiya Drain in relation to industrial sites and its downstream flow, ultimately merging with the Ganga River.

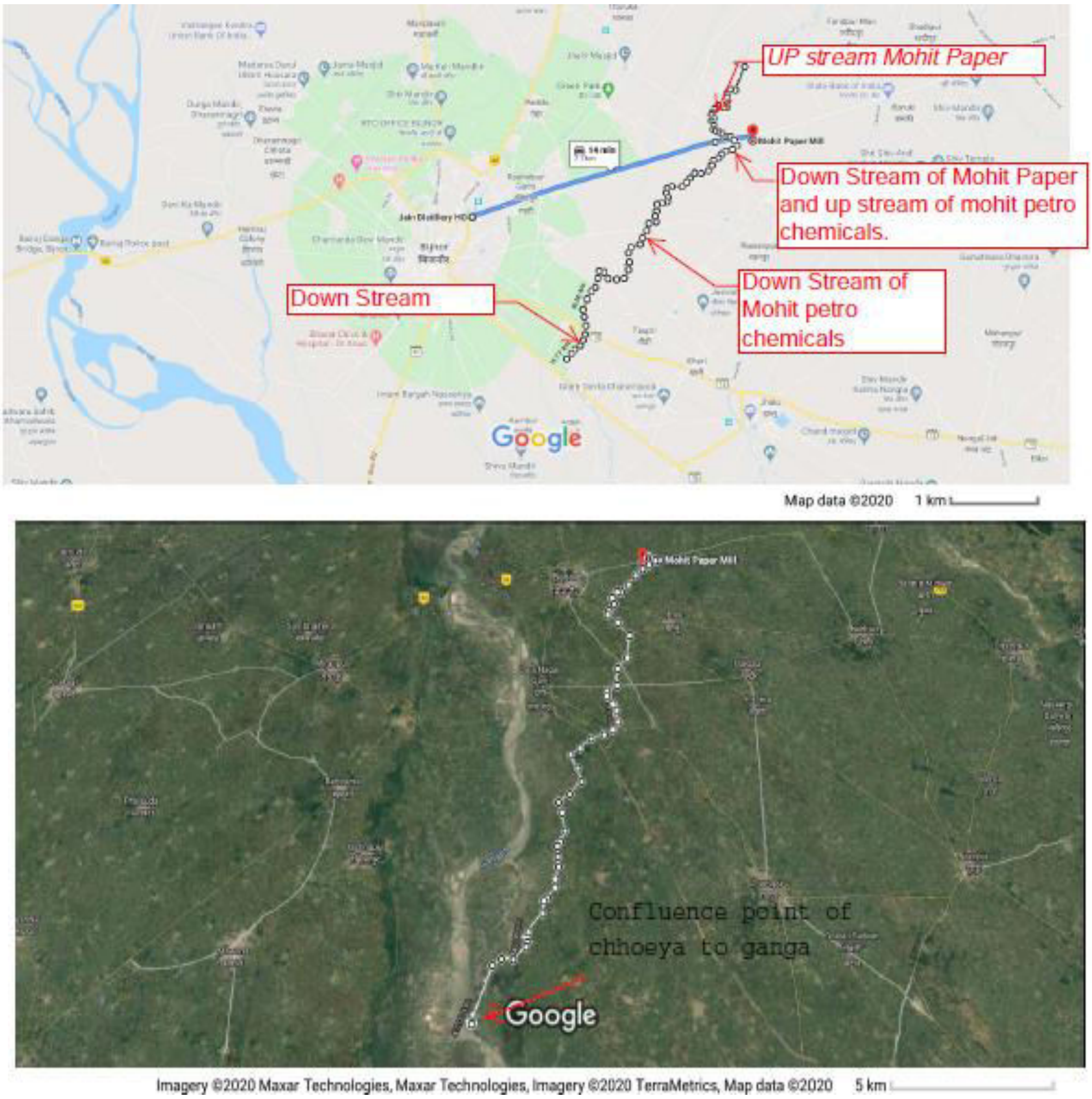

Fig. 1.1. Google map images of Chhoiyadrain merges with the Ganga River.

The permissible limit of some physicochemical parameters of surface water are summarized in Table 1.1.

Table 1.1: Permissible limit of some physicochemical parameters in surface water.

S.N.	Parameter	BIS (2012)
1.	Temperature (ºC)	20-30
2.	Dissolved Oxygen (mg/L)	>4
3.	pH	5.5-9
4.	Total Dissolved Solids (mg/L)	500
5.	Chemical Oxygen Demand (mg/L)	250
6.	Biochemical Oxygen Demand (mg/L)	30
7.	Total Suspended Solids (mg/L)	100
8.	Chlorides (mg/L)	500
9.	Nitrates (mg/L)	45
10.	Ammoniacal nitrogen (mg/L)	50

Aim of the present study to assess the impact of industrial discharges on the quality of surface water in drains and rivers that are tributaries of the Ganga and Ramganga rivers. The present study extended to examine the physical, chemical, and biological features of water in order to detect polluted river segments and to estimate the severity of changes in river and drain water quality.

An aeronautical reconnaissance coverage geographic information system (ArcGIS) interpolation technique is used to develop a surface water quality map (Kawo and Karuppannan 2018). This drainage map is prepared by using ArcGIS 10.2.2.

The fig. 1.2 is a detailed of ArcGIS map showing the study area where the Chhoiyadrain meets the Ganga River in Bijnor, Uttar Pradesh, India. The map highlights the path of the Chhoiya drain, which can be identified as the blue winding water body running through the region. It eventually flows into the Ganga River.The orange lines indicate roads connecting the villages. Major roads are clearly depicted, suggesting the presence of a local transport network.

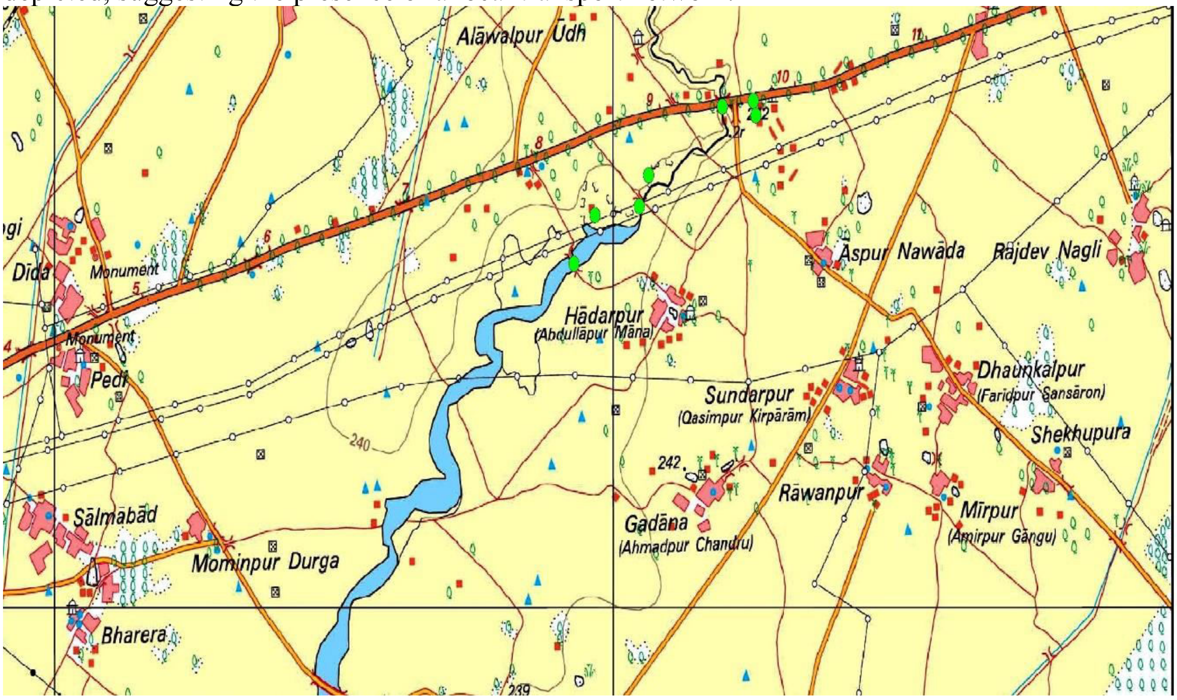

Fig 1.2. ArcGIS map of Chhoiyadrain meets the Ganga River in Bijnor, Uttar Pradesh, India.

2. Materials and Methods

Bijnor district occupies the area around 4561 Sq. Km. Two Major River Ganga and Ramganga pass through the Bijnor district. These rivers have their own watershed while the Ramganga is also a tributary of Ganga River. The district Bijnor alone has the total population about 3,682,713 numbers of Individuals as per 2011 census. The major portion of population in the district depend upon occupation of agriculture. Besides a few sugar factories, distilleries, Pulp and Paper industry and food process unit support the economic health.

The sampling was done in every month from September 2020 to March 2021. The samples were analyzed for 10 parameters. These are temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD) - 3 days at 27^{o}C, chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), Chloride, Nitrate and Ammoniacal nitrogen. To avoid collecting surface impurities such as oils, tree leaves, and other contaminants, the water sample was taken 40-50 cm below the surface. Two litres of samples were collected from each sampling sites and were transported to the laboratory under strict preservation conditionsAPHA 2017(Rodger et al., 2017). Temperature and DO of the water were measured using DO meter on the sites. The rest of the parameters were determined in the laboratory using established techniques APHA 2017 (Rodger et al., 2017). Table 2.1 summarizes various water quality parameters, their units, and analysis methodologies.

Table 2.1: Water quality parameters, abbreviations and their analytical methods

Parameters	**Abbreviations**	**Analytical methods**
Temperature (°C)	Temp	Thermometer
pH	pH	pH meter
Dissolved oxygen (mg/L)	DO	HACH's DO meter
Chemical oxygen demand (mg/L)	COD	Dichromate open reflex method
Biochemical oxygen demand (mg/L)	BOD	Winkler azide method
Total dissolved solids (mg/L)	TDS	Gravimetric
Total suspended solids (mg/L)	TSS	Gravimetric
Chloride (mg/L)	Cl^-	Argentometric method
Nitrate (mg/L)	NO_3^-	Spectrophotometric
Ammoniacal nitrogen (mg/L)	NH_3-N	Titrimetric method

Fig. 2.1. Photographic image of collection the water samples from Chhoiyadrain.

2.1 The Streeter Phelps Equation

The Streeter Phelps equation is a fundamental model used in the assessment of water quality in river systems. Developed by Streeter and Phelps in 1925, this model provides a mathematical framework for simulating the dynamics of dissolved oxygen (DO) in water bodies (Willis & McGarity, 2010)(Chaudhary, 2014).

The Streeter Phelps equation is based on the principle of mass balance, considering the rate of oxygen depletion due to the decomposition of organic matter and the reaeration of oxygen from the atmosphere. The model considers various factors, such as the initial dissolved oxygen concentration, the rate of biochemical oxygen demand (BOD) decay, and the reaeration rate, to predict the spatial and temporal distribution of dissolved oxygen in a river(Chaudhary, 2014)(Shukla et al., 2008).

The Streeter Phelps equation was first developed in the 1920s to address the issue of declining dissolved oxygen levels in the Ohio River (Nugraha et al., 2020). Streeter and Phelps recognized the need for a mathematical model to predict the impact of organic waste discharge on the river's water quality. The equation they developed has since become a cornerstone in the field of water quality modelling, providing a framework for understanding and managing the delicate balance of oxygen in aquatic ecosystems.

Dissolved oxygen is a critical parameter in water quality assessment, as it is essential for the survival and health of aquatic organisms (Tian, 2020) (Talke et al., 2009). The decomposition of organic matter by microorganisms can deplete the available dissolved oxygen, leading to hypoxic or anoxic conditions, which can have severe consequences for aquatic life (Tian, 2020). The Streeter Phelps equation provides a way to quantify this oxygen depletion and predict the impact of various factors on the dissolved oxygen levels in a river or estuary.

The oxygen sag or oxygen deficit in the stream at any point of time during the self-purification process is the difference between the saturation DO content and actual DO content at that time.

Oxygen deficit, D = Saturation DO – Actual DO

The saturation DO value for freshwater depends upon the temperature and total dissolved salts present in it, and its value varies from 14.62 mg/L at 0° C to 7.63 mg/L at 30° C, and lower DO at higher temperatures.

The analysis of oxygen sag curve can be easily done by superimposing the rates of deoxygenation and reoxygenation as suggested by the Streeter – Phelps analysis. The rate of change in the DO deficit is the sum of the two reactions as explained below:

$$\frac{dD_t}{dt} = f(Deoxygenation\ and\ Reoxygenation) \qquad 2.1$$

$$\frac{dD_t}{dt} = K^{'}L_t - R^{'}D_t \qquad 2.2$$

Where,

D_t = DO deficit at any time t,

L_t = amount of first stage BOD remaining at any time t,

$K^{'}$= BOD reaction rate constant or deoxygenation constant (to the base e),

$R^{'}$= Reoxygenation constant (to the base e),

t = time (in days),

$\frac{dD_t}{dt}$ = rate of change of DO deficit.

Now,

$$L_t = L_o e^{-K^{'}t} \qquad 2.3$$

Where, Lo = BOD remaining at time t = 0 i.e. ultimate first stage BOD

Final Equation using the above equations:

$$D_t = \frac{K^{'}L_o}{K^{''}-K^{'}}\left[e^{-K^{'}t} - e^{-K^{''}t}\right] + D_0 e^{-K^{"}t} \qquad 2.4$$

This is the Streeter-Phelps Sag Equation. The equation describes the balance between the rate of oxygen depletion due to the decomposition of organic matter (represented by the first term) and the rate of oxygen replenishment from the atmosphere (represented by the second term).

It is important to note that the Streeter Phelps equation relies on several key assumptions, such as steady-state conditions, homogeneous and well-mixed water bodies, and constant flow and temperature conditions (Näykki et al., 2013). These assumptions may not always hold true in realworld scenarios, and the model's limitations should be considered when applying it to specific water bodies.

Determination of Critical DO deficit (D_c) and distance X_c.

The value of D_c can be obtained by putting $\frac{dD_t}{dt}$= 0 in equation 2.4, Hence,

$$D_c = \frac{K'}{K''} L_o e^{-K' t_c} \qquad 2.5$$

Where t_c is the time required to reach a critical point. The value of 't_c' can be obtained by differentiating equation 2.4 with respect to 't' and setting $\frac{dD_t}{dt}$= 0.

Therefore,

$$t_c = \frac{1}{K''-K'} \ln \frac{K''[1-\frac{Do(K''-K')}{Lo}]}{K'} \qquad 2.6$$

The distance X_c is given by $X_c = t_c \times u$

Where u = velocity of flow in the stream

The curve shown in fig.2.2 is the final curve obtained by modelling using Streeter Phelps Equation which shows the DO variation with time.

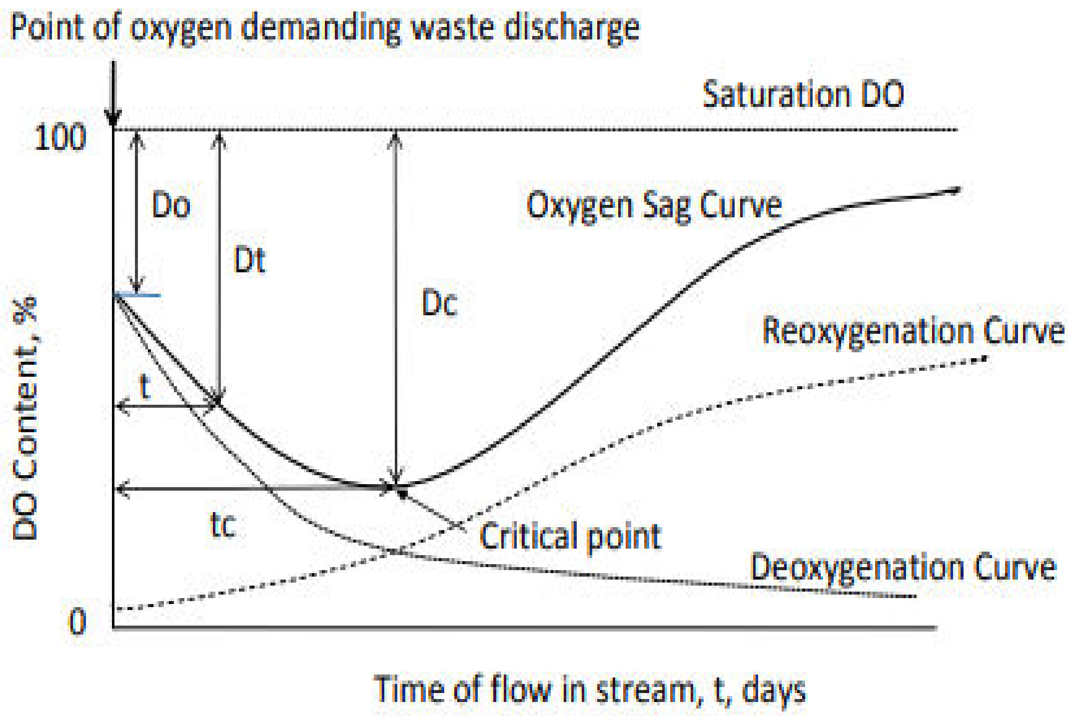

Fig. 2.2. the final curve obtained by modelling using Streeter Phelps Equation

3. RESULT AND DISCUSSION

The Streeter Phelps equation is a fundamental model used in the assessment of water quality in river systems. Developed by Streeter and Phelps in 1925, this model provides a mathematical framework for simulating the dynamics of dissolved oxygen (DO) in water bodies (Willis & McGarity, 2010) (Chaudhary, 2014). The modelling of water quality of a drain is also rarely used in the frame of river improvement. The use of system analysis and mathematical modelling for formulating and solving large water stream pollution problem is of relatively recent vintage and has been used widely during the last three decades.

The deoxygenation curve was determined using the laboratory analysis of oxygen uptake of the water from the drain, the water sample was collected from the two-point upstream and downstream of the drain. Between these two points, there may be several points through which pollution load is

discharged. Laboratory analysis of DO concentrations was done using HACH's DO meter. The daily usage of DO will help in determining BOD generally used for modelling purpose and as per Indian Gadget 3 days 270C. The sag analysis curve obtained using Streeter Phelps equation is highly accurate.
The fig. 3.1represent the concentrations of various water quality parameters at upstream (u/s) and downstream (d/s) locations of an industry along the Chhoyia drain.Since all parameters are within permissible limits, this suggests that the water quality in the Chhoyia drain before reaching the industry is generally good, with no significant signs of pollution. The water is likely safe and uncontaminated for most uses.While most parameters remain within safe, permissible limits after the industry, the BOD (Biological Oxygen Demand) is an exception. The elevated BOD (42.25 mg/l) levels downstream indicate that the industry is contributing organic pollutants or other waste that require oxygen for decomposition, leading to a reduction in available oxygen for aquatic organism.

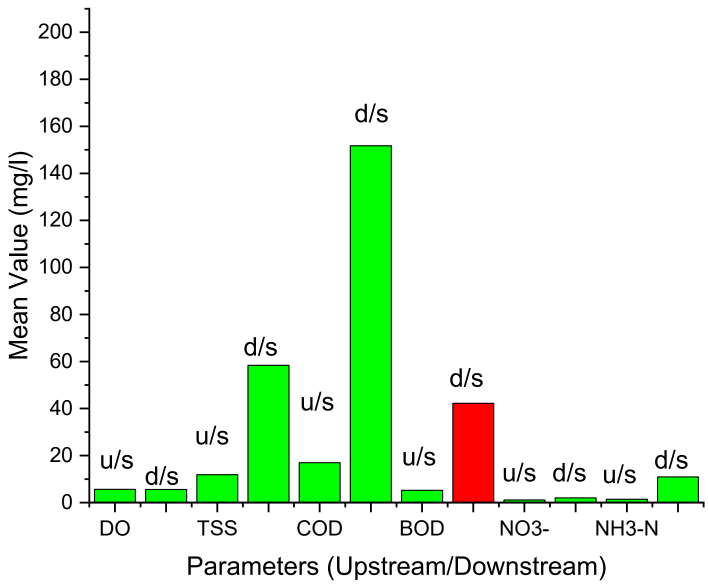

Fig. 3.1. The concentrations of various water quality parameters measured at upstream (u/s) and downstream (d/s) of an industry located along the Chhoyia drain.

This suggests that the industry's discharge has specifically impacted the oxygen-demanding waste in the water, while other water quality indicators such as pH, TSS, or COD remain unaffected or within permissible limits. Elevated BOD levels can reduce dissolved oxygen in the water, potentially harming aquatic life and the overall ecosystem health downstream.
Since BOD is elevated downstream, the industry may need to improve wastewater treatment processes to reduce organic pollutants in their discharge.Continuous monitoring of BOD levels and other water quality parameters both upstream and downstream would help track the impact of the industry and ensure compliance with environmental regulations.
The table3.1presents the water quality and pollution load of the Chhoyia drain at upstream and downstream points, along with the contribution of three industries in the area.The flow rate at the upstream point is 1.53 MLD, indicating the amount of water flowing into the drain before reaching the industrial zone.The flow rate contributed by three industries is 7.22 MLD, which makes up the majority of the downstream flow.The industries are contributing significantly high BOD (50.1 mg/L) and COD (180.35 mg/L)concentrations to the drain, which explains the elevated levels observed downstream.The industries contribute a substantial portion of the total pollution load observed downstream, with the majority of the BOD (361.65 kg/day) and COD (1301.77 kg/day)load coming from these industrial sources.

Table 3.1. The water quality and pollution load (including three industries) of the Chhoyia drain.

	Flow rate (MLD)	BOD (mg/l)	COD (mg/l)	BOD (kg/day)	COD (kg/day)
Upstream	1.53	5.25	17	8.04	26.04
Downstream	8.75	42.25	151.75	369.69	1327.81
Industrial load (Including three industries)	7.22	50.10	180.35	361.65	1301.77

The water quality before the industrial discharge is relatively clean, with low BOD and COD concentrations and a low pollution load.After receiving effluent from three industries, the water quality deteriorates significantly. BOD and COD levels rise sharply, reflecting the increased organic and chemical pollution. The pollution load downstream is significantly higher than upstream due to the industrial effluents.The majority of the pollution load downstream is directly attributed to the industrial discharge. The industries contribute the bulk of the flow and pollution, accounting for the substantial rise in BOD and COD downstream.

This indicates that the industries are the primary sources of water pollution in the Chhoyia drain, emphasizing the need for better wastewater management practices to mitigate their environmental impact.

The heatmap visually represents the correlation matrix between various water quality parameters measured in the Chhoyia drain as shown in the fig. 3.2.

Fig. 3.2. The heatmap of the correlation between various water quality parameters measured in the Chhoyia drain.

DO has a negative correlation with most other parameters, especially:TDS (-0.18), NH_3^-N(-0.073), and NO_3^- (-0.26), indicating that as the concentration of dissolved solids, ammonia, and nitrate increases, DO decreases. This makes sense, as increased pollutants reduce oxygen availability in water.TDS shows a strong positive correlation with many parameters:TSS (0.88), COD (0.71), and BOD (0.61), indicating that as the dissolved solids in the water increase, suspended solids and organic pollutants (reflected in BOD and COD) also rise.COD and BOD have an almost perfect correlation (0.97), indicating that areas with high BOD also tend to have high COD, reflecting heavy organic pollution in the water that requires oxygen for both biological and chemical decomposition.

The heatmap indicates strong correlations between several water quality parameters, especially between TSS, TDS, BOD, COD, Cl-, and NO_3^-. This suggests that increased pollution in one form

(like organic pollutants or suspended solids) typically results in elevated levels of other contaminants. The notable exception is dissolved oxygen (DO), which tends to decrease as other pollutants increase, highlighting the negative impact of pollution on oxygen levels in the Chhoyia drain.
These correlations highlight areas where pollution mitigation strategies should focus, particularly on managing organic and chemical pollution sources to improve the overall health of the water body.
The scatter plot in the fig 3.3presents the relationship between Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in water samples from the Chhoyia drain.

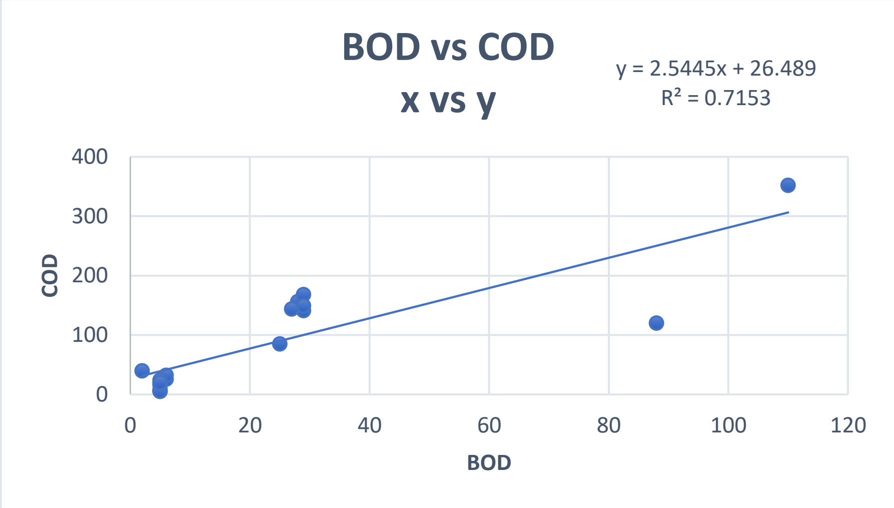

Fig. 3.3. The scatter plot between BOD and COD in water samples from the Chhoyia drain.
The plot shows a positive linear correlation between BOD and COD. As the BOD increases, the COD also tends to increase. This is expected because both BOD and COD are measures of the pollution load in the water, especially related to organic matter.The slope of 2.5445 indicates that for every unit increase in BOD, COD increases by approximately 2.54 units.The R^2 value of 0.7153 indicates a moderately strong correlation between BOD and COD. This means that approximately 71.53% of the variability in COD can be explained by the changes in BOD. While this is a significant correlation, other factors (such as non-biodegradable pollutants or industrial chemicals) are also contributing to the COD.
This scatter plot reveals a significant linear relationship between BOD and COD in the Chhoyia drain's water samples. The increasing trend shows that as biodegradable organic pollutants (BOD) rise, the overall pollution load (COD) also increases. The R^2 value supports the idea that BOD is a major, though not the only, contributor to the water's chemical oxygen demand. This underscores the need for comprehensive water quality management, especially in dealing with both organic and chemical pollutants from industries.
The fig. 3.4 represents a DO (Dissolved Oxygen) sag curve for the Chhoyia drain, showing the variation of DO concentration over time (in days).

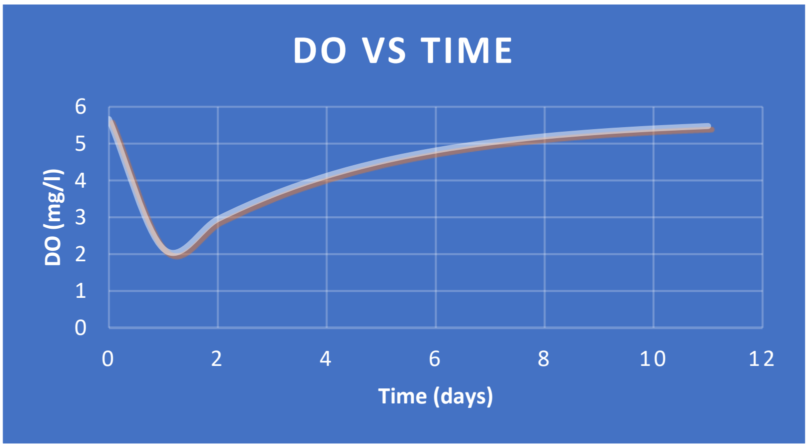

Fig. 3.4. Sag CurveDO vs Time for the Chhoyia drain.

At the start(Day 0 to Day 2), the DO level decreases rapidly. This represents the initial impact of organic pollution.When organic pollutants enter the water, microorganisms begin breaking them down through aerobic respiration, consuming oxygen in the process. This increases the Biochemical Oxygen Demand (BOD) and reduces the available dissolved oxygen.The lowest point on the curve, usually referred to as the DO sag, occurs when oxygen consumption due to decomposition of organic matter is at its peak.The value of DO drops to a critically low level, which could be harmful to aquatic life if sustained for too long. In this case, the DO drops close to 2 mg/L, which is a critical threshold for the survival of many aquatic species.After reaching the minimum DO level, the curve shows a gradual recovery, with dissolved oxygen levels slowly increasing again.This recovery (Day 2 to Day 12)occurs because the organic matter is increasingly broken down, and oxygen from the atmosphere begins to dissolve back into the water through reaeration. Additionally, the natural flow of the river helps bring more oxygen into the system.Toward the end of the graph(Day 8 to Day 12), the DO levels begin to stabilize around 5 mg/L, indicating that the oxygen depletion from organic pollution has been largely compensated by the natural replenishment of oxygen.The stabilization suggests that the water body has somewhat returned to its natural state, though complete recovery can take even longer.

The sag curve for the Chhoyia drain suggests that the discharge from the drain is initially depleting oxygen levels, but the water body has a mechanism for recovery over time. This process indicates the self-purifying ability of the water, but if pollution loads are too high, the sag could be more severe, leading to long-term negative impacts on aquatic life.

The fig. 3.5 shows the Dissolved Oxygen (DO) concentration (in mg/l) versus distance (in km) along the Chhoyia drain.

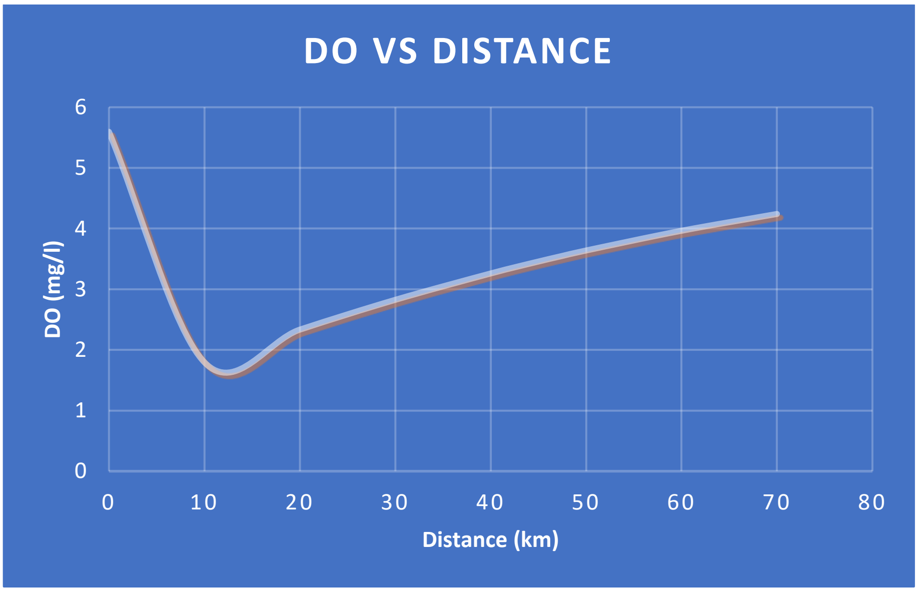

Fig. 3.5. Sag CurveDO vs Distance for the Chhoyia drain.

As in a typical sag curve, there is an initial sharp decline(0 to ~10 km) in dissolved oxygen levels within the first few kilometers after the pollution enters the waterway. This drop reflects the oxygen consumed by microorganisms that are actively breaking down the organic pollutants introduced by the drain or industrial effluents.The DO level decreases significantly and quickly as biological oxygen demand (BOD) rises. This is the point where oxygen depletion is most severe, reaching its minimum.Around 10 km downstream, the DO reaches its lowest point, likely dropping to levels that are harmful to aquatic life (around 2 mg/L).This represents the maximum oxygen demand in the system, where organic matter decomposition is at its peak, and oxygen is in short supply.After reaching the minimum point, the graph shows a gradual increase in dissolved oxygen levels as you move further downstream. This recovery is due to two main processes:

Reaeration: Oxygen from the atmosphere dissolves back into the water, particularly if there is turbulence or faster flow.

Dilution: As the water moves downstream, it gets diluted with cleaner water, and the effect of the pollutants diminishes.
This phase shows the natural recovery capacity of the water body, although the rate of recovery depends on various factors such as water velocity and temperature.After 50 km, the DO levels begin to stabilize around 4-5 mg/L. This is still below optimal levels (usually considered above 5 mg/L for healthy aquatic ecosystems), but the water quality improves significantly compared to the minimum point.
The DO vs Distance curve for the Chhoyia drain shows a typical sag where oxygen levels initially drop significantly due to organic pollution. As the water flows downstream, the natural reaeration and dilution processes allow the oxygen levels to gradually recover, approaching more acceptable levels. This curve emphasizes the importance of controlling pollution at the source to avoid oxygen depletion that can harm aquatic life.
The table 3.2 shows the water quality and pollutant load of the Chhoyia drain at the confluence point with the Ganga River, located at 47.5 km.The flow rate of 8.75 MLD represents the total volume of water flowing from the Chhoyia drain into the Ganga River. Given the high flow rate, the pollutant load (BOD and COD) will have a significant impact on the water quality at the confluence point.The low DO concentration of 3.55 mg/L at the confluence point suggests that the water entering the Ganga River from the Chhoyia drain is oxygen-depleted. Low DO levels are harmful to aquatic life and indicate heavy pollution. This can lead to hypoxic (low-oxygen) conditions, negatively affecting fish and other organisms in the Ganga River.A BOD of 41.32 mg/L (361.54 kg/day) indicates a significant organic pollutant load. High BOD levels mean that the water contains a substantial amount of biodegradable organic matter, such as waste from the three industries contributing to the drain. This organic matter will consume oxygen as it decomposes, further reducing DO levels downstream, especially at the confluence point.The COD value of 131.62 mg/L (1151.71 kg/day) reflects both organic and inorganic pollutants, including industrial effluents, that require chemical oxidation. A high COD load suggests that the water contains a large amount of chemicals and pollutants that contribute to the degradation of water quality.

Table 3.2. Pollutant load(including three industries) of the Chhoyia drain at the confluence point with the Ganga River.

Flow rate (MLD)	**DO (mg/l)**	**BOD (mg/l)**	**COD (mg/l)**	**DO (kg/day)**	**BOD (kg/day)**	**COD (kg/day)**
8.75	3.55	41.32	131.62	31.05	361.54	1151.71

The high BOD and COD levels indicate that the Chhoyia drain is carrying significant amounts of pollution, particularly from organic matter and chemical substances. When this polluted water mixes with the Ganga River at the confluence point (47.5 km), it will likely decrease the overall water quality of the Ganga, potentially leading to oxygen depletion and harm to aquatic ecosystems.The industrial load (as indicated by the high pollutant levels) is a major contributor to the poor water quality of the Chhoyia drain. The industries are discharging organic and chemical pollutants that significantly increase the BOD and COD downstream, leading to a substantial environmental impact at the confluence with the Ganga River.Given the low DO levels (3.55 mg/L), the water from the Chhoyia drain will exacerbate oxygen depletion in the Ganga, creating conditions that could be harmful for fish and other aquatic life in the area.
At the confluence point with the Ganga River, the Chhoyia drain carries a significant pollution load, primarily from three industries. The high BOD and COD levels indicate severe organic and chemical pollution, which will negatively affect water quality in the Ganga River. The low DO concentration suggests that the water is oxygen-depleted, which could lead to hypoxic conditions harmful to aquatic ecosystems. This emphasizes the need for better pollution management and treatment of industrial effluents before they enter the river system.

SUMMARY AND CONCLUSIONS

The study examines the water quality of the Chhoiya Drain in Bijnor district, Uttar Pradesh, which flows into the Ganga River. The drain supports local agriculture, but industrial discharge significantly affects water quality. Water samples were collected upstream and downstream of industrial sites to assess the impact of pollution.

While upstream water quality is good, downstream levels of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) show substantial increases. Downstream BOD reaches 42.25 mg/l, and COD rises to 151.75 mg/l, indicating severe pollution.The flow rate of the drain increases downstream due to industrial discharge. Industries contribute the majority of pollution, with BOD loads of 361.65 kg/day and COD loads of 1301.77 kg/day. These elevated levels indicate significant organic and chemical pollution.The DO levels drop sharply downstream, reaching critical lows around 2 mg/l, suggesting oxygen depletion and potential harm to aquatic life.

The Chhoiya Drain faces severe pollution from industrial sources, contributing to a significant increase in organic and chemical contaminants downstream. The high BOD and COD levels, combined with low dissolved oxygen, pose a threat to aquatic ecosystems, especially as the drain merges with the Ganga River. Immediate measures to treat industrial effluents and reduce pollutant loads are necessary to improve water quality and prevent further environmental degradation.

Authors contribution

Vijay Kumar collected the water samples and analyzed in laboratory. Vijay Kumar and Chandrajit Balomajumder conceived and designed the analysis. Vijay Kumar performed the analysis and Chandrajit Balomajumder supervised the research. Vijay Kumar wrote the manuscript, and Chandrajit Balo Majumder edited the manuscript. All authors read and approved the final manuscript.

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The authors have no competing interests to declare that are relevant to the content of this article.

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