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A Comprehensive Study of Seasonal Variations in Water Quality Parameters of the Kal River, Mangaon, Raigad (Maharashtra, India)

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Abstract: *This study presents a detailed assessment of the seasonal variations in the water quality of the Kal River, located in Mangaon, Raigad district, Maharashtra, India. Water samples were collected from selected sites along the river during three distinct season pre-monsoon, monsoon, and post-monsoon to analyze key physicochemical and biological parameters, including pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, total dissolved solids (TDS), and microbial load. The results indicate significant seasonal fluctuations influenced by rainfall patterns, surface runoff, and anthropogenic activities such as agriculture and domestic discharge. The Water Quality Index (WQI) was computed to classify the water based on its suitability for drinking and irrigation purposes. The findings reveal that water quality tends to deteriorate during the monsoon due to increased runoff and contamination, while relatively better quality is observed during the pre- and post-monsoon seasons. The study highlights the need for regular monitoring and sustainable watershed management practices to preserve the ecological and public health functions of the Kal River.*

Keywords: Kal River, water quality, seasonal variation, physicochemical parameters, Raigad district, Maharashtra, Water Quality Index (WQI), river pollution, monsoon effect, surface runoff

I. INTRODUCTION

The hydrosphere represents one of the most critical components of the Earth's environment, encompassing all forms of water—surface water, groundwater, rivers, lakes, oceans, and more. Water is indispensable for sustaining all forms of life on the planet. In our daily lives, we often take for granted the availability of clean, safe water—whether it is used for drinking, cooking, cleaning, or irrigation. Ideally, water should be colourless, odourless, and free from harmful contaminants to ensure its suitability for human consumption and ecological health.

Despite being a common substance, water possesses unique physical and chemical properties that make it vital for life. Its existence in liquid form on Earth is considered a rare and remarkable phenomenon within our solar system. Water vapor plays a crucial role in regulating the Earth's climate and enabling life processes, distinguishing our planet as habitable.

II. MATERIALS AND METHODS

Five sampling stations (S1 to S5) were strategically selected along the Kal River, based on their proximity to industrial discharge points and the common effluent treatment plant (CETP). These locations were chosen to assess the impact of industrial and treated effluents on river water quality.

Water samples were collected manually during daylight hours, which ensured optimal visibility and accuracy in sampling. Each sample was drawn approximately 6 inches below the surface by immersing the container against the

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flow of water and opening it to allow natural filling. To ensure minimal contamination, sterile glass-stoppered bottles were used and handled carefully near the base during collection.

The physico-chemical properties of the water were analyzed following the standard protocols prescribed by APHA (1987) and Trivedi & Goel (1984). Key parameters such as electrical conductivity (EC), pH, and dissolved oxygen (DO) were measured using calibrated electronic instruments and iodometric techniques at ambient temperature. Water hardness was determined through the EDTA titrimetric method, while chloride concentration was measured via the argentometric method. Biological Oxygen Demand (BOD) was assessed by incubating the samples at 25°C for a period of five days.However, increasing industrialization and human activities have led to the pollution of natural water sources, raising serious concerns. Industrial effluents often contain toxic substances such as heavy metals, acids, radioactive materials, and organic pollutants. These contaminants not only pose a direct threat to public health by introducing pathogenic microorganisms into water bodies, but also degrade water quality, making it unfit for recreational use and harming aquatic ecosystems. The need for continuous monitoring and responsible management of water resources has become more urgent than ever to ensure sustainability for future generations.

Parameters and methods employed in the chemical examination of samples.

Sr.No.	Parameters	Methods
1	Temperature	Thermometer
2	P^H	PH meter
3	EC	Conductivity meter
4	TS	Turbidimeter
7	DO	Winkler's Iodometric method
8	BOD	Incubation method
9	COD	Open reflux method
10	Carbonate	Titrimetric method
11	Chloride	Titrimetric method
12	Sulphate	Turbidimetric method
14	Magnesium	Titrimetric method
15	Calcium	Titrimetric method.

III. RESULTS AND DISCUSSION

Rapid industrialization, while driving economic growth, has significantly contributed to environmental degradation—especially in the form of water pollution. Among the most pressing concerns is the discharge of untreated or inadequately treated sewage and industrial effluents into natural water bodies. These pollutants pose a serious threat to the ecological balance and public health, especially in a country rich in biodiversity and water resources like India.

Municipal and industrial waste entering river systems has led to a marked decline in water quality, with observable impacts on both aquatic life and human communities. In this context, the monitoring and management of water pollution are critical to achieving sustainable development and safeguarding human well-being. Industrial wastewater in particular has been linked to widespread health hazards, including increased rates of disease and disability.

To assess the extent of water pollution in the Kal River, a comprehensive analysis of wastewater characteristics was conducted. Key physico-chemical parameters studied included temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, alkalinity, acidity, total hardness, chloride content, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), calcium (Ca), magnesium (Mg), phosphate, and sulphate concentrations.

The data presented in Tables 1 to 3 summarize the results obtained from water quality monitoring carried out from 2023 to 2024. These values reflect seasonal variations and spatial differences in water quality across different sampling locations along the Kal River.

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Table 1: Physico-chemical characteristics of Kal River water at various sampling sites during the pre-monsoon Season

Parameters	KAL RIVER SITES				
	Mangaon Highway Bridge 1	Khandad 2	Dhangadwadi 3	Talegaon 4	Goregaon Dam 5
Air Temp. 0C	36.0.00	35.00	39.00	35..00	35.00
Water Temp.0C	30.00	30.00	33.00	33.00	28.00
EC mhos/cm	8850.00	7949.00	7848.00	8040.00	8782.00
Salinity %	5.30	4.20	4.22	3.29	6.80
TS mg/L	7531.00	6552.00	5834.00	5864.00	7874.00
TDS mg/L	6642.00	6500.10	6462.00	6600.00	5732.00
TSS mg/L	98.00	43.30	49.20	62.20	80.50
pH	7.50	7.80	8.62	8.00	8.20
DO mg/L	11.50	9.30	7.80	9.20	12.30
BOD mg/L	6.50	3.70	3.90	4.30	7.40
COD mg/L	10.00	09.00	09.50	9.30	8.30
CO_3^- mg/L	2.050	21.00	17.40	16.20	9.40
Cl^- mg/L	1703.00	1544.00	1532.00	1520.200	1580.20
SO_4^- mg/L	572.00	520.00	322.40	322.30	321.00
Ca^{2+} mg/L	160.10	156.00	122.10	135.80	126.00
Mg^{2+} mg/L	132.30	115.20	101.20	95.82	70..10

Table (2):- Physico- chemical parameters of **Kal River Water** at different sites during monsoon Season.

Parameters	KAL RIVER SITES				
	Mangaon Highway Bridge 1	Khandad 2	Dhangadwadi 3	Talegaon 4	Goregaon Dam 5
Air Temp. 0C	25.00	22.00	22.20	23.00	23.00
Water Temp.0C	21.00	18.00	15.00	18.00	15.00
EC mhos/cm	6272.00	5317.00	5189.00	4495.00	4611.00
Salinity %	6.10	3.10	3.20	3.10	6.10
TS mg/L	5228.00	5182.00	4962.00	5005.00	5048.00
TDS mg/L	7938.00	3982.00	4266.00	4394.00	4802.00
TSS mg/L	102.0	98.00	154.00	205.00	149.00
P^H	9.04	8.20	7.20	8.00	7.40
DO mg/L	10.00	8.00	7.00	6.70	6.30
BOD mg/L	6.00	3.00	1.00	1.40	2.80
COD mg/L	7.10	3.00	4.00	3.00	5.80
HCO_3^- mg/L	326.00	354.40	371.00	338.00	359.00
Cl^- mg/L	1809.00	1771.50	1760.50	1760.00	1846.00
SO_4^- mg/L	490.00	544.00	509.60	536.00	518.55
Ca^{2+} mg/L	218.40	200.00	200.00	200.00	200.40
Mg^{2+} mg/L	115.89	95.00	87.72	93.00	126.20

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Table (1):- Physico- chemical parameters of **Kal River Water** at different sites during post-monsoon Season

Parameters	KAL RIVER SITES				
	Mangaon Highway Bridge 1	Khandad 2	Dhangadwadi 3	Talegaon 4	Goregaon Dam 5
Air Temp. ^{0}C	17.00	15.00	15.00	18.00	13.00
Water Temp.^{0}C	20.00	17.00	14.00	12.00	10.00
EC mhos/cm	7300.00	8700.00	4611.00	6881.00	6543.00
Salinity %	4.47	3.40	2.82	2.70	5.40
TS mg/L	8794.00	7821.00	4888.90	4888.00	5125.00
TDS mg/L	863.50	870.00	489.20	481.10	583.20
TSS mg/L	100.80	125.00	120.90	83.10	55.00
pH	7.50	7.90	8.40	8.35	7.80
DO mg/L	9.50	9.22	6.66	6.46	5.30
BOD mg/L	5.30	580	5.10	5.35	5..00
COD mg/L	6.90	6.30	8.80	8.50	8.40
CO_3^{2-} mg/L	22.30	17.10	13.50	22.30	11.10
Cl^- mg/L	1758.50	1559.00	1215.10	1355.10	1298.00
SO_4^- mg/L	425.20	243.50	292.10	255.10	189.90
Ca^{2+} mg/L	70.80	90.40	73.42	63.10	60.20
Mg^{2+} mg/L	235.10	169.00	200.10	215.00	150.20

Results of Physico-Chemical Parameters

Temperature:

Water temperature varied significantly with seasonal changes. The lowest temperatures were recorded during the winter season, ranging from 18°C to 20°C across all sampling locations. In contrast, the highest temperatures were observed in the summer, reaching between 34°C and 38°C.

pH:

The pH values of the river water generally remained within the acceptable range for lotic (flowing) water systems, which is between 7 and 12. Any deviation from this range may suggest the intrusion of either acidic or alkaline substances into the water body.

Conductivity:

Electrical conductivity, which reflects the concentration of dissolved ions in the water, ranged from 4050 µmhos/cm² to 8990 µmhos/cm². The lowest conductivity value was recorded at Station S1- during the Pre-mansoon season, indicating reduced ionic concentration during this period.

Total Dissolved Solids (TDS):

TDS levels in the river exceeded the safe limit for drinking water (5000 mg/L) at several locations. High TDS concentrations suggest the presence of a substantial amount of dissolved salts and minerals, rendering the water unsuitable for direct consumption.

Turbidity:

Turbidity values remained consistently low across all sampling stations throughout the study period, indicating minimal presence of suspended particles or sediments.

Total Alkalinity:

Alkalinity, which represents the buffering capacity of water and its ability to neutralize acids, was found to be lowest at all stations (S-1 to S-5), with a minimum recorded value of 40 mg/L. This suggests a limited presence of natural salts such as carbonates and bicarbonates.

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Acidity:

Acidity levels were consistently low across all seasons and stations, with a minimum value of 0.6 mg/L recorded uniformly from Station 1 to 5. This indicates minimal presence of free acids in the water.

Total Hardness:

Total hardness, primarily influenced by calcium and magnesium concentrations, ranged from 62 mg/L to 510 mg/L. This parameter is important for evaluating the water's suitability for domestic, industrial, and drinking purposes. The observed range suggests variability in mineral content across locations and seasons.

Summary

Maharashtra, India's third-largest state by size and population, includes 35 districts and seven key industrial regions. It is home to major rivers like the Krishna, Godavari, Bhima, Tapi-Purna, and Wardha-Wainganga. However, rapid industrial growth and human activity have severely degraded water quality over time. This pollution, primarily caused by human actions, has escalated over the last 80 years, raising significant environmental and public health concerns.Recognizing this, the study aimed to investigate the physico-chemical characteristics of lotic (flowing) water, particularly in relation to its suitability for consumption and other uses. This is essential for the effective management and conservation of aquatic resources.

Lotic and groundwater sources have historically served as reliable drinking water supplies due to their natural purity.

The challenge of providing safe drinking water is a global issue, exacerbated by human-induced pollution, especially in both rural and urban settings.

The infiltration of organic and inorganic pollutants has led to noticeable degradation in water quality, particularly in groundwater sources.

Against this backdrop, the present study focused on evaluating the physico-chemical parameters of lotic water, using data derived from both fieldwork and existing literature, to assess its socio-environmental significance.

As part of the assessment, five water sampling stations (designated S1 through S5) were established across the Mangaon Tehsil.

These stations were strategically located in the influence zone of the Kal River, which flows through areas with significant agricultural activity in the Mangaon Tehsil and Raigad districts.

Parameters analyzed included temperature, pH, electrical conductivity, total dissolved solids (TDS), total hardness, chlorides, sulfates, phosphates, dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), acidity, and alkalinity.

In-situ parameters such as temperature, pH, and DO were measured directly at the sampling sites, while other parameters were analyzed within 24 hours in the laboratory to ensure data accuracy.

The measured values for most parameters were within permissible limits set by the World Health Organization (WHO) and Indian Standards Institution (ISI), indicating general compliance with water quality guidelines.

However, findings also reveal early signs of increasing contamination, likely linked to the discharge of untreated or partially treated industrial effluents into the river system.

Therefore, continuous monitoring and proactive water quality management are essential across all sampling stations to prevent future health risks and ensure sustainable water use.

IV. CONCLUSION

The current investigation into the pollution levels of the Kal River across five wards in Satara and Pune districts has aimed to present a case study based on the analysis of lotic (flowing) water systems. Water samples were collected from various stations, and key physicochemical parameters were examined. The findings clearly indicate that several water quality indicators exceed the permissible limits as defined by Indian standards. To safeguard the environment and aquatic biodiversity, it is imperative that such contaminated water be treated adequately before being released into the natural watercourse.However, to obtain more reliable and conclusive results, it is essential to continue collecting and analyzing such data over an extended period. Long-term monitoring will offer a more accurate representation of effluent quality and help formulate effective pollution control strategies for the Kal River.

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Key observations and recommendations include:
Existing literature and reports on Kal River pollution are fragmented and lack consistency. A structured, long-term monitoring program with standardized protocols is urgently needed.
The collected data can inform strategic efforts to restore the river's ecological balance.
Effective regulation of urban expansion and civil activity in watershed regions is necessary to ensure sustainable water quality and public health.
Land-use policies along riverbanks critical sources of water supply should be reevaluated.
Key research areas in restoration ecology should be identified and supported by government-funded academic initiatives.
Public awareness and environmental education are crucial. A dedicated curriculum on water pollution, based on current data, should be integrated into educational systems from primary to tertiary levels.

Suggestions

1.Safe water supply and hygienic waste disposal should be a priority in the area.
2.The waste from households, Gram Panchayat and Tehsil should be recycled in an appropriate manner instead of discharging it directly into water bodies.
3.Special attention should be given to the various water parameters and WHO efficacy levels of these parameters to characterize the water for safe drinking water supply to the people.
4.Health education is also necessary in these areas as it plays an important role in the success of water programming.
5.Remediation of residential areas around mangaon Tehsil is the best solution to the health hazards posed by water and air pollution

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