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Editorial

The fifth edition of BODHI, once again, has a rich collection of articles in all the three sections, BODHI ARTHAM, BODHI BIJNAN and BODHI KALA. The articles address a rich variety of topics and reflect the sincerity and scholarship of our contributors. The education sector saw a major upheaval during the pandemic with online classes replacing offline chalk and board system. We are extremely thankful that the old order once again is in place which also gave us the impetus to publish this esteemed journal and the call for papers really had an overwhelming and encouraging response. The college too gave us tremendous support in the continuation of this journey.

We are grateful to our contributors for their enthusiastic response which has enabled us to publish this Volume and hope to have them with us in the future too.

15 May 2023

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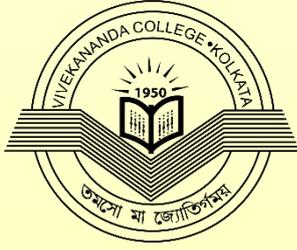
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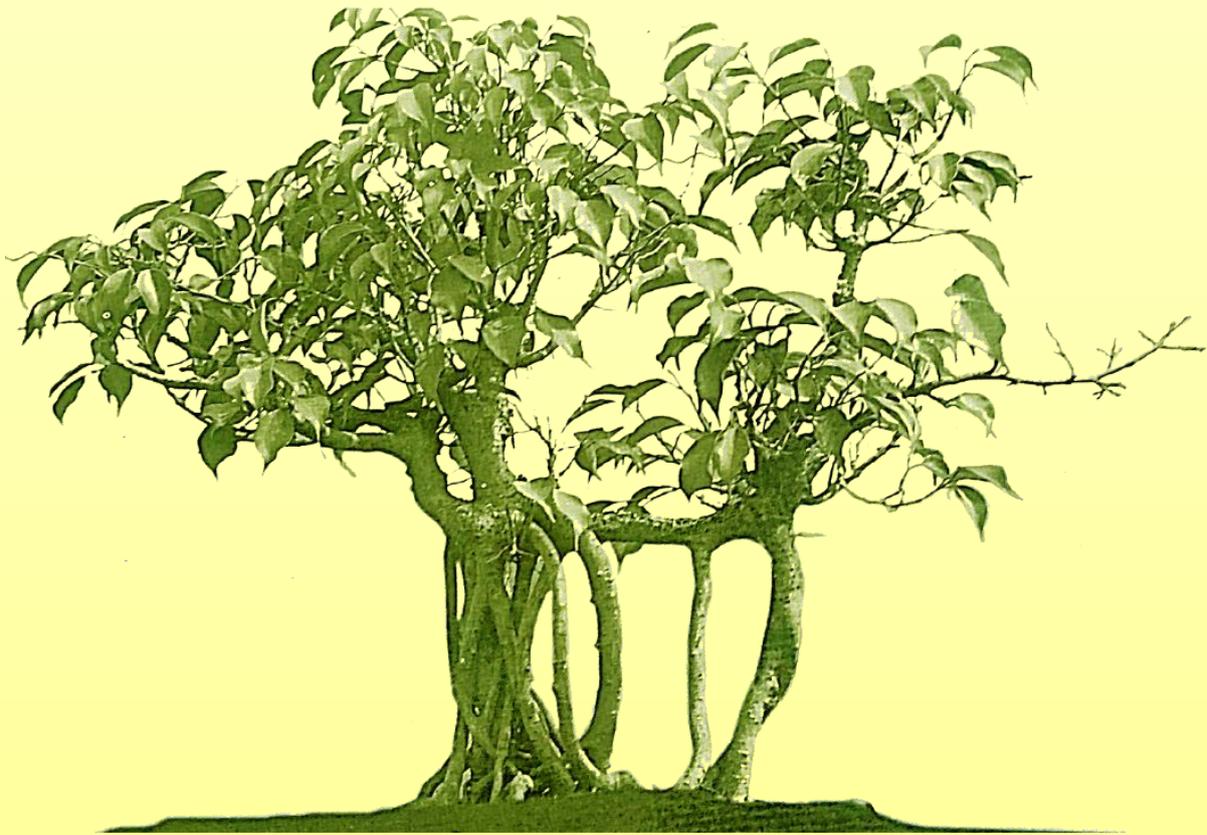
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Examining cross-market dynamics: an in-depth analysis of the interrelationship between the Indian stock market index and the Shanghai SE composite index using monthly data

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Abstract

India and China are major world powers. In both these countries, checking of stock market interdependency is a matter of high interest for investors and policy makers. To study the same, monthly data from 2005 to 2023 has been considered and statistical tests like unit root test, Johansen's cointegration test and Granger causality were applied. The findings suggest that there is absence of cointegration among these variables and in the short run neither granger cause each other.

Introduction

The interconnectedness of global financial markets underscores the significance of understanding cross-market dynamics, particularly in the context of major stock market indices. In this study, we embark on an in-depth analysis of the interrelationship between two prominent indices, namely the Indian Stock Market Index and the Shanghai SE Composite Index, leveraging monthly data. As the world economy continues to witness increasing globalization and interconnectivity, comprehending the interdependencies between these indices holds immense importance for investors, policymakers, and analysts alike. The Indian Stock Market Index, represented by benchmarks such as the S&P BSE Sensex and the NIFTY 50, serves as a crucial barometer of the Indian economy's health and performance.

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With India emerging as one of the fastest-growing major economies globally, its stock market has garnered significant attention from domestic and international investors seeking exposure to its growth prospects, demographic dividend, and expanding consumer market. As a result, fluctuations in the Indian stock market index not only reflect the sentiments and performance of domestic companies but also serve as indicators of broader economic trends and investor sentiment within the region.

On the other hand, the Shanghai SE Composite Index stands as a key benchmark for the Chinese stock market, representing a diverse array of companies listed on the Shanghai Stock Exchange. China's remarkable economic growth trajectory over the past few decades has propelled its stock market to the forefront of global finance, attracting considerable interest from investors seeking exposure to its burgeoning economy, burgeoning consumer base, and technological advancements. Consequently, movements in the Shanghai SE Composite Index not only reflect the performance of Chinese companies but also provide insights into broader macroeconomic trends, government policies, and global market sentiment. Given the increasing integration of global financial markets, understanding the interrelationship between the Indian Stock Market Index and the Shanghai SE Composite Index is imperative for several reasons. Firstly, it facilitates risk management and portfolio diversification for investors with exposure to both Indian and Chinese markets, enabling them to navigate market volatility and optimize their investment strategies. Secondly, it offers valuable insights into the transmission of economic shocks and contagion effects between these two major emerging markets, thereby aiding policymakers in formulating effective monetary and fiscal policies. Moreover, analyzing the cross-market dynamics between these indices sheds light on the broader macroeconomic linkages, trade flows, and investor sentiments shaping the global financial landscape. In light of these considerations, this study endeavors to provide a comprehensive examination of the interrelationship between the Indian Stock Market Index and the Shanghai SE Composite Index, utilizing rigorous statistical analyses and methodologies. By unraveling the intricacies of their interdependencies, the researchers aim to contribute to a deeper understanding of cross-market dynamics and provide actionable insights for investors, policymakers, and analysts navigating the complex and interconnected world of global finance.



Literature Review

Nath & Verma (2003) find no cointegration between Indian, Singaporean, and Taiwanese stock markets from 1994 to 2002, indicating no long-term equilibrium. Mild causality is observed in specific years, suggesting intermittent interlinkage. Despite occasional interdependence, the overall conclusion is the absence of a long-run equilibrium among the three markets.

Ahmed *et. al.* (2005) reveals no long-term relationship between the Indian equity market and US and Japanese markets. The causal link between Nasdaq and Nikkei is pronounced during 1999-2001 but diminishes in 2002-2004. Nasdaq and Nikkei movements are uncorrelated with Sensex and Nifty, indicating market segmentation and supporting investment diversification. Increased Foreign Institutional Investor (FII) investments in the Indian equity market are seen as a manifestation of this trend.

The paper by Seshaiyah (2006) identifies bidirectional causality between the Indian stock market and Mexico, Japan, with shorter lags, diminishing over time. No significant impact from the Indian market is observed on France, Germany, Switzerland, and the UK. Further categorization into Asian, developed, and developing markets enhances the analysis of their relationships.

Mukherjee & Bose (2008) find that the U.S. market exhibits information leadership over all Asian markets, with Japan playing a distinct role in their integration. The U.S. market is influenced by information from major Asian markets, including India, and returns on the Indian market significantly impact stock returns in major Asian markets.

Menon *et. al.* (2009) investigates the cointegration of Indian stock markets with leading stock markets from China, Singapore, America, and Hong Kong using the Engle Granger test. Data from NSE Nifty index and major stock indices from the mentioned countries over a ten-year period (April 1997 to May 2007) are analyzed. The findings reveal relationships between Indian markets and some global markets, offering valuable insights into their cointegration.

Vanitha (2010) finds that the Indian stock market is integrated with the US but not with Japan, the UK, and China. Unidirectional causality is observed, emphasizing the influence of the US stock market on its Indian counterpart. These findings have implications for investment



and speculative decisions, revealing the level of integration and interdependence between the Indian stock market and global counterparts.

Singh & Singh (2010) find correlation between Chinese and Indian stock markets with developed ones, limiting short-term diversification benefits. Bidirectional causality is observed between Chinese and Hong Kong markets, supporting high correlation. Similarly, bidirectional causality between China and India indicates a relationship. Indian stock indices (Sensex and Nifty) are co-integrated with developed markets, suggesting long-term equilibrium. The high correlation of China and India with the US is expected due to the influence of the US stock market and its role as a trading partner for both nations.

Subha *et. al.* (2010) analyzed co-movements with developed and regional emerging markets. Their study provides insights into portfolio diversification gains and the Indian stock market's vulnerability during a regional crisis. Findings indicate increased integration due to the liberalization of the Indian capital market, with investments through the FII route playing a pivotal role.

Chittedi (2011) investigates the integration of the Indian stock market with developed countries (USA, UK, Japan, France, Australia) from October 1, 1997, to October 1, 2007, utilizing unit roots, Granger causality, co-integration, and error correction mechanism. It reveals co-integration between India and these countries, indicating a long-run relationship between their stock markets.

The findings of Iqbal *et. al.* (2011) indicates an absence of cointegrating relationships between the US equity market and emerging markets of India and Pakistan. As a result, the study suggests that portfolio diversification in the Bombay and Karachi stock exchanges would be beneficial in the long run.

Taneja (2012) finds a significant long-run association between Indian stock markets and those of the US, France, Japan, Taiwan, and Singapore. One-way Granger causality is observed for S&P CNX 500, and two-way Granger causality exists for BSE Sensex. The influence of US, Japan, and France market factors on the Indian financial market is emphasized. The study highlights short-run interdependency and changing dominance of developed markets



in India, suggesting potential diversification for global investors and an international trade framework for policy coherence between developed and emerging economies.

Tripathi *et. al.* (2012) investigates short and long-term inter-linkages between the Indian stock market and advanced emerging markets, specifically Brazil. The study, utilising VAR-based co-integration tests and Johansen's methodology, aims to determine whether the Indian stock market is interlinked with advanced emerging markets in the long run. The research contributes valuable insights into these inter-linkages, adding to the existing literature in this research area.

The study by Gupta *et. al.* (2012) explores links between the Indian stock market and developed Asian markets (Hong Kong, Japan, Singapore). Johansen methodologies reject long-run relationships, but the Gregory-Hansen test supports cointegration with structural breaks. Long-term investing benefits in India are found to be limited. Time-varying conditional correlation relationships are estimated, revealing correlations spiking during crises and returning to initial levels afterward. The paper employs a dummy variable for structural changes and a GARCH (1,1) model for time-varying conditional correlations.

Sakthivel (2012) identifies strong co-integration relationships among Asian, European, and US stock markets. Using Johansen-Juselius co-integration and Vector Error Correction models, the study reveals that the US and certain European and Asian markets lead the Indian stock market. Notably, the impact of the US market on Indian stock returns is more pronounced than the reverse, highlighting the asymmetry in their influence over both short and long-run periods.

Kapoor *et. al.* (2013) examine stock market co-integration in South Asian countries, emphasizing India and its regional counterparts. The study offers insights for investors, suggesting that if stock markets exhibit co-integration, diversification may not yield profits. Conversely, the absence of co-integration presents significant opportunities for profit through effective portfolio diversification, guiding individual and corporate investors in their strategic investment decisions.

In Patel's (2013) study, the investigation of the Indian Stock Market's association with developed equity markets, including the US, UK, Germany, Australia, France, Canada, and



Japan, reveals the absence of a long-run equilibrium relationship. Granger causality tests indicate that neither the Indian stock market index nor the developed country indices mutually influence each other. The Vector Error Correction Model (VECM) underscores the Indian market's autonomy, as it is primarily influenced by lagged values of its own, with insignificant coefficients from other market.

Patel (2014) reaffirms dynamic linkages between the Indian stock market and other Asian equity markets. The study highlights a negative correlation between the Indian and Japanese markets, suggesting potential portfolio diversification opportunities for Indian portfolio managers utilizing the Japanese market.

Panda's (2015) study explores dynamic price linkages and interdependence between the Indian stock market and global markets (US, UK, Japan, Singapore, Hong Kong, Malaysia, South Korea, Taiwan, China). Using the Johansen-Juselius multivariate cointegration test, the findings reveal long-run equilibrium relationships and co-movements. The study contributes insights into international financial integration and highlights the vulnerability of the Indian stock market during regional crises, particularly evident during events like the global financial crisis in 2008.

Rajkumar's (2015) study examines the relationship between the Indian stock market and ASEAN countries (Indonesia, Malaysia, Singapore) using daily closing prices over ten years (2004-2014). Granger-causality and co-integration tests reveal a significant short-term unidirectional influence from the Indian market to the ASEAN countries, but no long-term relationship (co-integration) exists.

Mohanasundaram *et. al.* (2015) investigate stock market associations and forecasting ability among certain countries. The study reveals a high correlation between NIFTY and JALSH, with the latter Granger causing the former. Despite the short-term relationship, no long-run association exists between these stock market indices.

Veerappa's (2016) study investigates the short and long-run equilibrium relationship between the Indian stock market and global markets using the Engel-Granger test and Johansen. The findings affirm a significant short and long-run relationship among Asian stock markets, including India. The Vector Error Correction Model (VECM) underscores the importance of analyzing both short and long-run relationships for stock market integration.

Bhattacharjee *et. al.* (2016) use the Engle-Granger co-integration test to assess India's stock market integration with selected countries. They find increasing co-integration, particularly post-financial liberalization. The Indian market is more responsive to other Asian markets during recessions. Policy initiatives and capital flows, influenced by reduced risk perception and low policy rates in advanced economies, contribute to India's stock market growth.

Singh *et. al.* (2017) investigate linkages among developed stock exchanges, focusing on the Nifty index. Daily returns from 2007 to 2016 are analyzed. Johansen co-integration tests reveal no long-term association with other indices. Unidirectional causality is found, with the Indian market influencing Japanese and Hong Kong markets, while being influenced by the USA and UK markets.

Goyal *et. al.* (2019) examine co-movements between Indian and US stock markets. Unidirectional causality is observed, with US market returns influencing Indian market returns, but not vice versa. The findings suggest potential benefits for investors in portfolio diversification in the US market, both in the short and long run.

Rizwanullah *et. al.* (2020) find strong long-term cointegration among the top eight Asian stock markets, suggesting benefits for diversification. Granger causality tests reveal bidirectional and unidirectional causal relationships, indicating interdependence and potential portfolio diversification opportunities. Integrated markets can reduce financial instability and asymmetric shocks, enhancing economic resilience and mitigating the risk of international financial contagion. Efficient portfolio diversification across these Asian stock markets is still viable, warranting further research into the reasons behind cointegration.

Objectives

This study aims to thoroughly investigate the interrelationship between the Indian Stock Market Index and the Shanghai SE Composite Index using monthly data. The research seeks to uncover short-term fluctuations and long-run connections through a meticulous analysis. Employing statistical tools such as correlation analysis, unit root tests, vector autoregression, cointegration tests, variance decomposition, and impulse response functions, the study aims to provide a comprehensive understanding of the complex cross-market dynamics shaping the interaction between these two prominent indices.

Methodology

Monthly data of both NIFTY and Shanghai SE Composite Index (2005-2023) has been considered and econometrics software Eviews12 was used for statistical analysis. Initiated by logarithmic transformations, the study targets linearity in variables while concurrently addressing issues of skewness and heteroskedasticity. This transformation is pivotal, as it lays the groundwork for subsequent analyses. Correlation analysis is performed to assess the existence of relationship between the variables. Before delving into deeper analyses, the dataset's stochastic nature is rigorously scrutinized through unit-root tests, namely the Augmented Dickey Fuller, Phillips-Perron, and Breakpoint tests. These tests offer insights into the presence of stochasticity and structural breaks in the time series data, crucial considerations for robust analyses. The subsequent step involves lag order selection using the Vector Autoregression (VAR) model, ensuring an appropriate foundation for subsequent analyses. Cointegration, a vital concept reflecting long-term relationships among variables, is then explored using Johansen's approach. This methodology goes beyond traditional unit-root tests by considering interdependencies among variables over time, providing a more nuanced understanding of their relationships. To assess temporal connections, the bivariate Granger Causality Test is applied, offering insights into the forecasting ability of variables based on their past values. Following this, the Impulse Response Function (IRF) becomes a focal point, providing a dynamic visualization of how shocks to one variable reverberate through the entire system over time. This offers a nuanced understanding of the temporal dynamics within the VAR framework. To fortify the credibility of VAR results, the study employs the Correlation LM test to identify the possibility of sequential association in residuals. This is crucial as serial correlation in residuals can jeopardize the reliability of model inferences. Significance of specific coefficients is assessed via Wald tests, probing whether the variables mutually influence each other. Altogether, this meticulously designed methodology aims to capture the intricate web of relationships, temporal dependencies, and dynamic interactions within the economic system under consideration.

Findings and Discussion

Table 1 shows the result of correlation analysis. It can be seen that there exists positive correlation between the two stock markets. However, to understand the extent to which these markets are related further analysis has been conducted.

Table 1: Showing results of correlation

	LNSE	LSSEC
LNSE	1	0.642298
LSSEC	0.642298	1

[Source: Computed in Eviews12, summarised by author]

Before conducting further analysis the stationarity of variables have to be checked. Three unit root tests has been considered for the purpose; namely Augmented Dickey Fuller Test (Dickey & Fuller, 1979), Phillips-Perron Test (Phillips & Perron, 1988) and Breakpoint Test (Perron, 1997). The results are summarized in the table below. It is found that in all the tests the level data was non-stationery, hence for further analysis first difference of data was tested and were found to be stationery. In all the tests, the Durbin Watson was close to 2, which states that the model is a good fit for further analysis. The results are summarized in Table 2.

Table 2: Showing results of Unit Root Tests

ADF Test; Based on SIC				
	LNSE		LSSEC	
	Intercept		Intercept	
	Level	1 st Difference	Level	1 st Difference
P-values	0.6262	0	0.1129	0
Durbin Watson	1.9978	1.9978	1.8411	2.0001
PP Test; Based on Newey-West				
	LNSE		LSSEC	
	Intercept		Intercept	
	Level	1 st Difference	Level	1 st Difference
P-values	0.6206	0	0.0494	0
Durbin Watson	1.9645	1.9978	1.84114	2.0001
BPU Test; Based on SIC				
	LNSE		LSSEC	
	Intercept		Intercept	
	Level	1 st Difference	Level	1 st Difference
P-values	0.8934	<0.01	0.0598	<0.01
Durbin Watson	1.915	2.05583	2.00978	1.96148

[Source: Computed in Eviews12, summarised by author]

After checking for the stationarity of the variables, optimum lag length was tested, the results of which are displayed in Table 3. As can be seen the Schwarz Information Criterion (SC) and Hannan-Quinn information Criterion (HQ) yield the same result of optimum lag to be 1, indicated by the asterisk mark. Hence, lag 1 has been considered for further analysis.

Table 3: Showing Lag Length Criteria

Endogenous Variables: LNSE LSSEC			
Lag	AIC	SC	HQ
0	1.507529	1.538986	1.52024
1	-5.10387	- 5.009497*	- 5.065735*
2	-5.075114	-4.917285	-5.011555
3	-5.116968*	-4.896764	-5.027986

[Source: Computed in Eviews12, summarised by author]

Table 4 shows the result of Johansen’s Cointegration test with optimum lag 1. The p-value is found to be greater than 0.05 for both Trace statistics and Max-Eigen statistics, which means the null hypothesis of no cointegration cannot be rejected. Hence there exists no long run equilibrium relationship between NIFTY and SSEC. However, to understand the short run relationship, test for vector autoregression has been conducted.

Table 4: Showing results of Johansen's Cointegration Test

Coefficients	Eigenvalue	Trace Stats	0.05 Critical Value	Probability
None	0.035923	8.944367	15.49471	0.3705
At most 1	0.004063	0.89577	3.841465	0.3439
Coefficients	Eigenvalue	Max-Eigen Stats	0.05 Critical Value	Probability
None	0.035923	8.048597	14.2646	0.3738
At most 1	0.004063	0.89577	3.841465	0.3439

[Source: Computed in Eviews12, summarised by author]

The results of VAR as shown in Table 5 reveals that LNSE(-1) is significant for LNSE and LSSEC(-1) is significant for LSSEC. These values are quite high and it means that these variables are impacted by its own lagged variable.

Table 5: Showing Results of VAR

	LNSE	LSSEC
LNSE(-1)	0.993856	0.006937
	(-0.01001)	(0.01212)
	[99.2465]	[0.57215]
LSSEC(-1)	-0.010307	0.952428
	(-0.01714)	(0.02075)
	[-0.60135]	[45.8967]
C	0.145571	0.318329
	(0.10371)	(0.12556)
	[1.40365]	[2.53531]

[Source: Computed in Eviews12, summarised by author]

From the above we can thus model our VAR as follows:

$$\text{LNSE} = 0.993856\text{LNSE}(-1) - 0.010307\text{LSSEC}(-1) + 0.145571$$

$$\text{LSSEC} = 0.006937\text{LNSE}(-1) + 0.952428\text{LSSEC}(-1) + 0.318329$$

Following the test for VAR, the coefficients were tested as the first causality test, the results of which are given in Table 6 below. From the test results it is evident that coefficient of LNSE (-1) given by C(1) has a p-value less than 0.05 and the coefficient of LSSEC(-1) given by C(5) has a p-value less than 0.05. This implies that both these variables are significant at 95% level of confidence.

Table 6: Showing the results of Significance of coefficients

	Coefficient	Std. Error	t-Statistic	Probability
C(1)	0.993856	0.01001	99.2465	0.0000
C(2)	-0.010307	0.01714	-0.60135	0.5479
C(3)	0.145571	0.10371	1.40365	0.1611
C(4)	0.006937	0.01212	0.57215	0.5675
C(5)	0.952428	0.02075	45.8967	0.0000
C(6)	0.318329	0.12556	2.53531	0.1160

[Source: Computed in Eviews12, summarised by author]

Followed by the coefficient tests, the Block Endogeneity Test was conducted to test the above results. Table 7 reveals the results as given below. It can be seen that the above results have been reconfirmed from a different perspective. The null of lagged variables of LSSEC not causing LNSE and the null of lagged variables of LNSE not causing LSSEC cannot be rejected since the p-value in both cases are more than 0.05.

Table 7: Showing the results of Granger Causality/ Block Endogeneity Test				
Dependent Variable: LNSE				
	Excluded	Chi-sq	df	Prob
	LSSEC	0.36162	1	0.5476
	All	0.36162	1	0.5476
Dependent Variable: LSSEC				
	Excluded	Chi-sq	df	Prob
	LSSEC	0.327359	1	0.5672
	All	0.327359	1	0.5672

[Source: Computed in Eviews12, summarised by author]

Further, Wald test was conducted to test the significance of coefficients and it was found that null hypothesis of lagged variables of LNSE not influencing LNSE and the null hypothesis of lagged variables of LSSEC not influencing LSSEC is rejected because p-values are less than 0.05. However, lagged variable of LNSE not influencing LSSEC and null hypothesis of lagged variable of LSSEC not influencing LNSE cannot be rejected.

Table 8: Showing the results of Wald Test			
	ChiSquare	df	Probability
C(1)	9849.861	1	0.0000
C(2)	0.361620	1	0.5476
C(4)	0.327359	1	0.5672
C(5)	2106.591	1	0.0000

[Source: Computed in Eviews12, summarised by author]

Sometimes, the results of Wald test and Block Endogeneity may contradict and it is thus important to reconfirm the fact by Pair wise Granger Causality test, the result of which is shown in Table 9. Pair wise Granger Causality Test shows the direction in which one variable impacts the other. From the results below it is seen that LSSEC and LNSE do not granger cause each other. Hence, there exists no causality between these two variables.

Table 9: Showing results of Pairwise Granger Causality Test

Null Hypothesis	Observations	F-Statistic	Probability
D(LSSEC) does not Granger Cause D(LNSE)	220	0.27156	0.6028
D(LNSE) does not Granger Cause D(LSSEC)		0.01558	0.9008

[Source: Computed in Eviews12, summarised by author]

From the above causality test, it is seen that the results are not contradictory and hence it can be safely concluded that NIFTY and Shanghai SE Composite Index are not related and these do not granger cause each other. In fact it can be said safely that these are independent of each other. However, to reconfirm our results the residual diagnostic test for presence of serial autocorrelation was conducted. The result of which is given in Table 10. The null hypotheses states that there is no presence of serial correlation, and the null cannot be rejected because the p-value is greater than 0.05.

Table 10: Table showing results of Autocorrelation LM Test

Lag	LRE*Stat	df	Prob.	Rao F-stat	df	Prob
1	1.501033	4	0.8265	0.375040	(4, 430.0)	(0.8265)

[Source: Computed in Eviews12, summarised by author]

Now that NIFTY and Shanghai SE composite index are independent of each other, we have discovered that these are influenced by their own lagged variables. The extent to which they are impacted can be evaluated using Variance decomposition, the results of which are shown below in Table 11. It is very clear that LNSE is impacted by its own lag to the extent of 100%

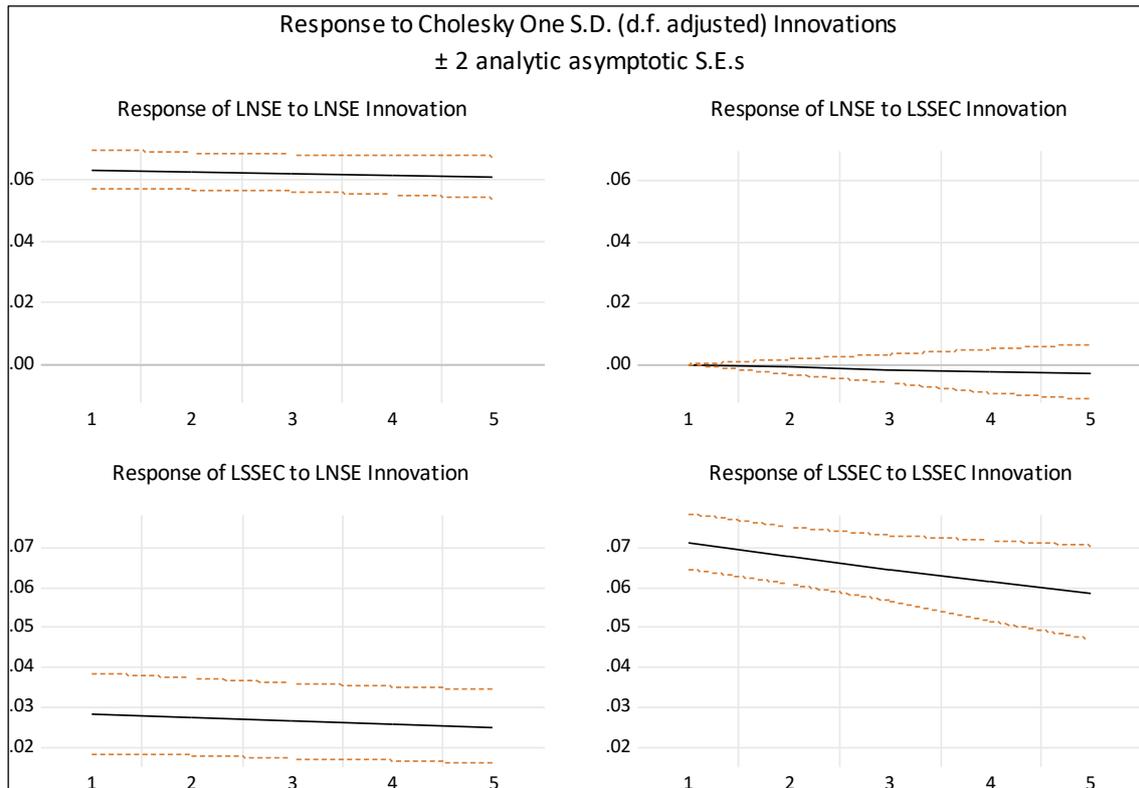
at one lag and from 2nd to 5th lag by more than 99%. LSSEC is explained by its first order lag to the extent of 86% and from 2nd lag to 5th lag it is explainable by more than 85%. These are very high numbers and clear evidences of their independent nature.

Table 11: Showing results of Variance decomposition

Variance decomposition of LNSE			
Period	S.E.	LNSE	LSSEC
1	0.063368	100.0000	0.000000
2	0.089138	99.99321	0.006789
3	0.108599	99.97810	0.021899
4	0.124753	99.95542	0.044577
5	0.138771	99.92588	0.074117
Variance decomposition of LSSEC			
Period	S.E.	LNSE	LSSEC
1	0.076718	13.73399	86.26601
2	0.106060	13.91804	86.08196
3	0.127027	14.10211	85.89789
4	0.143492	14.28602	85.71398
5	0.157003	14.46960	85.53040

[Source: Computed in Eviews12, summarised by author]

Corresponding to the variance decomposition results, Impulse response function has been presented in the figure below. It shows that any shock in LNSE has high response in LNSE and the same can be said when there is a shock in LSSEC that there is a high response in LSSEC, that is why they are higher up in the graph. Whereas, any shock in LNSE has minimal or no response in LSSEC and vice versa.



[Source: Computed in Eviews12]

Conclusion

The absence of cointegration and Granger causality between the NIFTY50 and Shanghai SE Composite Index bears significant implications for the understanding of their relationship. Cointegration, a long-term equilibrium relationship, and Granger causality, a measure of temporal precedence, are crucial in assessing the interdependence of two financial time series. The absence of these relationships suggests that the NIFTY50 and Shanghai SE Composite Index move independently of each other in both the short and long run. From a trading or investment perspective, this implies that there may not be persistent arbitrage opportunities or predictable patterns that can be exploited for profit. Traders and investors should be cautious about assuming spillover effects or inter-market dependencies between these indices.

The lack of cointegration indicates that there is no stable, long-term relationship that could be exploited for portfolio diversification or risk management purposes. Furthermore, the absence of Granger causality implies that past values of one index do not contain information that can help predict the future values of the other. This result suggests that the information flow between the NIFTY50 and Shanghai SE Composite Index is not unidirectional. Thus, incorporating information from one index may not improve forecasting accuracy for the other.



Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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Greening the Roads: Hydrogen Fuel Cells Transforming Mobility Landscape

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Abstract:

This article provides an overview of green hydrogen as an alternate energy source over fossil fuel and battery powered EVs for future transport technology highlighting the benefits of green hydrogen production using renewable sources of electricity. The technology is at a nascent stage, however with combined efforts from all stakeholders to the environment and society, green hydrogen is more sustainable option for future.

Background:

According to IQ Air's 5th Annual World Air Quality Report, India ranks eighth in the world for worst air quality. India is home to 80% of the top 15 most polluted cities in South and Central Asia. The report reveals that around 60% of Indian cities included in the study recorded PM_{2.5} levels annually exceeding WHO guidelines by at least seven times (Ministry of Environment, 2022). World Air Quality Report, 2022 reveals facts that are quite alarming, stating that vehicular pollution contributes to 20-35% of total air pollution (The Hindu, 2022). The National Clean Air Programme (NCAP) is an initiative by the Central Government to address air pollution at the national level. It falls under the "Control of Pollution" Scheme and aims to comprehensively tackle air pollution across the country. The initiative establishes precise objectives aiming to realize a decrease of 20% to 30% in PM₁₀ and PM_{2.5} levels by 2024, utilizing 2017 as the reference year for assessment. The NCAP is a long-term, time-bound strategy designed to combat air pollution effectively (Ministry of Environment, 2022).

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Present Scenario:

At present in 2021, there has been an accelerated focus on the vehicular sector. Bharat Stage VI Phase I has been implemented as a new regulatory, a step jump over previously planned BS V compliance for vehicle manufacturers (Khodke, 2021). However, this regulation pertains to internal combustion engines. The target of Indian Government is to have hundred percent electric vehicles by the year 2030 (Irfan Khan, 2022; Soman, 2019). Which means manufacturers would have to give up construction of internal combustion engines totally by 2030. It is just nine years from the original deadline and India being the fifth largest automobile market, this target seems quite ambitious. To accelerate transition towards electric vehicles, Indian Government has provided incentives on two fronts- to the manufacturers of electric vehicles and to the consumers. Manufacturers have received financial support through a Rs. 10,000 crore budgets under the Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles (FAME) scheme. Consumers are incentivized with discounts, refunds, lower interest rates on vehicle loans, road tax waivers, free registrations, income tax deductions, and scrapping incentives for replacing internal combustion engine vehicles with electric ones (Niti Aayog, n.d.). With the collective efforts of the government and rising environmental concerns, the EV industry has seen a considerable growth. The year-on-year growth of EV sales has been 154% over financial year 2021-22, with EV industry hitting record sales (Evreporter, 2022).

Energy generation scenario:

Electric vehicles will definitely exert pressure over the present electricity demands. At present fossil fuels contribute to about 57% of electricity generation and non-fossil fuels contribute about 43% (Ministry of Power, 2022). It is clearly evident that electricity energy demands are being met mostly through the usage of fossil fuels. If vehicles are running on electricity, it doesn't mean fossil fuels are not being burnt. With present scenario it is evident that about 57% of the electricity requirement is being met by burning fossil fuels and as EVs increase in number the demand for electricity will increase too. The cheaper solution to immediately meet energy requirements is to burn fossil fuels than to set up billion-dollar projects. Moreover, India is not an energy surplus country when it comes to electricity. According to the report of Ministry of Power (2022), India has not yet seen an electricity generation surplus in over a decade. The requirement as per table 2 for the year 2021-22 and 2022-23 was 13,79,812 million units and



15,11,847 million units, but power availability for the respective years were 13,74,024 million units and 15,04,264 million units. Evidences of shortage in generational capacity is factual at present (Lebrouhi et. al., 2021). To meet true EV targets for mobility, new power generation plants have to be set up along with shift from fossil fuel reliance or maybe an alternative green mobility solution has to be pursued (Vidhi & Shrivastava, 2018).

Concerns for battery production:

Lithium-ion is widely used as the main component for batteries. To manufacture batteries nickel and cobalt is required. Mining of cobalt has recently faced several human rights issues due to the exploitations; child labours and sexual harassment cases reported in the largest depository of cobalt in the world, that is in the African Democratic Republic of Congo (Carson, 2022). Global guidelines on purchase of this material from authentic source is ineffective as it is difficult to trace the mixture of cobalt from both legal and illegal sources as the supply chain is quite complex and directed through China (Anna Pienaar, 2020; Northwestern University, 2021). Mining of nickel has several environmental concerns (Buratovic et. al., 2017) which led Philippines government to either suspend or close seventeen mines (The Guardian, 2017). With increased effort to transform transportation sector to fully electric, these issues will pose as ethical and social challenges. In recent times, Tesla has shifted from cobalt as component of battery to iron-phosphate. The result is a low range electric vehicle. There is no perfect substitute yet to cobalt and nickel, hence with continued promotion of EVs as cleaner travel option, cobalt and nickel mining and their related issues are still going to co-exist. Adding to the problem is the issue of safe disposal of these batteries post their service life (Grigore & Kifor, 2021). Also, the elevated production and recycling expenses associated with batteries can lead to electric vehicles having a higher price tag compared to conventional vehicles. Enhancing recycling efficiency is essential to make recycled lithium economically feasible. It's imperative to decrease the reliance on such rare metals in batteries for a sustainable shift towards electric vehicles. Developing improved recycling methods to efficiently reclaim valuable metals from used car batteries is vital. Furthermore, the priority lies in ensuring ecologically safe recycling processes that safeguard human health (Castelvecchi, 2021).

Alternative Option:

There is an alternative to battery powered electric vehicles and that is through the fuel cell electric vehicles technology powered by green hydrogen. Green hydrogen is generated via electrolysis, a process using renewable sources like solar, wind, or hydroelectric power to split water (H₂O) into hydrogen (H₂) and oxygen (O₂) using electricity (Cunanan et. al., 2021). This method is eco-friendly and sustainable, as the electricity employed is derived from renewables. Unlike fossil fuel-dependent hydrogen production emitting greenhouse gases, green hydrogen has substantial potential to cut carbon emissions and aid the shift toward a cleaner and sustainable energy system (Acar et. al., 2019). Green hydrogen can be used as a clean fuel in various applications, including transportation, industry, and energy storage (Abdalla, et. al., 2018)

Fuel cell mechanism:

Hydrogen fuel cells are electrochemical units that transform the chemical energy of hydrogen into electricity, heat, and water. They are predominantly utilized in hydrogen fuel cell electric vehicles (FCEVs) to energize electric motors, eliminating the need for extensive battery storage. In FCEVs, the hydrogen fuel cell ionizes hydrogen at the anode, allowing protons to pass through a membrane and react with oxygen, resulting in water production (Cunanan et. al., 2021). The stripped electrons from hydrogen can power the vehicle's electric motors or charge its battery, ensuring zero tailpipe emissions and no combustion (Burns et. al., 2002). This sustainable mechanism involves hydrogen intake, oxygen supply, electrochemical combination, energy utilization, and water by-product. Hydrogen, a renewable source, reduces fossil fuel dependence and emissions, being producible from renewables (Hosseini & Butler, 2020). With fuel cells achieving high efficiencies and emitting minimal pollutants, they're considered a clean and versatile energy option, especially for transportation, supporting a sustainable future (Srinivasan et. al., 1999).

Comparison of fuel cell over battery EVs:

FCEVs present benefits in comparison to battery electric vehicles (BEVs) includes extended travel distances, quicker refuelling suitable for commercial purposes, and decreased vehicle weight and expenses as large batteries are unnecessary (Cunanan et. al., 2021). However,



FCEVs are presently costlier than BEVs due to expensive fuel cell systems and low production volume (Grube et. al., 2021). Limited hydrogen refuelling stations hinder long-distance travel for FCEV owners, and the flammable nature of hydrogen demands specialized storage. Hydrogen production can be energy-intensive and reliant on non-renewable sources, potentially offsetting environmental benefits (Cunanan et. al., 2021). FCEVs excel for ranges over 160 km, considering factors like mass, volume, cost, greenhouse gas reduction, refuelling time, energy efficiency, and life cycle costs, especially when using natural gas or biomass as sources (Thomas, 2009).

Challenges:

Hydrogen fuel cell vehicles currently face cost challenges due to the expensive fuel cell systems and limited production (Alaswad et. al., 2016), making them pricier than conventional vehicles. The existing scarcity of hydrogen refuelling stations hampers long-distance travel for FCEV owners (Krafft, 2020). Storing and transporting highly flammable hydrogen requires intricate and costly methods (Najjar, 2013). FCEVs have constrained ranges relative to traditional vehicles, with temperature and humidity influencing fuel cell system efficiency (Veziroglu & Macario, 2011). Additionally, hydrogen fuel production is energy-intensive processes and reliance on non-renewable sources can counteract environmental advantages (Kreith & West, 2004). In comparison to internal combustion engines powered by fossil fuels, FCEVs also demonstrate reduced efficiency and power output (Szalek et. al., 2021). Numerous hurdles like safety concerns, high costs, storage limitations, energy density issues, thermal control requirements, and sensitivity to temperature challenge the rapid advancement of hydrogen-based internal combustion engines.

Future Prospect:

India's National Green Hydrogen Mission, supported by a budget of Rs 19,744 crore, aspires to establish a prominent role for the nation in green hydrogen production. The mission's goal encompasses achieving an annual capacity of 5 million metric tons and a consequential 50 million metric ton reduction in greenhouse gas emissions by 2030 (National Portal of India, n.d.). A key focal point involves hydrogen-powered FCEV trucks, envisioning 12,000 of these vehicles on Indian roads by 2030 (Schlosser, 2022). Collaborations with industry leaders like Tata Motors and Cummins expedite the integration of hydrogen-based mobility solutions in



India's e-mobility sector, amalgamating environmental benefits with technological progress in the pursuit of sustainable transportation (Cummins Newsroom, 2022). Moreover, exploring supercapacitors and fuel cells as alternate energy sources for hybrid electric vehicles (HEVs) illustrates their potential for regenerative braking and energy storage, while fuel cells offer opportunities for chemical energy conversion (He et. al., 2020). When coupled with renewable energy sources, these technologies present promising hybrid systems for future transportation needs. In a related context, recent progress in making hydrogen fuel cell engines suitable for transportation systems, combined with integrating hydrogen fuel cells with batteries and control systems for hybrid vehicles, suggests that hydrogen fuel cells are poised to play a substantial role in transportation, power generation, and electricity industries (Hoffman, 2012). In the foreseeable future, there's an expectation of increasing demand for hydrogen fuel cell electric vehicles (FCEVs) from the 2030s to the 2050s, accompanied by cost reductions, enhanced energy efficiency, extended travel ranges, and a expanding network of hydrogen refuelling stations (Tanç, 2019). This trend may lead to FCEVs becoming more cost-effective, having extended ranges, and gaining higher popularity over the next two decades.

Government initiative:

The National Green Hydrogen Mission is a governmental effort in India aimed at encouraging the adoption of green hydrogen across diverse sectors and curbing carbon emissions. The mission aims to create a green hydrogen ecosystem and provide opportunities for innovation and investment across the value chain. The Ministry of Petroleum and Natural Gas will facilitate the development of regulations and plan new refineries and city gas projects to be compatible with green hydrogen deployment. The Ministry of Skill Development and Entrepreneurship will develop courses and programs to skill manpower across the value chain. The Ministry of Power will enact measures and rules to guarantee the cost-effective provision of renewable energy for producing green hydrogen. The regulatory framework will be established to allow storage and dispensing of hydrogen at par with international norms. The mission will also align with globally prevalent standards and regulations to tap into the international market (Ministry of New and Renewable Energy, n.d.).



Suggestions:

Suggested strategies for advancing hydrogen fuel cell technology encompass government-backed initiatives, infrastructure expansion, cost-effective hydrogen generation, adoption of non-carbon-based methodologies, enhanced manufacturing of stack components, and bolstering demand (Rajalakshmi, 2021). Governmental support is crucial to propel infrastructure and research in hydrogen fuel cells, with a specific focus on developing comprehensive hydrogen production, storage, and distribution networks. A paramount objective involves curtailing hydrogen generation costs to heighten competitiveness vis-à-vis alternative fuels. Prioritizing non-carbon-based approaches for hydrogen production is vital to mitigate the process's carbon footprint. Augmenting manufacturing capabilities for stack components is imperative to meet the escalating demand for fuel cells. By elevating the demand for fuel cells, cost reductions will be stimulated, propelling further research and developmental endeavours.

Conclusion:

The Government of India is in an active state of incorporating technologies and enactment of federal laws that will attempt to achieve carbon net zero in the future. Constant innovations and research are taking place in the field of alternate energy. It is imperative that the corporates and general population of the country would also take the initiative to participate along with the Government in this endeavour, because sustainability is for all.

Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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Looking back: Educational thoughts and practices of Debendranath Tagore

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Abstract

Nineteenth Century Bengal was a period of educational experiments. One of the major thinkers' of this period was Debendranath Tagore. He tried to assimilate the traditional education system of India with newly introduced western education. This essay tries to find out the essence of his educational thought and how it is relevant till today.

Key words: Western Education, Pathshala, Tatvabodhini Sabha, secular, mass education, nationalism

“Knowledge is virtue” – Socrates

“Education should develop a kind of reason in children in order that they may feel a harmony between the soul and the various things of the world. This harmony is true virtue.” – Plato

The advent of East India Company rule in Bengal in late eighteenth century was marked by the cultural interaction between the East and the West. No doubt, spread of Western education was the most important outcome of this interaction. The necessity of manpower to run the administrative set up in this country, led to the Governmental effort to educate Indians in Western law, science and literature. The Missionaries and the Bengali ‘Bhadralok’ community extended their help towards the spread of Western education. The names of Raja Rammohan Roy, Raja Radhakanta Deb, Prasanna Kumar Tagore, Ishwar Chandra Vidyasagar are very well known in this field. Maharshi Debendranath Tagore, on the other hand, is known more for his religious contribution. But his contribution in the field of education was not less important. The present paper would try to bring out his thoughts, efforts and legacy in this field.

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After the Grant of diwani (1765) and establishment of Supreme Court (1774), the Bengali tradition, society and culture faced a huge transformation. The education system was not divided in primary, secondary and higher learning before and Pathshala was the foundation of education. Ramayana, Mahabharata, Mangal-kavyas were read and folk performances like Kirtana and Yatras imbibed values in society. Pathshala education was part of this process, Tols, Chatuspathis and Madrasas helped higher learning and understanding of Hindu and Islamic culture. The zamindars of rural Bengal were the patrons of such culture and education. The Permanent Settlement of 1793 witnessed the decline of old zamindars and the neo-rich became landholders. To them, adoption of British educational system seemed convenient and lucrative.

The education system that was introduced in Bengal with the advent of British, was characterised by certain features. In the first place was the concentration of educational effort on the upper sections of society and neglect of masses. Second feature was the promotion of English language as medium of higher education and acceptance of western knowledge as the principal content. The last feature was the entirely academic character of education neglecting practical and technical training. The principle of education based on very narrow utilitarianism, meant recruitment for subordinate services at a low cost. The missionaries on the other hand, saw it as an opportunity to reach to Indian society to spread the doctrines of Christianity. The receiver of this education, the wealthy section of Bengali society, either became professionals in law, medicine and teaching or joined the government services in the capacity of subordinate judges or deputy collectors. The abysmal ignorance of the vast masses was a major hindrance to the progress of the country. The new education meant neglect and decline of the indigenous education system. In this background, we will try to evaluate the contribution of Maharshi Debendranath Tagore in the field of education.

Debendranath received, his primary education in Anglo Hindu School set up by Raja Rammohan Roy in 1823. The Raja considered that no education was complete without religious education. Debendranath was much influenced by Raja Rammohan Roy. In 1839, to popularise *Brahmo* religious movement among Bengalis, Debendranath established *Tatvabodhini Sabha*. He realized that spread of education was essential to run the organization smoothly. At the same time, he was aware of the necessity of western knowledge in the then Bengali Society. The practical outcome, of these realisations, was the establishment of



“*Tatvabodhini Pathshala*” on 13th June 1840. The 1843 – 44 resolutions of *Tatvabodhini Sabha* clearly depicts that the main purpose of the ‘Pathshala’ was to promote religious education along with other subjects. The medium of instruction was Bengali. Akshay Kumar Dutta wrote Physics, Mathematics and Geography text books in Bengali.ⁱ

The number of students in the school was, however, meagre, as the wealthy section of Calcutta had a tendency to admit their children in English schools, those were present in quite a good number in the vicinity of Calcutta. So, the members of *Tatvabodhini Sabha* decided to shift the Pathshala to Bangshabati or Bansbere village in Hugli district (1843). The founders thought that the establishment of a model school in rural area would help the local population to learn languages and science and religion. The curriculum of the newly built school included English, Bengali, Sanskrit, Science and Upanishadic religion. On the foundation day of the school Debendranath in his speech said that, as knowledge was spreading through the medium of English, Indian traditional knowledge of Vedanta was almost disappearing. Hence it was necessary to bring that knowledge to forefront. (এই ক্ষণে ইংরাজী বিদ্যার দ্বারা চতুর্দিকে জ্ঞানের স্ফূর্তি হইতেছে, অতএব ... আমাদের চিরকালের যে বেদান্ত শাস্ত্র, তাহা গুপ্ত থাকার জন্য প্রায় লুপ্ত হইয়াছে তাহাই এইক্ষণে প্রকাশ করা অতি আবশ্যিক হইয়াছে...। স্বধর্মে থাকিয়া ঈশ্বর জ্ঞান দ্বারা চরিতার্থ হইলে কে পরধর্মের আশ্রয় লইবে’)ⁱⁱ He explained that the purpose of the Pathshala was to impart scientific and religious knowledge through the medium of Bengali.

This thought of Debendranath was reflected in the basic characteristic features of *Tatvabodhini Pathshala*. The first important feature was the decision to use Bengali as a medium of teaching at a time when Bengali prose writing was just taking shape. The effort to enrich the vocabulary of the language through books on science and other fields of knowledge was a major contribution of the Pathshala. In fact, Debendranath, from a very early age, tried to contribute to the development of Bengali Prose literature. At the age of fifteen, he, along with some other students of ‘Anglo Hindu School’ established ‘*Sarvatatvadeepika Sabha*’ in 1832, to have discussion on Bengali language. The members also decided that the discussions will be only in Bengali.ⁱⁱⁱ It must be noted that, although establishment of debate clubs or other literary organisations were not so rare in those days, the medium of communication in them was always English. This loyalty towards his mother tongue and the feeling of pride attached to it, was one of the major characteristic features of Debendranath’s educational thought.



The second characteristic feature of the *Pathshala* was the practice and spread of traditional Indian religious thought as conceived by Debendranath and his followers. In fact, William Adam in his Education Report of 1835, recommended for the inclusion of religious education in curriculum. But that proposal was in favour of teaching the basic system of Pathshalas, there was no scope for formal religious education. The nineteenth century Bengali intelligentsia wanted to see and re-establish the traditional Hinduism in the light of the rationalism of newly acquired western knowledge. *Tatvabodhini Pathshala* made a unique effort to spread these ideals among the people who were not so well informed. This was specially mentioned in English periodicals. “The Calcutta Courier” on 3rd June, 1840 opined: “The boys will further receive religious deduction which is a new feature in the system of native instruction”.^{iv}

The curriculum of *Tatvabodhini Pathshala* included Physics, Mathematics, Geography, History of Bengal and English language and grammar. This shows, that the subjects of importance for the period, was taught in this school through the medium of vernacular language. It further enhanced the change of bringing in the masses within the fold of modern education. Thus we find, that, Debendranath actually wanted to bring back the Gurukul tradition of ancient India, with certain modifications to make it suitable for modern times.

Other than *Tatvabodhini Pathshala*, Debendranath also helped the establishment of ‘*Barrackpore Pathshala*’ (1846) and ‘*Sukhasagara School*’ (1846) of Nadia. Mention must be made of Debendranath’s role in the establishment of ‘*Hindu Hitarthi Vidyalaya*’ (1st March, 1845). The whole of Bengali Hindu society united to bring up this school. Debendranath was in the forefront of the movement to minimize the differences between various groups of the then Bengali ‘*bhadralok*’ community. His efforts, for the first time, brought together the members of Brahmasamaj and Dharmasabha for a noble purpose. To save and uplift the religion and culture of the region and to unite the Bengali Hindu society, Debendranath Tagore’s effort was undoubtedly an important event of the 19th century social history of Bengal. In his autobiography, Debendranath expressed that if united, Bengalees can create a much better educational institution than the Christian missionaries.^v It shows, although he wanted to check the spread of Christianity, Debendranath was very much interested in the development of different fields of modern knowledge in India.



In this context, it is necessary to mention his thought about mass education. For the expansion of mass education, the Government of India in 1859 sought the opinion of Civilians, Missionaries and eminent Indians. Debendranath was one of them. The letter he wrote to the Government on 8th August, 1859, speaks of his thoughts on how to spread education among masses. The letter emphasized the importance of the role of ‘Calcutta school society’ (1818), established by David Hare, in the betterment of the pathshalas of Bengal and urged a continuation of this work. One major suggestion of Debendranath was to make provisions to train the teachers in the modern methods of teaching. He wanted an appraisal system where both the students and the teachers would be appreciated for their success by giving them appropriate prizes. He also suggested distribution of books among students that would be informative and enjoyable at the same time. In the curriculum of primary education his suggestion was to include reading, writing, spelling, arithmetic and mensuration for the beginners, primary scientific knowledge about agriculture, training in accounts of agriculture and trade, primary knowledge about law of the country regarding man and property, introduction to History and Geography and moral education.

About the hindrances in the spread of education for masses, he pointed out some basic problems. In his view, the people who themselves were illiterate, had an apathy for their children’s education. A second group could not afford to educate their children due to financial constraint. The third group was afraid that their children would convert to Christianity after receiving education. There was yet another group who opposed female education as they thought it to be unnecessary and socially and morally corrupt practice.^{vi}

This brings us to Debendranath Tagore’s views about female education. As evident from his letters and Rabindranath Tagore’s writing. Debendranath was very much in favour of female education. He sent his daughter Soudamini to Bethune School.^{vii} He had no different attitude towards his daughters-in-law. He urged his youngest son Rabindranath to send his wife to Loreto House for English education.^{viii} He was the chairperson of “*Samajonnoti Vidhayini Suhrit Samiti*”, an organization that declared spread of women’s education as its major goal.

The foregoing discussion, then, brings out the salient features of Debendranath Tagore’s Educational activities. As a student of Anglo Hindu School, Rammohan Roy’s ideas about incorporating religious education in any curriculum, was naturally imbedded in his persona.



The schools established under his leadership always included the teaching of principles of traditional Vedic Hinduism. But his recommendations on Governmental effort to spread mass education included moral teachings and not religious education. It shows, that he wanted the Government patronised education system to be secular and impartial.

The second most important feature was that Debendranath Tagore created a balanced curriculum in the schools, *Tatvabodhini Pathshalla* taught Modern Science, Social Science and English language along with Bengali. Debendranath's idea of teaching modern subjects in Bengali medium led to the development of Bengali prose and at the same time popularised the Western education among a populace who lacked the knowledge of English. A deep respect towards Bengali was one of the central characteristic features of Debendranath's educational thought.

At a time, when education meant education for the elite, Debendranath had a clear vision about women's education in some way or the other, Debendranath set an example by sending his female family members to modern educational institutions. It must be noted here that this decision was not contradictory of the principles followed in *Tatvabhodhini Pathshala* as those principles were practised regularly at his home. His recommendations for inclusion of agriculture, accountancy and law came at a time when vocational or technological education was mostly neglected by the state.

In the field of education, the greatest success of Debendranath Tagore perhaps lies in the fact, that he was able to communicate his ideals to his youngest son Rabindranath. The establishment of '*Shantiketan Brahmacharyasrama*' by Rabindranath Tagore was an outcome of his father's ideology about education. His ideas about wholesome education (*Sarvangin Shiksha*), mass education and women's education were greatly influenced by his father Maharshi Debendranath Tagore. The incorporation of these ideologies, as expressed in Rabindranath's several writings and essays, was the secret behind the success of one of the major institutions of National Education Movement till today. The concept of nationhood and reverence for his motherland was something that Rabindranath inherited from his father. Bankim Chandra Chattopadhyay, whose spirit of nationalism is beyond doubt, wrote about the limitations of English bookish education in his '*Lokashiksha*' essay. Debendranath reflected on this problem long ago and tried to alter the process in his own capacity, leaving a permanent impact on his



future generation. *Tatvabodhini Pathshala* has not survived, but the two schools in Shantiniketan and Sriniketan still continue to impart knowledge through Gurukul tradition. Palli Shiksha Bhavana or the Department of Agriculture and the Department of Social Work in Sriniketan are inseparable part of Viswa Bharati till this date. The role of State in imparting a secular and impartial education is the need of even today's world. It all shows the relevance of Debendranath Tagore in today's educational scenario, and how he was far ahead of his times.

Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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- ⁱ Chattopadhyay Bandana; Debendranath O Rabindranath: *Oitiya O Swatantryo*, p. 44, 1st Baishakh 1400 Bangabda, Subranarekha, Kolkata
 - ⁱⁱ *Tatvabodhini Patrika*, quoted in Chattopadhyay Bandana, p. 44.
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 - ^{iv} Bagal Yogeshchandra; Debendranath Thakur, 1384 Bangabda, p. 32
 - ^v Thakur Debendranath; *Atmajeebani* ed. By Chakravarty Satish Chandra, 1917, p. 104.
 - ^{vi} Banerjee Brajendranath; *Tagore Debendranath on Schools for The Masses*, vide *The Modern Review*, December 1928, pp. 633 – 34
 - ^{vii} Thakur Debendranath; *Patrabali*, Letter no. 30, quoted in Chattopadhyay Bandana, p. 48.
 - ^{viii} Thakur Rabindranath; *Maharshi Debendranath*, 1375 Bangabda, p. 197

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স্বামী বিবেকানন্দের দৃষ্টিতে আধ্যাত্মিকতা এবং ভারতবর্ষের সামাজিক অগ্রগতি

প্রজ্ঞা ভট্টাচার্য*

সহকারী অধ্যাপিকা, দর্শন বিভাগ, বিবেকানন্দ কলেজ, ঠাকুরপুকুর, কলকাতা: ৭০০০৬৩

সারসংক্ষেপ

স্বামী বিবেকানন্দকে কেবলমাত্র একজন গৃহত্যাগী সন্ন্যাসী বলে মনে করলে ভুল হবে। তিনি ছিলেন অত্যন্ত আধুনিক কুসংস্কার মুক্ত দূরদর্শী পুরুষ। সমাজকে সার্বিক ভাবে এগিয়ে নিয়ে যাওয়ার প্রচেষ্টায় রত হয়েছিলেন তিনি। ধর্মকে কুসংস্কারের কবল থেকে মুক্ত করে প্রকৃত আধ্যাত্মিকতার মধ্য দিয়ে জন মানসের হিত সাধনের চেষ্টায় নিজেকে নিয়োজিত করেছিলেন স্বামীজি। দেশবাসীর সার্বিক উন্নতিকেই তিনি ধর্ম বলে মনে করেছিলেন। শ্রী রামকৃষ্ণের প্রদর্শিত পথে এগিয়ে স্বামীজি হিন্দু ধর্মকে নতুন ভাবে দেখার চেষ্টা করেছিলেন। তাঁর মতে অনাহারে থাকা মানুষ কখনো ধর্মের পথে যাত্রা করতে পারে না। বরং জীবনের বাস্তব সমস্যা সমাধান করতে করতেই একদিন আধ্যাত্মিক পথে পদার্পণ করতে হয়। স্বামীজি প্রদত্ত সেই পথের সন্ধান করাই উক্ত প্রবন্ধের লক্ষ্য।

সূচক শব্দঃ আধ্যাত্মিকতা, স্বামী বিবেকানন্দ, ধর্ম, কর্মযোগ।

মূল প্রবন্ধ

স্বামী বিবেকানন্দ কেবল একজন গৃহত্যাগী সন্ন্যাসী ছিলেন না। তিনি ছিলেন অত্যন্ত আধুনিক কুসংস্কার মুক্ত দূরদর্শী পুরুষ। ভারত আত্মার সামাজিক উন্নয়নের মূর্ত বিগ্রহ তিনি। সমাজকে সার্বিক ভাবে এগিয়ে নিয়ে যাওয়ার প্রচেষ্টায় রত হয়েছিলেন তিনি। ধর্মকে কুসংস্কারের কবল থেকে মুক্ত করে প্রকৃত আধ্যাত্মিকতার মধ্যে দিয়ে জন মানসের হিত সাধনের চেষ্টায় নিজেকে নিয়োজিত করেছিলেন স্বামীজি। এই প্রসঙ্গে উল্লেখ করা যেতেই পারে যে, স্বামীজির কাছে ধর্ম শুধুমাত্র ঈশ্বর আরাধনা ছিল না, বোধ করি তিনি কর্ম, উপাসনা, মনসংযোগ অথবা জ্ঞান এর দ্বারা নিজের মনের ভাব ব্যক্ত করা ও মুক্ত হওয়াকে ধর্ম বলে মনে করেছেন। তিনি আরো বিশ্বাস করতেন যে আমাদের প্রকৃত স্বরূপকে উপলব্ধি করাই ধর্মের মুখ্য উদ্দেশ্য। তাঁর মতে জপ, ধ্যান, শাস্ত্র পাঠ, পূজা অর্চনা করাকে আমরা ধর্ম বলে মনে করলেও এগুলি ধর্মের গৌণ অংশ। বাহ্যিক আচার আচরণ মাত্র। প্রকৃত ধর্ম

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মানুষের সেবা করা। শিব জ্ঞানে জীবের সেবা করাকেই তিনি বিশেষ গুরুত্ব দিয়েছিলেন।^১ সেই কারণেই হয়তো অশিক্ষার অন্ধকারে আচ্ছন্ন ভারতবাসীকে তিনি আলোকজ্জ্বল ভবিষ্যতের দিকে নিয়ে আসতে চেয়েছিলেন। দেশবাসীর সার্বিক উন্নতিকেই তিনি ধর্ম বলে মনে করেছিলেন। তিনি বিশ্বাস করতেন যে পরার্থে কর্মানুষ্ঠান বা কর্মযোগের সাধনাই পারে আমাদের দেশের উন্নতি সাধন করতে।^২

ভারতবর্ষকে স্বামীজী কেবলমাত্র একটি ভূখণ্ড বলে মানতে চাননি। ভারতবর্ষ শুধুমাত্র একটি প্রাচীন বাসভূমি নয়। স্বামীজীর চোখে ভারতবর্ষ পুণ্যভূমি, দেবভূমি। ভারতবর্ষ এক মহান আদর্শের প্রতীক। সে নিজেই যেন এক জীবন দর্শন। দেশ মাতৃকার প্রতি তার ভালোবাসা বোঝা যায় যখন তিনি দৃষ্ট কণ্ঠে বলে ওঠেন "ভারতবর্ষ সম্বন্ধে যখন আমি বলতে আরম্ভ করি, তখন কোথায় গিয়ে থামতে হবে তা কখনো জানিনা।"^৩ দেশ মাতাকে তিনি ঈশ্বরের ন্যায় শ্রদ্ধা করতেন। দেশের প্রতি, দেশের নাগরিকের প্রতি তার ভালোবাসার প্রমাণ পাওয়া যায়, যখন তিনি মৃত্যুর কিছু কাল পূর্বেও অসুস্থ শরীরে সাধারণ মানুষের সাথে দেখা করে তাদের মানসিক ও আধ্যাত্মিক উন্নতির জন্য তাদের সাথে কথা বলতেন, গল্পের ছলে নীতি শিক্ষা দিতেন। শিষ্যরা বাধা দেওয়ায় তিনি এ কথাও বলেছিলেন যে তাঁর এই দেহ গেলেই বা কি আসে যায়-দেহ তুচ্ছ, দেশের লোকের হৃদয়নিহিত আত্মাকে মুক্তির আলোক দেখাবার জন্য তিনি শত শত বার মৃত্যু যন্ত্রণা ভোগ করতে রাজী ছিলেন। কিন্তু যে মহামানবের দেশের প্রতি এমন ভালোবাসা, দুর্ভাগ্যবশত তাঁর আবির্ভাব কালে সেই ভারতবর্ষই ছিল অশিক্ষার অন্ধকারে নিমজ্জিত। পরাধীনতার যন্ত্রণায় কাতর ভারতবাসী ভুলে গেছিলেন তাদের প্রাচীন ঐতিহ্য। স্বামীজীর অন্তরে ছিল আধ্যাত্মিকতার বীজ। সেই কারণে তিনি আধ্যাত্মিক দৃষ্টিভঙ্গি থেকে সমাজের পরিবর্তন সাধন করতে চেয়েছিলেন। প্রতিটি জাতির জীবনের একটি উদ্দেশ্য থাকে। ভারতীয় জনগোষ্ঠীর জীবন গড়ে উঠেছিল ধর্মের উন্নত আদর্শকে কেন্দ্র করে। এই ধর্মীয় আধ্যাত্মিকতার আদর্শই ভারতবর্ষকে অন্যান্য দেশের থেকে স্বতন্ত্র করে রেখেছে। প্রাচীন কালে সেই ধর্মের মধ্যে কোন পঙ্কিলতা ছিল না। কিন্তু কালক্রমে সেই ধর্মকে কিছু ধূর্ত ব্রাহ্মণ, উচ্চ বর্ণের হীন মানুষ কালিমা লিপ্ত করে। দেশের ধর্মীয় ও সামাজিক অন্তর্দ্বন্দ্বের সুযোগ নিয়ে কখনও ভিন ধর্মী কখনো বা বিদেশী শত্রু ভারতবর্ষের উপর আঘাত হেনেছে। আর সাধারণ মানুষ নিজের অজান্তেই এই সব পঙ্কিলতায় নিমজ্জিত হয়ে নিজেকে আর সমাজকে মৃত প্রায় করে তুলেছে। স্বামীজী মনে করতেন যে পূর্বের সেই উন্নত সমাজ সম্পূর্ণ বিলুপ্ত হয়ে যায়নি। সম্পূর্ণ মরেনি। শুধু ছাই চাপা পড়েছে। তিনি সেই অর্ধ মৃত সমাজকে নতুন করে বাঁচাতে চাইলেন। প্রাচীন গৌরব ফিরিয়ে আনতে, বর্তমান দীনতা ও দুর্দশা ঘোচাতে যুব সমাজকে অনুপ্রানিত করে বলে উঠলেন-"ওঠ, জাগো, আর ঘুমিও না; সকল অভাব, সকল দুঃখ ঘুচাবার শক্তি তোমাদের নিজের ভিতর রয়েছে, একথা বিশ্বাস কর, তাহলেই ঐ শক্তি জেগে উঠবে।"^৪ আবার কখনো সিংহের ন্যায় হুঙ্কার দিয়ে বলে উঠেছেন "উত্তীর্ণত জাগ্রত প্রাপ্য বরান্ নিবোধত" -"Arise! Awake! And stop not till the goal reached",^৫ তিনি বিশ্বাস করতেন যে মানুষের পশুত্বের আবরণ অপসৃত করে চির পবিত্র অমর আত্মরূপে প্রকাশ করার জন্য যে শিক্ষার প্রয়োজন সেই শিক্ষা লাভের পুণ্যভূমি এই দেশ। ভারতবর্ষের আধ্যাত্মিক মানসিকতা

মানুষকে সেই শিক্ষা দেয় যা শুধুমাত্র ব্যক্তির মানসিক উন্নয়নে সহায়তা করে না বরং সমাজের সার্বিক উন্নয়নে সাহায্য করে। তাঁর মতে ভারতবর্ষের বায়ু শান্তি প্রধান। ভারতবাসীর মূল মন্ত্র ত্যাগ। স্বামীজী ও তাঁর গুরু শ্রীরামকৃষ্ণের যুগ্মসত্তায় এক সার্থক নবজাগরণের সূচনা হয়। একদিকে শ্রীরামকৃষ্ণের ধর্মীয় ভাবনা ও আধ্যাত্মিকতা অন্য দিকে বিবেকানন্দের যুক্তিবাদী মনের মেলবন্ধনে প্রস্তুত হয় সামাজিক অগ্রগতির সোপান। শ্রী রামকৃষ্ণ স্বামীজীর জীবনে আধ্যাত্মিকতা-বোধের ও সজ্জ শক্তির জাগরণ ঘটাতে চেয়েছিলেন। যোগ্য গুরুর আদর্শ শিষ্য স্বামীজী নিজেকে শুধু ভারতীয় ষড়্দর্শন বা চার্বাক, বৌদ্ধ, জৈন দর্শন বা রামায়ন, মহাভারত ও গীতা উপনিষদের জ্ঞানের মধ্যেই আবদ্ধ করে রাখেননি, পাশ্চাত্যের জড়বাদ, অজ্ঞেয়বাদ থেকে শুরু করে ফরাসী বিপ্লবের ইতিহাস, নানক, কবির প্রমুখর জীবনী পাঠ করে, বিজ্ঞানের বিভিন্ন বিষয়ের জ্ঞান আহরণ করে নিজেকে সমৃদ্ধ করে তুলেছিলেন। ভারতের হিন্দু ধর্মকে দেবতার মন্দিরের চার দেওয়ালের বাইরে বার করে, সমুদ্র পার হয়ে শিকাগোয় বিশ্ব ধর্ম সম্মেলনে যোগ দিয়ে প্রকৃত হিন্দু ধর্মের প্রচার করেছিলেন। যদিও যে সময় স্বামীজী এই ধর্ম প্রচারের উদ্দেশ্যে আমেরিকায় যাত্রা করেছিলেন সেই সময় সমাজের একজন হিন্দু সন্ন্যাসীর পক্ষে সাগরের কালাপানি অতিক্রম করার কথা ভাবাও ছিল দুঃসাধ্য বিষয়। এই সমাজের চোখে এ যেন এক গর্হিত অপরাধ। কিন্তু তিনি কুসংস্কারের অন্ধকার থেকে নিজেকে মুক্ত করে ভারতবর্ষের মহান ঐতিহ্য রূপ হিন্দু ধর্মকে বিশ্বের দরবারে পৌঁছে দেওয়ার জন্য দেশ হতে দেশান্তরে ঘুরে বেড়িয়েছেন। বেদান্ত দর্শনের চিন্তাকে ব্যবহারিক জীবনের উপযুক্ত করে নবরূপে জনগণের সম্মুখে এনে তাদের শিক্ষিত করে তোলার প্রচেষ্টায় তিনি ব্রতী হয়েছিলেন। জাতির অন্তর্গত প্রতিটি মানুষকে উন্নত করে একটি সুন্দর জাতীয় জীবন গঠন করা সম্ভব বলে স্বামীজী বিশ্বাস করতেন। অনেক সময়ই তিনি তথাকথিত পুঁথিগত শিক্ষায় শিক্ষিত যুবকদের মাতৃভূমির সেবা করার কথা বলতেন। হয়ত তিনি ভাবতেন যে এই যুবকরা এই সব বক্তব্যের মর্ম উপলব্ধি করে সমাজের সর্বস্তরে তাঁর এই বার্তা পৌঁছে দিতে পারবে। তাঁর জীবনের সর্ব শ্রেষ্ঠ আদর্শ ছিল পরের কাজে নিজেকে সঁপে দেওয়া। তিনি বিশ্বাস করতেন যে সেবার মধ্যেই সুগু আকারে নিহিত রয়েছে মানসিক শান্তির বীজ। সন্ন্যাসী হয়েও স্বামীজী ভক্তিয়োগের পাশাপাশি কর্মযোগে গভীর ভাবে বিশ্বাস করতেন। তাঁর মনে হয়েছিল যে পরাধীন ভারতবর্ষের অন্ধকার সমাজের ক্লান্ত, পরাজিত অলস মানুষের মনে বৈরাগ্য বা সংসারের প্রতি উদাসীনতা আনার চাইতে কর্মে উৎসাহিত করা অনেক বেশী কঠিন কাজ। এই প্রসঙ্গে বলে রাখা প্রয়োজন যে কর্ম শব্দটি নানা ভাবে ব্যবহৃত হয়ে থাকে। কিন্তু যখন আমরা কর্মযোগের আলোচনা করতে গিয়ে "কর্ম" শব্দটি প্রয়োগ করি তখন কার্য অর্থে শব্দটিকে বুঝতে হবে। তাঁর রচিত কর্মযোগ গ্রন্থের প্রথম অধ্যায়ে তিনি ভগবত গীতা অনুসরণ করে বলেছেন "কর্মেই আমাদের অধিকার, ফলে নয়"। তিনি আরো বলেছেন "ফল যাহা হইবার হউক-উহার সহিত কোন সম্পর্ক রাখিও না। কোন লোক কে সাহায্য করিবার সময় সেই ব্যক্তির ভাব তোমার প্রতি কিরূপ হইবে, সেই বিষয়ে মনে কোনরূপ চিন্তাকে স্থান দিও না।"^৬ স্পষ্টতই বোঝা যায় যে সাধারণ মানুষ যাতে নিঃস্বার্থ ভাবে দেশের জন্য কর্ম সম্পাদন করতে শেখে সে বিষয়ে উৎসাহিত করতেই তাঁর এই রূপ বার্তা। তাঁর মতে মানুষের

অন্তরে নিহিত দেবত্বকে জাগ্রত করে সেই দেবত্বকে দৈনন্দিন জীবনে ফুটিয়ে তুলতে পারলেই মানব সভ্যতার উন্নতি ঘটা সম্ভব। আধ্যাত্মিকতার পথই পারে আমাদের অন্তরের দেবভাবকে জাগ্রত করতে।

শ্রী রামকৃষ্ণের প্রদর্শিত পথে এগিয়ে স্বামীজী হিন্দু ধর্মকে নতুন ভাবে দেখার চেষ্টা করেছিলেন। জীবের সেবাকেই শিবের সেবা মনে করে তিনি আত্মদান করতে প্রস্তুত ছিলেন। তাঁর মধ্যে যে আধ্যাত্মিক জাগরণ হয়েছিল, তা উত্তরাধিকার সূত্রে তিনি তাঁর গুরু শ্রী রামকৃষ্ণের কাছ থেকে লাভ করেছিলেন। ভক্তি, জ্ঞান ও কর্ম যোগের মধ্য দিয়ে জীবের সেবা করার যে পথ তিনি দেখিয়ে গেছেন, মানব জাতির উন্নয়নে তথা দেশের সার্বিক উন্নয়নে তা বিশেষ ভাবে কার্যকর। শ্রী রামকৃষ্ণ একদা বলেছিলেন "তোমাদের চৈতন্য হোক"। তাঁর সুযোগ্য শিষ্য স্বামীজী মানব সেবার মাধ্যমে সেই চৈতন্য উদয়ের পথ প্রশস্ত করেছিলেন। স্বামীজী মানব সেবার যে মহান কার্যে ব্রতী হয়েছিলেন সেই মানসিকতা তিনি যে শুধুমাত্র তাঁর গুরুর কাছে পেয়েছিলেন এমন ভাবা উচিত হবেনা। স্বামীজীর গৃহত্যাগী সন্ন্যাসী পিতামহ দুর্গাপ্রসাদ, পিতা বিশ্বনাথ ও মাতা ভুবনেশ্বরীদেবীও তাঁর মনে মানব সেবার বীজ বপন করেছিলেন। প্রাচ্যের বেদান্তকে মানব-সেবার কাজের অনুশীলনের মাধ্যমে আধ্যাত্মিক প্রয়াসের মানবীকরণ ও সামাজিকীকরণের মধ্য দিয়ে তিনি বিশ্ব বিবেককে জাগ্রত করতে চেয়েছিলেন।^১ আধ্যাত্মিকতায় নিত্যস্নাত শ্রী রামকৃষ্ণ প্রথাগত শিক্ষায় শিক্ষিত না হয়েও কঠোর সাধনার সাহায্যে ঈশ্বরকে উপলব্ধি করেছিলেন। নিজে গৃহী জীবনে বাস করেও কিভাবে কর্মযোগের মাধ্যমে সন্ন্যাস যাপন করতে হয়, ধর্ম পথে চলতে হয় সে শিক্ষা ভক্তদের প্রদান করেছিলেন। তিনি উপলব্ধি করতে পেরেছিলেন যে সত্ত্বগুণের নাম করে সমগ্র দেশের মানুষের মধ্যে বাসা বেঁধেছে আলস্য। পরাধীন দেশের নাগরিক হতভাগ্য ভারতবাসী হীনমন্যতায় ভুগে যে কোন কার্যে উৎসাহ হারিয়েছে। তারা ভুলে গেছে তাদের দেশের অতীত গৌরব। নিজেরা অকর্মণ্য হয়ে দিনাতিপাত করতে করতে তারা নিজের ক্ষতি করছে, এমন কি এরূপ চলতে থাকলে যে তারা পরবর্তী প্রজন্মের জন্য একটি সুন্দর স্বাস্থ্যকর সমাজ উপহার দিতেও ব্যর্থ হবে সে কথাও তারা আর ভাবতে পারে না। এই হতাশাময় জীবন থেকে দেশের নাগরিককে মুক্ত করতে না পারলে দেশের স্বাধীনতা আসবে না। আর সেই সঙ্গে দেশের সামগ্রিক উন্নতিও স্তব্ধ হয়ে যাবে এই চরম সত্য অনুধাবন করেই স্বামীজী কর্মযোগের উপর জোর দিয়েছিলেন। স্বামীজী শ্রীরামকৃষ্ণের যোগ্য উত্তরসূরী রূপে সেবধর্মকে জীবনের আদর্শ করে জন হিতার্থে ব্রতী হয়েছিলেন। তিনি বিশ্বাস করতেন যে সকল উপাসনার সার-শুদ্ধচিত্ত হওয়া এবং অপরের কল্যাণ সাধন করা। দরিদ্র, দুর্বল, রোগী-সকলেরই মধ্যে যিনি শিব দর্শন করেন, তিনি প্রকৃত অর্থে শিবের উপাসনা করেন।^২ তাঁর রচিত কবিতায় নিজের এই মনের ভাব প্রকাশ করে তিনি বলেছিলেন-

"...ব্রহ্ম হতে কীট-পরমানু, সর্বভূতে সেই প্রেমময়,
মন প্রাণ শরীর অর্পণ কর সখে এ সবার পায়।
বহুরূপে সম্মুখে তোমার, ছাড়ি কোথা খুঁজিছ ঈশ্বর?
জীবে প্রেম করে যেই জন, সেই জন সেবিছে ঈশ্বর।"^৩

ভারতবাসীকে উজ্জীবিত করে উপনিষদের উল্লেখ পূর্বক তিনি বলেছিলেন "ন প্রজয়া ন ধনেন ত্যাগেনৈকে অমৃদ্ধমানশুঃ"- অর্থাৎ সন্তান বা ধনের দ্বারা নয়, ত্যাগের দ্বারাই অমৃতত্ব লাভ করা সম্ভব।^{১০} সমগ্র মানব জাতির আধ্যাত্মিক রূপান্তরকেই স্বামীজী ভারতীয় জীবন সাধনার মূল মন্ত্র বলে মনে করতেন। সেই কারণেই বারংবার তিনি ভারতীয়দের বিদেশীদের অন্ধ অনুকরণ, পরমুখাপেক্ষিতা ত্যাগ করে নিজের দেশের প্রকৃত ঐতিহ্যকে অনুসন্ধান করার পরামর্শ দিয়েছেন। তাঁর মনে দৃঢ় বিশ্বাস ছিল যে রাজনৈতিক বা সামাজিক পরিবর্তনের মধ্য দিয়ে মানব জীবনের সামগ্রিক পরিবর্তন সাধন করা সম্ভব নয়। মানুষের দুঃখ-কষ্ট তখনই দূর হবে যখন আধ্যাত্মিক দিক থেকেও সে উন্নত হতে সক্ষম হবে। আধ্যাত্মিক ও নৈতিক শিক্ষা মানুষকে অন্ধকার থেকে আলোর পথে, অসৎ থেকে সতের পথে চালিত করতে পারে। বৃহদারণ্যক উপনিষদে এই প্রার্থনা করেই বলা হয়েছে-

" অসতো মা সদগময়

তমসো মা জ্যোতির্গময়

মৃত্যোর্মামৃতং গময়।" ^{১১}

অর্থাৎ ঈশ্বর যেন আমাদের অসৎ থেকে সতের পথে, অন্ধকার থেকে আলোয়, মৃত্যুর থেকে অমৃতের পথে যেতে সহায়তা করেন। এই একই বক্তব্য ধ্বনিত হয় স্বামীজীর কণ্ঠে। মানুষ যখন নিজের অন্তরাত্মাকে উপলব্ধি করে সততার পথে নিজেকে চালিত করবে তখনই সে সমগ্র মানব জাতিকে সৎ পথে চালিত করতে সক্ষম হবে। স্বামীজী বিশ্বাস করতেন যে মানুষ নিজের ইচ্ছায় নিজের জীবনকে উন্নত করতে পারে। শিক্ষার মধ্য দিয়ে মানুষ নিজের আত্মিক উন্নতি ঘটাতে পারলে সামগ্রিক ভাবে সমাজের উন্নতি সাধন সম্ভব। ধর্ম আর শিক্ষাকে স্বামীজী পৃথক ভাবে দেখতে চাননি। তাঁর মতে শিক্ষা মানুষের অন্তরের সহজাত প্রকাশ। অপর দিকে ধর্ম হল মানুষের অন্তরের সহজাত ব্রহ্মত্বের প্রকাশ। স্বামীজী ধর্মকে শিক্ষার ভিতরকার সার বস্তু বলে মনে করেছেন। সেই জন্য প্রকৃত অর্থে ধর্মকে জানতে হলে যথার্থ শিক্ষায় শিক্ষিত হতে হবে। মনকে অসংখ্য তথ্য দিয়ে পরিপূর্ণ করে রাখাই শিক্ষা নয় বরং মন নামক যন্ত্রকে সম্পূর্ণ বশীভূত করে তোলার নামই শিক্ষা। তিনি ভারতবাসীদের নিদ্রাভঙ্গ করতে চেয়েছিলেন। তাঁর মনে হয়েছিল যে এক শ্রেণীর ভারতবাসী নিজেদের অজান্তেই নিজেদের ক্ষতি করে চলেছে। তারা অজ্ঞাতে পাশ্চাত্যের অন্ধ অনুকরণ করে নিজেদের প্রাচীন ঐতিহ্যকে বর্জন করছে। কিন্তু স্বামীজী একথাই বলতে চেয়েছিলেন যে নিজ দেশের প্রাচীন ঐতিহ্যকে সামগ্রিক ভাবে বর্জন না করেও জীবনে আধুনিকতা আনা সম্ভব। যে আধুনিকতা সমাজ তথা দেশের প্রকৃত উন্নতি করতে পারে। ভারতবর্ষের উন্নতি করতে হলে জনসাধারণের জীবনযাত্রার মান উন্নয়ন করার পাশাপাশি দরিদ্র ব্যক্তির দারিদ্র দূর করতে হবে, ক্ষুধার্ত ব্যক্তির ক্ষুধা বৃদ্ধি করতে হবে, আবার একই সঙ্গে বিজ্ঞান সাধনাও করতে হবে। ক্ষুধার্ত ব্যক্তির পক্ষে ধর্ম চর্চা সম্ভব নয়। তাই তো তিনি বলেছিলেন "যে ভগবান আমায় রুটি দিতে পারেন না, সে ভগবানে আমার বিশ্বাস নেই।"^{১২} তিনি দেশবাসীকে পাশ্চাত্য সমাজের রজ গুণ অনুসরণ করতে বলেছিলেন। যে রজগুণের অধিকারী হলে

ভারতবাসী বিপ্লবের মধ্য দিয়ে নিজেদের দুঃখ দূর করতে পারবে। কারণ সামাজিক বিপ্লব পারে মানুষের দারিদ্র দূর করতে। অনাহারে থাকা মানুষ কখনো ধর্মের পথে যাত্রা করতে পারে না। আধ্যাত্মিক চিন্তার পথে বাধা হয়ে দাঁড়ায় তার ক্ষুধা তৃষ্ণার বোধ। দারিদ্র দূর হলে সে আধ্যাত্মিক চিন্তায় মনোনিবেশ করতে পারে। নিজের আত্মিক উন্নতির কথা ভাবতে পারে। সেই কারণে সবার আগে দারিদ্র দূর করতে হবে। তার জন্য প্রয়োজন শিক্ষার। শিক্ষার আলোয় আলোকিত মানুষ পারে নিজের যোগ্যতা দিয়ে সং পথে অর্থ উপার্জন করে দারিদ্রের দুঃখ মোচন করতে। অর্থাৎ একথা স্পষ্ট যে জীবনের বাস্তব সমস্যা সমাধান করতে করতেই একদিন আধ্যাত্মিক পথে পদার্পণ করতে হয়। সন্ন্যাসী বিবেকানন্দ আধ্যাত্মিকতার কথা বললেও তাঁর আধ্যাত্মিকতার সাথে আধুনিক জীবন বা বিজ্ঞান শিক্ষার কোন দ্বন্দ্ব হয়নি। তিনি স্বয়ং নিজের গুরু শ্রী রামকৃষ্ণকে যাচাই করে নিয়েছিলেন। ঠিক তেমনি সাধারণ মানুষকেও অন্ধ ভাবে ধর্ম পথে পাড়ি না দিয়ে ধর্মকে যাচাই করে নিতে বলেছিলেন। সেই জন্যই তিনি বলেছিলেন "অন্ধ বিশ্বাস করা অন্যায্য; নিজের বিচারশক্তি ও যুক্তি খাটাইতে হইবে। কার্যে করিয়া দেখিতে হইবে যে, শাস্ত্রে যাহা লিখিত আছে তাহা সত্য কিনা"^{১৩} আমরা যেভাবে জড় বিজ্ঞানের শিক্ষা গ্রহণ করি ঠিক একই ভাবে ধর্ম বিজ্ঞানের শিক্ষা অর্জন করার উপদেশ দিয়েছিলেন স্বামীজী। যোগীগণ বলেন ধর্মের সত্য অনুভব না করলে প্রকৃত ধর্মকে জানা যায় না। আর প্রকৃত ধর্মকে জানতে হলে আত্মাকে চিনতে হবে। যোগ সাধনার দ্বারা সেই আত্মা রূপ সত্যকে উপলব্ধি করা সম্ভব। স্বামীজীও এই মতে বিশ্বাসী ছিলেন। তাই যুব সমাজকে উদ্যোগ করে কর্মযোগের পাশাপাশি রাজযোগের পথ অবলম্বন করতে বলেছিলেন। এই রাজযোগ আমাদের নিজের অন্তর আত্মাকে পর্যবেক্ষণ করতে শেখায়। অষ্টাঙ্গ যোগ শিক্ষা লাভের মাধ্যমে একাগ্রতা শক্তি অর্জন করতে সক্ষম হলে যোগী প্রকৃত ধর্মকে জানতে পারবেন। আসলে যোগ কোন অলৌকিক বিষয় নয়। যোগ হ'ল একপ্রকার বিজ্ঞান, যা মানব দেহের মেরুদণ্ডের মধ্যে অবস্থিত ইড়া ও পিঙ্গলা নামক স্নায়বীয় শক্তি প্রবাহ এবং মেরুদণ্ড ও মজ্জার মধ্যে স্থিত সুষুম্না নামক নালীর নিম্ন দেশে অবস্থিত কুন্ডলিনীর শক্তিকে জাগ্রত করার পদ্ধতি বিশেষ। কুন্ডলিনী জাগ্রত হলে তা সেই শূন্য নালীর মধ্য দিয়ে বেগে উর্ধ্ব মুখে যাত্রা করে। আর তখনই যোগী স্বাভাবিক মানুষের তুলনায় অতিরিক্ত কিছু ক্ষমতা অর্জন করেন। এই ভাবে দীর্ঘ দিন সাধনার ফলে কুন্ডলিনী মস্তকে উপস্থিত হলে সম্পূর্ণ রূপে শরীর ও মন থেকে পৃথক রূপে নিজের আত্মাকে মুক্ত ভাবে অনুভব করতে সক্ষম হন।^{১৪} শারীরবৃত্তীয় এই পদ্ধতিকে এক বিশেষ ধরনের বিজ্ঞান না বলার অবকাশ নেই। যুক্তি দিয়ে স্বামীজী সে কথা তার রাজযোগ গ্রন্থে বুঝিয়ে দিয়েছেন। আর প্রকৃত ধর্ম যেহেতু আমাদের মুক্তির পথ দেখায়, তাই যথাযথ ধর্মকে বিজ্ঞান হিসেবে গণ্য করা যেতে পারে। সাধারণ মানুষ নিজেকে সম্পূর্ণ রূপে যোগীতে পরিণত করতে না পারলেও দীর্ঘ দিনের যোগ অভ্যাস তাকে সংকীর্ণতা থেকে মুক্ত হতে সাহায্য করবে। পরিচ্ছন্ন মনে ব্যক্তি সমাজের হিতার্থে কাজ করার শক্তি লাভ করতে পারবে। যে দেশের নাগরিক স্বচ্ছ চিন্তার অধিকারী হওয়ার শিক্ষা পায়, একদিন সে দেশ অগ্রগতির শিখরে পৌঁছাতে পারে বলে স্বামীজী বিশ্বাস করতেন।

আসলে স্বামীজী নিজের চিন্তা ভাবনায় সর্বদা আধুনিকতার ছাপ রেখেছেন। তিনি দেশের কথা ভাবতে গিয়ে একদিন এই সত্য অনুধাবন করেছিলেন দেশের সামগ্রিক উন্নতি তখনই সম্ভব যখন দেশের প্রতিটি নারী পুরুষ শিক্ষিত হবে। তিনি বলেছিলেন "There is no chance of the welfare of the world unless the condition of women is improved. It is not possible for a bird to fly on one wing."^{১৫}

একথা সত্যিই অনস্বীকার্য যে দেশের প্রতিটি পরিবার যখন কুসংস্কার মুক্ত হয়ে সমাজ তথা জাতির উন্নতির জন্য অগ্রসর হয় তখনই দেশের সামগ্রিক অগ্রগতি সম্ভব। আর নারী পুরুষ উভয়ের সমান ভাবে উন্নতি না হলে পরিবারের সার্বিক উন্নতি ব্যাহত হয়। কারণ একটি পরিবারের শিশু জন্মের পর পিতা মাতা উভয়ের কাছ থেকেই প্রাথমিক শিক্ষা অর্জন করে। শিশুরাই দেশের ভবিষ্যৎ নাগরিক। আর সেই শিশুদের মানসিক বিকাশ তখনই পরিপূর্ণতা লাভ করবে যখন পরিবারের প্রতিটি সদস্য উন্নত চিন্তার অধিকারী হয়ে শিশুকেও প্রকৃত অর্থে মানুষ হওয়ার শিক্ষা দিতে সক্ষম হবে। তিনি মনে করতেন যে শুধু পুরুষের উন্নতির কথা ভাবলেই চলবে না।। আমাদের দেশে নারীর ভালো মন্দর কথা তার সুখ সুবিধার কথাকেও ভাবে না। উন্নত চিন্তার অধিকারী স্বামীজী বিশ্বাস করতেন যেখানে স্ত্রীলোকেরা সুখী, সেই পরিবারের উপরে ঈশ্বরের কৃপা বজায় থাকে। তিনি স্ত্রী জাতিকে মহাশক্তি রূপে কল্পনা করেছিলেন। তাঁর মনে হয়েছিল যে, স্ত্রী জাতির অসম্মান করে আমাদের দেশের জন সাধারণ এই শক্তির অবমাননা করেছে। আর তাই দেশের উন্নতিও স্তব্ধ হয়ে গেছে। নিজের পরিবারের উন্নতি কল্পে সমাজের উন্নতির স্বার্থে যদি নারীরা এগিয়ে আসতে সক্ষম হয় তাহলেই সমাজের সামগ্রিক বিকাশ সম্ভব হবে।

একজন সন্ন্যাসী রূপে স্বামীজী নিজেকে কেবল মূল্যবান মূর্তিরূপে ইশ্বর আরাধনার মধ্যে সীমাবদ্ধ করে রাখেন নি। বরং নররূপী নারায়ণের সেবায় ব্রতী হয়েছেন। তাঁর দেহাবসানের পরও যাতে সেবার কার্য স্তব্ধ না হয়ে যায় সেই কারণে বেলেড়ো নিজের গুরু শ্রী রামকৃষ্ণের নামাঙ্কিত মঠ ও মিশন প্রতিষ্ঠা করেছেন। দেশে বিদেশে ছড়িয়ে দিয়েছেন এই মঠের বিভিন্ন শাখা। যাতে সমাজ সেবার আদর্শ কেবলমাত্র ভারতবর্ষের মধ্যেই সীমিত না থাকে। যেতে যেতে দৃষ্ট কণ্ঠে বলে গেছেন-"আমরণ কাজ করে যাও - আমি তোমাদের সঙ্গে সঙ্গে রয়েছি, আর আমার শরীর চলে গেলেও আমার শক্তি তোমাদের সঙ্গে কাজ করবে।"^{১৬} তাঁর এই সহায় বাণী আজও আমাদের এগিয়ে নিয়ে যেতে পারে। আমরা এই বাণীকে মনের মন্ত্র করে এগিয়ে চললে এক দিন নিশ্চয়ই আমাদের দেশও জগৎ সভায় শ্রেষ্ঠ আসন গ্রহণ করতে সক্ষম হবে।

Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable



গ্রন্থপঞ্জি

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- ১১/ ভট্টাচার্য্য সমরেন্দ্র। ২০১০। ভারতীয় দর্শন। কলকাতা। বুক সিডিকিট প্রাইভেট লিমিটেড
- ১২/ দত্ত ডঃভূপেন্দ্রনাথ। স্বামী বিবেকানন্দ; স্বামী বিবেকানন্দঃজাতীয় ভাবধারা; পৃষ্ঠাঃ:১৭১ প্রকাশনাঃ নবভারত পাবলিশার্স
- ১৩/ বিবেকানন্দ স্বামী। রাজযোগ; ১ম অধ্যায়; পৃষ্ঠাঃ ১৩; প্রকাশনাঃ উদ্বোধন কার্যালয়
- ১৪/ বিবেকানন্দ স্বামী। রাজযোগ; পৃষ্ঠাঃ:৪৯; প্রকাশনাঃ উদ্বোধন কার্যালয়
- ১৫/ <http://www.scribd.com/document/51163064/SWAMI-VIVEKANANDA-EDUCATION-OF-WOMEN>)
- ১৬/ নিরাময়ানন্দ স্বামী। স্বামীজীর আহ্বান। পৃষ্ঠাঃ ৮৪; কলকাতা। প্রকাশনাঃ উদ্বোধন কার্যালয়

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চণ্ডালিকা: রূপ ও রূপান্তরে

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নিত্য পরিবর্তনশীলতা রবীন্দ্র সৃষ্টির অন্যতম বৈশিষ্ট্য। প্রত্যেক শিল্পীর মধ্যে থাকে এক অতৃপ্তি, আত্মপ্রকাশের অতৃপ্তি। আত্মপ্রকাশের অতৃপ্তি থেকেই স্রষ্টার সৃষ্টির নবরূপ লাভ করে। তাঁরা যে ভাবের দ্বারা আক্রান্ত হন, তাকে পরিপূর্ণভাবে রূপদান করতে চান। এটাই স্রষ্টার প্রথম শর্ত বা লক্ষ্য। কিন্তু কখনো কখনো নিজেরই অসাধারণতার কারণে বা পারিপার্শ্বিক পরিস্থিতির চাপে তিনি তাঁর অনুভূতির তীব্রতা ও গভীরতাকে স্পষ্ট রূপে ব্যক্ত করতে পারেন না। ফলে, তার মধ্যে আরেক ধরনের অতৃপ্তি জেগে ওঠে। পূর্ণতার অতৃপ্তি। তিনি যা বলতে চান, দেখাতে চান পাঠককে - একসময় মনে হয় তিনি সেটা যথার্থভাবে পারেননি। ফলে তাঁর সৃষ্টিকে ভেঙে আরেক নতুন সৃষ্টি গড়ে তোলেন। আপাত দৃষ্টিতে মনে হতে পারে যে এগুলি এক কিন্তু কবির ভাবনালোকের বৈচিত্র্য ও তাৎপর্য প্রত্যেকটি রচনাকে নতুনত্ব দান করে। *চণ্ডালিকা*র বিভিন্ন রূপ - গদ্য থেকে পদ্য বা নৃত্যনাট্যে রূপান্তরের মধ্যেও তাঁর এই মানসিকতা খুঁজে পাওয়া যায়।

*চণ্ডালিকা*র (১৯৩৩) গদ্যরূপের প্রথম দৃশ্যে আমরা দেখতে পাই আনন্দের স্মৃতি এবং তার কথায় মুগ্ধ প্রকৃতি। বর্ণভেদের পঙ্ক থেকে উদ্ধারের জন্য উদগ্রীব হয়ে হঠাৎ তার হৃদয়। সে তার মাকে জানিয়েছে তার হৃদয়ের আর্তি, কখনো কথায়, কখনো গানে। দুটি চরিত্র আবর্তিত হয়েছে প্রথম দৃশ্যে। স্মৃতিতে এসেছে রাজার ছেলে, যে প্রকৃতির রূপে মুগ্ধ আর আনন্দ; যে প্রকৃতিকে নবজীবন দান করেছে। অন্যদিকে *চণ্ডালিকা* (১৯৩৮) নৃত্যনাট্যে প্রথম দৃশ্যে তীব্রতা পেয়েছে জাতিভেদে। ফুলওয়ালীর দলের কাছে প্রকৃতি ফুল চাইতেই তাকে ঘৃণা করে চলে গেল। দইওয়ালার কাছে দই কিনতে চাইলে এবং চুড়িওয়ালার কাছে চুড়ি নিতে হাত বাড়ালে প্রকৃতিকে শুনতে হয়েছে, “ওকে ছুঁয়ো না, ছুঁয়ো না, ছি,/ ও যে চণ্ডালিনীর বি” রবীন্দ্রনাথ ঠাকুর জাতিভেদের তীব্রতাকে সভ্যতার সংকটরূপে প্রকাশ করার জন্যে *চণ্ডালিকা* নৃত্যনাট্যে দইওয়ালী, ফুলওয়ালী, ও চুড়িওয়ালাদের চরিত্র এনেছেন। এই ঘৃণা, এই অবজ্ঞার প্রতিবাদে প্রকৃতি সংকল্প করেছে -

“যে আমাদের পাঠাল এই

অপমানের অঙ্ককারে

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পূজিব না, পূজিব না, সেই দেবতারে, পূজিব না।
কেন দিব ফুল, কেন দিব ফুল,
কেন দিব ফুল আমি তারে-
যে আমারে চিরজীবন
রেখে দিল এই ধিক্করে। ” (*চণ্ডালিকা* , নৃত্যনাট্য, প্রথম দৃশ্য)

প্রকৃতি এখানে ধর্মের বিরুদ্ধে প্রতিবাদ করছে, যে ধর্ম জাতপাত সৃষ্টি করে, যে ধর্ম মানুষের অস্তিত্ব অস্বীকার করে, আমিত্বের কোন জায়গা নেই যে ধর্মে , প্রকৃতি তার প্রতিবাদ করছে। আসলে রবীন্দ্রনাথ *চণ্ডালিকা* নৃত্যনাট্যের প্রথম দৃশ্যে জাতপাত ভেদাভেদ, মানবতার অপমানের তীব্রতাকে উপস্থিত করতে চেয়েছেন। *চণ্ডালিকা*র গদ্যরূপের থেকে নৃত্যনাট্যে রূপান্তর এই জন্যই জরুরি হয়ে উঠেছে। এখানে প্রকৃতি নিজের সঙ্গে নিজে লড়াই করে জয়ী হতে চেয়েছে, প্রতিজ্ঞা করেছে বার বার করে। গদ্যনাট্যের প্রথম দৃশ্যে আনন্দ শুধু স্মৃতিতেই জাগ্রত, আর *চণ্ডালিকা* নৃত্যনাট্যের প্রথম দৃশ্যে আনন্দকে আমরা প্রত্যক্ষ করি। তিনি প্রকৃতিকে বলেছেন,

“যে মানব আমি সেই মানব তুমি কন্যা
সেই বাড়ি তীর্থবারি
যাহা তৃপ্তি করে তৃষিতেরে,
যাহা তাপিত শান্তরে ম্লিঙ্ক করে
সেই তো পবিত্র বারি, ” (*চণ্ডালিকা*, নৃত্যনাট্য, প্রথম দৃশ্য)

আসলে আনন্দের উপস্থিতির মাধ্যমে রবীন্দ্রনাথ দর্শক মনে প্রকৃতির বেদনা, জাতিভেদ, বর্ণভেদ, সামাজিক অবমাননা তীব্র করে মুক্তির দিশা দিতে চেয়েছেন। আমরা *চণ্ডালিকা* গদ্যনাট্যে প্রকৃতির মায়ের মন্ত্রপাঠ এবং মায়াদর্পণের প্রসঙ্গ নৃত্যনাট্যের তৃতীয় দৃশ্যে নাটকীয়ভাবে উপস্থাপিত হতে দেখি। রাজবাড়ির অনুচরের মুখ দিয়ে সে খবর পাঠকের কাছে পৌঁছায়। আসলে নৃত্যনাট্যে আমরা দেখতে পাই প্রথম অধ্যায়টিতে অপ্রত্যক্ষ প্রত্যক্ষে এনেছেন অর্থাৎ এই অধ্যায়টি নবনির্মাণ বলা চলে। রবীন্দ্র ভাবনাকে পরিপূর্ণ এবং তীব্রভাবে দর্শকের সামনে উপস্থিত জন্যে প্রথম দৃশ্যের অবতরণ।

গদ্যনাট্যের প্রথম অধ্যায়কে রবীন্দ্রনাথ নৃত্যনাট্যের দ্বিতীয় অধ্যায়ে উপস্থিত করেছেন। এখানেও পরিবর্ধন, পরিমার্জন ঘটিয়েছেন তিনি। *চণ্ডালিকা*র গদ্যনাট্যে আমরা দেখতে পেয়েছিলাম মা মেয়ের প্রত্যক্ষভাবে উপস্থিত, পথে শ্রমণেরা মন্ত্র পাঠরত। এছাড়া আনন্দ এবং রাজার ছেলে চরিত্র দুটি স্মৃতিচারণায় উপস্থিত। এদের মধ্যে আনন্দ আবার সকল কথায়, ভাবনায়, গানে রয়ে গেছে। নৃত্যনাট্যের প্রথম অধ্যায় শেষ হওয়ার পূর্বেই শেষ হয়ে যাচ্ছে।

নৃত্যনাট্যের দ্বিতীয় দৃশ্য শুরু হচ্ছে বৌদ্ধনারীদের মন্দিরে প্রবেশ দিয়ে। প্রকৃতি, তার মা, রাজার অনুচর, প্রকৃতির মায়ের শিষ্যদল, বৌদ্ধভিক্ষুগণ - এরা প্রত্যেকেই প্রত্যক্ষভাবে উপস্থিত আর আনন্দ পরোক্ষভাবে। নৃত্যনাট্যে নৃত্যনাটককে আরও বোধগম্য এবং নাটকীয় করে তোলার জন্যে রবীন্দ্রনাথ প্রত্যক্ষ চরিত্র বেশী এনেছেন। ১৯৩৩ থেকে ১৯৩৮ এ যখন তিনি পুনর্নির্মাণ করলেন *চণ্ডালিকা* নাটককে, তখন তিনি অনুভব করেছিলেন, নাট্যরস দর্শকদের পূর্ণরূপে আত্মাদিত করাতে গেলে প্রত্যক্ষ ঘটনা এবং প্রত্যক্ষ চরিত্র নির্মাণ বেশি দরকার।

নৃত্যনাট্যের তৃতীয় দৃশ্য শুরু হচ্ছে গদ্যনাট্যের প্রথম দৃশ্যের শেষের দিকে যেখানে প্রকৃতি বলছে, “ঐ দেখ, পশ্চিমে জমল মেঘ, ঝড়ের মেঘ। মন্ত্র খাটবে, মা, খাটবে। উড়ে যাবে শুষ্ক সাধনা, শুকনো পাতার মতো। নিববে বাতি।” (*চণ্ডালিকা*, গদ্যনাট্য, প্রথম দৃশ্য)

“ওই দেখ পশ্চিমে মেঘ ঘনালো,

মন্ত্র খাটবে মা, খাটবে-

উড়ে যাবে শুষ্ক সাধনা সন্ন্যাসীর

শুকনো পাতার মতন।” (*চণ্ডালিকা*, নৃত্যনাট্য, তৃতীয় দৃশ্য)

অলংকারের অভিনবত্বে নৃত্যনাট্য অনেক বেশী মর্মস্পর্শী।

রবীন্দ্রনাথ ঠাকুরের *চণ্ডালিকা* গদ্যনাট্য ও নৃত্যনাট্যের মধ্যে সংরূপগত পার্থক্য হচ্ছে গদ্যনাট্য গদ্যসংলাপ ও গানের মাধ্যমে উপস্থাপন করা আর নৃত্যনাট্য নৃত্যসহযোগে সংগীতের মাধ্যমে উপস্থাপন করা। তাই গদ্যনাট্যের অনেক গান নৃত্যনাট্যে বর্জন করেছেন। গদ্যনাট্যে আমরা পনেরোটি সংগীত দেখতে পাই। গদ্যনাট্যের মাত্র চারটি সংগীতকে নৃত্যনাট্যে গ্রহণ করা হয়েছে। আমরা দেখতে পাই রবীন্দ্রনাথ ঠাকুর নৃত্যনাট্যের প্রয়োজনে এই সংগীত গুলোর অবস্থানগত পরিবর্তন ঘটিয়েছেন। ভাব, ভাষা এবং পরিস্থিতি সাথে সাযুজ্য রাখা এর প্রধান কারণ।

চণ্ডালিকা গদ্যনাট্য এবং নৃত্যনাট্যের উভয়েরই নাম এক। রচনার ব্যবধান পাঁচ বছর। কাহিনী অপরিবর্তিত। পরিবর্ধন, পরিমার্জন, পরিবর্তন করে আঙ্গিকগত পরিবর্তন করা হয়েছে। উপস্থাপন রীতির এই পরিবর্তন ফলে গদ্যরূপের কাহিনী পদ্যে অর্থাৎ সংগীতে পরিণত হয়েছে। তাই শব্দ প্রয়োগের ক্ষেত্রে তিনি কাব্যিক শব্দ চয়ন করেছেন। লোকপ্রচলিত শব্দরূপ থেকে তিনি তার তত্ত্ব ও তৎসম রূপকে নৃত্যনাট্যে জায়গা দিয়েছেন।

“যে মানুষ আমি তুমিও সেই মানুষ, সব জলই তীর্থজল যা তাপিতকে স্নিগ্ধ করে, তৃপ্ত করে তৃষিতকে।” (*চণ্ডালিকা*, গদ্যনাট্য, প্রথমদৃশ্য)

“যে মানব আমি সেই মানব তুমি কন্যা

সেই বাড়ি তীর্থবারি

যাহা তৃপ্তি করে তৃষিতেরে," (চণ্ডালিকা, নৃত্যনাট্য, প্রথম দৃশ্য)

উদাহরণ দুটিকে লক্ষ্য করলে দেখতে পাচ্ছি যে, ‘মানুষ’ হয়েছে ‘মানব’, ‘জল’ হয়ে গেছে ‘বারি’।

“তাকিয়ে বসে থাকব না, মন্তর জানিস তুই, সেই মন্তর হোক আমার বাহুবন্ধন, আনুক তাকে টেনে।”
(চণ্ডালিকা, গদ্যনাট্য, প্রথম দৃশ্য)

“ওগো মা, ওই কথাই তো ভালো

মন্ত্র জানিস তুই,

মন্ত্র পড়ে

দে তাঁকে তুই এনে।” (চণ্ডালিকা, পদ্যনাট্য, দ্বিতীয় দৃশ্য)

এখানে 'মন্ত্র' শব্দ 'মন্তর' হয়েছে।

এছাড়াও ‘পুড়ে’র পরিবর্তে ‘জ্বলনে’; ‘নিন্দে’র স্থানে ‘নিন্দা’, ‘মিথ্যে’র খানে মিথ্যা, ‘ঝড়’র পবিত্রে ‘ঝঞ্ঝা’, ‘বুক’-এর স্থানে ‘বক্ষ’ এবং ‘দর্পন’-এর স্থানে ‘আয়না’ ব্যবহৃত হয়েছে।

গদ্যনাট্য থেকে নৃত্যনাট্যে রূপান্তরের সময় মুখের গদ্য সংলাপকে সাংকেতিক রূপ দিতে হয়েছিল রবীন্দ্রনাথ ঠাকুরকে। গদ্য তাই পরিবর্তিত হয়েছিল পদ্যে, পদক্রমেও দেখা গিয়েছিল তার প্রভাব। শব্দের বাক্যের গ্রহণ বর্জন ঘটেছে। যেমন,

“পুরানকথা শুনেছি, উমা তপ করেছিলেন ঘর ছেড়ে বাইরে, রোদে পুড়ে, তোর কি তাই হল?” (চণ্ডালিকা, গদ্যনাট্য, প্রথম দৃশ্য)

নৃত্যনাট্যে আমরা দেখতে পাই এই কথাগুলোই নবরূপ লাভ করেছে একটু পরিবর্তিত হয়ে।

“পুরাণে শুনি না কি তপ করেছেন উমা

রোদের জ্বলনে,

তোর কি হল তাই?” (চণ্ডালিকা, পদ্যনাট্য, দ্বিতীয় দৃশ্য)

পাপ-পুণ্য, কল্যান-অকল্যানের ধারণায় গদ্যরূপ আর পদ্যরূপ যে পরিবর্তন হয় রবীন্দ্রনাথ ঠাকুর তাই দেখিয়েছেন তার চণ্ডালিকার রূপান্তরের মধ্যে।

গদ্যনাট্যের প্রথম দৃশ্যের শেষ থেকে শুরু করে দ্বিতীয় দৃশ্যের পুরোটাই নৃত্যনাট্যের তৃতীয় দৃশ্যে এসে যুক্ত হয়েছে। মা, তার কন্যাকে জাতপাতের লাঞ্ছনা, গঞ্জনার থেকে মুক্ত করার জন্যে উচ্চারণের করেছে আনন্দকে ফিরিয়ে আনার মন্ত্র। যে মন্ত্র তার প্রাণ, শরীরকে অবশ করে জীবন পর্যন্ত উৎসর্গ করে কন্যার জন্মগত পাপমুক্তি ঘটিয়েছেন। নৃত্যনাট্যের তৃতীয় দৃশ্যে আমরা কিন্তু দেখতে পাই আনন্দ 'নাগপাশ-বন্ধন মন্ত্র'-র বিষ সয়েও অসীম ক্ষমায় উচ্চারণ করেছেন "কল্যান হোক তব, কল্যানী" প্রকৃতির মা মৃত্যু বরণ না করে সকলের সঙ্গে উচ্চারণ করেছেন,

বুদ্ধো সুসুদ্ধো করুণামহাশিবো,
যোচ্চন্ত সুদ্ধবর এগ্নলোচনো
লোকস্ম পাপুপকিলেসঘাতকো
বন্দামি বুদ্ধং অহমাদরেণ তাং।। (চণ্ডালিকা, তৃতীয় দৃশ্য)

Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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Pedagogy in times of Covid-19: a case study of students' responses from rural Howrah

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Abstract:

The rapid outbreak of corona virus pandemic and the subsequent lockdown had brought all activities to a halt. All public and private institutions had to be closed down. People were directed to physically restrict themselves at home. The only medium of interactions could be achieved through electronic communication. In the field of education too, online teaching learning became a regular part and parcel of the curriculum. In this background, a survey was conducted that aimed to assess the teaching learning experiences of students of a college in the district of rural Howrah, West Bengal during the coronavirus pandemic. A Google Form anonymous questionnaire was sent by WhatsApp Messenger to students as well as informal interviews were conducted among students of odd semester for the academic year 2021-22. Seventy-two students answered the questionnaire. As a new experience, there was a mixed reaction from students regarding online participation. This could give a probable direction that hybrid education can take. Furthermore, it can give a direction to the priorities that policy making can take for the development of in the rural education and include a detailed plan for the future.

Keywords: lockdown, infection, education, online, student

Introduction

With the spread of globalization, the risks have increased manifold. One such consequence has been the spread of a disease which has affected the lives of one and all. The corona virus pandemic has affected the lives of all sections of society. People were asked to self-quarantine

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in their homes to prevent the spread of the virus. The state directed lockdown has had serious implications on the education system as schools and colleges were closed down. As a result, online learning and classes are increasingly becoming part of the curriculum worldwide. For the Indian education system, moving towards online teaching and learning was a paradigm shift in the domain. As per the 2011 census, 72.2% of the population lives in rural areas, about 638,000 villages and the remaining 27.8% lives in more than 5,100 towns and over 380 urban agglomerations. A major challenge was to continue the process of education among all the educational institutions. Inadequate digital infrastructure in rural India had to be accommodated according to the 21st Century.

Rationale of the Study

The study was conducted to look into the adaptability and progress of online teaching learning among rural students. At a time marked by acceptance of online education as the only medium of dissemination of knowledge, this study intends to bring out the views of the major stakeholders of the system, the students. Pandemic threw a serious challenge to students from rural background as there are infrastructure and connectivity problems. Irrespective of this, how far could online teaching reach out to these students is the main objective of my study. This study would help in throwing light into digital and education policy making by future governments.

Literature review

There is a wide variety of literature regarding perceptions of online education facilities and its effectivity. Aman Jindal and Dr. B P S Chahal (2018) have identified key factors which will boost online education in India and the major hurdles that need to be overcome.

An ORF Research paper by Rammohan Khanapurkar (2020) analyses the state of digitalised education in India. It outlines current government guidelines on digital-mode schooling, and uses the case of Maharashtra's five-year-old efforts at digitalising government schools to gauge preparedness for implementing the guidelines.

Muthuprasad, T. et al. (2021) focuses on understanding students' perception and preference towards the online learning through an online survey of students at a private university.

Chakraborty, Pinaki, et al. (2021) survey in which we asked undergraduate students in an Indian university about their opinion on different aspects of online education during the ongoing pandemic.

Kundu, Arnab, and Tripti Bej. (2021) examines how far and of what depth online education has made its place among students' minds need to be studied to leverage its full potential to transform students' learning needs.

Materials and Methods:

In order to explore the impact of this pandemic on the education process of students, a Google form questionnaire- based survey was conducted to the sixth semester students. Seventy-two students responded who were of different age groups from a rural college in Howrah, India. Apart from this, informal interviews were taken via phone conversations and Google meet platform.

Results and Interpretations:

The responses of students in google form is plotted through different graphs. Majority of the students find online teaching helpful in absence of alternative offline mode. Though from informal discussion with teachers it came to the researchers attention that there was multiple disruptions in online and network connectivity, the process could be sustained due to active participation of teachers.

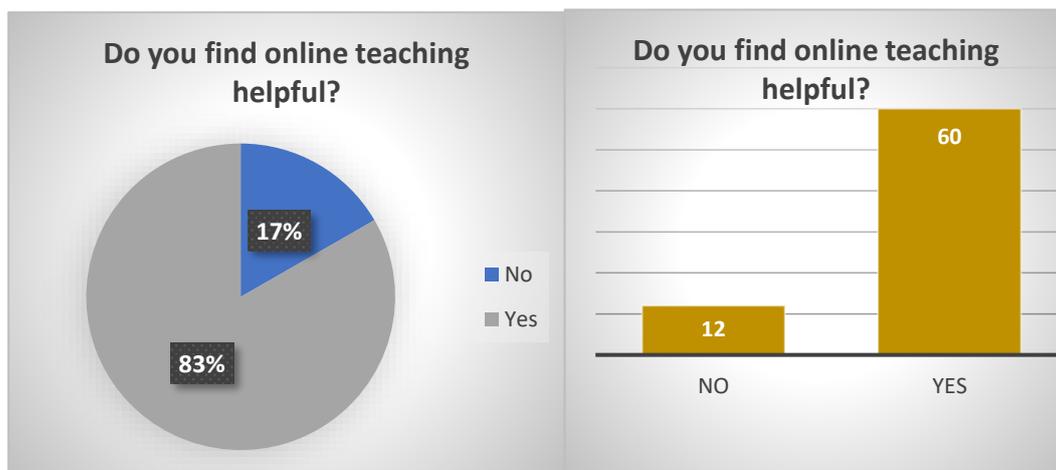


Figure 1: (1) Pie chart showing the percent of respondents found online teaching helpful, (2) Bar diagram showing the number of respondents found online teaching helpful.

Online education was more or less helpful for students to keep in touch and proved effective. Final as well as mid term exams were conducted keeping the online process intact.

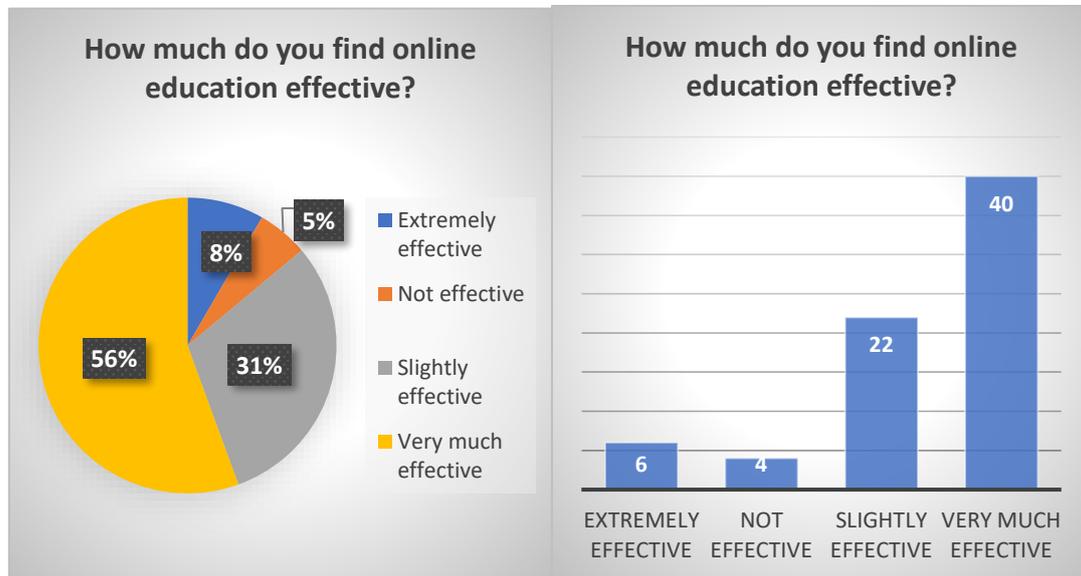


Figure 2: (1) Pie chart showing the percent of respondents found online teaching effective, (2) Bar diagram showing the number of respondents found online teaching effective

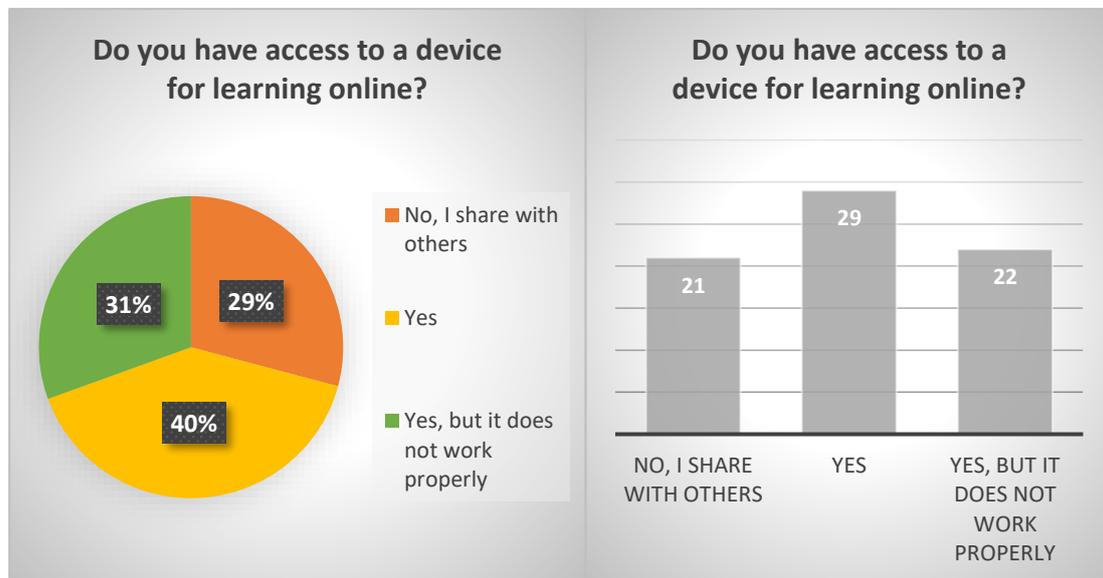


Figure 3: (1) Pie chart showing the percent of respondents who have own access to device, (2) Bar diagram showing the number of respondents who have own access to device.

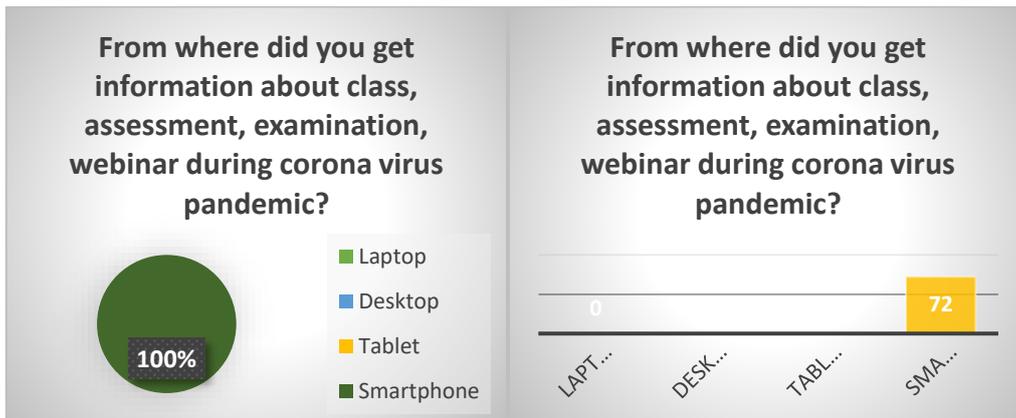


Figure 4: (1) Pie chart showing the percent of the source of online information, (2) Bar diagram showing the source of online information

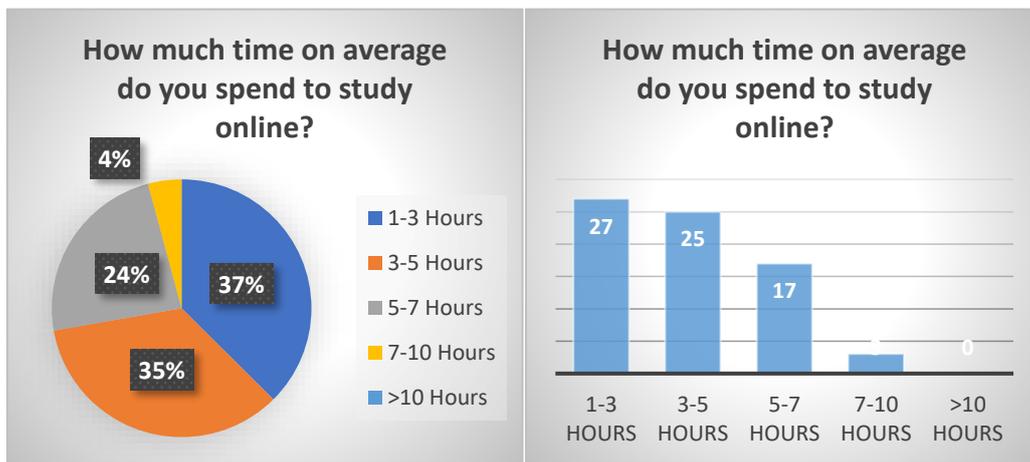


Figure 5: (1) Pie chart showing the time spend on an average by respondents on online teaching, (2) Bar diagram showing the time spend on an average by respondents on online teaching

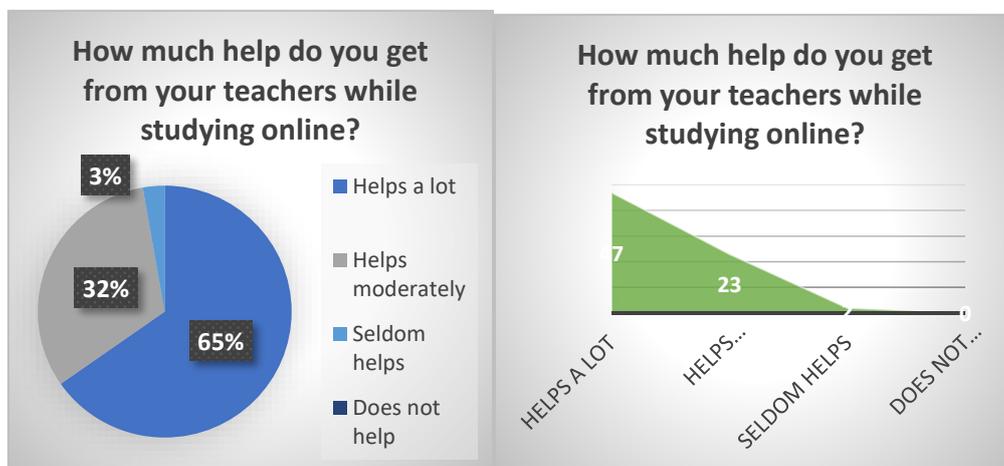


Figure 6: (1) Pie chart showing the percent of respondents found online teaching helpful, (2) Bar diagram showing the number of respondents found online teaching helpful

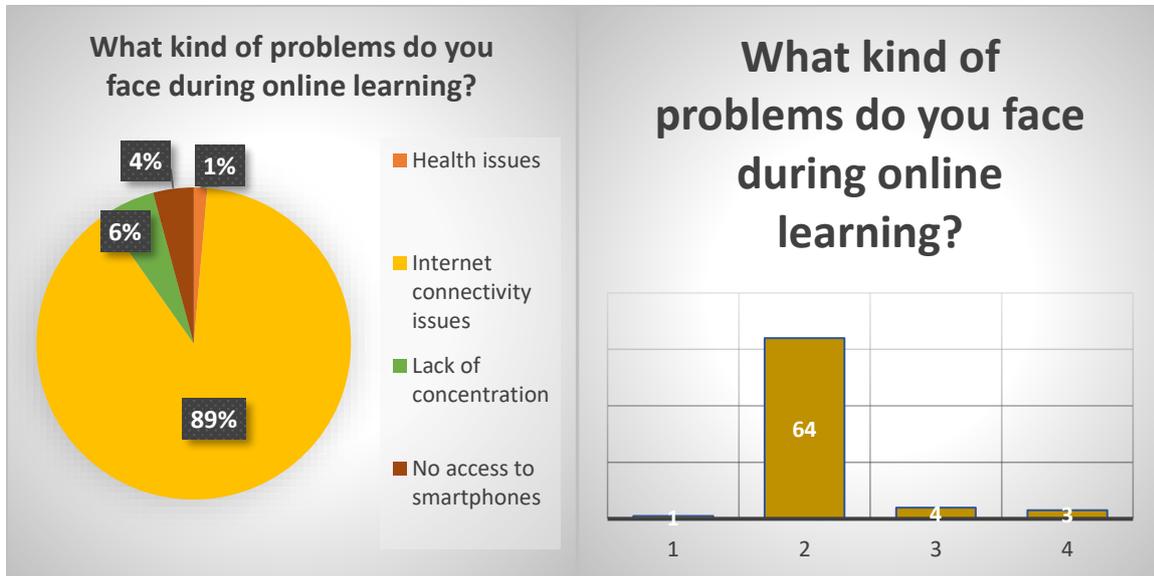


Figure 7: (1) Pie chart showing the kind of problems faced during online learning, (2) Bar diagram showing various problems faced in attending online classes

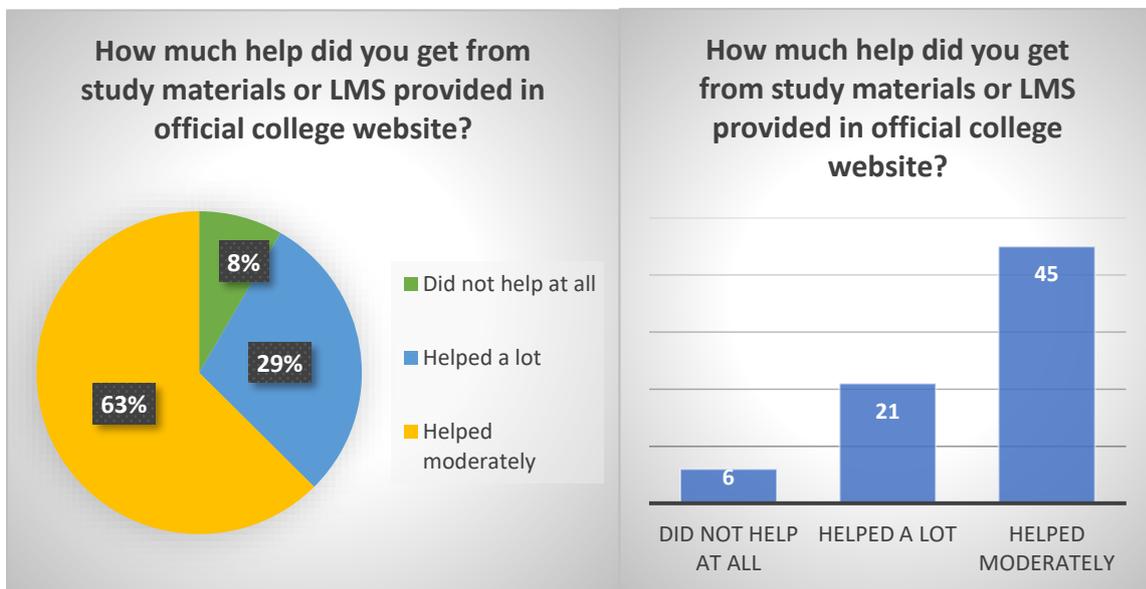


Figure 8: (1) Pie chart showing the percent of respondents who got help from online materials, (2) Bar diagram showing the number of respondents who got help from online materials.

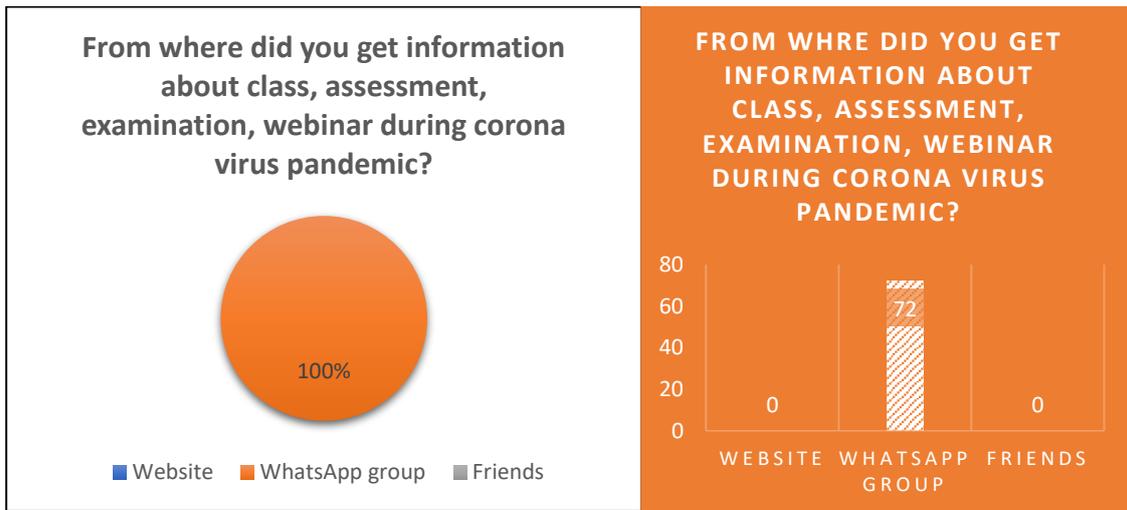


Figure 9: (1) Pie chart showing the percent of respondents who got help from online materials, (2) Bar diagram showing the number of respondents who got help from online materials

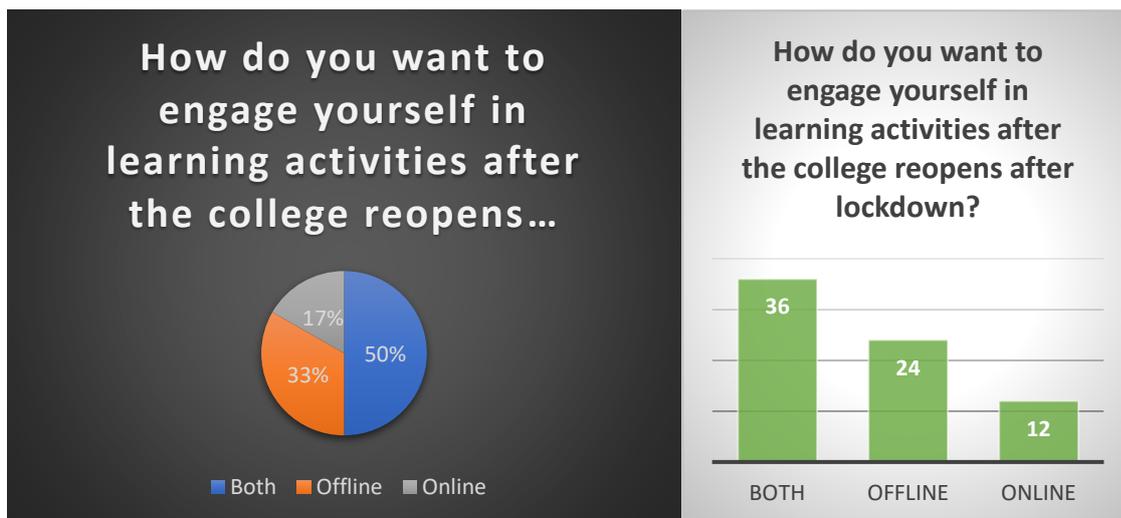


Figure 10: (1) Pie chart showing the choice of respondents after college reopens after lockdown, (2) Bar diagram showing the choice of respondents after college reopens after lockdown.

Discussion

Before the COVID-19 pandemic, India had already been making slow forays into digitalised education. The pandemic lockdown has hastened the process. In present scenario, condition of rural education is still very poor. In some villages, there are very few educational institutions. Students have to travel far away distances to avail these facilities and most colleges in these



locations do not provide computer education. Thus, there is unfair burden on students who need to buy a smart phone and need internet recharge as has been reported through informal interviews. Nevertheless, the present emergency situation, online education was left as the only choice due to home confinement. This kind of education was meant to adapting to student needs, using meaningful examples, motivating students to do their best, facilitating the course effectively, delivering a valuable course, communicating effectively, and showing concern for student learning. It will be a good approach to make the rural students understand the social and technological development of world. In this way they can easily understand to connect with their rural life condition. This kind of online related educational programme will provide employment opportunity to computer and other educated youths in rural as well as areas. It will also help the rural students to understand computer related training and wide knowledge about recent developments in world.

Conclusion

Although the central and the state governments are aware of the inadequacies of the existing digital ecosystem, especially in rural areas, online education is still seen as a viable option. Online channel has made education convenient and easily accessible by one and all. Though online and distance courses have been there from a long time, introduction of the online mode of taking classes in comparison to the traditional face to face classroom approach in universities and colleges have been considered only in the last few years in India. When it comes to the Indian educational system, face to face classroom approach has always been the most prominently used. Familiarity and ease of using offline methods and lack of requirement for online channels of teaching has been the major barriers for adoption of online channels of education. However, in the wake of current COVID-19 pandemic situation conduction of online classes has become inevitable part of the education system. In many cases results from conduct of online exams became equivalent to offline courses in the same discipline. Hence it is need of the hour to bring inclusivity in education by more government budgetary allocation to cater to the student community by building infrastructure. The aim should be to reduce the digital divide gap and make the fruits of technology available to all.

Conflict of interest

The authors have no conflict of interest in publishing this paper



Data availability statement

The data that support the findings of this study are available from the author upon reasonable request.

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'ডাইনী'- অন্ধবিশ্বাস বনাম তারাশঙ্করের বিজ্ঞানমনস্ক মন

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ছাত্র ও গবেষক, বাংলা বিভাগ, কলিকাতা বিশ্ববিদ্যালয়

সারসংক্ষেপ –

তারাশঙ্কর বন্দ্যোপাধ্যায় কল্লোল যুগের এক অবিস্মরণীয় নক্ষত্র। কল্লোল যুগের লেখক, কিন্তু কল্লোল গোষ্ঠীর লেখক নন। কল্লোল যুগ মানে সাহিত্যে বিজ্ঞান চেতনা। তারাশঙ্করের ছোটগল্প 'ডাইনী' তেও তাই রাঢ় বাংলার কুসংস্কারাচ্ছন্ন জীবন আবহের আড়ালে ধরা পড়েছে লেখকের বিজ্ঞানমনস্ক মন। আপাত দৃষ্টিতে ধরা না পড়লেও যুক্তিবাদী পাঠকদের কাছে লেখকের এই বিজ্ঞানচেতনা অধরা থাকেনা। অত্যন্ত নির্মোহ, নির্মম দৃষ্টিতে লেখক সোরধনির জীবন কাহিনী বর্ণনা করলেও কাহিনীর পরতে পরতে লুকিয়ে আছে লেখকের বিজ্ঞান দৃষ্টি এবং মানব দরদী সত্তা যা সহৃদয় পাঠকের মনেও আবেদন সৃষ্টি করে। কীভাবে গ্রামীণ সংস্কারের বশে একজন অনাথ বালিকা সামাজিক জীবন প্রবাহ থেকে বিচ্ছিন্ন হতে হতে 'ডাইনী' তে রূপান্তরিত হল, কীভাবে রাঢ়ের রুক্ষ পরিবেশ সেই ডাইনীকে ফুটিয়ে তুললো, কীভাবে ডাইনী সত্তা এবং মানবী সত্তার দ্বন্দ্ব জর্জরিত মেয়েটি এগিয়ে গেল এক ভয়ানক পরিণতির দিকে, সেই যাত্রার কথাই বর্ণিত রয়েছে আলোচ্য গল্পে এবং এই যাত্রাপথেই সুস্পষ্টভাবে রয়েছে লেখকের যুক্তিবোধ তথা বিজ্ঞানচেতনা যার সন্ধান আলোচ্য প্রবন্ধের মূল লক্ষ্য।

Keyword - ছোটগল্প 'ডাইনী', তারাশঙ্করের বিজ্ঞানচেতনা, রাঢ় বাংলার কুসংস্কার, মানবদরদী তারাশঙ্কর, তারাশঙ্করের সাহিত্যভাবনা, তারাশঙ্করের ছোটগল্প, অন্ধবিশ্বাস বনাম বিজ্ঞানমনস্কতা।

মূল প্রবন্ধ –

জীবনের নির্মম কথাকার তারাশঙ্কর বন্দ্যোপাধ্যায়ের 'ডাইনী' গল্পটি ১৩৪৭ বঙ্গাব্দের আষাঢ় সংখ্যায় 'প্রবাসী' পত্রিকায় প্রথম আত্মপ্রকাশ করেছিল। তাঁর অন্যান্য সৃষ্টির মতোই এই গল্পেও রাঢ় বঙ্গের সমস্ত রুক্ষতা, আদিমতা, লোকসংস্কার ও গ্রামীণ কুসংস্কার উজ্জ্বলভাবে প্রকাশ লাভ করেছে। 'ডাকিনী বিদ্যা বা ডাইনীতন্ত্র বলতে আমরা বুঝি প্রাচীনতম এক সংস্কারকে, যার সঙ্গে রয়েছে মানুষের চিরকালীন এক ধর্মভয়। তবে এই ধর্মভয়ের সঙ্গে মিলেমিশে আছে মানুষের সহজাত অন্ধবিশ্বাস ও একধরনের পাপবোধ। এই প্রাচীন বিষয়টিকে নিয়ে তারাশঙ্করের মতন বিভূতিভূষণ বন্দ্যোপাধ্যায় এবং আরো অনেকে গল্পরচনা করলেও তা কিন্তু তারাশঙ্করের মতন বলিষ্ঠ নয়'¹।

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তারাশঙ্করের 'ডাইনী' গল্পটি শিল্প বৈশিষ্ট্য ও রীতিনীতির বিচারে অনন্যতার দাবি রাখে। 'ডাইনী' গল্পে আমরা পাই প্রেমবঞ্চিত হতভাগ্য এক নারীর জীবনের ছায়াচিত্র। যে নারী গ্রামীণ অন্ধ- কুসংস্কারে, মানুষের অবজ্ঞা, ঘৃণা ও ভয়ে বঞ্চিত হতে হতে পাপবোধে আক্রান্ত হয়ে একসময় নিজের মনোলোকে নিজেই রূপান্তরিত হয়ে ওঠে ডাকিনীতে। যদিও এই ডাকিনী বা ডাইনীর আড়ালে লুকিয়ে থাকে এক দুঃখী নারীর মুখ², যার রয়েছে একটি পিতৃদত্ত নাম। 'সোরধনি' ওরফে 'সরা' নামী এই নারীকে কেন্দ্রীয় চরিত্র করে লেখক 'ডাইনী' গল্পটি বুনেছেন সমাজ ও পারিবারিক দর্পনের প্রতিবিম্বে কুসংস্কার ও মানুষের অলৌকিক বিশ্বাসের মোড়কে। গল্পটিতে লেখক সামান্য কাহিনীর প্রেক্ষাপটে তুলে ধরেছেন এক অসাধারণ ট্রাজেডীর চিত্র, যা পাঠকের হৃদয়কে কেবল নাড়িয়েই দেয় না, বরং আধুনিক মানুষকে এক গভীর উপলক্ষের মুখোমুখি দাঁড় করিয়ে দেয়³। আমরা বুঝতে পারি লোকপ্রচলিত তর্কমা 'ডাইনী' নামটি সত্য নয়, বরং সত্য হল 'ডাইনী' নামের অন্তরালে থাকা চিরবঞ্চিত হতভাগ্য তৃষ্ণার্ত প্রেমময়ী অতি সাধারণ এক মেয়ের তিল তিল করে মৃত্যুর কাছে পৌঁছে যাওয়া অশ্রুসজল জীবনের নিঃসঙ্গ ছবিটি।

‘বীরভূমের এক তাপদগ্ধ, রক্ষ ও অনুর্বর প্রান্তরের পটভূমিকায় 'ডাইনী' গল্পের সূত্রপাত’⁴। গ্রামীণ লোক মানসের ধারণা অনুযায়ী ডাইনী হল এমন এক নারী যার ওপর ‘ক্ষতিকর অশুভ অলৌকিক শক্তির ভর হয়, আর ডাইনীর চাহনি, ইচ্ছা, বানমারা, তুকতাকের ফলে গ্রাম জীবনে অশুভ ঘটনার প্রাদুর্ভাব ঘটে। ফলে সেই ডাইনী হয়ে ওঠে সকলের ভীতি ও ঘৃণার পাত্র’⁵ এবং সামাজিক দিক থেকে সে হয়ে পড়ে একঘরে। জলহীন, জনহীন, ছায়াশূন্য, অভিশপ্ত ছাতিফাটার মাঠের পূর্ব প্রান্তের এক আমবাগানে দীর্ঘ চল্লিশ বছর ধরে একঘরে অবস্থায় দিন কাটাচ্ছে এই গল্পের ডাইনী। তার সম্পর্কে নানান ধরনের ভয়ঙ্কর জনশ্রুতি প্রচলিত আছে। লোকে তাকে পরিহার করে চললেও, চল্লিশ বছর ধরে তারা সবাই তাকে লক্ষ্য করেছে। দেখেছে-

“তাহার দৃষ্টি নাকি অপলক স্থির, আর সে দৃষ্টি নাকি আজ চল্লিশ বছর ধরিয়াই নিস্তব্ধ হইয়া আছে ঐ মাঠখানার উপর।”⁶

- তার অতীত সম্পর্কে জনশ্রুতি এই যে, সে তিন চারখানা গ্রাম প্রায় ধ্বংস করে অবশেষে একদিন আকাশপথে একটা গাছ চালিয়ে উড়ে যেতে যেতে এই ছাতিফাটার মাঠের নির্জন রূপ দেখে মুগ্ধ হয় এবং এখানে নেমে এসে ঘর বাঁধে। আসলে "নির্জনতাই উহারা ভালোবাসে, মানুষের সাক্ষাৎ উহারা চায় না।"⁷ ডাইনীর নিজের স্বভাবের প্রাথমিক পরিচয় লেখক দিয়েছেন এই ভাবে- “মানুষ দেখলেই তার অনিষ্টস্পৃহা জেগে ওঠে”⁸, অর্থাৎ মানুষের যে স্বাভাবিক বৃত্তি ভালোবাসার ক্ষমতা - তা লোপ পেয়ে প্রবল হয়ে উঠেছে মানব বিদ্বেষ; তা যে অকারনে হয়নি তা পরবর্তী বিশ্লেষণে বোঝা যাবে।

বৃত্তান্ত শুরু হয়েছে বহুকালের পুরানো আয়নায় ডাইনী'র নিজের মুখ দেখার ঘটনা দিয়ে। “ জরা কুণ্ডিত মুখ, শনের মতো সাদা চুল, দন্তহীন মুখ”⁹ -এর বৃদ্ধা প্রতিবিশ্ব দর্শনের মাধ্যমে ফিরে গিয়েছে তার শাপগ্রস্ত বাল্যকালে। তখন 'সোরধনি' র বয়স দশ-এগারো। সহজ, সরল, নিষ্পাপ এই অনাথ বালিকাকে প্রথমবার 'ডাইনী' অপবাদে ভূষিত করেছিল বামুন পাড়ার হারু চৌধুরী। মেয়েটির অপরাধ সে তার “নরুন দিয়ে চেরা, ছুরির মত চোখে বিড়ালীর মত এই দৃষ্টিতে”¹⁰তাকিয়েছিল হাবুর ছেলের খাবারের দিকে এবং তার পরেই তার ছেলে পেটের যন্ত্রণায় অসুস্থ হয়ে পড়েছে। আসলে আম দিয়ে মুড়ি মেখে খাওয়ার ফলে তার ছেলের অল্পশূল হয়েছে – এই সামান্য বিষয়টি বুঝতে পারেনি কুসংস্কারাচ্ছন্ন হারু, হয়তো বা বুঝতে চায়ও নি। স্বাভাবিক নিয়মেই তার কোপ এসে পড়েছে অসহায় মেয়েটির উপর। 'সরা' কে 'ডাইনী' অপবাদ দিয়েই হারু চৌধুরী ক্ষান্ত থাকেনি, তার ওপর শারীরিক অত্যাচারও করে সে। যদিও হারুর ছেলেটি বার দুই বমি করে করার পর সুস্থ হয়ে ওঠে কিন্তু তার বলা 'ডাইনী' শব্দটি নিষ্পাপ বালিকার হৃদয়ে দগদগে ঘায়ের মত রয়ে যায়, ফলে সে হারিয়ে ফেলে আত্মবিশ্বাস। ক্রমশ সে আবিষ্কার করে যে, কোনো কিছু'র প্রতি ভালোলাগা বা ভালোবাসার টান অনুভব করলেই ঘটে বিপর্যয়। তার সংস্কারাচ্ছন্ন মনে এ দুয়ের মধ্যে একটা কার্যকারণ সম্পর্কের ধারণা দৃঢ়মূল হয়ে যায়। ফলত যে চোখ হতে পারতো তার সৌন্দর্যের প্রতীক, সেই চোখ-ই হয়ে ওঠে তার জীবনের অভিশাপ। গল্পে পরপর এর নিদর্শন লেখক দিয়েছেন। যেমন – বন্ধু সাবিত্রীর নবজাত পুত্র সন্তানটিকে দেখা মাত্র তার নারী মনে বাৎসল্যের টান উৎসারিত হয়; তখন তার মনে হয়েছিল “এ বুঝি কোলে লইয়া আদর করিবার সাধ”¹¹, কিন্তু পরবর্তী ঘটনায় দেখা যায় যে, সে সুনিশ্চিত হয়েছে – এ হল তার ডাইনী চোখের দৃষ্টি, কারণ কিছুক্ষণ পরে সে জানতে পারে – “সাবিত্রীর ছেলেটি নাকি ধনুকের মতো বাঁকিয়া গিয়াছে আর এমনভাবে কাতরাইতেছে যে ঠিক ঠিক যেন কেহ তাহার রক্ত চুষিয়া লইতেছে।”¹² বাচ্চাটির এরূপ অবস্থা হওয়ার বাস্তব কারণটা হল ধনুষ্কার, কিন্তু তা সেও বোঝেনি, গ্রামের লোকেও বোঝেনি – উভয়পক্ষই দায়ী করেছে সরার ডাইনী বৃত্তিকে। অগত্যা জীবন রক্ষার্থে সে গ্রাম ত্যাগ করে। নিজ পরিচিত গ্রাম ছাড়লেও দুর্ভাগ্য কিন্তু তার সঙ্গ ছাড়ে না। এরপর সে যে অভিজ্ঞতা লাভ করে তা তার জীবনের মূল ট্রাজেডির কারণ। তাকে ভালোবেসে বিয়ে করে দশাসই চেহারার বেপরোয়া এক হৃদয়বান যুবক, তাকে স্ত্রীর মর্যাদা দেয় এবং সেই জোয়ান মরদের সঙ্গে সরা অতিবাহিত করে তার জীবনের শ্রেষ্ঠ কয়েকটি দিন। কিন্তু দেখা যায় সেই জোয়ান মরদ ক্রমশ রোগগ্রস্ত হয়ে “তিলে তিলে শুকাইয়া ফ্যাকাসে হইয়া মরে যায়।”¹³ এই মৃত্যুর কারণ হল যক্ষ্মারোগ। বৈজ্ঞানিক দৃষ্টিতে এঘটনার ব্যাখ্যাও সাধারণ। যে দরিদ্র যুবক কারখানায় হাড়ভাঙ্গা খাটুনি খাটে অথচ পর্যাপ্ত পরিমাণে আহার পায়না, সেই যুবকের দেহে যক্ষ্মা রোগের বাসা বাঁধা আশ্চর্যের কিছু নয়। কিন্তু ইতিমধ্যেই চারপাশের কুসংস্কার সরার মনকে এতটা প্রভাবিত করেছে যে তার মনে হয়েছে যাকে সে প্রানের চেয়েও ভালোবাসতো, কোনোদিন যার ওপর এতটুকু রাগও করেনি সেও তার দৃষ্টিতে শুকিয়ে নিঃশেষে দেহের রক্ত তুলে মরে গেছে। ফলত তার নিজের ভালোলাগাকে সে ভয় করতে শুরু করে- এর চেয়ে নিষ্ঠুরতম আত্মিক মৃত্যু আর কিছু হতে পারে না। একদিকে সে নিজের

অলৌকিক অশুভ শক্তির অধিকার সম্বন্ধে সুনিশ্চিত, অন্যদিকে গাঁয়ের লোকেরও সেই একই বিশ্বাসের ফলে সে 'নগর বাহিরী' সর্ব বর্জিত জীবনযাত্রা নির্বাহে বাধ্য হয়; এতে যেমন তার নিজের সুবিধা, কারণ ভালোলাগার হাত থেকে সে রেহাই পায়, তেমনই আবার যারা তাকে ভীতির পাত্রী হিসেবে ঘৃণা করে আর তাদের প্রতি তার চরম আক্রোশ, এই দ্বন্দ্ব তার জীবনের চল্লিশ বছরের বাস্তব সত্য।

শেষে দেখা যায় দুটি ঘটনা। প্রথমটি: ছাতিফাটা মাঠ পেরিয়ে বুকের সন্তান আগলে এক মায়ের আশ্রয় সন্ধানে আসা। সে ঐ অপরিচিতা পথচারিণীর গরম লাগা বাচ্চাটিকে দেখে প্রবল সমবেদনা অনুভব করে, যা থেকে তার বেদনা - ব্যথিত ডাইনী চরিত্রের আড়ালে সোরধনির মানবিক অনুভূতি - সম্পন্ন মাতৃহৃদয়ের চিরকালীন নারী-সত্তার রূপ ধরা ধরা পড়ে -

"এঃ ছেলেটা কি ভীষন ঘামিতেছে! দেহের সমস্ত জলই বাহির হইয়া আসিতেছে! চোখ দুইটা লাল হইয়া উঠিয়াছে!"¹⁴

কিন্তু এই ভালোলাগার মুহূর্তটি তাকে সচকিত করে দেয় এর পরিণতি সম্পর্কে, এবং সে নিতান্ত অসহায়ের মতো আর্তস্বরে বলে ওঠে -

"খেয়ে ফেললাম ছেলেটাকে খেয়ে ফেললাম রে। পালা পালা, তুই ছেলে নিয়ে পালা বলছি "¹⁵

কিন্তু বৃথা প্রচেষ্টা, প্রবল গ্রীষ্মের প্রতিক্রিয়ায় ছেলেটি বাঁচেনি। আর এতে ডাইনীর নিজের এবং গ্রামবাসীদের ধারণাটা আরো সমর্থিত হয়েছে।

শেষ ঘটনা - এক যুবক-যুবতীর গোপন প্রেমকে তার ভালো লাগার ব্যাপার। এ ঘটনায় সোরধনির প্রেমময়ী নারীসত্তার প্রকাশ লক্ষ্য করা যায়। যা সে হারিয়েছে, যার স্মৃতি তার অবচেতনে মধুর- রসসিক্ত হয়ে আছে - তারই পুনরাভিনয় তার নীরস অস্তিত্বের মধ্যে রসের ধারা এনেছে। সে স্বামী পরিত্যক্তা বাউরী বউ ও বাউরী যুবকটির মিলনের পথে যে টাকা পয়সার বাধা তার সুরাহা করবার জন্য নিজের স্বল্পতম পুঁজিও ভাঙতে উদ্যোগী হয়েছে-

"মোটে তো তাহার এক কুড়ি টাকা আছে, তাহার মধ্য হইতে দুইটা টাকা না হয় পাঁচটা সে দিতে পারে। তাহাতে কী হইবে ? মেয়েটা আর বোধ হয় আপত্তি করিবে না; আহা! জোয়ান বয়স, সুখের সময়, শখের সময়, আহা ! ছেলেটিকে ডাকিয়া রূপার চুড়ি ও টাকা সে দিবে, আর উহার সঙ্গে নাতি ঠাকুরমার সম্বন্ধ পাতাইবে....

মাটিতে হাতে ভর দিয়া কুঁজির মতো সে ছেলেটার কাছে আসিয়া দাঁড়াইল। ছেলেটা যেন ধ্যানে বসিয়াছে, লোকজন আসিলেও খেয়াল নাই। হাসিয়া সে ডাকিল, বলি, ওহে লাগর শুনছ?"¹⁶

কিন্তু ফল হয়েছে বিপরীত -

" দন্তহীন মুখের অস্পষ্ট ব্যথার সাড়ায় ছেলেটি চমকিয়া মুখ ফিরাইয়া আতঙ্কে চীৎকার করিয়া উঠিল, পরমুহূর্তেই লাফ দিয়া উঠিয়া মে প্রাণপনে ছুটিতে আরম্ভ করিল।"¹⁷

যুবকটির এইরূপ ঘৃণা, ভীতি ও অবজ্ঞার প্রত্যাহাতের জন্যই বৃদ্ধা সরার মধ্যে জেগে ওঠে 'ডাইনি'র প্রত্যক্ষ ভয়ঙ্কর রূপচিহ্নটি - " ক্রুদ্ধ মার্জারীর মত ফুলিয়া উঠিয়া সে বলিয়া উঠিল, মর্ মর্ - তুই মর, সঙ্গে সঙ্গে ইচ্ছা হইল, ক্রুদ্ধ শোষণে উহার রক্ত, মাংস, মেদ, মজ্জা সব নিঃশেষে শুষিয়া খাইয়া ফেলে। "¹⁸

বাউরী যুবকটির পরিনতি হল ভয়ানক, তবে সেই পরিনতিটিও বিজ্ঞানসম্মত। যুবকটি ছুটে পালাতে গিয়ে পায়ে বিঁধিয়েছিল হাড়ের টুকরো; যার পরিনাম টিটেনাস, এবং অনিবার্য মরণ।

এই ঘটনাটির পরিপ্রেক্ষিতেও লেখক গ্রাম বাংলার কু- সংস্কারাচ্ছন্ন মননটিকে চিত্রায়িত করেছেন -

"পরদিন দ্বিপ্রহরের পূর্বেই গ্রামখানা বিস্ময়ে শঙ্কায় স্তম্ভিত হইয়া গেল। সর্বনাশী ডাইনী বাউরীদের একটা ছেলেকে বান মারিয়াছে..... অতি তীক্ষ্ণ একখানা হাড়ের টুকরা মন্ত্রপুত করিয়া নিষ্ক্ষেপ করিতেই সেটা আসিয়া তাহার পায়ে গভীর হইয়া বসিয়া গিয়াছে। টানিয়া বাহির করিয়া ফেলিতেই সে কি রক্তপাত। তাহার দেহখানি ধনুকের মত বাঁকাইয়া দিয়া দেহের রস নিঙড়াইয়া লইতেছে।"¹⁹

এরপর ডাইনীকে জব্দ করার জন্য গ্রামবাসীরা নিয়ে এসেছে এক গুণীনকে। অসুস্থ সোরধনি মানসিক ও শারীরিক যন্ত্রনায় যখন অস্বস্তি বোধ করছে তখন তার মনে হয়েছে গুণীন তাকে 'মন্ত্র প্রহারে জর্জর' করার চেষ্টা করছে। এরপরে প্রান বাঁচানোর তাগিদে সোরধনি এক দুর্যোগপূর্ণ রাতে গৃহত্যাগ করেছে। এই গৃহত্যাগের ফলেই প্রবল ভয়ঙ্কর ঝড় ও বৃষ্টির জন্য পথে তার দেহত্যাগ ঘটে। এক কথায় শোচনীয় মৃত্যু। গল্পের শেষ দিকে দুটি স্তবকে লেখক যা চিত্রশিল্পীর মতন আমাদের কাছে তুলে ধরেছেন বীভৎস ভয়াল ঘটনার প্রেক্ষাপটে -

"কিছুক্ষণের মধ্যেই সমস্ত পায়ের ধূলার আস্তরণের মধ্যে বিলুপ্ত করিয়া দিয়া কালবৈশাখীর ঝড় নামিয়া আসিল। সেই ঝড়ের মধ্যে বৃদ্ধা কোথায় বিলুপ্ত হইয়া গেল। দুর্দান্ত ঘূর্ণি ঝড়! মাত্র দুই-চারি ফোঁটা বৃষ্টি।

পরদিন সকালে ছাতি - ফাটার মাঠের প্রান্তে সেই বহুকালের কণ্টকাকীর্ণ খৈরী গুল্মের একটা ভাঙা ডালের সূঁচালো উগার দিকে তাকাইয়া লোকের বিস্ময়ের আর অবধি রইল না; শাখাটার তীক্ষ্ণগ্র প্রান্তে বিদ্ধ হইয়া ঝুলিতেছে ডাকিনী।"²⁰

“ নামিয়া আসিতেছে শকুনির পাল।”²¹ গল্পটির এই শেষ পংক্তিটি বীভৎসরসের জ্বলন্ত ছবি। যা বড়ই মর্মান্তিক এইভাবে 'ডাইনী' গল্পে, খন্ড খন্ড ছোট ছোট চিত্রহারে লেখক তারশঙ্কর বন্দ্যোপাধ্যায় অসামান্য শিল্পদক্ষতায় 'ডাইনী'র প্রতিবিম্বে অন্ত্যজ শ্রেণীর এক প্রেম-স্নেহ-ভালোবাসা বঞ্চিতা নিঃসঙ্গ একাকী নারী চরিত্রের বাস্তব অসহায়তার রূপ সমাজচিত্রের দর্পনে আমাদের সামনে হাজির করেছেন। 'ডাইনী' ব্যাপারটিই যে সমাজকল্লিত একটা দুরারোগ্য ব্যাধি তা লেখক বুঝিয়ে দিয়েছেন। এটি আসলে অশিক্ষিত সমাজে বসবাসকারী মানুষদের অবৈজ্ঞানিক ধ্যান-ধারণা ও অন্ধবিশ্বাস ছাড়া কিছু নয়। 'ডাইনী' ওরফে সোরধনি বা সরা-র চরিত্রটি ছেনে-ছেনে লেখক আমাদের কাছে যে সত্যদর্শনটির উদঘাটন করেছেন - তা হল সোরধনি ওরফে সরা আসলে মানবী-ই! মানবীর যে বিনাশ মাঝে-মধ্যেই তার মন ও বোধের ভেতরে লক্ষ্য করা যায় - তা মূলত সে প্রেম-ভালোবাসার প্রতিদান না পাওয়ার জন্য এবং সদা-সর্বদা সামাজিকভাবে নিঃসঙ্গ জীবনযাপন করার জন্যই।

প্রসঙ্গক্রমে বলতে হয়, বীরভূমের তাপদন্ধ রক্ষ ও অনুর্বর প্রান্তর তথা ছাতিফাটার মাঠ এই 'ডাইনী' গল্পের একটি গুরুত্বপূর্ণ অঙ্গ। বলা চলে এই রক্ষ পরিবেশই ডাইনীকে ফুটিয়ে তুলতে সাহায্য করেছে। গল্পের শুরুতেই লেখক গ্রাম্য কুসংস্কার ও কিংবদন্তীকে অবলম্বন করে এক অস্বাভাবিক ও অতিপ্রাকৃত আবহাওয়ার সৃজন করলেন -

" কে করে নামকরণ করিয়াছিল সে ইতিহাস বিস্মৃতির গর্ভে সমাহিত হইয়া গিয়াছে, কিন্তু নামটি আজও পূর্ণ গৌরব বর্তমান। ছাতিফাটা মাঠ। জলহীন, ছায়াশূন্য, দিগন্ত বিস্মৃত প্রান্তরটির এক প্রান্তে দাঁড়াইয়া অপর প্রান্তের দিকে চাইলে ওপারের গ্রামচিহ্নের গাছপালাগুলিকে কালো প্রলেপের মতো মনে হয়।..... শূন্যলোকে ভাসে একটি ধূমধূসরতা, নিম্নলোকে জনচিহ্নহীন মাঠে সদ্য নির্বাপিত চিতাভস্মের রূপ ও উত্তপ্ত স্পর্শ।....বড়ো গাছ এখানে জন্মায় না। কোথাও জল নাই-গোটাকয়েক শুষ্কগর্ভ জলাশয় আছে। কিন্তু জল তাহাতে থাকে না।

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গল্পের 'ডাইনী' নামক নারী-চরিত্রটির যে রূপচিত্র লেখক তারশঙ্কর অঙ্কিত করেছেন তার সঙ্গে বীরভূমের এই তাপদন্ধ রক্ষ ও অনুর্বর মাটি প্রান্তরের কোথায় যেন একটা সাযুজ্য রয়ে গেছে! এ কথা বলার কারণ 'ডাইনী' ওরফে 'সোরধনি' অর্থাৎ 'সরা'র ভেতরে প্রেমবঞ্চিতা যে হতভাগ্য রূপটি আমরা পাই তা তাপদন্ধ প্রান্তরের মতই রসহীন রক্ষতায় ভরা ও অনুর্বর। গল্পের শেষেও রয়েছে ছাতিফাটার মাঠের জ্বলন্ত চিত্রের continuation, যা ডাইনীর অন্তিম পরিনতির মতই ভয়াবহ -

"অতীত কালের মহানাগের বিষের সহিত ডাকিনীর রক্ত মিশিয়া ছাতিফাটার মাঠ আজ আরও ভয়ংকর হইয়া উঠিয়াছে। চারিদিকের দিকচক্রেরখার চিহ্ন নাই; মাটি হইতে আকাশ পর্যন্ত একটা ধূমাচ্ছন্ন ধূসরতা.... নামিয়া আসিতেছে শকুনির পাল।”²³

এইভাবেই তারাশঙ্কর প্রকৃতির আদিমতা দিয়ে মানুষের আদিম স্বভাবের প্রতিষ্ঠা করতে বসে মানুষের মধ্যকার নিয়তির অসহায়তাকে দীর্ঘশ্বাসের পতনের পরিবেশে ভয়াল বীভৎস করছেন। শ্রদ্ধেয় নারায়ণ গঙ্গোপাধ্যায় 'ডাইনী' গল্পটি সম্পর্কে তাই যথার্থ মূল্যায়ন করেছেন – “কুসংস্কারের ভিত্তিতে একটি গ্রামের মেয়ের দুর্ভাগ্যের ইতিবৃত্ত এতে বর্ণনা করা হয়েছে, কিন্তু অদ্ভুত বলিষ্ঠতায়, অনুভূতির তীক্ষ্ণতায় আর পরিবেশের রুদ্রতায় সমস্ত গল্পটিতে যেন অতিলৌকিক পরিবেশ গড়ে উঠেছে।”²⁴

Conflict of interest

The authors have no conflict of interest in publishing this paper

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Representation of gender minorities in mainstream newspapers in West Bengal

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Abstract

In the contemporary time, mainstream media especially the daily newspapers, magazines, television news broadcast and new media play a crucial role in influencing the public opinion and behaviour of masses in a state. The present study tries to understand the nature and content of gender coverage in mainstream media and moreover why some kind of stereotypical gender representations are getting reported in mainstream newspapers in West Bengal? How differently these gender reports are getting reflected in English and regional language newspapers. It also tries to explore the role of development journalism in social inclusion and exclusion of gender minority people (lesbian, gay, bisexual, transgender and queer) in the present time. The findings show that homophobia within the news media, journalists' lack of awareness and/or understanding of the social concerns of lesbian, gay and bisexual people, public pressure and lack of communication between the lesbian, gay and bisexual community and journalists contribute to processes by which lesbian, gay and bisexual people become socially excluded. In order to promote developmental and inclusive journalistic practices, measures like building the capacities of journalist, media professionals and media students along with discussing and presenting the needs of the LGBT community using appropriate language and avoiding misrepresentation.

Keywords: Gender minorities, development Journalism, inclusive

Introduction

After attaining independence from colonial rule, India adopted a secular democratic political system along with socialistic economic policies beginning from the early 1950s. In the given socio-political milieu, the media were mainly used as government mouthpieces tasked with integrating the people and promoting development based on development journalism practices. Gradually from the early 1980s the socio-political systems shifted to deregulated policies in their political, economic and communication systems. According to Ramaprasad (2001), this shift was triggered

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with the fall of socialism and communism along with demands of international aid and United Nations agencies, international financial institutions and overall effects of intensifying globalization. This shift to deregulated policies incorporated political pluralism, free market economies, emphasis on press freedom, advocacy for gender equality and protection of women's and human rights (Haji, 2008; Geertsema, 2009a; Myers, 2009; Ramaprasad, 2001). The relevance of media in development is mainly attached to the role's media play in relation to society and the government. Based on Rogers (1983), 'development' is defined from a humanistic perspective as a participatory process aimed at positive social change for the people concerned. 'Development journalism' focuses on empowering the ordinary people towards achieving their development. It seeks to report on achievements and shortcomings in development plans and processes while criticizing the government accordingly (Xiaoge, 2009).

Gender, as a social construction of what is expected from being a man or a woman, is constructed within media (Myers, 2009). According to Van Zoonen (1988), media are platforms within which negotiations of meanings and values of being a man or a woman that inform the ways of life (culture), take place. Development journalism by definition and purpose is supposed to serve the ordinary people not the elite. The term 'ordinary people' refers to the marginalized, poor and less privileged people (Xiaoge, 2009a). However, over time the practice has been criticized for ignoring ordinary people, women and people from gender minority in particular (Pandian, 1999).

Objectives

- To understand how stories related to Gender Minorities are being reflected in Kolkata editions of English and Bengali Dailies under the same Media House
- To assess the representation patterns of news stories on Gender Minorities in Kolkata Editions of English and Bengali Dailies under the same Media House

Review of literature

Development journalism in particular was one of the remedies suggested during the NWICO debates to correct the imbalances in the news flow between the developed and the developing world, and give voice to the voiceless. Yet, gender-focused reporting was not considered as an integral part of development journalism in its varying practices, just like the other types of journalism continued to exclude women's voices (Fair, 1988; Shah, 1990; Srebenry, 1996; Pandian, 1999). This anomaly is surprising given that various studies suggest that development journalism and gender are related. For example, it has been established that female journalists are more likely



than their male colleagues to employ professional strategies suggested for successful development journalism: relying on minority sources; placing emphasis on social or economic concerns; covering people-oriented news stories; value audience preference above policy-makers interests; avoid sensationalism in favour of depth and sensitivity; and performing advocacy roles.

In 2009, High Court of New Delhi announced that Section 377, Chapter XVI, of the IPC is “unconstitutional”. While Supreme Court of India denied this decision in 2013, which caused mixed feelings within both LGBTQ and human rights advocates. The law employed by the British Rule, criminalizes same-sex intimate relations and alternative gender identities. Simultaneously, supportive statements suggest that alternative sexuality gains recognition and (to some extent) acceptance within conservative and nationalist circles.

Steiner (2009) stresses more on revising ways of understanding and representing issues related to the third gender by creating newsroom structures, content, policies and decision-making that emerge from feminist theorizing and critique. Based on this argument, she proposes new political sensibility and feminist epistemology that will form “new kinds of newsrooms and new forms of journalism to be able to serve the political and social needs of ordinary disadvantaged people”. Steiner’s call for critical actors and action (critical journalism) concurs with both Xiaoge’s (2009b) and Banda’s (2007) models on development journalism as they both argue for a critical journalism.

Research methodology

This study explores the development journalistic practices and reflections of gender minorities in Kolkata based mainstream English and Bengali newspapers- The Telegraph and Ananda Bazar Patrika respectively. It tries to involve both quantitative and qualitative newspaper analytical research approach. This decision was based on Lindlof and Taylor (2002) who recommend qualitative approaches when the goal is to understand the complexities of the meaning of communication practices. The data for this study was collected from two newspapers (The Telegraph and Ananda Bazar Patrika) for six months from July 2022 to December 2022. A qualitative analysis was done in order to understand the how such issues are reflected in English and Bengali daily newspapers of the same media house.

Newspaper Analysis (using Quan-Qual Method)

The content of newspapers both in English and Vernacular language- Bengali (The Telegraph and Ananda Bazar Patrika) were studied throughout the six months from July 2022 to December 2022 and the necessary parameters concerned have been represented in tabulated manner as mentioned in the following tables given below.

Table 1: Number of stories on issues related to gender minorities

Newspapers	July 2022	August 2022	September 2022	October 2022	November 2022	December 2022	Total
The Telegraph	2	0	1	0	4	1	8
Ananda Bazar Patrika	1	0	0	0	1	1	3

From the above table -1, The Telegraph – Kolkata edition has represented only 8 news stories on issues related to Gender minorities throughout the six months from July to December 2022. On the other hand, Ananda Bazar Patrika – Bengali Daily in its Kolkata Edition represents only 3 news stories on the concerned subject, which is much lesser than its English sister publication from the same media house. It clearly reflects that the coverage of issues related to gender minorities is given less significance and priorities in comparison to other social issues in both the newspapers. It also depicts that the news stories on issues related to gender minorities rarely represented in Bengali daily having the largest circulation across the state, thus reflecting the general notion and awareness on social inclusion of vernacular language dailies is lesser than its English sister publication.

It is also noticed that the vernacular newspaper (like Ananda Bazar Patrika being the most circulated Bengali daily in West Bengal) ignores the identity and reflections of gender minority issues in their newspapers and does not involve a gender balanced approach as most of the content tends to relate broader areas of politics, crime and health issues thus completely neglecting the presence of third gender and their perspectives in newspaper. The point here is that gender ideologies and development journalism claim to serve the ordinary people, yet their practical connection towards realizing this goal has remained vague since the minorities continue to be marginalized by the practice and the media in general. The newspapers are very

market oriented and publish more controversial issues of socio-political realities in the country. Whereas it is seen that some news from the grassroots are more environment and development oriented and focus on women's problems then people like to read this news too.

Table 2: Headlines of News Stories on issues related to Gender Minorities with placement positions in selected Newspapers

Newspapers	Date	Headlines of News Stories	Placement
The Telegraph	09.07.22	Tata Contest for LGBTQ+ students	T2 Supplement – Second Half Full
	16.07.22	Drag queen story time for UK school children	Page 2 – Fourth Quadrant
	25.09.22	Trans Charity Mermaids to be investigated	Page 3 – Third Quadrant
	07.11.22	Sperm Retrack	Page 11- Left Side Chimney Column
	12.11.22	In US first, openly lesbian Governor	Page 2 - Right side Chimney Column
	21.11.22	5 Dead in Shooting at Colorado LGBTQ Club	Page 2 – Third Quadrant below
	26.11.22	SC Poser on LGBTQ Marriage	Page 4 - Fourth Quadrant below
	09.12.22	US: Same sex union bill cleared	Page 2 – Fourth Quadrant below
Ananda Bazar Patrika	31.07.22	CWG 2022: ব্রিটেনে এলজিবিটি আন্দোলনের মুখ দ্যুতি	Page 13- Fourth Quadrant below
	26.11.22	রাশিয়াতে সমকামিতার প্রচার নিষিদ্ধ করতে নতুন আইন	Page 2 – Fourth Quadrant below
	09.12.22	মার্কিন আদালতে ,সমলিঙ্গে বিয়ের অধিকার	Page 3 – Third Quadrant below

Afore mentioned Table 2 portrays the brief subject matters through its corresponding headlines on news stories related to issues concerning gender minorities and also tries to throw light of its placement positions – Page number, Quadrant positions of broadsheet, position in supplementary pages that reflect several other perspectives of the media house in general that publishes the daily newspaper. Quadrant positions referred in table 2 refers to four quadrants of the newspapers if it is equally divided into four parts. The first quadrant of newspaper refers to the Top left hand side part of the paper, second quadrant refers to the Top Right hand side of the paper, Third Quadrant refers to the bottom left hand side of part of the newspaper and fourth quadrant refers to the bottom right hand side part of the paper, where it follows the general readers' eye movement that moves from top left hand side to top right hand side of the

page, then diagonally moves down in the bottom left hand side to right hand side of the page generally.

From table 2 as shown above, reflects six foreign country-oriented news stories on LGBT issues and one national and one regional story concerning gender minorities. It tries to portray a general notion that these gender constructs are not a common phenomenon in India but an international issue that tries to influence the socio-political and cultural ethos of our society and thus it is represented less in the pages of the selected English daily. In comparison to the Bengali daily from the same media house, it shows a more vulnerable reflection by portraying all the three news stories in the last six months' time period as an international issue.

The placement of such news stories as shown in table 2 also reflects an indifferent attitude towards such issues as most of the news stories concerning such issues are placed in third and fourth quadrant of page 2, 3, 11 and 13 pages of the two selected newspapers. One such stories are also placed in T2, one of supplementary pages of the Telegraph that showcased a Multi-National Company's sponsored contest for Youth that contains the ideas and initiatives progressive in nature for proliferating gender inclusion amongst youth.

Table 3: Space Allotment / Size Dimensions of gender minorities related news stories in English & Bengali Daily Newspaper

Newspapers	July 2022 (Size Dimensions in cm ²)	August 2022 (Size Dimensions in cm ²)	September 2022 (Size Dimensions in cm ²)	October 2022 (Size Dimensions in cm ²)	November 2022 (Size Dimensions in cm ²)	December 2022 (Size Dimensions in cm ²)	Total Space (Size Dimensions in cm ²)
The Telegraph	[(20.3x17.78) = 157.934cm ² + (8.12x119.05) = 154.686 cm ²] = 312.62 cm ²	--	(16.24x17.78) = 288.747 cm ²	--	[(4.06x12.7) = 51.56 cm ² + (4.06x 15.24) = 61.874cm ² + (8.12x 16.51) = 134.0612 cm ² + (16.24 x 17.78) = 288.7472 cm ²] = 536.24 cm ²	(12.18 x 17.78) cm ² = 216.5604 cm ²	1354.1674 cm ²
Ananda Bazar Patrika	(12.18x 17.78) = 216.5604 cm ²	--	--	--	(8.12x 15.24) = 123.7488 cm ²	(12.18 x 19.15) = 233.247 cm ²	573.5562 cm ²



Table 3 as shown above also strongly asserts to the fact that the two mainstream newspapers have an indifferent attitude towards issues related to the LGBT community by catering very less space or sometimes no news stories to such issues have been reflected. This meagre representation of news stories related to gender minorities and their rights depicts to trivialize such issues from regular socio-cultural discourse and tries fade out such happenings thus leading to a phenomenon on social invisibility. Social invisibility, a lack of recognition or acceptance in public spheres, leads to the social exclusion of LGBT people from public life and this social exclusion affects both the quality of life of individuals and the equity and cohesion of society as a whole. Negative attitudes that are also closely linked to homophobia and heterosexism treat LGBT people as the ‘other’ and contribute to their invisibility. All these discourage LGBT people from engaging with civic and political life, pushing them to edges of society thus marginalizing them.

The analysis shows that in the case of LGBT people, the mainstream media fail to challenge heteronormativity and under-represent LGB-related issues and that, even when these are represented, they rely on stereotypes. Under-representation or negative portrayal of marginalized groups in the media enhances the notion that these groups are not culturally valued.

Mainstream newspapers have the ability to challenge the public’s perception of marginalized groups and argues that despite journalism’s tendency to marginalize, denigrate and demonize certain groups, newspapers content changes stereotypes about these marginalized groups ‘by “fleshing out” – that is, embodying and humanizing – the status of former ‘others’, repositioning them inside the imagined social universe of collective care and politics and acknowledging their denied humanity’. He explains that journalism, using its communicative modes of deliberation and display, can symbolically rehabilitate these ‘others’ by providing them with ‘mediatised recognition’.

The English daily in comparison to the vernacular paper covered stories related to LGBTQ community in a more elaborate and clearer manner but it somewhere tries to portray the stories of LGBTQ community in a non substantive manner. The Newspaper policies are very much audience oriented to the point that journalists are focused on satisfying their urban readers and



publish stories according to the urban taste. The newspaper's policy makers decide on the policy, and journalists do not have any influence at this level. As central offices of many leading English-Language newspapers are based in Kolkata and other metro cities, the focus is on the interest of metro readers and problems in this city. According to the above-mentioned house policy, the stories on gender do not have a chance of being covered by the press since urban readers is not interested to read about the gender problems which happen in rural areas. Whereas it is seen to report stories of gender minorities related to western countries that does not specifically relate to our country and therefore these kinds of depictions somewhere strengthen the conservative structures and view points of the society.

Conclusion

The issues reflect the lack of knowledge and awareness of journalists to the complexities of gender issues. Journalists' motivation is another factor which has significant impact on the coverage. Journalists can take part in the production of news or writing an analysis with various motivations. Since the general policy of most newspapers does not support the Development Journalism and the coverage of gender related issue therefore these kinds of socially inclusive content continue to grow gradually. With the inception of regular capacity building workshops, training and discussion forums on development journalism could help the media fraternity and society to overcome such practices in the near future.

Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

All data used in this article have not been taken from any secondary data.

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Suicide: A Philosophical review

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Abstract

Suicide is a complex and deeply philosophical topic that has been contemplated by thinkers, philosophers, and scholars throughout history. It raises questions about the nature of life, the value of existence, and the ethics surrounding self-determination. Philosophical perspectives on suicide often span various ethical, existential, and metaphysical dimensions.

Keywords: Ethical Perspectives, Existential Perspectives, Metaphysical Perspectives, Psychological Perspectives, Cultural Perspectives of Suicide.

1. Ethical Perspectives

Utilitarianism:

Utilitarianism, a moral theory attributed notably to philosophers like Jeremy Bentham and John Stuart Mill, offers a consequentiality framework for evaluating the morality of actions. It posits that the right action is the one that maximizes overall happiness or pleasure and minimizes suffering or pain for the greatest number of people affected by the action. Within this ethical paradigm, suicide becomes a subject of contemplation, inviting an analysis of its consequences and its potential alignment with utilitarian principles.

The utilitarian perspective on suicide diverges from many traditional moral frameworks by emphasizing the importance of consequences over intrinsic moral rules or duties. Rather than relying on fixed moral precepts, utilitarianism directs attention to the outcomes of actions, weighing the balance of pleasure and pain they generate. This consequentiality approach

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extends to the evaluation of suicide, where the moral permissibility of self-termination is assessed based on its anticipated effects on overall happiness and suffering.

In considering suicide through a utilitarian lens, it becomes essential to explore the various factors that contribute to its moral evaluation. These factors encompass not only the individual's motivations and circumstances but also the broader societal implications and consequences. Utilitarian analysis demands a nuanced examination of the potential outcomes of suicide, both immediate and long-term, as well as its impact on the well-being of individuals and communities.

One of the primary considerations in the utilitarian assessment of suicide is the alleviation of suffering. Utilitarians argue that if an individual's life is marked by unbearable suffering, terminating that life could serve to minimize overall pain and promote happiness. For instance, in cases of terminal illness or chronic, debilitating conditions, suicide may be viewed as a means of ending prolonged suffering, thereby fulfilling the utilitarian imperative of maximizing utility.

Furthermore, utilitarianism acknowledges the interconnectedness of individuals within society, emphasizing the ripple effects of actions on the collective well-being. In the case of suicide, the consequences extend beyond the individual to family members, friends, and wider social circles. Utilitarian analysis necessitates an examination of the potential impact of suicide on these stakeholders, considering both the immediate grief and long-term consequences for their happiness and welfare.

Moreover, utilitarianism underscores the importance of autonomy and personal agency in moral decision-making. From this perspective, individuals possess the right to determine their own course of action, provided that it does not infringe upon the rights or well-being of others. In contexts where suicide is a rational and informed choice made by a competent individual, utilitarians argue that respecting autonomy aligns with the principle of maximizing overall happiness. However, this autonomy is not absolute and must be balanced against potential harms to oneself and others.



Critics of utilitarianism raise various objections to its application to suicide, highlighting potential challenges and limitations inherent in this ethical framework. One such concern revolves around the subjective nature of happiness and suffering, which may vary significantly among individuals and defy quantification. Assessing the overall utility of suicide becomes inherently complex when confronted with divergent perspectives on what constitutes a meaningful or fulfilling life.

Furthermore, utilitarianism's focus on aggregate outcomes may overlook the intrinsic value of individual lives and the moral significance of respecting human dignity. Critics argue that reducing moral decision-making to a calculation of utility risks instrumentalizing human beings and neglecting their inherent worth and rights. From this perspective, the permissibility of suicide cannot be solely determined by its potential consequences but must also consider the inherent value of human life.

Additionally, utilitarian analysis of suicide raises ethical dilemmas regarding the treatment of mental illness and psychological suffering. While utilitarians recognize the importance of alleviating mental anguish, they must grapple with the complexities of decision-making capacity and the potential for impaired judgment in individuals experiencing mental health crises. Balancing the promotion of autonomy with the prevention of harm poses significant challenges in assessing the moral permissibility of suicide within a utilitarian framework.

Deontological Ethics:

Deontological ethics, exemplified notably by the philosophical framework of Kantian ethics developed by Immanuel Kant, offers a distinct perspective on the moral evaluation of actions, including suicide. Rooted in the notion of duty, Kantian ethics emphasizes the importance of moral principles, rationality, and universalizable maxims in guiding ethical conduct. Within this framework, suicide is often regarded as morally impermissible, based on the principle of treating oneself and others as ends in themselves rather than as mere means to an end. Kantian ethics condemns suicide as a violation of one's duty to oneself and to others, reflecting a commitment to the inherent dignity and moral worth of human beings.

Central to Kantian ethics is the concept of the categorical imperative, a universal moral law that commands individuals to act according to principles that could be willed as universal laws



of nature. Kant articulates the categorical imperative in various formulations, including the principle of universalizability, which states that individuals should act only on those maxims that they can consistently will to be universal laws without contradiction. Applied to the evaluation of suicide, Kantian ethics prohibits self-destructive actions that cannot be rationally willed as universal laws, thereby condemning suicide as a violation of moral duty.

From the Kantian perspective, suicide is regarded as inherently self-contradictory and morally impermissible because it involves treating oneself as a mere means to escape suffering or achieve personal ends, rather than as an end in oneself possessing intrinsic moral worth. Kant argues that human beings possess inherent dignity and worth by virtue of their rational autonomy, which entails the capacity for moral agency and self-legislation. By choosing to end one's life, individuals undermine their rational autonomy and violate their duty to respect and preserve their own dignity and well-being.

Moreover, Kantian ethics emphasizes the importance of consistency and coherence in moral reasoning, prohibiting actions that involve treating oneself or others as mere means to an end. Suicide, as an act of self-destruction or self-harm, violates the principle of treating oneself as an end in oneself, as it entails using one's own life as a means to escape suffering or achieve personal goals. Kant argues that individuals have a duty to preserve and cultivate their own well-being and to refrain from actions that undermine their rational autonomy or moral worth.

Furthermore, Kantian ethics prohibits suicide based on its potential impact on others and the broader moral community. Kant articulates the principle of humanity, which asserts that individuals have a duty to treat others as ends in themselves and to respect their inherent dignity and moral worth. Suicide, by its very nature, disrupts social relationships, inflicts emotional harm on loved ones, and undermines the moral fabric of society. Kantian ethics condemns suicide as a violation of one's duty to others, reflecting a commitment to the interconnectedness of moral agency and the inherent value of human relationships.

Critics of Kantian ethics raise various objections to its treatment of suicide, highlighting potential challenges and limitations inherent in this moral framework. One such concern revolves around the rigid and absolutist nature of Kantian principles, which may overlook the complexities of human suffering, mental illness, and the moral dilemmas faced by individuals in extreme circumstances. Assessing the moral permissibility of suicide becomes inherently



complex when confronted with the diverse experiences and contexts that shape individual choices and actions.

Moreover, Kantian ethics has been criticized for its emphasis on duty and obligation at the expense of compassion and empathy towards those who struggle with suicidal thoughts or behaviors. While Kantian ethics emphasizes the importance of rational autonomy and moral agency, it may overlook the role of mental illness, coercion, or societal factors in influencing individual decisions and actions. Balancing the demands of duty with considerations of empathy and compassion poses significant challenges in assessing the moral dimensions of suicide within a Kantian framework.

Virtue Ethics: Virtue ethics, a moral philosophy rooted in the works of ancient thinkers like Aristotle and further developed by contemporary philosophers such as Alasdair MacIntyre and Martha Nussbaum, offers a distinctive approach to understanding moral actions. Unlike consequentialist theories that focus on outcomes or deontological theories that emphasize rules or duties, virtue ethics directs attention to the character of the moral agent and the cultivation of virtuous dispositions. In the context of suicide, virtue ethicists engage in a nuanced exploration of the motivations, character traits, and moral virtues involved in the decision to end one's life.

Central to virtue ethics is the notion of eudaimonia, often translated as "flourishing" or "well-being." Virtue ethicists contend that moral actions are those that contribute to the realization of human flourishing, which is achieved through the cultivation of virtues—excellences of character that enable individuals to live a good life. In examining suicide, virtue ethicists inquire into the ways in which the decision reflects or deviates from the cultivation of virtues and the pursuit of eudaimonia.

One of the virtues that virtue ethicists may consider in the context of suicide is courage. Courage, as Aristotle conceived it, is the mean between recklessness and cowardice—the disposition to confront fear and adversity with rational resolve and fortitude. In evaluating the moral character of suicide, virtue ethicists may inquire into whether the decision to end one's life arises from a courageous acceptance of unavoidable suffering or a cowardly evasion of life's challenges. Individuals facing terminal illness or insurmountable hardships may exhibit courage by choosing to confront their circumstances with dignity and autonomy, even in the



face of death. Conversely, suicide prompted by fear, despair, or a lack of resilience may indicate a deficiency in the virtue of courage—a failure to confront adversity with moral steadfastness and perseverance.

Moreover, virtue ethicists examine the role of other virtues, such as temperance, wisdom, and compassion, in the decision to end one's life. Temperance, or self-control, involves the moderation of desires and emotions in pursuit of virtuous ends. In the context of suicide, individuals may demonstrate temperance by resisting impulsive or irrational impulses and carefully weighing the consequences of their actions on themselves and others. Wisdom, the practical application of knowledge and understanding, enables individuals to discern the true nature of their circumstances and make informed decisions about the value of life and death. Suicide prompted by a reasoned assessment of terminal illness or irreparable suffering may reflect the exercise of wisdom in navigating complex moral dilemmas. Furthermore, compassion, the virtue of empathy and benevolence towards others, plays a crucial role in considering the impact of suicide on loved ones and broader social networks. Individuals contemplating suicide must reckon with the potential harm their actions may inflict on others and strive to minimize suffering through compassionate consideration and care.

In addition to virtues, virtue ethicists consider the interplay of motivations and intentions in shaping moral actions. Suicide may stem from a myriad of motives, ranging from existential despair and psychological anguish to altruistic sacrifice and moral conviction. Virtue ethicists delve into the underlying motivations driving the decision to end one's life, discerning whether they align with virtuous aims and values or betray moral flaws and deficiencies. Suicide motivated by selfish desires, such as the avoidance of pain or the pursuit of personal gain, may reflect a lack of virtue—a failure to cultivate altruism, empathy, and selflessness. Conversely, suicide driven by self-sacrifice or moral conviction, such as political protest or martyrdom, may embody virtues of courage, integrity, and commitment to higher principles.

Furthermore, virtue ethicists recognize the importance of context and relationality in assessing the morality of suicide. Individuals exist within a web of social relationships and communal obligations that shape their moral identities and responsibilities. Suicide not only affects the individual but reverberates throughout the social fabric, impacting family members, friends, and wider communities. Virtue ethicists consider the relational dimensions of suicide,



examining how the decision reflects broader social norms, cultural values, and ethical commitments. Suicide prompted by social isolation, alienation, or systemic injustices may reveal underlying deficiencies in social virtues such as solidarity, empathy, and justice. Conversely, suicide arising from a sense of duty to protect loved ones or advance collective goals may manifest virtues of loyalty, altruism, and solidarity.

Critics of virtue ethics raise various objections to its application to suicide, highlighting potential challenges and limitations inherent in this ethical framework. One such concern revolves around the subjective nature of virtue and the diversity of moral values across cultures and contexts. Assessing the moral character of suicide becomes inherently complex when confronted with divergent perspectives on virtues, vices, and the nature of human flourishing. Furthermore, virtue ethics' emphasis on moral exemplars and role models may obscure the experiences of marginalized individuals and overlook the structural factors that contribute to their suffering and despair. Balancing the cultivation of virtues with the recognition of systemic injustices poses significant challenges in assessing the moral permissibility of suicide within a virtue ethics framework.

2. Existential Perspectives:

Existentialism: Existentialism, a philosophical movement that emerged in the 19th and 20th centuries, offers a profound exploration of the human condition, emphasizing individual freedom, responsibility, and the search for meaning in an indifferent universe. Existentialist philosophers like Jean-Paul Sartre and Albert Camus delve deeply into the absurdity and meaninglessness of existence, confronting fundamental questions about the nature of life, death, and the human experience. From the existentialist perspective, suicide emerges as a profound and existential act, reflecting both the absurdity of life and the individual's response to it.

Central to existentialist thought is the recognition of the absurd—the inherent tension between the human desire for meaning and the indifference of the universe. Existentialists contend that existence precedes essence, meaning that individuals are thrust into a world devoid of inherent meaning or purpose. In confronting this existential void, individuals grapple with the absurdity of their existence, navigating a world characterized by uncertainty, contingency, and ultimately, meaninglessness. Sartre famously encapsulates this existential dilemma in his



assertion that "existence precedes essence," highlighting the existentialist insistence on human freedom and responsibility in the face of an indifferent universe.

Suicide, within the framework of existentialism, emerges as a response to the absurdity of life—an assertion of individual freedom and autonomy in the face of existential despair. For existentialist thinkers like Camus, suicide represents the ultimate philosophical question, confronting individuals with the choice between life and death in a universe devoid of inherent meaning. Camus famously proclaims that "there is but one truly serious philosophical problem, and that is suicide," highlighting the existential significance of the decision to end one's life.

From the existentialist perspective, suicide can be understood as a radical assertion of individual freedom and autonomy—an existential rebellion against the absurdity of existence. In choosing to end one's life, individuals assert their agency and autonomy in the face of existential despair, refusing to succumb to the indifference and meaninglessness of the universe. Sartre famously asserts that "existence precedes essence," emphasizing the existentialist insistence on human freedom and responsibility in shaping the meaning of one's life. In choosing suicide, individuals exercise their freedom to define their own existence, asserting control over their fate in a world devoid of inherent meaning.

Moreover, existentialist philosophers explore the complex interplay between freedom and responsibility in the decision to end one's life. While suicide represents an assertion of individual freedom and autonomy, it also entails a profound sense of responsibility for one's actions and their consequences. Sartre famously articulates the concept of "radical freedom," highlighting the existentialist belief in the absolute autonomy of the individual in shaping the meaning of their existence. In choosing suicide, individuals confront the existential reality of their freedom and responsibility, acknowledging the consequences of their actions in a world devoid of inherent meaning.

Critics of existentialism raise various objections to its treatment of suicide, highlighting potential challenges and limitations inherent in this philosophical framework. One such concern revolves around the existentialist emphasis on individual freedom and autonomy, which may overlook the social, cultural, and psychological factors that contribute to suicidal behavior. Assessing the moral character of suicide becomes inherently complex when confronted with the diverse experiences and contexts that shape individual choices and actions.



Furthermore, existentialism's focus on the absurdity and meaninglessness of existence may lead to nihilistic interpretations of suicide, overlooking the potential for human agency and resilience in confronting life's challenges.

Absurdism: Absurdism, a philosophical perspective developed notably by Albert Camus in response to existentialist ideas, offers a unique lens through which to examine the human condition and the existential challenges posed by the inherent absurdity of life. Absurdism builds upon existentialist themes of alienation, meaninglessness, and freedom, positing that while life may lack inherent meaning or purpose, individuals have the capacity to create meaning through their actions and defiance against the absurdity of existence. Within the framework of absurdism, suicide emerges as a profound and existential act—one that reflects not a rejection of the absurd, but rather a surrender to it.

Central to absurdism is the recognition of the inherent tension between humanity's search for meaning and the indifference of the universe. Camus famously articulates the concept of the absurd in his essay "The Myth of Sisyphus," drawing upon the mythological figure condemned to eternally roll a boulder up a hill, only to watch it roll back down again. In the face of this futile and absurd task, Sisyphus finds meaning not in the outcome of his actions, but in the act of defiance itself—in the sheer act of continuing to roll the boulder despite its futility. Similarly, Camus contends that life is inherently absurd, characterized by the tension between humanity's search for meaning and the indifference of the universe. In confronting this existential absurdity, individuals must grapple with the fundamental question of whether life is worth living in the absence of inherent meaning or purpose.

From the perspective of absurdism, suicide can be understood as a response to the existential dilemma posed by the absurdity of life—an acknowledgement of the futility of human existence and the impossibility of finding ultimate meaning or purpose. In choosing to end one's life, individuals confront the absurdity of their existence and the inherent meaninglessness of their actions. However, unlike existentialism, which may emphasize the possibility of creating meaning through personal choice and authenticity, absurdism suggests that such attempts at meaning-making are ultimately futile and illusory. In this sense, suicide may be viewed as a surrender to the absurd—a recognition of the impossibility of finding meaning in a world devoid of inherent purpose.



Moreover, absurdism emphasizes the importance of embracing the absurdity of existence and finding solace in the sheer act of defiance against it. Camus famously asserts that "the struggle itself towards the heights is enough to fill a man's heart," highlighting the existential significance of the journey rather than the destination. In this light, suicide may be seen as a failure to embrace the absurdity of life and to find meaning in the act of defiance itself. By choosing to end one's life, individuals forego the opportunity to confront the absurdity of existence and to assert their autonomy and freedom in the face of it.

Furthermore, absurdism challenges traditional notions of morality and ethics, suggesting that the pursuit of meaning and purpose may ultimately be futile in a universe devoid of inherent values or goals. Unlike deontological or utilitarian ethics, which emphasize moral duties or the consequences of actions, absurdism contends that moral principles are ultimately arbitrary and illusory. In the absence of inherent meaning or purpose, individuals are left to confront the absurdity of their existence and to navigate the existential challenges posed by it.

Critics of absurdism raise various objections to its treatment of suicide, highlighting potential challenges and limitations inherent in this philosophical framework. One such concern revolves around the nihilistic implications of absurdism, which may lead to a sense of despair or hopelessness in confronting the absurdity of life. Assessing the moral permissibility of suicide becomes inherently complex when confronted with the nihilistic implications of absurdism and the existential struggles faced by individuals in navigating the inherent absurdity of existence.

Moreover, absurdism has been criticized for its emphasis on individualism and existential freedom at the expense of social or collective values. While absurdism emphasizes the importance of individual autonomy and defiance against the absurd, it may overlook the interconnectedness of human relationships and the ethical responsibilities that arise from them. Balancing the demands of existential freedom with considerations of compassion, empathy, and social solidarity poses significant challenges in assessing the moral dimensions of suicide within an absurdism framework.

3. Metaphysical Perspectives:

Religious Perspectives: Religious perspectives on suicide are multifaceted and diverse, reflecting the beliefs, values, and teachings of different religious traditions. Throughout history,



various religious doctrines and scriptures have addressed the topic of suicide, offering guidance, moral injunctions, and theological interpretations. From considering suicide a grave sin to viewing it as a complex moral and spiritual issue, religious perspectives on suicide encompass a wide range of attitudes and interpretations, each shaped by the particular teachings and cultural contexts of different faith traditions.

One prevalent view across several religious traditions is that suicide is considered a grave sin, often condemned as a violation of divine law and a rejection of the sanctity of life. Within Christianity, for example, many denominations historically regarded suicide as a mortal sin, resulting in damnation and eternal punishment. This perspective is rooted in theological interpretations of biblical passages, such as the Sixth Commandment's prohibition against murder and the belief in the sanctity of human life as created in the image of God. The Catholic Church, for instance, historically considered suicide a mortal sin, as it represents the deliberate taking of one's life, thereby usurping God's prerogative as the author of life and death. However, contemporary Catholic teachings recognize the complexity of factors that may contribute to suicide, such as mental illness, and emphasize compassion and pastoral care for those who struggle with suicidal thoughts or behaviors.

Similarly, in Islam, suicide is generally considered haram (forbidden) and is condemned as a violation of Islamic law and the divine will. The Quran explicitly states, "Do not kill yourselves, for verily Allah is to you most merciful" (Surah An-Nisa, 4:29), reflecting the prohibition against self-harm and suicide. Islamic teachings emphasize the sanctity of life as a trust from Allah and emphasize patience, perseverance, and reliance on divine guidance in facing life's trials and tribulations. However, like in other religious traditions, interpretations of Islamic teachings on suicide may vary, with some scholars considering the circumstances of the individual and the presence of mental illness or coercion in assessing moral culpability.

In Judaism, suicide has historically been viewed with ambivalence, with conflicting interpretations and attitudes towards the moral status of the act. While Jewish law traditionally regards suicide as a serious transgression, there is debate among Jewish scholars regarding the spiritual and moral consequences for the individual who takes their own life. Some interpretations of Jewish teachings emphasize compassion and understanding towards those who struggle with mental illness or unbearable suffering, recognizing the complexities of



human experience and the limitations of human judgment. However, the overall emphasis within Judaism is on the sanctity of life and the obligation to preserve and protect it whenever possible.

Contrasting with the condemnation of suicide found in some religious traditions, others offer more nuanced perspectives that consider the complexities of human suffering, moral agency, and divine mercy. In Hinduism, for example, attitudes towards suicide vary across different philosophical schools and cultural contexts. While suicide is generally discouraged as a violation of dharma (duty) and the spiritual path of self-realization, Hindu scriptures recognize the concept of prayopavesa, a form of voluntary fasting or renunciation undertaken by individuals facing terminal illness or unbearable suffering. In certain circumstances, prayopavesa may be considered a righteous and spiritually meritorious act, representing a conscious and voluntary decision to hasten the process of death in pursuit of moksha (liberation) from the cycle of birth and death.

Similarly, within Buddhism, suicide is generally regarded as a negative act stemming from delusion and attachment, contrary to the ethical precepts of non-harming and compassion. However, Buddhist teachings acknowledge the complex causes and conditions that contribute to suicidal thoughts and behaviors, including mental afflictions such as depression and despair. Compassion and understanding are emphasized towards individuals who struggle with suicidal impulses, with an emphasis on cultivating mindfulness, wisdom, and compassion as antidotes to suffering. Some Buddhist traditions also recognize the concept of self-sacrifice or self-immolation as a form of protest or spiritual practice, although such actions are often controversial and debated within Buddhist communities.

Furthermore, in certain religious contexts, suicide may be valorized or interpreted as a form of martyrdom or spiritual sacrifice. Within Christianity, for example, certain historical figures, such as martyrs and saints, have been venerated for their willingness to endure persecution and death rather than renounce their faith. While suicide itself is not condoned, the act of willingly sacrificing one's life for a higher purpose or cause may be regarded as a manifestation of heroic virtue and faithfulness to religious principles. Similarly, in Islam, the concept of jihad (struggle or striving) encompasses both internal spiritual striving and external struggle in defense of Islam and the Muslim community. While suicide attacks or acts of terrorism are condemned as



violations of Islamic teachings and ethical norms, the concept of jihad may be invoked in certain contexts to justify acts of self-sacrifice or martyrdom in defense of religious beliefs or communal values.

Nihilism: Nihilism, a philosophical perspective characterized by skepticism towards traditional beliefs and values, posits that life lacks inherent meaning or value. Rooted in the recognition of the apparent absurdity and emptiness of existence, nihilism challenges prevailing notions of purpose, morality, and significance. From the nihilistic perspective, suicide emerges as a logical response to the realization of life's inherent meaninglessness—an assertion of individual autonomy and freedom in the face of existential despair.

Central to nihilism is the rejection of transcendent values, absolute truths, and overarching meanings attributed to life and existence. Nihilists contend that human existence is ultimately devoid of inherent purpose or significance, with no inherent moral or existential framework to guide individuals in navigating the complexities of existence. Friedrich Nietzsche, one of the most prominent proponents of nihilism, famously declared that "God is dead," signaling the collapse of traditional religious and metaphysical beliefs that provided a sense of meaning and order in the world. In the absence of transcendent values or truths, nihilism confronts individuals with the unsettling realization that life is inherently meaningless and devoid of ultimate purpose.

From the nihilistic perspective, suicide can be understood as a logical response to the existential predicament posed by the inherent meaninglessness of existence. In choosing to end one's life, individuals confront the absurdity and emptiness of life, asserting their autonomy and freedom in the face of existential despair. Suicide represents a radical assertion of individual agency and self-determination, a rejection of societal norms, and a defiance against the futility of human endeavors. Nihilists argue that if life lacks inherent meaning or value, then individuals have the right to determine the course and end of their own existence, free from external constraints or moral judgments.

Moreover, nihilism challenges traditional notions of morality and ethics, suggesting that moral values are ultimately arbitrary and subjective constructs. In the absence of objective moral standards or transcendent truths, nihilists contend that ethical principles are merely social conventions or personal preferences, devoid of inherent significance or authority. From this



perspective, suicide may be regarded as a morally neutral or even morally justifiable act—an exercise of individual freedom and autonomy in the face of life's inherent meaninglessness. Nihilists reject the notion of moral obligations or duties that constrain individual actions, asserting instead the primacy of personal choice and existential freedom.

Furthermore, nihilism emphasizes the importance of confronting the existential void and embracing the absurdity of existence. Rather than succumbing to despair or nihilistic nihilism, which denies the possibility of meaning or value altogether, nihilists advocate for a radical acceptance of life's inherent meaninglessness. Suicide, from the nihilistic perspective, may be viewed as a courageous act—an assertion of individual autonomy and self-assertion in the face of the existential void. By choosing to end one's life, individuals confront the absurdity of existence and assert their freedom to determine their own fate, independent of external constraints or societal expectations.

Critics of nihilism raise various objections to its treatment of suicide, highlighting potential ethical, psychological, and social concerns inherent in this philosophical framework. One such concern revolves around the nihilistic implications of denying the possibility of meaning or value in life, which may lead to a sense of despair, hopelessness, or moral relativism. Assessing the moral permissibility of suicide becomes inherently complex when confronted with the nihilistic implications of nihilism and the existential struggles faced by individuals in navigating the inherent meaninglessness of existence.

Moreover, nihilism has been criticized for its emphasis on individualism and existential freedom at the expense of social or collective values. While nihilism emphasizes the importance of individual autonomy and self-determination, it may overlook the interconnectedness of human relationships and the ethical responsibilities that arise from them. Balancing the demands of existential freedom with considerations of compassion, empathy, and social solidarity poses significant challenges in assessing the moral dimensions of suicide within a nihilistic framework.



4. Psychological Perspectives:

Psychological Well-being

Suicidality: Exploring suicidality from a philosophical perspective delves into profound questions about agency, autonomy, and the nature of suffering. Philosophers examine the complex interplay of individual choice, societal influences, and existential dilemmas inherent in suicidal thoughts and behaviors. By engaging with these philosophical inquiries, we can gain deeper insights into the ethical, existential, and psychological dimensions of suicidality.

One fundamental question that philosophers grapple with is the nature of agency and autonomy in the context of suicidality. Agency refers to the capacity of individuals to act intentionally and exercise control over their actions, while autonomy pertains to the ability to make self-governing decisions free from external coercion or undue influence. Philosophers explore whether individuals who experience suicidal thoughts or engage in suicidal behaviors possess genuine agency and autonomy, or whether they are subject to internal or external factors that constrain their freedom of choice.

Existentialist philosophers like Jean-Paul Sartre emphasize the radical freedom and responsibility of individuals in shaping their own lives. From this perspective, individuals confronted with the existential absurdity and meaninglessness of life must grapple with the fundamental question of whether to continue living or to end their lives. Sartre contends that even in the face of despair and anguish, individuals retain the freedom to choose their own path and to assert their existential freedom in the face of the absurd. However, critics argue that existentialist notions of freedom may overlook the psychological and social factors that influence suicidal behavior, such as mental illness, trauma, or societal pressures.

Moreover, philosophers explore the ethical dimensions of suicidality, considering questions about the permissibility, justifiability, and moral implications of suicide. Ethical theories such as utilitarianism, deontology, and virtue ethics offer different frameworks for evaluating the moral status of suicide and its impact on individuals and society. Utilitarianism, for example, assesses the consequences of actions in terms of maximizing overall happiness or reducing suffering. From this perspective, suicide may be considered morally permissible if it alleviates unbearable suffering or prevents greater harm to oneself or others. However, critics raise



concerns about the potential for utilitarian calculations to justify suicide in ways that overlook the intrinsic value of human life and the complexities of moral decision-making.

Deontological ethics, exemplified by the philosophical framework of Kantian ethics, emphasizes moral duties, principles, and obligations that constrain individual actions. From this perspective, suicide may be regarded as morally impermissible based on the principle of treating oneself as an end rather than a means. Kantian ethics prohibits self-destructive actions that undermine the inherent dignity and moral worth of human beings, emphasizing the importance of preserving life and respecting the autonomy of individuals. However, critics question the applicability of deontological principles to the complex moral dilemmas posed by suicidality, which may involve conflicting duties and obligations.

Furthermore, virtue ethicists consider the motivations, character traits, and moral virtues involved in the phenomenon of suicidality. Virtue ethics emphasizes the cultivation of virtues—excellences of character that enable individuals to live a good life—in navigating moral dilemmas and existential challenges. From this perspective, individuals struggling with suicidal thoughts or behaviors may lack certain virtues, such as resilience, hope, or compassion, that enable them to confront adversity and navigate life's challenges. However, virtue ethicists also recognize the importance of compassion, empathy, and understanding in responding to individuals who experience suicidality, emphasizing the need for supportive and empathetic responses that foster healing and growth.

Moreover, existentialist philosophers like Albert Camus and Friedrich Nietzsche explore the existential dimensions of suffering and despair inherent in the phenomenon of suicidality. Camus famously contends that life is inherently absurd, characterized by the tension between humanity's search for meaning and the indifference of the universe. In confronting the absurdity of existence, individuals must grapple with the existential dilemma of whether to continue living or to end their lives. Nietzsche similarly emphasizes the role of suffering and adversity in shaping human existence, arguing that the will to power and the affirmation of life are central to overcoming nihilism and embracing the inherent challenges of existence.

Critics of philosophical explorations of suicidality raise various objections, highlighting potential challenges and limitations inherent in these inquiries. One such concern revolves around the potential for philosophical discussions to overlook the lived experiences and



subjective realities of individuals who experience suicidality. Philosophical abstractions and theoretical frameworks may fail to capture the complexities of human suffering, psychological distress, and social factors that contribute to suicidal thoughts and behaviors. Additionally, critics question the moral and ethical implications of philosophical analyses of suicidality, raising concerns about the potential for stigmatization, victim-blaming, or oversimplification of complex moral dilemmas.

5. Cultural Perspectives:

Cultural Attitudes: Attitudes towards suicide indeed vary significantly across cultures and historical periods, reflecting diverse cultural values, religious beliefs, social norms, and philosophical traditions. Some cultures stigmatize suicide as a taboo and morally reprehensible act, while others may perceive it as an acceptable or even honorable course of action under specific circumstances. Understanding these cultural attitudes towards suicide requires examining the complex interplay of cultural, historical, and socio-economic factors that shape perceptions of life, death, and the human condition.

In many Western societies, particularly those influenced by Judeo-Christian traditions, suicide has historically been stigmatized and condemned as a moral transgression and a violation of religious teachings. Christianity, for example, has traditionally regarded suicide as a grave sin, reflecting theological interpretations of biblical injunctions against taking one's own life. The Catholic Church, in particular, has historically condemned suicide as a mortal sin, denying burial rites and sacraments to those who die by suicide. This stigmatization of suicide as a sinful and morally reprehensible act has persisted in Western cultures for centuries, contributing to social taboos and negative attitudes towards suicide and mental illness.

Similarly, in Islamic cultures, suicide is generally condemned as a violation of Islamic law and the divine will. The Quran explicitly prohibits self-harm and suicide, emphasizing the sanctity of life as a trust from Allah. Islamic teachings emphasize patience, perseverance, and reliance on divine guidance in facing life's trials and tribulations, discouraging individuals from resorting to suicide as a means of escape from suffering or hardship. However, attitudes towards suicide may vary across different Muslim communities and cultural contexts, with some interpretations of Islamic teachings emphasizing compassion and understanding towards individuals who struggle with mental illness or existential despair.



Contrasting with the stigma and condemnation of suicide found in certain cultural and religious traditions, other cultures may hold more nuanced or accepting attitudes towards suicide under specific circumstances. In certain historical periods and cultural contexts, suicide has been perceived as an acceptable or even honorable course of action under conditions such as extreme suffering, terminal illness, or societal upheaval. For example, in ancient Rome and Greece, suicide was sometimes regarded as a noble and honorable act, particularly among philosophers and political leaders who chose to end their lives rather than submit to tyranny or dishonor. Philosophers like Seneca and Socrates famously chose to take their own lives as a final assertion of personal autonomy and dignity in the face of adversity.

Moreover, in some cultural traditions, suicide may be perceived as a form of martyrdom or sacrifice, reflecting cultural values of honor, duty, and self-sacrifice. In Japanese culture, for example, the practice of seppuku, or ritual suicide, has historical roots in samurai culture and Bushido ethics. Seppuku was considered an honorable means for warriors to preserve their honor or atone for failure or disgrace. While seppuku is no longer practiced in contemporary Japan, its cultural legacy continues to shape attitudes towards suicide and notions of honor and sacrifice.

Furthermore, attitudes towards suicide may be influenced by socio-economic factors, such as access to mental health care, social support networks, and economic disparities. In societies with limited resources and inadequate mental health services, individuals may face greater barriers to seeking help for mental health issues or accessing treatment for suicidal ideation. Cultural attitudes towards suicide may also be shaped by broader social and economic inequalities, including disparities in education, employment, and healthcare access. Addressing the stigma and taboo surrounding suicide requires not only cultural sensitivity and awareness but also systemic efforts to improve mental health care, reduce social inequalities, and promote community support and resilience.

Literary and Artistic Representations: Literature and art have served as powerful mediums for exploring the complex and multifaceted phenomenon of suicide, offering insights into its psychological, social, and existential dimensions. Through diverse literary and artistic representations, creators have confronted the existential dilemmas, moral ambiguities, and



emotional complexities surrounding suicide, inviting audiences to reflect on the human condition and the challenges of navigating life's existential struggles.

One of the most notable literary works that grapples with themes of suicide is Leo Tolstoy's epic novel "Anna Karenina." The tragic character of Anna Karenina ultimately chooses to end her own life as a response to the societal pressures, personal conflicts, and existential despair she experiences. Tolstoy's portrayal of Anna's descent into despair and her eventual suicide offers a poignant exploration of the psychological and social factors that contribute to suicidal thoughts and behaviors. Through Anna's story, Tolstoy examines themes of love, betrayal, isolation, and existential longing, inviting readers to contemplate the complexities of human emotions and the consequences of societal expectations and norms.

Similarly, Fyodor Dostoevsky's novel "Crime and Punishment" delves into the moral and psychological dimensions of suicide through the character of Raskolnikov, a young student who contemplates and ultimately commits murder as a means of asserting his superiority and testing his theories of moral relativism. Raskolnikov's existential crisis and moral dilemmas culminate in his decision to surrender to the authorities and accept punishment for his crimes, representing a form of existential redemption and moral awakening. Dostoevsky's exploration of guilt, redemption, and the search for meaning in a world marked by suffering and injustice offers profound insights into the existential struggles that underlie suicidal thoughts and behaviors.

6. Conclusion:

In summary, philosophical perspectives on suicide encompass a wide range of ethical, existential, metaphysical, psychological, and cultural considerations. Through rigorous inquiry and reflection, philosophers seek to understand the complexities of suicide and its implications for individuals and society. By engaging with these diverse perspectives, philosophers contribute to a deeper understanding of the ethical dilemmas, existential struggles, and moral complexities that surround this deeply emotive and often contentious topic. Through interdisciplinary dialogue and collaboration, philosophers, psychologists, clinicians, and social scientists work together to address the complex challenges of suicide prevention, mental health promotion, and compassionate care for individuals who struggle with suicidal thoughts and behaviors. As we continue to grapple with the existential, ethical, and cultural dimensions



of suicide, philosophical inquiry offers valuable insights into the human condition and the quest for meaning, dignity, and well-being in the face of existential despair.

Conflict of interest

The authors have no conflict of interest in publishing this paper

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Contribution of Rabindranath Tagore, adapted and translated in the field of contemporary Sanskrit literature: an overview

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Abstract

Rabindranath Tagore's literary creation is the inspiration for many future poets. Rabindra-sahitya has been translated in numerous Indian languages since decades. Moreover, his writings is based on some of the captivating topics, which have been expanded furthermore. Rabindranath was a skilled artist by himself. He was able to understand the truth of life, saddest thoughts in human beings. Thus, his writings are still retained and enlightens the present minds.

Keywords: Translation, Adaptation, Literature, Tagore, Contemporary.

Rabindranath was a famous poet, philosopher, dramatist, actor, novel-writer, composer of articles, essays, writer of short stories, critic, singer, painter, artist, composer of songs, ideal teacher as well as writer of dance-drama. He strung the beads of the garland based on Vedic literature, Smriti, Tantra, Philosophy, Epics, Classical Sanskrit literature, History, *Purāṇs*, *Pāli*, *Prākṛt*, *Avadānaśataka* etc.

His main creation is in Bengali but the Bengali literature is also been translated in different languages like *Hindī*, *Mārāthī*, *Tāmil*, *Oḍiā* etc i.e. all modern Indian languages.

During his life he studied Sanskrit. In his childhood he used to recite mantras from *Upaniṣads* and after *upanayana* he got charmed at the time of recitation of *Gāyatrī mantra*¹. His respect towards Sanskrit literature was inherited from his father, *Mahaṛṣi* Debendranath Tagore who made him grow his interest in the *Gītā* and *Gītāgovindam*. *Paṇḍit* Ramasarvasva Bhattacharya gave him lessons on *Abhijñāśakuntalam*.

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In the influence of cultural environment, he established Asrama school in Shantiniketan and translated some texts of Sanskrit literature such as *Raghuvamśam*, *Kumārsambhabam* etc. He wrote *Vālmiki-Pratibhā* and *Kālmṛgayā*, the two masterpieces (*Gītikāvya*s) based on the *Rāmāyaṇa* precisely *Nārada-Vālmiki-saṃbādḥ* from the first canto of *Bālkāṇḍa*. *Krauñcavadham* o *Vālmiki-prati-ādeśḥ* are taken from second canto of the *Bālkāṇḍa*. Again, *Vālmiki-Pratibhā* was translated into Sanskrit by Dr. B. Raghavan, published in *Samṣkṛta Rabīndram* from Sahitya Akademi, New Delhi, 1966.

Rabindranath got inspiration from *Śyāmājātaka* in the *Mahāvastu* for composing literary gems like *Parīśodh* (a narrative poem), *Parīśodh* (an operetta) and *Śyāmā* (a dance drama) in Bengali language.

Being a scholar, Rabindranath tirelessly collected jewels from the Sanskrit literature and led to the creation of timeless works in Bengali literature, which were re-translated back into Sanskrit. It shows a great symbiotic relationship between two literatures.

Rabindranath wrote *Citrāṅgadā* by collecting the narrative part of the story from the *Ādiparba* of the *Mahābhārata* written by *Krishna Dvaipayana Vedavyas*. Rabindranath's creation *Vidāyay-abhiśapa* based on the story of *Yayāti-upākhyāna* related to *Kac-Devyānī* episode. Vidubhusan Nyayacharya gave the Sanskrit version of this poem and gave the title, *Kac-Devyānī-Saṃbādḥ*. Poet Rabindranath wrote *Gāndhārīr Āvedana* with the combined narrative of *Ādi-Strī-Sabhā-Āśramvāsika parvas*. The Sanskrit translation of this poem is *Gāndhārya-āvedanam* by *Kāśyapabi Kalipada Tarkacharya*. Thus many Sanskrit poetries are translated Rabindra-Sahitya into Sanskrit. Rabindranath's short stories have been translated by Vishnupada Bhattacharya. He translated from the short story *Kaṅkāla* into *Kaṅkālam*, published in Sanskrit Sahitya Parishat Patrika. Dr. Tanmoy Kumar Bhattacharya, Narayan Dash and Rakesh Kumar Das have translated some short stories from Bengali to Sanskrit. These were published in the book entitled *Kabīndra-kathā-kallolinī*, 2011. Now I am quoting some examples from roots with its own translations too in different languages. Examples are given below.



First poem from *Gītāñjali*, written on 1313 *baṅgābdo*.

আমার মাথা নত করে দাও হে তোমার

চরণধূলার তলো

সকল অহংকার হে আমার

ডুবাও চোখের জলো

নিজেরে করিতে গৌরব দান

নিজেরে কেবলই করি অপমান,

আপনারে শুধু ঘেরিয়া ঘেরিয়া

ঘুরে মরি পলে পলে |²

Gītāñjali is been translated in Sanskrit as गीताञ्जलि-प्रतिच्छाया by श्रीकाश्यपकविः कालीपदतर्काचार्यः।

मम-शीर्ष-नय-नतिमयि!तव

चरणरेणुतले|

सकलमहंकारं-मम

मज्जयाक्षिजले|

साधयितुं-सगौरवं

दधे-सदा-स्वपरिभवं

केवलमावेष्ट्य-निजं

घूर्णे प्रतिपले |³

Poet Rabindranath translated his poem in English.

Make me bow, kneel down

at your feet

Submerge my arrogance in tears

To lavish honour on myself

All I do is insult this self

Encircling ensaring myself

Each moment I spiral to death

Submerge my arrogance in

tears.⁴



Another exmple is from बोधिसत्त्वावदानकल्पलता (बौद्धसत्त्वावदानकल्पलता)। Lord Buddha and buddhist text has influenced Rabindranath's writings a lot. Thus, I am quoting from the poem *Abhisāra*.

सन्न्यासी उपगुप्त
मथुरापुरीर प्राचीरैर तले
एकदा छिलेन सुप्त-
नगरीर दीप निबेछे पवने,
दुयार रुद्ध पौर भवने,
निशीथेर तारा श्रावणगगने
घन मेघे अबलुपुत्रा⁵

Ābhisāra was translated by Indramohan Chakravarty as अभिसारः (बोधिसत्त्वावदानकल्पलतायाः)

सन्न्यासी-उपगुप्तः
मथुरापुरीप्राचीरतले
आसीदेकदासुप्तः।
पुरदीपमाला-अन्धा-पवनैः,
भवनद्वारं-रुद्धं-पौरैः;
निशीथ-तारका-गणो घनमेघैः श्रावण-गगने लुप्तः।⁶

In English,

Sanyasi Upagupta

Was once asleep at the foot of the

Mathurapuri walls-

The breeze had blown out the lamps of the city.

Doors of the city hall were shut.

The stars of the night sky were hidden

Behind heavy clouds of monsoon.⁷

Next example is from the poem *Brāhman*, main theme of the poem is taken from *Jabālā - satyakāma* episode of the *Chāndogya Upaniṣads*. Rabindranath wrote-

অন্ধকার বনচ্ছায়ে সরস্বতীতীরে

অস্ত গেছে সন্ধ্যাসূর্য; আসিয়াছে ফিরে

নিস্তন্ধ আশ্রম-মাঝে ঋষিপুত্রগণ



মস্তকে সমিধভার করি আহরণ

বনাস্তর হতে⁸

It is been translated by চন্দ্রকুমারকাব্যব্যাकरणतीर्थ. Some verses are ब्राह्मणः

सरस्वतीतीरवनान्तराले तमोवृते सान्ध्यरवौ प्रयाते|

नीत्वा च शीर्षेषु कुशेन्धनानि समागताश्चाश्रमवासिशिष्याः|⁹

In English,

Dark are the blanks of river

Saraswati, sylvan, shaded,

The sun has set, twilight has faded,

The sons of rishis return to an Asrama silently dwelling

Bearing on their heads loads of kindling.¹⁰

There were many other scholars who translated Rabindranath like *Bhāratīrthe* expressed as *Bhāratīrtham* by Dhirendranath Mukhopadhyay. Kalidasa's *Meghadūtā* was transliterated into Bengali as *Meghadūta* and it was back to Sanskrit entitled as *Meghadūtā* by Dhirendra nath Mukhopadhyay. *Ratherraśi* into *Ratharajju* by Bimal Krishna Matilal. *Muktadhārā* arrived from *Muktadhārā*, *Raktakarabī* as *Raktakarāī* etc. Ramjivan Acharyya translated *Mukut*, Bengali drama to *Mukutam*. Kamala, a female poet who translated Rabindranath's *Antyṣṭi- Saṃskār* in Sanskrit. Dr. Sutapa Bhattacharya translated a reputed Rabindra Saṃgēt to Sanskrit.

আনন্দলোকে মঙ্গলালোকে বিরাজ সত্যসুন্দর

মহিমা তব উদ্ভাসিত মহাগগনমাবে,

বিশ্বজগত মণিভূষণ বেষ্টিত চরণে ॥

গ্রহতারক চন্দ্রতপন ব্যাকুল দ্রুত বেগে

করিছে পান, করিছে স্নান, অক্ষয় কিরণে ॥

ধরণী'পর বারে নির্বর, মোহন মধু শোভা

ফুলপল্লব-গীতগন্ধ-সুন্দর-বরনে ॥

বহে জীবন রজনীদিন চিরনূতনধারা,

করুণা তব অবিশ্রাম জনমে মরণে ॥

স্নেহ প্রেম দয়া ভক্তি কোমল করে প্রাণ,



कत साङ्गुन करे बर्यर्ण सङ्तापहरणे ॥

जगते तव की महोत्सव, बन्दन करे विश्व

श्रीसम्पद भूमास्पद निर्भयशरणे ॥¹¹

आनन्दलोके मङ्गलालोके

विराजस्व सत्यसुन्दर॥

महिमा तव उद्भासितो महति गगने

विश्वजगन् मणिभूषणवेष्टिते चरणे॥

ग्रहतारकचन्द्रतपना व्याकुला

द्रुतवेगेन,

पिवति च स्नाति च अक्षये किरणे॥

धरणीपरे प्रस्रवति मोहना मधुरा शोभा -

पुष्पपल्लवगीतगन्धरञ्जिते वर्णे॥

वहति जीवनं रजनीदिवसं

चिरनवीना धारा॥

करुणा तव अविरता जनने मरणे॥

स्नेहः प्रेम दया भक्तिः कोमलायते प्राणान्

कीयत् सान्त्वनं वर्षति स सन्तापहरणे॥

जगति तव को महत्सवो वन्दयति विश्वम्,

श्रीसम्पदि भूमाष्पदि निर्भयशरणे॥¹²

These are translatory works. Now the time to discuss about adaptation.

Nityananda Mukhopadhyay gave Sanskrit forms with the subject of short stories and some of the eminent even turned them into dramas.

Prof. Dhyanesht Narayan Chakraborty translated two extraordinary stories of *Muktadhārā* and *Dākghar* into Sanskrit dramas and retitled as *Muktadhārā* and *Bātrāgṛha*. But these are not



short stories, these are allegorical compositions. But Nityananda Mukhopaddhay has the credit of turning the short-stories into Sanskrit dramas. These are examples of adaptation in different fields of contemporary Sanskrit literature.

Literary adaptation is been seen from other ethnic languages such as Bengali, *Mārāthī*, English, etc. Rabindranath's creation in the field of Bengali literature is treasured with romanticism and dramatic approaches that it became an important literary source for adapting and making a work of art based upon it.

In imaginative literature words are the vehicle of sensation and associations and convey meanings beyond the literal or denotative meanings. It is being debated that literature cannot be translated successfully from one language to other. Sometimes it is unable to furnish the actual grace of the work. Adaptation is a method where copying of an existing work is not done. But the flavour of the literature remains unchanged and untouched. Adaptation of Tagore's short stories and retitling them into Sanskrit drama was done by late Pandit Nityananda Mukhopadhyaya, a renowned person in modern Sanskrit literature. Based on the short stories of Tagore, dramas were constructed with different retitling in Sanskrit. Such as - *Khokābābur Pratyāvartana* was transliterated into *Putra-Pratyāvartanam*, *Postmaster* was converted into *Vārtagṛhadhyakṣa-vaco*, *Rāsmāñir chēlē* into *Rasmañiputram*, *Śrī-Nalina-parābhavam* arrived from *Phel*, *Putrayajña* as *Putrayajñam*, *Guptadhana* expressed as *Guptadhanam* etc.

Short story and drama are two different areas of Kavya and both of them have different approaches. As Rabindranath Tagore's short stories have beautiful theatrical expression, this poet Nityananda converted selected short stories into drama efficiently. But he constructed dramatic plot according to his wish. He introduced new characters after naming them. In *Putra-Pratyāvartanam*, *Shyamali*, sister of *Raicarana* has inserted and *Mohona*, the master's son of *Raicarana* is renamed by poet Nityananda. Rabindranath Tagore emphasized on secondary or tertiary relationship in his short stories like *Kabuliwala* and *Mini*, *Postmaster* and *Ratan* etc. When Nityananda portrayed these relations, he maintained the storyline same with full enthusiasm. So, those adaptations are justified.

Rabindranath created great depth into his characters. Nityananda reembraced the characters of the drama with compassion and designed it with innate psychological analysis and made it more genuine and contemporary.

Nityananda intruded dramatic excitements and clashes among characters in his creations. Some of his drama, based on Rabindranath's short story was concluded it tragedy and pathos (except *Rogī- Bāndhabam*). Societal activities of both pernicious as well as favourite situations had been delineated by Tagore. Nityananda replicated Gurudev's ideas and replicated Rabindranath's ideas and reflected it unamended.

Drama is dialogue based performance. Characters exposed their motely feelings through dialogues and actions. Here, dialogues are short and witty but expressed deep meaning several times.

Nature has played a vital role in Rabindranath's short story. But it is totally invisible in Nityananda's drama. Pandit Mukhopadhyay tried also to make familiar Sanskrit language among common people. His effort is quite applaudable in this context.

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Conflict of interest

The authors have no conflict of interest in publishing this paper

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All data used in this article have not been taken from any secondary data.



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Enhanced Heat Capacity in Carbon Nanotube-Polymer Liquid Crystal Nano-Composite through First-order Isotropic-Nematic Transition: A Theoretical Study

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Abstract:

Arrangement and distribution of Carbon nanotubes (CNTs) inside polymer liquid crystal (PLC) plays vital role in regulating various properties including the thermal property of the composite. It is found that proper alignment of CNTs inside PLC greatly influence and enhance the heat capacity as well as the thermal conductivity of the mixture. Proper realization and theoretical understanding of the mechanism of CNT alignment inside PLC is needed in order to explain the reason behind the improvement of heat capacity of the composite. In this work we have utilized the free energy model proposed by Landau-de Gennes and Doi to develop the free energy profile of CNT-based PLC composite. Subsequent mathematical calculations show that CNTs undergo first order isotropic-nematic transition inside PLC through which they align themselves in the nano-composite and thereby help in increasing the heat capacity of the overall nanofluid. Results show rapid growth in both CNT order parameter and heat capacity with increase of CNT volume fraction in the nano-composite. Effects of PLC order parameter as well as mixing temperature on CNT ordering have also been investigated and analyzed in details.

Keywords: Carbon nanotube; Nano-composite; Phase transition; Heat capacity; Mathematical Modelling

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1. Introduction:

For the past few decades carbon nanotubes (CNTs) and CNT-based nanocomposites and nanofluids have been among the pivotal interests for research workers due to their immense applications in the emerging areas like nanoelectronics, solid-state device fabrication, photovoltaic and field emission displays etc. [1-5]. Besides these fields, application of CNT-based nanocomposites as heat transfer materials has also proven to be extremely beneficial due to their high aspect ratio and large surface-to-volume ratio which help them to possess a high value of thermal conductivity and hence an ideal material to be used as an additive in a heat-transfer nanofluid such as engine oils and lubricants [6,7].

Previous reports suggest that both crystalline and amorphous CNTs (ACNTs) have been used as additives in heat transfer fluids and both are proven to be helpful in enhancing the thermal conductivity of the nanofluid [8,9]. ACNTs are observed to be more advantageous in these cases due to its simple synthesis procedure and large amount production [9,10]. However stable dispersion of CNTs in nanofluid has always been a challenge due to high Vander-wall force of attraction among the nanotubes which makes nanotubes aggregated and agglomerated inside the nanofluid and thereby restrains the process of uniform and stable dispersion. This problem can be overcome by functionalization of CNTs in which specific functional groups are attached to the surface of nanotubes to generate repulsive force (steric hindrance force) among the nanotubes which helps them to overcome the Vander-wall attractive force and prevent the agglomeration and thereby helps in getting a stable dispersion. Owing to the defects in their carbon network, ACNTs have inherent presence of some common functional groups and therefore are ideal candidate for further functionalization [9-12].

To understand the theoretical aspect of increased thermal conductivity of CNT-dispersed thermos fluids we need to focus on the dimension, morphology, alignment and changing dynamics of nanotubes inside the nanofluid. Previous reports suggest that CNTs undergo a first order phase transition from isotropic to lyotropic nematic phase with increase of CNT volume fraction inside polymer liquid crystal (PLC) [13]. Windle's group was the first to report and explain the isotropic-nematic phase transition of CNTs in aqueous suspension [14,15]. Later Dierking *et al.* also explained the ability of liquid crystal (LC) to self-organize and induce nematic alignment towards dispersed CNTs [16,17]. Degree of alignment of CNTs



in LC depends primarily on the anchoring energies of nematic molecules over CNT surfaces and also on their dependence on the temperature and, hence, on the strength of their coupling to the nematic fluid [18,19]. It is seen that with increasing CNT concentration, the alignment is strongly enhanced through excluded-volume interactions.

Isotropic-nematic transition plays crucial role in the ordering and alignment of CNTs inside PLC. While both thermotropic and lyotropic LC are found to boost alignment of CNTs, lyotropic LC can also work as surfactants for CNTs which prevents aggregation of CNTs with the hydrophobic tails adsorbing onto the CNT surface while the hydrophilic heads point outwards in the solution, making it possible to achieve isolated dispersion. As the value of conductivity depends on the direction along which the measurement is performed, alignment of CNTs during phase change provides easier channel for heat conduction along the axial direction. In the nematic phase the conductivity is lower perpendicular to the director and higher parallel to it, reflecting the higher ionic mobility along the director [20].

Both experimental and theoretical works are reported previously on synthesis of CNT-based polymer nanocomposites and their thermal behaviour [21,22]. However, first order phase transition of CNTs inside polymer matrix and its effect on overall thermal properties of the nanofluid have not been discussed earlier in details to the best of authors' knowledge. In this work we have developed a free energy profile for CNT-based PLC on the basis of Landau-de Gennes and Doi type free energy model [23] and analysed the variation of order parameters and heat capacity with CNT concentration. Results showed that CNT order parameter is highly influenced by the amount of CNTs added to the nano-composite and rapid alignment of CNTs with concentration can be seen during first order phase transition. The alignment also helps to increase the heat capacity of the nanofluid and change of heat capacity with CNT concentration was also investigated and analysed. Variations of CNT order parameter with both mixing temperature and PLC order parameter have also been examined thoroughly.

2. Free energy of CNT based PLC nanofluid:

To construct the free energy profile of CNT based PLC nanofluid let us consider V_1 volume of CNTs mixed in V_2 volume of PLC to generate the nanofluid having total volume of $V = V_1 +$

V_2 . Hence the volume fractions of CNTs and PLC are now $\phi = V_1/V$ and $(1 - \phi) = V_2/V$, respectively. The total free energy density of CNT-PLC suspension can now be written as,

$$F = F_{\text{mix}} + F_{\text{CNT}} + F_{\text{PLC}} + F_{\text{CNT-PLC}}. \quad (1)$$

The first term in the above expression F_{mix} depicts the free energy for mixing CNTs in PLC and can be written as proposed by Flory [24,25] as,

$$F_{\text{mix}} = \frac{K_B T}{V_1} \phi \ln \phi + \frac{K_B T}{V_2} (1 - \phi) \ln(1 - \phi) + \frac{K_B T}{V_2} \chi \phi (1 - \phi). \quad (2)$$

The first and the second terms in the above equation represent free energy provided by mixing entropy for CNTs and PLC in isotropic phase respectively. While, the last term plays the key role in this equation as it stands for the isotropic interaction between CNTs and the nematogens. The parameter χ is known as Flory-Huggins interaction parameter signifies the extent of contact that can be achieved in between CNTs and the polymer in the mixture. Here χ is taken as $\frac{U_0}{K_B T}$, where U_0 is strength of isotropic interaction between CNTs and polymer chain, K_B is Boltzmann constant and T is absolute temperature. While deducing equation (2) it is assumed that $V_2 \approx V_0$, where V_0 is the volume of the Flory lattice cell.

The second term in equation (1) F_{CNT} is the free energy for first order isotropic-nematic transition of CNTs and can be written as [23]

$$F_{\text{CNT}} = \frac{K_B T}{V_1} \phi \left[\frac{1}{2} \left(1 - \frac{U}{3} \right) S_1^2 - \frac{U}{9} S_1^3 + \frac{U}{6} S_1^4 \right]. \quad (3)$$

Here U stands for nematic potential which in this case is generated from the combination of excluded-volume interaction and Maier–Saupe type anisotropic mean-field attraction between the CNTs [26]. Hence, we take, $U = \frac{L}{D} \phi \left(\frac{5}{4} + 2\kappa \frac{\theta}{T} \right)$, where first term $\frac{5}{4} \frac{L}{D} \phi$ in U is genuinely from excluded-volume interaction, whereas, the second term $2\phi \kappa \frac{L}{D} \frac{\theta}{T}$ is resulted from the attractive mean-field interaction between CNTs. In this second term κ denotes the ratio between anisotropic and isotropic parts of the mean-field potential and θ represents ‘effective temperature’ at which the isotropic part of the mean-field potential disappears. θ in this case is analogous to ‘effective polymer temperature’ [27], which stands as the critical temperature where the excluded-volume interaction and mean-field type attractive interaction between flexible macromolecules balance each other. Similarly, θ can also be portrayed as the relevant

characteristic scale of isotropic interaction in this system, which somehow depicts the characteristics of the PLC base.

The free energy density term for PLC can be derived from Landau-de Gennes expansion and written in terms of order parameter S_2 of PLC as [28],

$$F_{\text{PLC}} = (1 - \varphi) \left[\frac{3}{2} A(T - T^c) S_2^2 - \frac{3}{4} B S_2^3 + \frac{9}{4} C S_2^4 \right] \quad (4)$$

The parameters 'B' and 'C' are called standard Landau-de Gennes coefficients which are independent of temperature and mainly depend on the properties of the material. On the other hand, coefficient 'A' is temperature dependent with T^c representing the temperature at which the Isotropic phase of pure LC exists.

Nature of anchoring strength within PLC molecules over CNT surface plays key role in developing the interaction energy between CNT and PLC [16]. Development of soft or strong anchoring strength depends on molecular structure of CNTs as well as the London-type attractive forces between the corresponding benzene rings [29]. It was found Multiwalled-CNTs provide strong anchoring due to more number of well-distributed benzene rings, whereas Singlewalled-CNTs develop soft anchoring [30]. Brochard and de Gennes developed the first successful theory based on the idea of rigid anchoring [31]. Subsequently it was refined and rectified by Burylov and Raikher [32] by incorporating the strong anchoring conditions and is used here as an interaction energy between CNT and PLC.

$$F_{\text{CNT-PLC}} = -\gamma\varphi(1 - \varphi) S_1 S_2^2 \left(1 - \frac{S_1}{2} \right) \quad (5)$$

Now combining all equations from (2) to (5) we can write the total expression for free energy of CNT dispersed PLC as,

$$\begin{aligned} F = & \frac{K_B T}{V_1} \varphi \ln \varphi + \frac{K_B T}{V_2} (1 - \varphi) \ln(1 - \varphi) + \frac{K_B T}{V_2} \chi \varphi (1 - \varphi) \\ & + \frac{K_B T}{V_1} \varphi \left[\frac{1}{2} \left(1 - \frac{U}{3} \right) S_1^2 - \frac{U}{9} S_1^3 + \frac{U}{6} S_1^4 \right] \\ & + (1 - \varphi) \left[\frac{3}{2} A(T - T^c) S_2^2 - \frac{3}{4} B S_2^3 + \frac{9}{4} C S_2^4 \right] - \gamma\varphi(1 - \varphi) S_1 S_2^2 \left(1 - \frac{S_1}{2} \right) \end{aligned} \quad (6)$$

For convenience the above equation can be made dimensionless by modifying as follows,

$$f = \frac{FV_1}{K_B T} = \varphi \ln \varphi + R(1 - \varphi) \ln(1 - \varphi) + R\chi\varphi(1 - \varphi) + \varphi \left[\frac{1}{2} \left(1 - \frac{U}{3} \right) S_1^2 - \frac{U}{9} S_1^3 + \frac{U}{6} S_1^4 \right] \\ + (1 - \varphi) \left[\frac{3}{2} a \left(1 - \frac{T^C}{T} \right) S_2^2 - \frac{3}{4} b S_2^3 + \frac{9}{4} c S_2^4 \right] - \delta \varphi (1 - \varphi) S_1 S_2^2 \left(1 - \frac{S_1}{2} \right) \quad (7)$$

In the above equation the coefficients are also modified as, $R = \frac{V_1}{V_2}$, $a = \frac{AV_1}{K_B}$, $b = \frac{BV_1}{K_B T}$, $c = \frac{CV_1}{K_B T}$ and $\delta = \frac{\gamma V_1}{K_B T}$ respectively.

3. Results and Discussion:

In this section we have explained the results obtained by calculating the first order isotropic-nematic phase transition of CNTs dispersed in PLC and analysed the variation of CNT order parameter (S_1) with volume fraction (φ) for various polymer temperature (θ). Next, the dependence of CNT ordering (S_1) on polymer ordering (S_2) was investigated. Finally, variation of Heat Capacity (C) of the nano-composite with CNT volume fraction (φ) was also calculated and analysed explicitly.

3.1. CNT ordering in PLC due to Isotropic-Nematic phase transition:

Equation (7) was minimalized with respect to CNT order parameter S_1 to get,

$$S_1 = -\frac{1}{2} + \frac{3 \{1 + S_2^2 \delta(1 - \varphi)\}}{2 \frac{L\varphi}{D} \left(1 + \frac{\theta\kappa}{T} \right)} - \left[\sqrt{\frac{\{3S_2^2 \delta(\varphi - 1)\}}{\frac{L\varphi}{D} \left(1 + \frac{\theta\kappa}{T} \right)} + \left[\frac{3 \{1 + S_2^2 \delta(1 - \varphi)\}}{2 \frac{L\varphi}{D} \left(1 + \frac{\theta\kappa}{T} \right)} - \frac{1}{2} \right]^2} \right] \quad (8)$$

From above equation we can get the variation of CNT order parameter (S_1) with CNT volume fraction (φ) for different polymer temperatures (θ). For this purpose, we have fixed the PLC order parameter (S_2) at 0.2, mixing temperature T at 300 K, κ at 1 and L/D is taken as 50. The variation of S_1 with φ is shown in figure 1a. Figure shows sharp rise of S_1 with φ for all polymer temperatures. We have discussed earlier that effective polymer temperature (θ) depicts the

nature of the PLC. From the graph we can see that as θ increases from 100 K to 400 K, the rise of S_1 gets sharper, which means to achieve same ordering we need more amount of CNTs when θ is low. However rapid increase of S_1 with ϕ for all θ ensures that CNTs get more ordered and aligned as more amount of CNTs are getting dispersed in the nanofluid.

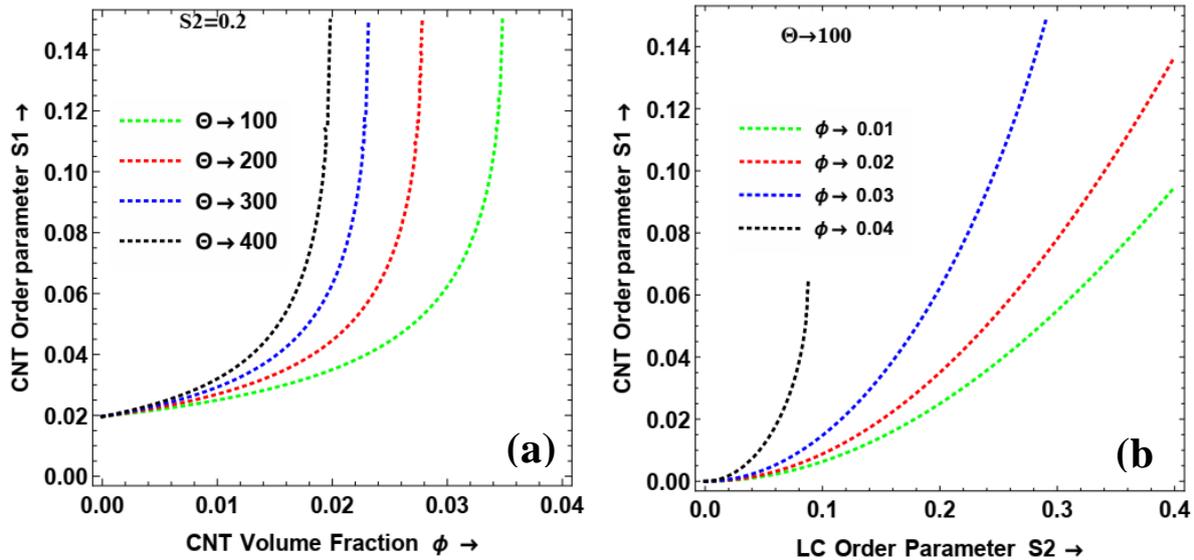


Fig.1 (a) Variation of CNT order parameter (S_1) with CNT volume fraction (ϕ) for different polymer temperature (θ); (b) Variation of S_1 with polymer liquid crystal order parameter (S_2)

Fig.1b shows the variation of CNT order parameter (S_1) with PLC order parameter (S_2) for different CNT volume fraction (ϕ). The other parameters were kept same as before with θ fixed at 100 K and δ taken as 0.5. Graph shows steady increase of S_1 with increasing S_2 for all ϕ , which is quite understandable as more ordering of PLC with help CNTs to be more ordered and get them aligned with each other inside the nanofluid. Secondly, rise of S_1 with S_2 gets sharper with increasing ϕ which is also very much expected as more amount of CNTs inside PLC helps in increasing the order parameter of CNTs as already seen in fig.1a.

3.2. Effect of Nematic transition on the Heat Capacity of the Nanofluid:

To calculate the heat capacity (C) of the nanofluid during phase transition we need to apply the following equation,

$$C = -T \frac{\partial^2 f}{\partial T^2} \tag{9}$$

The relation between S_1 and S_2 as obtained from equation (8) was used in the free energy equation (7) to replace S_2 in terms of S_1 using the following relation,

$$S_2 = \frac{b}{4c} - \frac{1}{9b} \left[12a \left(1 - \frac{T^c}{T} \right) + 4S_1 \delta \varphi (1 - \varphi) (S_1 - 2) \right] \quad (10)$$

The new free energy appeared as a polynomial equation containing higher powers of S_1 , where coefficients those are having powers up-to cube of S_1 were taken into account for further calculation and terms with more than cubic power of S_1 were neglected. Again, the terms involving $\left(\frac{\theta}{T^2} - \frac{1}{T^3} \right)$ with power more than cubic order were neglected for high T . Finally the free energy was written as follows,

$$f = A_0 + A_1 S_1 + A_2 S_1^2 + A_3 S_1^3 + R(1 - \varphi) [\varphi \chi + \log(1 - \varphi)] + \varphi \log \varphi \quad (11)$$

where, A_0, A_1, A_2, A_3 are coefficients which depend on modified Landau-de Gennes coefficients a, b, c and as well as on $\delta, \kappa, \theta, \varphi$ and T .

To get the expression for heat capacity expression of free energy 'f' from equation (11) was used in equation (9) and we get,

$$C = -T(C_0 + C_1 S_1 + C_2 S_1^2 + C_3 S_1^3), \quad (12)$$

$$\text{where } C_0 = \frac{\partial^2 A_0}{\partial T^2}, C_1 = \frac{\partial^2 A_1}{\partial T^2}, C_2 = \frac{\partial^2 A_2}{\partial T^2}, \text{ and } C_3 = \frac{\partial^2 A_3}{\partial T^2}.$$

Variation of heat capacity (C) of the CNT-dispersed nanofluid was plotted against CNT volume fraction (φ) for different CNT order parameter (S_1) and shown in figure 2.

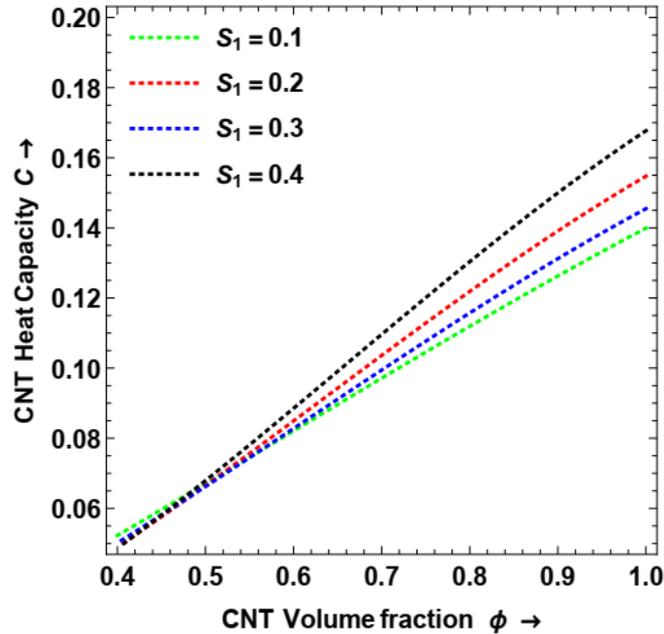


Fig.2. Variation of heat capacity (C) of CNT-dispersed PLC with increasing CNT volume fraction (ϕ) for different CNT order parameter (S_1).

Graph shows steady increase of C with increasing ϕ for all values of S_1 . The result can be explained considering the phenomena of first order isotropic-nematic phase transition for CNTs dispersed in PLC which ensures ordering of CNTs within the mixture. Previous result in fig. 1a showed rapid growth in ordering and unidirectional orientation in CNTs with increasing volume fraction (ϕ) in the mixture. These alignments are proven to be helpful for easy flow of heat through the nanofluid which in-turn increase the heat capacity as well as the thermal conductivity of the nano-composite. It is also important to note from the graph that for a fixed value of ϕ , heat capacity C is lowest for low value of S_1 , and C gradually increases as S_1 increases. This result is also quite expected as bigger value of S_1 corresponds to better ordering i.e. alignment of CNTs which provides easier conduction of heat and hence better heat capacity (C) of the nano-composite as explained earlier.

4. Conclusion:

In this work we have formulated the free energy equation for CNT-dispersed PLC with the help of Landau-de Gennes and Doi type free energy model to analyse its orientation and thermal behaviour during first order Isotropic-nematic phase transition. Graphical representation derived from theoretical calculations shows sharp increase in CNT order parameter with increasing CNT volume fraction which proves that more amounts of CNTs in the composite

encourage more CNTs to be ordered and get aligned among themselves within the mixture. Mathematical calculations also suggest that increasing order parameter of PLC also helps to increase the ordering of CNTs. Finally, the heat capacity of the nano-composite was calculated for different CNT order parameter and plotted against CNT volume fraction which shows steady increase of heat capacity with CNT volume fraction. This observation is well in coherence with the hypothesis set forth and results obtained earlier which showed greater alignment of CNTs inside nanofluid with increasing CNT volume fraction. CNTs are experimentally proven to be good conductor of heat and thus aligned CNTs provide easier path for heat flow through the composite making it an excellent heat-transfer fluid. The results and investigations carried out in this article helps in realizing and explaining the theoretical aspects of heat flow through CNT-based polymer liquid crystal.

Competing interests:

No potential conflict of interest was reported by the authors.

Authors' contribution:

A. Jha: Conceptualization, Writing - original draft and editing.

S. Biswas: Software, Investigation, Visualization.

Data availability statement

Not applicable

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Urban Avifaunal diversity: A case study of the Santragachi Jheel

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Abstract

Santragachi Jheel, nestled amidst the urban landscape of West Bengal, exemplifies the coexistence of biodiversity within an urban setting. Despite its proximity to human habitation and urban development, the lake sustains a diverse array of flora and fauna. From various bird species like waterfowl, waders, and migratory birds to amphibians, fish, and aquatic plants, the jheel supports a thriving ecosystem. During the winter months, it becomes particularly bustling as migratory birds from distant regions flock to its shores in search of refuge from harsher climates. The presence of diverse birdlife in Santragachi Jheel not only enriches the local ecosystem but also plays a vital role in maintaining ecological balance.

Keywords: Santragachi jheel, Avifaunal diversity, Feeding guilds

1. Introduction

West Bengal has several large and small water bodies having diverse aquatic flora and fauna. These wetlands also provide suitable habitat for resident and migratory water birds and contribute much to the biodiversity of India. One such abode of migratory birds is *Santragachi Jheel*, a 30 minutes' drive from the main city of Kolkata. This wetland ecosystem acts as a crucial haven for a plethora of bird species, both resident and migratory. During the winter months, the lake becomes a bustling sanctuary for migratory birds, offering them respite and sustenance on their arduous journeys from distant lands. Species such as waterfowl, waders,

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kingfishers, raptors, and countless others grace its waters and surrounding marshlands, creating a vibrant tapestry of avian life.

The number has increased in recent years, as migratory birds have started to avoid destinations like the lakes in Alipore Zoo, Kolkata. Birds like sarus crane from North America and Australia, gadwall, northern shoveller, northern pintail, garganey from north of the Himalayas, and many other local migratory birds such as cotton pygmy goose, and knob-billed ducks are spotted here during this season. However, the lesser whistling duck is the most dominant species visible here.

The lake area is owned by South Eastern Railway, though the Forest Department of West Bengal also looks after the place. Every year before the migratory birds are expected to arrive, the Forest department cleans Water hyacinth from the lake, though leaving some portion of it which adds up to an environment suitable for the birds. Efforts are made by local residents, Forest Department and Railways to improve the environment for the birds. The Forest Ministry of the State Government of West Bengal intends to convert the lake to a wildlife conservation centre. The present study was conducted to prepare a checklist of birds that visited the Jheel for the year 2018-2019.

The lake's ecological importance cannot be overstated. It serves as a vital breeding ground, feeding area, and stopover site for numerous bird species, contributing significantly to their conservation and survival. Furthermore, the presence of diverse birdlife in Santragachi Jheel enriches the local ecosystem, playing a crucial role in nutrient cycling, pest control, and pollination. Beyond its ecological significance, Santragachi Jheel holds cultural and recreational value for nearby communities. It serves as a spiritual sanctuary, a source of livelihood for fishermen, and a picturesque destination for tourists and birdwatchers alike. Protecting and preserving this wetland habitat is paramount not only for safeguarding avian diversity but also for ensuring the well-being of local ecosystems and communities that depend on it.

2. Materials and methods

2.1. Study Site

The Santragachi Lake or Jheel is a roughly rectangular area in Howrah district about 8 km from Kolkata, India (22°34'60" N, 88°17'60" E) as shown in Fig. 1. The study of avian fauna was conducted at Santragachi Jheel, a half an hour drive from the main city of Kolkata, during the month of December, 2018.



Fig. 1: Location of Santragachi Jheel from Google Map

2.2. Study team

The extensive data on the birds could be obtained as because study team was big enough. It included Dr. Malabika Bhattacharjee as the faculty under the supervision of whom the 3rd year Honours, 2nd year Honours and 1st Semester Hons Undergraduate students of Department of Zoology, Vivekananda College, Kolkata-700064, could ably compile the data.

Visit Details-

1. Venue	: Santragachi Jheel
2. Date of Visit	: 9 th December, 2018
3. Duration of the visit	: 7.00 am – 1:30pm

2.3. Study Methodology

The birds were spotted by binoculars. Care was taken for their proper identification by Fig: map of the study site (Santragachi jheel). Source: google map. All identifications were based according to Grimmett *et al.* (1998) and Ali, S (2002). In some occasions, birds' calls were also noted.

2.3.1. Binocular and Camera Models

2.3.1.1. Binocular-Birds were initially observed with the help of an Olympus 8 x 40 DPSI Field binocular

2.3.1.2. Camera-Photographs were taken with

Canon PowerShot SX420 IS, Canon PowerShot SX540, Canon 750d; Sony DSC-W210, SonyDSLR Alpha-58; Nikon D5300

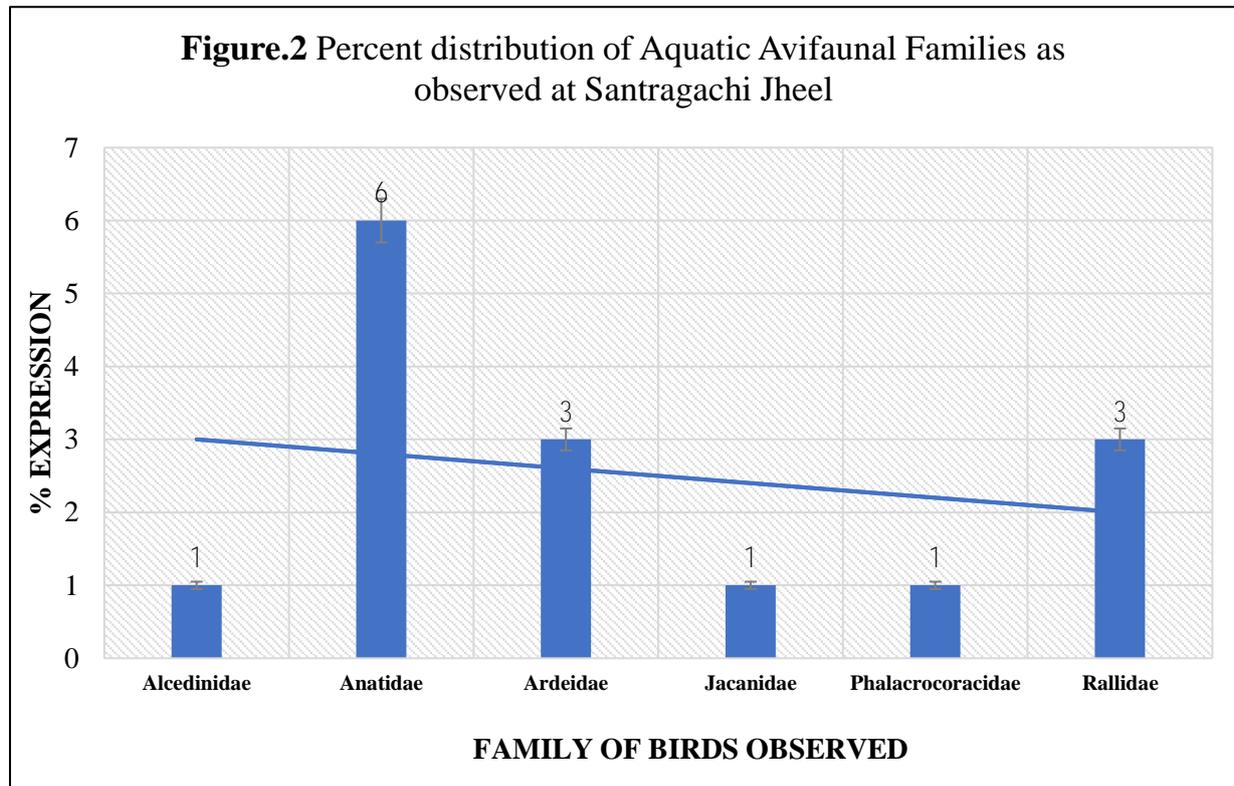
3. Results and Discussion

Species of birds identified are presented in table 1. Altogether **15** species of aquatic birds were identified. Among the birds - *lesser whistling duck* was found to be the dominant ones followed by Gadwall and Northern Pintail. In our study we found the threatened duck species – Ferruginous pochard. The local breeding birds of lake are the Bitterns and jacanas. The easily spotted birds include, common moor hen, cotton pygmy goose, little cormorant, Pond heron and Bronze winged jacana. Table 2 represents the variety in trophic niche of the observed aquatic birds.

Table.1: Birds observed at Santragachi Jheel

Sl. No.	Family	Common Name	Scientific Name	Authority	Breeding range	Size	Status	IUCN Status	WLPA 1972
1.	Alcedinidae	White Throated Kingfisher	<i>Halcyon smyrnensis</i>	Linnaeus, 1758	OR : widespread, also Middle East	28 cm	R	LC	Sch IV
2.	Anatidae	Fulvous whistling duck	<i>Dendrocygna bicolor</i>	Vieillot, 1816	Americas, AF, Indian Subcontinent, Myanmar	45–53 cm	R	LC	Sch IV
3.		Ferruginous pochard	<i>Aythya nyroca</i>	Güldenstädt, 1770	EU, AF, Asia	35-40 cm	M	NT	Sch IV
4.		Lesser Whistling Duck	<i>Dendrocygna javanica</i>	Horsfield, 1821	OR : widespread	42 cm	R	LC	Sch IV
5.		Cotton Pygmy Goose	<i>Nettapus coromandelianus</i>	Gmelin, JF, 1789	OR : widespread	30-37 cm	WM	LC	Sch IV
6.		Gadwall	<i>Anas strepera</i>	Linnaeus, 1758	NA, EU : widespread	39-43 cm	WM	LC	Sch IV
7.		Northern Pintail	<i>Anas acuta</i>	Linnaeus, 1758	NA, EU : Widespread	51-56 cm	WM	LC	Sch IV
8.		Ardeidae	Little Egret	<i>Egretta garzetta</i>	Linnaeus, 1766	EU, AF, OR, AU : widespread	55-65 cm	R	LC
9.	Cattle Egret		<i>Bubulus ibis</i>	Linnaeus, 1758	EU, AF, NA, MA, SA: s Europe to Iran, Africa, Indian Ocean Is., North and Latin America.	48-53 cm	WM	LC	Sch IV
10.	Indian Pond Heron		<i>Ardeola grayii</i>	Sykes, 1832	EU, OR : Persian Gulf to Myanmar, Maldiv Islands	42-45 cm	R	LC	Sch IV
11.	Jacanidae	Bronze-Winged Jacana	<i>Metopidius indicus</i>	Latham, 1790	OR : widespread	28-31 cm	R	LC	Sch IV
12.	Phalacrocoracidae	Little Cormorant	<i>Phalacrocorax niger</i>	Vieillot, 1817	OR : widespread	51 cm	WM	LC	Sch IV
13.	Rallidae	Common coot	<i>Fulica atra</i>	Linnaeus, 1758	EU, Asia, AU, AF	32–42 cm	M	LC	Sch IV
14.		White breasted water hen	<i>Amaurornis phoenicurus</i>	Pennant, 1769	OR : widespread	32 cm	R	LC	Sch IV
15.		Common Moorhen	<i>Gallinula chloropus</i>	Linnaeus, 1758	EU, AF, IO, OR, PO : widespread	32-50 cm	R	LC	Sch IV

Of the 15 families of aquatic birds thus recorded and as observed from graphical representation of the data on documented birds in figure 2, the Families *Anatidae*, *Ardeidae* and *Rallidae* had a greater preponderance as compared to the remaining 3 families.

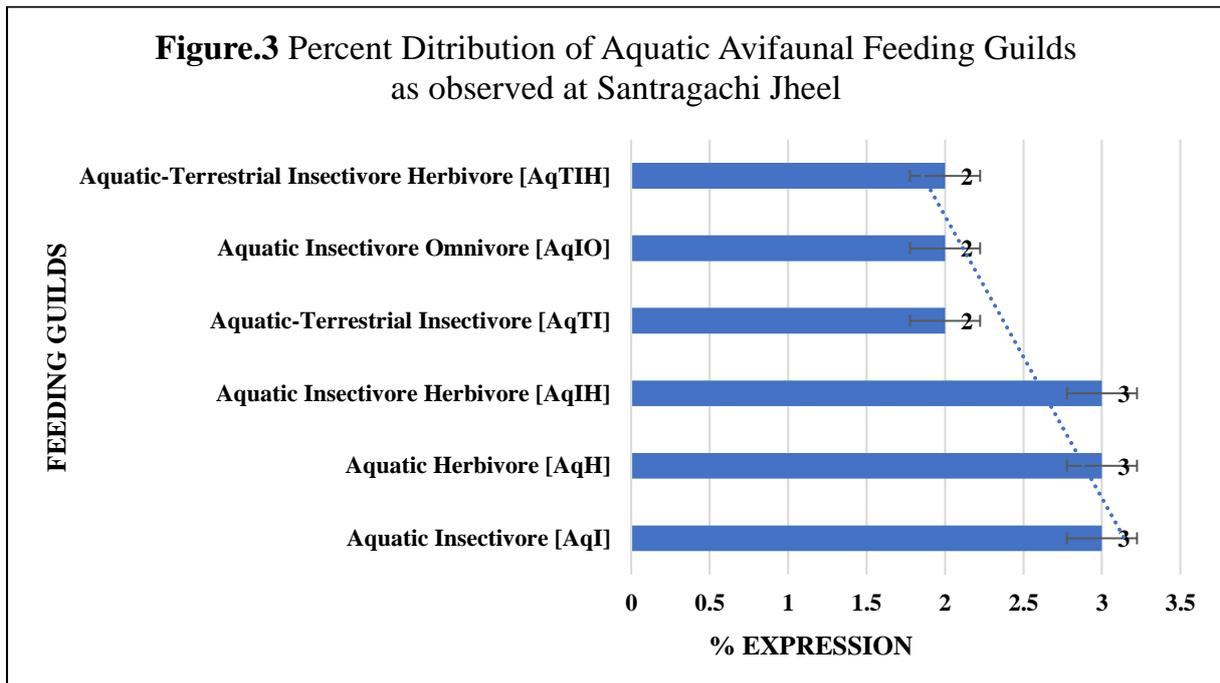


The 15 species of birds belonging to 6 families were also studied for their feeding preferences. All the birds were aquatic birds but subtle variations were observed in their feeding preferences Table.2. Thus, the aquatic food habitat could be further divided into 5 feeding guilds viz; *Aquatic Insectivore*, *Aquatic herbivore*, *Aquatic-Insectivore Herbivore*, *Aquatic-Terrestrial Insectivore*, *Aquatic Insectivore Omnivore* and *Aquatic Terrestrial Insectivore Herbivore*.

Table.2 Variety of trophic niche of the birds that were observed at Santragachi Jheel

Sl. No.	Family	Common Name	Feeding guild
1.	Alcedinidae	White Throated Kingfisher	Aquatic Insectivore [AqI]
2.	Anatidae	Lesser Whistling Duck	Aquatic Herbivore [AqH]
		Cotton Pygmy Goose	Aquatic-Terrestrial Insectivore Herbivore [AqTIH]
		Gadwall	Aquatic Herbivore [AqH]
		Northern Pintail	Aquatic Insectivore Herbivore [AqIH]
		Fulvous whistling duck	Aquatic Herbivore [AqH]
		Ferruginous pochard	Aquatic Insectivore Herbivore [AqIH]
3.	Ardeidae	Little Egret	Aquatic-Terrestrial Insectivore [AqTI]
		Cattle Egret	Aquatic-Terrestrial Insectivore [AqTI]
		Indian Pond Heron	Aquatic Insectivore [AqI]
4.	Jacanidae	Bronze-Winged Jacana	Aquatic Insectivore Herbivore [AqIH]
5.	Phalacrocoracidae	Little Cormorant	Aquatic Insectivore [AqI]
6.	Rallidae	Common coot	Aquatic Insectivore Omnivore [AqIO]
		White breasted water hen	Aquatic-Terrestrial Insectivore Herbivore [AqTIH]
		Common Moorhen	Aquatic Insectivore Omnivore [AqIO]

Figure. 3 gives a reflection about the percent expression of the different feeding guilds with respect to the total species observed there.



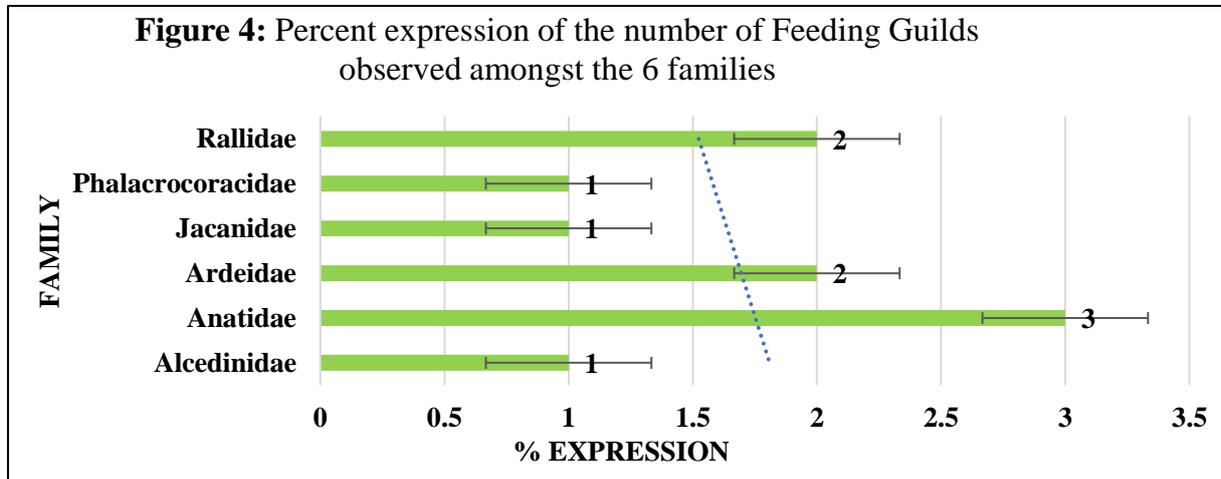
Further from the data obtained, the number of feeding guilds found in each family as documented in table 3 and figure 4 was observed and it was found that the Families *Anatidae*, *Ardeidae* and *Rallidae* topped the list.

Table.3 Variety of Feeding guilds as per families of birds observed at Santragachi Jheel.

Sl. No.	Family	Feeding guild
1.	Alcedinidae	Aquatic Insectivore [AqI]
2.	Anatidae	Aquatic Herbivore [AqH]
		Aquatic-Terrestrial Insectivore Herbivore [AqTIH]
		Aquatic Insectivore Herbivore [AqIH]
3.	Ardeidae	Aquatic-Terrestrial Insectivore [AqTI]
		Aquatic Insectivore [AqI]
4.	Jacaniae	Aquatic Insectivore Herbivore [AqIH]
5.	Phalacrocoracidae	Aquatic Insectivore [AqI]
6.	Rallidae	Aquatic Insectivore Omnivore [AqIO]
		Aquatic-Terrestrial Insectivore Herbivore [AqTIH]

Anatidae has 3 feeding guilds viz , *Aquatic herbivore*, *Aquatic Terrestrial Insectivore Herbivore*, *Aquatic-Insectivore Herbivore*.; *Ardeidae* included 2 feeding guilds viz: *Aquatic-*

Terrestrial Insectivore and Aquatic Insectivore; **Rallidae** also having **2** feeding guilds viz: *Aquatic Insectivore Omnivore* and *Aquatic Terrestrial Insectivore Herbivore*.



The species diversity thus documented of the avifauna, suggests that the study area provides a rich source of a variety of food resources. However, increasing human population and urbanization, decreasing green cover, pollution of water, disturbing railway tracks, cutting of trees surrounding the lake, dumping of plastics and other disposal products in and around the lake and lack of scientific management are some of the major threats the Santragachi Lake or Jheel is acutely facing.

4. Conclusion

Studying urban biodiversity at Santragachi Jheel provides a fascinating glimpse into how nature thrives amidst urbanization. Despite being surrounded by human settlements and infrastructure; this wetland ecosystem sustains a remarkable diversity of flora and fauna. Bird species ranging from waterfowl to migratory birds find sanctuary in its waters, while amphibians, fish, and aquatic plants contribute to its rich ecological tapestry. Understanding the dynamics of urban biodiversity at Santragachi Jheel is essential for effective conservation and management strategies. By studying the interactions between urbanization and biodiversity, researchers can uncover ways to mitigate the impact of human activities on this fragile ecosystem. Moreover, such studies can inform urban planning decisions, highlighting the importance of preserving green spaces like Santragachi Jheel for the well-being of both wildlife and local communities.



The findings of the present study underline the importance of water-bodies as a preferred habitat for birds. To conserve the avian diversity of the lake, an inventory of birds should be made with thorough investigation every year. Limnological studies should also be done to know the aquatic condition of the lake which supports so many resident and migratory birds. The avian diversity recorded at Santragachi Jheel showed a good variety of species and proper management plans should be made to save them. The present list of bird species is not conclusive and exhaustive and future exploration needs to be continued to update the checklist obtained during this work.

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Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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Communication in street dogs: studying the behavioural responses of free-ranging dogs in Kolkata using social communicative cues

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Abstract:

Communication is the transfer of information between individuals of the same species (conspecific) or between different species (heterospecific). Dogs have lived in close contact with humans for thousands of years, and hence have developed specific skills enabling them to communicate flexibly with humans. While humans primarily use verbal communication, dogs mainly communicate non-verbally through a vast and flexible repertoire of visual, vocal and olfactory signals including tail carriage and motion, ear and eye position, body position and movement, and facial expressions. Dogs have a wonderful perception of human emotions that allows them to adjust their behaviour during everyday interactions with humans and to respond appropriately.

Keywords: *Communication, dogs, human, behaviour, cues*

1. Introduction:

Communication occurs not only between members of the same species, but also between heterospecific individuals, e.g. between domestic dogs and humans [1]. After living in close contact with humans for at least 30,000 years [2], dogs have developed specific skills enabling them to communicate flexibly with humans [3]. Humans primarily use verbal communication,

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but dogs mainly communicate non-verbally using body language and secondarily through vocalizations. This body language includes tail carriage and motion, ear and eye position, body position and movement, and facial expressions. Knowledge of body language, and the ability to accurately identify it, will help decipher what a dog is trying to communicate.

When observing a dog's body language to determine what is being communicated, it is crucial to observe the *entire* dog, as well as the *situation/context*, in order to accurately determine what is being conveyed. For example, a wagging tail does not necessarily mean a friendly dog. A moving tail, as a part of the dog's body language, is often noticed first. However, if the dog's body is stiff, the ears are back and the dog is in a crouching position, then these features indicate that this is not a happy dog. Similarly, lip licking is suggested to be a signal of submissive behaviour and contact seeking. Lowering the head and increased changes of gaze direction is shown more often when the dogs are presented with a familiar person or a tasty food [4]. Not all the signals, in fact, are under voluntary control. When a dog experiences an emotional state, for example anxiety, it releases a specific body odour into the environment [5,6]. Despite being involuntary, this signal is received as a communicative signal by other individuals because it informs them about the sender's inner state, and it can produce changes in the receiver's behaviour [5].

Dogs are engaged in visual communication by modifying different parts of their body, in tactile communication, and in auditory and olfactory communication, with vocalizations and body odours [7]. Visual communication encompasses the gestures, postures, movements, and expressions dogs use to express a state of mind or intention. The most common body language in dogs expresses relaxation, alertness, playfulness, aggressiveness, fear, submission, etc. Auditory communication includes barking, growling, whining, screaming, howling, panting, and sighing. Olfactory communications can transmit all kinds of information, including sex, age, social status, diseases and reproductive status. For example, pheromones are picked up by the dog by smelling each other's butts.

Communication signals in dogs can be basically classified into five common groups as mentioned below. A dog can demonstrate more than one of these groupings in response to a given situation. For example, a dog may begin by displaying excitement signals in response to

a stimulus; decide whether that stimulus is a threat, and then switch to aggressive signals, fear signals, or even both.

A. Fearful Communication:

When a dog is frightened, it most likely will react to that fearful stimulus with his whole body. He may lick his lips (though not hungry) or yawn (though not tired). He may keep his mouth tightly closed, cower or lower his body, lower or tuck his tail, or put his ears back [Fig. 1]. He may also tremble or shake, look away to avoid eye contact, or lean back to avoid the stimulus that is perceived as frightening.

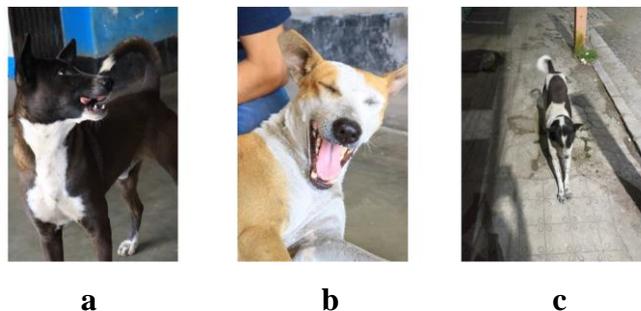


Fig. 1. Fearful Communication Signals. (a) The Black dog licks his lip being amazed after looking at one of our team mates. (b) The dog yawns though it is not sleepy. (c) The dog lowers its body when vocalizations were made.

B. Arousal Communication:

Arousal/excitement is often a response to a stimulus the dog likes, such as a person, dog, or toy. For example, a dog with soft, relaxed body, eyes, mouth, and a wagging tail that jumps up for attention is a dog that is seeing a *favourable* stimulus. However, arousal behaviours can also be due to *unfavourable* stimulus, such as an unwanted person, dog, or situation [Fig. 2]. Arousal signals in response to an unfavourable stimulus may be coupled with *fear signals*, such as trembling or a low/tucked tail. Arousal signals may also be paired with *aggressive signals* such as barking, or with *anxious signals* such as pacing or spinning.

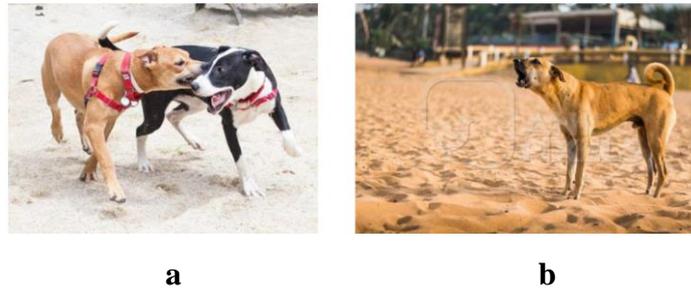


Fig. 2. Arousal Communication Signals. (a) Favourable Stimulus: Mouthing (biting without force) (b) Unfavourable Stimulus: Barking at an unwanted person
[Source: Google]

C. Anxious Communication:

The shelter environment can impact the level of stress a dog experiences. Dogs that are normally relaxed can become anxious and dogs with minimal anxiety on intake can become progressively anxious. Body language of an anxious dog includes excessive panting, pacing, and lack of focus. An anxious dog may demonstrate similar body language to a fearful dog. He may pant excessively (when not hot or recently exercised), lick his lips (when not hungry), yawn (when not tired), and have a slightly lowered body stance with his ears slightly back (Fig. 1). He may wag his tail slowly and look away or move away from people. An anxious dog in a kennel could be barking, pacing, circling, or bounding off kennel walls.

D. Aggressive Communication:

Aggression is a normal and natural behaviour in dogs. Often aggression is triggered by a perceived threat, such as a person, another dog, or any inanimate object. Aggressive body language includes stiffening or freezing of the body, eyes wide with a lot of white showing (whale eye), wrinkled nose, showing teeth, barking, growling, and air snapping. Aggression is used by the dog to protect itself and its “possessions” from a perceived threat. The dog uses aggressive communication signals to convey that it will defend itself, its territory, or its possessions. For example, if a dog is uncomfortable with an approaching person, he may stiffen, growl or show his teeth [Fig. 3]. At this point, if the person decides to continue and come closer, the dog could snap or bite, or he may not. Again, if a dog is fearful of something

and its fear signals have been misread or ignored, it may switch to aggressive signals as an escalated attempt at communication.



Fig. 3. Aggressive Communication Signal – Barking Dog

E. Relaxed Communication:

A relaxed dog keeps its mouth relaxed and slightly open with ends that could be turning up (almost appears to be smiling). His head and ears are in a neutral position. His body is loose, and eyes are soft. His tail may be wagging in a swishing back and forth, or even circular motion. He often will be lying down, sometimes even in the “frog-leg” position (Fig. 4).



a



b

Fig. 4. Relaxed Communication Signals (a) Mouth relaxed with a smiling face; head and ears neutrally positioned. (b) Smiling dog sitting in “frog-leg” position

Keeping such communications in mind, the main aim of the study was to subject free-ranging dogs in certain localities of Kolkata to different human social communicative cues (friendly and threatening), followed by a food provisioning phase, and test their responsiveness.

2. Methodology:

2.1. Subjects and Study Area:

The experiment was conducted in April-July, 2021 when the second wave of Covid-19 was at its peak, just after the death incident of more than 60 street dogs, as reported by the Kolkata Municipal Corporation (TOI, Feb 21, 2021, 13:27 IST). 20-30 adult, physically fit (in appearance; without any visible sign of injury or disease) street dogs were randomly chosen. Any kind of colour or sexual biasness was avoided. These dogs were located in different regions of south Kolkata — Thakurpukur (22.465°N, 88.307°E), Keorapukur (22.472°N, 88.337°E), and Behala (22.498°N, 88.310°E). The experimental trials were conducted in different residential areas, footpaths, market places, etc.

2.2. Experimental Procedure:

Three different experimental conditions were used incorporating targeted social cues to investigate the response of solitary free-ranging dogs towards an unfamiliar human. All the experimental trials were conducted on the same locations where the local free-ranging dogs were found (e.g., streets, markets, residential areas etc.). Assignment of experimental conditions was performed in a random fashion. One packet of biscuits (500g) was used as food.

The experimenter was consistent throughout the study and played specific role. The experimental conditions comprised of four phases, carried out in the following order:

a. Attention Seeking Phase:

Experimenter attracted the attention of a solitary dog using very short vocalizations for 1–2 seconds. This step was necessary as some dogs were lying down, resting or dozing. It was carried out in all the 3 experimental conditions [Fig. 5].



Fig. 5. Attention Seeking Phase- The dog looks at the experimenter just after the vocalization is made.

b. Transition Phase:

Once the dog was alerted, a stationary phase of 10 seconds was maintained. The experimenter remained at a distance of 2 metres from the dog, and the behavioural changes were observed [Fig. 6].



Fig. 6. Transition Phase - The dog becomes attentive once alerted.

c. Social Cue Phase (SCP):

Experimenter stood approached towards the dog, facing it. After standing (or sitting) at the specified spot, the experimenter provided the following predetermined social cues for a period of 30 seconds.

i. Friendly Cue (FC): A positive gesture was displayed by patting the dog (gentle stroke of hand beneath neck, on back or head). Though such posture has been described as a threat in the existing canine literature, people in India typically use such gestures (sometimes paired with positive vocalizations) to provide positive social rewards to dogs. While providing the social cue, eye-contact with the dog was maintained [Fig. 7].



Fig. 7. Friendly Cue offered – (a) Both the dogs knelt down on approach. (b) Dog closed the eyes on rubbing the head.

ii. Threatening Cue (TC): The experimenter raised one of his hands, kept it motionless and gazed at the dogs. The cue differed from FC in having a negative display of human gesture. People on the streets often raise one of their hands to scare, threaten or shoo away dogs. The same gesture was adopted to investigate the effects and associated responses [Fig. 8].

**a****b**

Fig. 8. Threatening Cue offered – (a) Arousal Communication signal. (b) Fearful Communication signal - noticed when the experimenter raised the hand.

iii. Neutral Cue (NC): Experimenter stood in a neutral posture and looked straight ahead and did not enact any gesture [Fig. 9].

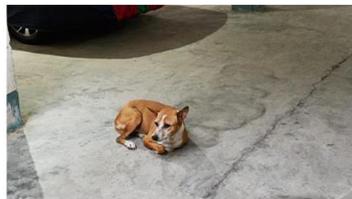


Fig. 9. Neutral Cue offered – No reaction in dog observed in either of the dogs.

d. Food Provisioning Phase (FPP):

Experimenter stood in a neutral position by extending the hand containing biscuit and looked straight, making eye contact with the dog (Fig. 10). FPP lasted 30 seconds or until the dog obtained the food, whichever was earlier. Food was removed in case a dog did not obtain it.



Fig. 10. Food Provisioning Phase – (a) After the Friendly Cue, food is being offered (b) Same dog as in 10 (a) [front view] (c) After the Threatening Cue, dog refuses to have food at once (d) Same dog as in 10 (c) after a few seconds (e) After a Neutral Cue, food is being offered to a dog.

3. Results and Discussion:

Except for the Social Cue Phase, all the other phases were constant and identical across the experimental conditions. Almost same observations were noticed in all the dogs in the first two phases, until the social cues were provided.

3.1. Number of Dogs Approaching the Experimenter:

Dogs approached differently in SCP and FPP of the three conditions. Most of the dogs approached in the FC condition. In the NC condition, initially few dogs approached, while the number increased in FPP significantly, thereby indicating a distinct positive impact of food. Least number of dogs approached in TC conditions. In this condition, none of the dogs approached at the beginning. Later, one or two dogs approached during FPP after waiting for around 2-3 minutes.

3.2. Reaction to a Social Cue:

The reactions were distributed differently in the three experimental conditions. In the NC condition, dogs showed varying levels of reactions. Some of the dogs showed gazing behaviour, few showed gazing with tail wagging, some stayed neutral, and displayed no particular reaction. None of the dogs showed a fear response. In the FC condition, most of the dogs showed gazing with tail wagging as their first reaction, while few showed gazing behaviour only. Some of them knelt or lied down, and a few of them closed their eyes indicating a relaxed communication signal. No dog showed a fear response, and all dogs responded.



Gazing along with tail wagging occurred at a significantly higher rate than only gazing behaviour. In the TC condition, the dogs showed fear response when the threatening gesture was enacted, indicating fearful communication signal. Dogs displayed mostly neutral and anxious behaviours in the NC condition. Agonistic or aggressive behaviours were absent.

3.3. Reaction to Food Provision:

Dogs reacted to FPP differently in the three conditions. In both the FC and NC conditions, dogs had the food with no refusal or hesitation, but the rate of having the food was lower (quicker) in FC conditions. In TC conditions, almost all the dogs refused to have the food, only one or two being exceptional, where the dogs had the food fearfully with hesitation.

4. Conclusion:

The results of the project underline the behavioural responses of free-ranging dogs in the context of their interactions with unfamiliar humans. The free-ranging dogs acted very specifically in the different conditions displaying a range of social responses that had a high degree of parity with the social cue provided in the experiment. Dogs adjusted their behaviour and showed situation-relevant responses to the social cues. Overall, they exhibited a tendency to approach more when food was provisioned compared to the social cue phases, emphasizing the dependence on humans for sustenance.

India has a huge population of both humans and free-ranging dogs, with regular interactions occurring between individuals of the two species, across habitats. Often, the outcomes of these interactions are adverse, leading to considerable dog—human conflict on the streets [8]. This could be significantly reduced by having a more affiliative or at least, neutral approach towards free-ranging dogs instead of making them anxious or stressed. Studies on dog-human interactions on streets can help us to understand how human behaviour can influence the behaviour of the free-ranging dogs. This study reveals the effects of different social cues on the dogs, thus helping us to understand dogs' understanding and sensitivity to human social actions.

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Conflict of interest

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Data availability statement

Not applicable

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A study of noise pollution levels and related survey in some selected places of Kolkata, West Bengal

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Abstract

A study has been conducted to understand the problem of noise pollution in the city of Kolkata in different areas of settlements in Central and South Kolkata. The data was collected between November to April 2022-2023. The results showed that noise pollution exceeded the allowable limit in central Kolkata (study source: Bada bazar Market) and South Kolkata (study area: Thakurpukur and Kudghat). The increase in noise level affects human health, such as insomnia, hearing loss, impotence heart disease, breathing and brain damage, and shortens human lifespan. In response to this growing problem, recommendations have been made for the implementation of noise pollution control strategies by applying appropriate measures to noise-affected areas. For our present study digital sound level meter (model: 8892) was used

Key word: Noise level, digital sound level meter (model: 8892), some parts of Kolkata, potential sources

Introduction

Pollution has significant impacts on human health, the environment, and even on how some of the Earth's systems, such as the climate, are functioning. Pollution touches all parts of the planet. It is affecting our health through the food we eat, the water we drink and the air we breathe. Approximately 19 million premature deaths are estimated to occur annually as a result of the way we use natural resources to support global production and consumption and which

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impact the environment. (Frank, T. D., Daffertshofer, A., Beek, P. J., & Haken, H. (1999).) Noise pollution is an invisible danger. It cannot be seen, but it is present nonetheless, both on land and under the sea. Sound is measured in decibels. There are many sounds in the environment, from rustling leaves (20 to 30 decibels) to a thunderclap (120 decibels) to the wail of a siren (120 to 140 decibels). Sounds that reach 85 decibels or higher can harm a person's ears. (Levak, K., Horvat, M., & Domitrovic, H .et al 2008). Sound sources that exceed this threshold include familiar things, such as power lawn mowers (90 decibels), subway trains (90 to 115 decibels), and loud rock concerts (110 to 120 decibels). Noise as a pollution has become so common that people do not even consider it as a pollution at first when they hear the word pollution. Approximately 60% of human population lives in urban area (Turner, W. R., Nakamura, T., & Dinetti, M. (2004).) where noise pollution is very common and an integral part of our everyday life from bus to metro, from school to playground we all have completely are totally accustomed to the problem of noise pollution. Noise pollution is defined as an unwanted sound which gets dumped into the environment and adversely affects the health of a person and produces ill effects in living and non-living thing. In present day times, commotion is perceived as a genuine medical condition. Development of streets, structures, lofts and different regions are likewise bringing about expanding the commotion. The most widely recognized medical issue induced by long term exposure to noise is that it causes Noise Induced Hearing Loss (NIHL). (Hong, O., Kerr, M. J., Poling, G. L., & Dhar, S. (2013). The high level of noise reduces the quality of work and thus reduces the concentration level. It causes different illnesses, for example, hypertension and mental problems to individuals as it upsets significant serenity. Exposure to loud noise is also linked with high blood pressure, heart disease, sleep disturbances, and stress. These health problems can affect all age groups, especially children. Many children who live near noisy airports or streets have been found to suffer from stress and other problems, such as impairments in memory, attention level, and reading skill.

Noise pollution also impacts the health and well-being of wildlife. Studies have shown that loud noises can cause caterpillars' dorsal vessels (the insect equivalent of a heart) to beat faster, and cause bluebirds to have fewer chicks. (Francis, C. D., & Barber, et al 2013) Animals use sound for a variety of reasons, including to navigate, find food, attract mates, and avoid predators. On top of that an average urban resident is exposed to noise pollution by 63% longer periods of time as compared to a non-city dweller (Findling & Wyart, 2021), and due to this



longer constant exposure its effect is clearly visible in the long run when the mental (Anees, M. M., Qasim, M., & Bashir, A. (2017). and heart conditions (Aluko, E. O., & Nna, V. (2015).) are assessed. The same is true in the Indian context too, where approximately 34% of its population (476 million) is living in urban areas (National Institute of urban affairs report 2021) and there is a 0.241% increment in the number every year. So, it becomes very important to assess.

Methodology

Since, India has a total of 28 cities with a total of 9 metro cities, which accounts for 64,012,177 (population census report 2011, Ministry of Home affairs) it is important to assess the level of noise pollution which has become an integral part of their everyday life. Due to time and monetary constraint the scope of the study was narrow down to only Kolkata metro city. After which various locations were selected on the basis of their nature i.e one from educational, one construction area etc, upon which 6 locations were finalized 5 from south Kolkata and one from North Kolkata which were Fair (Wireless park near udghat metro), Main road crossing (Thakurpukur crossing), Public transport such as bus (from Thakurpukur to Kalighat) and metro stations (park street, Maidan, Tollygunge, Baranagar and Dhakhineswar), Construction area (Near Behala Bazaar), Shopping area (Bada Bazaar) and Educational area (Vivekananda College Thakurpukur). For the above objectives, primarily data were collected by using Digital sound level meter instrument (model: 8892) from the predetermined locations of the city. The data was collected by lifting the device at a height of 1.5m from ground and at least 7 readings from each point were recorded. Then the collected data have further been processed by Microsoft excel at the end of the study to understand the actual noise conditions and its variation with day and night time within the premises of the city.

Study area:

For our study of noise pollution, we have chosen five different places of Kolkata.

1. Construction area
2. Market area
3. Mela (fair)
4. Transport area (both bus and metro)
5. Educational area

6. Main Road (near Vivekananda College Thakurpukur)

Choosing six different locations for noise pollution research gives us a thorough understanding of the various sources, intensities, and effects of noise pollution in various situations. Each chosen area has distinct features that contribute to the overall noise pollution landscape.

- **Construction sites** are notorious for producing excessive noise as a result of operations such as drilling, hammering, and heavy machinery operation. Investigating noise pollution in construction locations aids in determining the potential influence on neighbouring residential areas as well as employees' health and safety. It can help identify strategies to reduce noise emissions, install noise barriers, and provide standards for construction-related noise control.
- **Melas, or fairs,** are distinguished by enormous crowds, amusement rides, musical performances, and a variety of noisy activities. The study of noise pollution at such events aids in understanding the consequences on the well-being of participants, adjacent inhabitants, and the surrounding environment. It enables the use of noise management measures such as soundproofing stages or limiting noise levels during particular hours to reduce disturbance and safeguard public health.
- **Marketplaces** are often characterized by bustling activity, street vendors, and amplified music, leading to increased noise levels. It facilitates the implementation of noise reduction measures, such as time restrictions on amplified music, sound insulation for nearby buildings, and organizing market layouts to minimize noise propagation and maintain a pleasant shopping experience.
- In **transport area,** due to vehicle movements, engine noise, and passenger activity, transportation facilities such as bus terminals and metro stations can be substantial sources of noise pollution. The study of noise pollution in these locations aids in determining the effects on commuters, adjacent residents, and workers. It aids in the implementation of noise reduction measures such as acoustic barriers, optimised traffic flow patterns, and efficient vehicle maintenance practises in order to reduce noise pollution and improve the overall urban soundscape.

For educational area like schools, colleges, and hospitals, require a suitable acoustic environment for learning, healing, and focus. The study of noise pollution in these places aids in determining the influence of external noise sources such as traffic or local construction on

the occupants and patients of the institution. It allows for the deployment of noise control methods such as insulating classrooms, establishing quiet zones, and formulating noise management standards in order to create a more conducive environment for education and healthcare.

Result

The result highlights the noise pollution in 6 different areas and 2 public transport modes in the city of Kolkata. The areas studied ranged from Kudghat, Thakurpukur, Construction area, and Vivekananda College Thakurpukur all in the south Kolkata to Badabazar in the North Kolkata. In our study the area, having the highest noise pollution was Construction area followed by Badabazar. For mode of transport metro's are more noise making than the buses. Another striking feature of metros is there small range of noise pollution indicating that the area had a constant ongoing noise pollution, meanwhile the range for is approximately 20 dB(A). There is a variation among the metros themselves with newer blue models being less noise emitting and older ones (pink ones) generating higher sounds.

Sl.No	Locations	Sound level dB(A) L_{eq}				CPCB standards	
		Day time	Day mean	Night time	Night mean	Day time	Night time
1	Fair KMC Wireless park near Kudghat metro station	68.45-83.45	75.95	62.91-72.45	67.68	65	55
2	Badabazar (MG road)	90.15-104.19	97.16	80.85-95.5	88.17	65	55
3	Construction Area (Behala bazaar)	97.18-113.28	105.23	84.6-93.5	89.07	65	55
4	Bus	78.42-92.15	85.28	65.52-75.58	70.55	65	55
5	Metro					65	55
	1. Blue	82.73-93.91	88.32	74.36-85.78	80.07		
	2. Pink	84.93-97.88	91.41	78.3-89.83	84.06		
6	Silent zone (Educational area)	55.03-69.95	60.49	53.65-61.01	57.32	50	40
7	Main roads near Thakurpukur metro station	74.50-94.38	84.44	73.50-87.16	80.33	65	55

It is clear from the result that the problem of noise pollution in Kolkata and its nearby areas is very serious as none of the area has noise within the permissible limits. The issue is most severe for construction being held in day time at commercial areas which up took the noise almost 62% more than the allowed max limits. The same is observed for others areas like Wireless Park shows some of the greatest ranges of data, almost 25 dB(A) which is due to the fact that in day time the park is used by nearby people for walking and other leisure and social activities and at night there was a *mela* going on due to which huge crowd of people arrived there and it increased the overall noise of the area.

In case of shopping areas like Bada bazaar and construction area near Behala bazaar both have the highest ongoing noise pollution due to the high population density and in construction area it was further amplified due to machineries used for the same. Public mode of transport like metro has a constant high noise reaching a maximum of 102 dB(A) in case any announcement is made inside the metro. On top of that the older metros pink colored ones are found to be more noise polluting than the newer models with an average difference of 2 dB(A) for minimum and 4 dB(A) in highest recorded data.

The pattern shown by bus and Main Road in Thakurpukur shows the same problem of highly variable data due to sudden honking, variable vehicles ongoing, being struck at jam. All the data recorded for bus are variable and dependent on the location of the survey. While in Thakurpukur traffic jam is less seen and an average value within 15 dB(A) of variation is observed for most of the time.

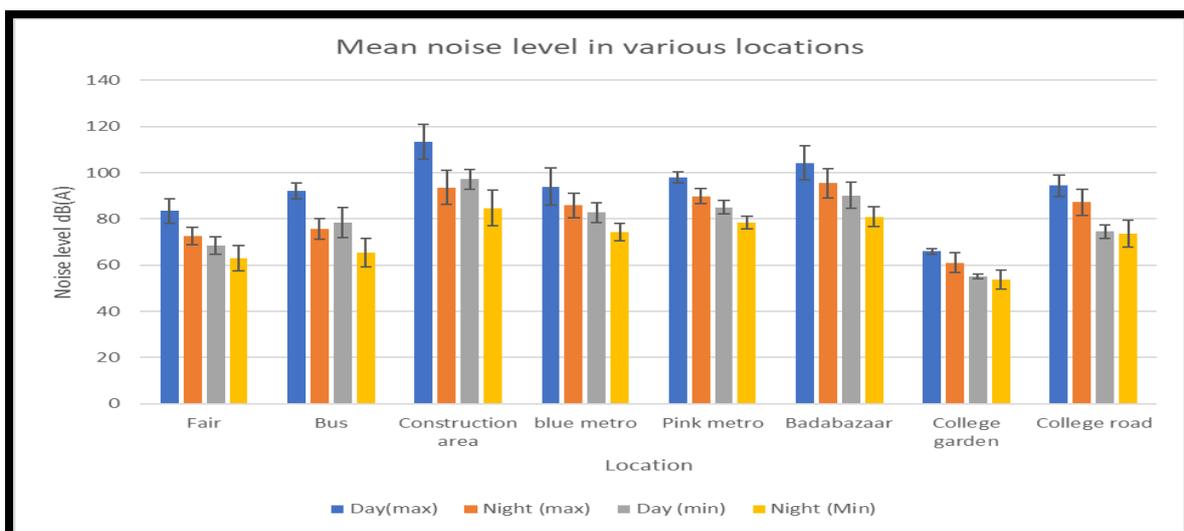


Fig. 1: The graph highlights the mean value of noise in dB(A) in various study locations with standard deviation



Conclusion

The analysis has revealed that noise pollution levels are more than the permissible limits in areas of Wireless Park (near Kudghat metro station), Bada Bazaar, Construction area near Behala bazaar, Transportation modes such as metro and bus, educational zone of Vivekananda College Thakurpukur and Main Road of Thakurpukur metro station. Appropriate controls should be implemented to reduce noise in these areas. Increasing traffic accidents are causing many problems in the city, such as weather and noise, traffic congestion, bad roads, poor parking, lighting, quality or control systems or overpass facilities. Urban traffic thus allows both local transport and heavy vehicles to pass through the main city without worry. Horns are a major source of noise pollution in Indian cities.

The World Health Organization (2011) (WHO) aims to achieve the highest level of health for all. The World Health Organization defines health as “[a] a state of complete physical, mental and emotional wellbeing and clean drinking, not merely the absence of disease or illness”. As a general concept that includes health, noise pollution can be attributed to “health” problems. To improve the current human health and environmental situation of Kolkata City, mitigation measures are recommended to reduce noise at these educational facilities.

Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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Indian Mathematician and the birth of Zero

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Abstract:

The number zero has played a significant role in mathematical history, revolutionising mathematics, science, and technology. It is not just a placeholder in the numerical system but also plays a role in language, physics, chemistry, computer science, and engineering. The origins of zero can be traced back to ancient civilizations, where rudimentary counting systems existed. In ancient India, mathematicians made significant strides in understanding the concept of zero, with the famous Indian mathematician and astronomer Aryabhata making significant contributions to the development of different mathematical ideas, including zero. Aryabhata's work primarily laid the foundation for the mathematical concept of zero, although Brahmagupta was the one who initially formalised it. The aim of this paper is to give a summary of the contributions made by ancient Indian mathematicians towards the development of zero.

Keywords: Zero, Shunya, Indian mathematicians, Aryabhata, Brahmagupta

1. Introduction

In the history of culture the discovery of zero will always stand out as one of the greatest single achievements of the human race.

-----Tobias Danzig

The number zero, a seemingly innocuous digit, has had a significant role in mathematical history. It is not merely a placeholder in our numerical system; rather, it is a concept that

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revolutionised mathematics, science, and technology. Zero's journey from its modest origins to its crucial place in contemporary mathematics has been documented throughout the history of human civilization. The history of zero is deeply connected to the Indian knowledge system, especially in the field of mathematics. India's contribution to the development and understanding of zero as a mathematical concept is widely acknowledged and celebrated.

The concept of zero may be explained with many phrases depending on the situation. In mathematics, zero is a number representing an empty quantity, i.e., adding zero to any number leaves that number unchanged. Zero plays a role not only in mathematics but also in physics, chemistry, computer science, and engineering. For example, in digital electronics, '0' often signifies a low or 'off' state in binary code. Modern computers store information in binary, using the two symbols "0" and "1". A zero can represent the truth value false in propositional logic. Also a zero of a function f means a point x in the domain of the function such that $f(x) = 0$. The idea of a zero function is also present. In physics, for some quantities, the zero level is naturally distinguished from all other levels. In English, other terms for zero are nought, naught, nill, etc. Sometimes it is referred to as "oh" in the context of reading out a string of digits, such as telephone numbers, street addresses, credit card numbers, military time, or years. There are specific terms for a score of zero in several sports, such as "love" in tennis, "the egg," and "duck" in cricket.

The zero cannot be credited to a single person as "invented." It simply did not happen that concepts were created and then widely applied. It's also reasonable to state that the concept of zero is not at all obvious. Early on in history, numbers were viewed in far more concrete ways. Back then, numbers were mainly used for counting. Naturally, their system of notation for numbers differed greatly from ours; however, they wouldn't be able to tell the difference between 2106 and 216 in our notation. It wasn't until approximately 400 BC that the Babylonians inserted two wedge symbols instead of a zero to distinguish the numbers. This demonstrates that the early usage of zero to represent an empty space was actually just the application of a punctuation mark to ensure that the numbers made sense. This is not exactly how zero is used as a number.

Now the primary goal of this paper is to examine the contributions made by ancient Indian mathematicians to the development of the concept of zero. In this context, knowledge of zero's early history is necessary.

2. Early History:

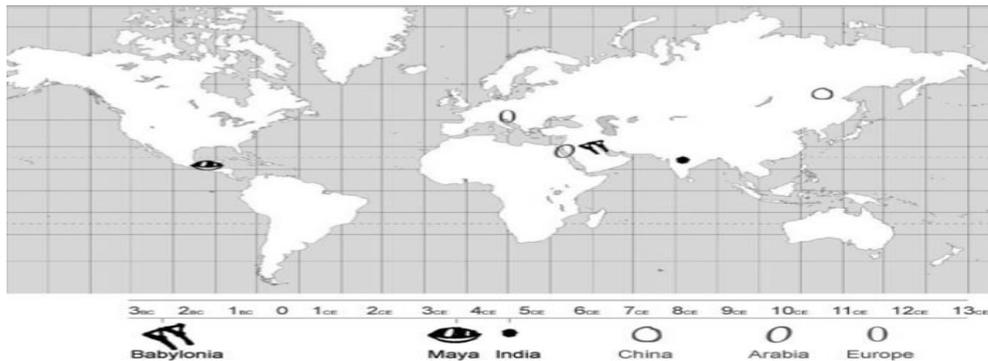


Fig 1. History of zero [14]

There was a time when there was no zero. People knew, of course, if they had nothing, but this was not expressed mathematically. Only three times was zero independently invented. First Babylonians are acknowledged for creating the zero in the third century BC. Nobody used a zero place holder for a considerable amount of time after that. In the fourth century CE, however, the Mayans, who lived in Central America halfway across the globe, independently created the zero. Although experts have argued this for a long time, the final independent invention of zero in India appears to have occurred in the middle of the fifth century. By the end of the seventh century, it entered Cambodia. It spread from India to China and finally to the Islamic world. In the twelfth century, Zero made a journey to Western Europe.

The concept of zero as a numerical placeholder is ancient, with its origins dating back to various cultures and civilizations. In Sanskrit, zero was called "śūnya" which means "empty" or "void." This term later evolved into the Arabic word "sifr," from which the English word "cipher" ultimately derives. [1-3] The Arabic numeral system, which included the digit zero, was introduced to Europe by Arab scholars during the Middle Ages, where it eventually became widely adopted. Zero was used in English for the first time in 1598.[3]

An ancient Hindu, the symbol consisting of a circle with a dot in the centre known as bindu, represents emptiness zero. These symbols were found in the text Atharvaveda. The origins of zero can be traced back to ancient civilizations, where rudimentary counting systems existed. Around 300 BCE, the Babylonians created a positional number system based on 60, including a placeholder symbol for zero. They created a unique symbol—two tiny wedges—to distinguish between magnitudes, similar to how zeros are used in modern decimal systems to distinguish between tenths, hundreds, and thousandths. In this time, the zero was not regarded as a number with a distinct value with its properties, rather, it was simply a placeholder. About the year 350 A.D., when the Mayans started using a zero marker in their calendars, a similar kind symbol appeared on its own in the Americas [3]. They did not, however, succeed in producing other important discoveries and innovations regarding zero. After that India produced the last independently development of zero. This use of 0 in modern mathematics comes from Indian mathematics, which was brought to Europe by Islamic mathematicians in the Middle Ages and became famous by Fibonacci.

The Sanskrit term "Sunya," also known as Zero, representing *nothingness*, was first used by Indian mathematician and Sanskrit scholar Acharya Pingala. The word 'Sunya' means void, empty, or nothingness. At the Chaturbhuj temple in Gwalior, India, the use of zero was written on the walls. The digits 270 and 50, which are carved into a wall, are the second-oldest known zeros in history. The "Bakshali Manuscript," an arithmetic manual for merchants, lists the zero symbol, which is a hollow dot that represents nothing or emptiness [4,10].

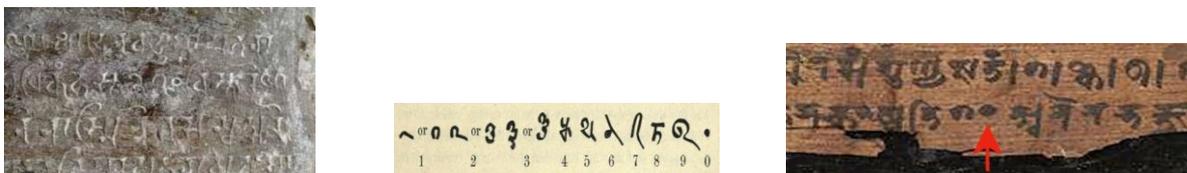


Fig 2. World oldest zero in Indian Sanskrit numbers including zero, Zero in Bakshali Manuscript [8] Gwalior Temple

In ancient India, around the 5th century CE, mathematicians made significant strides in understanding the concept of zero. The present decimal number system is believed to have been formally developed by Hindu mathematicians Aryabhata (born in 476 A.D.) and Brahmagupta (born in 598 A.D.). Famous Indian mathematician and astronomer Aryabhata made significant contributions to the development of mathematical ideas, including zero, in the fifth century



AD. Aryabhata's work primarily laid the foundation for the mathematical concept of zero, although Brahmagupta was the one who initially formalized it.

3. The contribution of the immense mathematician Aryabhata:

In the fifth century AD, the Indian mathematician and astronomer Aryabhata made significant developments in both mathematics and astronomy. His work had a major impact on the development of science and mathematics on the Indian subcontinent, and he is recognized as one of the greatest mathematicians of ancient India.

He was born in Pataliputra. But Aryabhata is identified by Bhaskara-I as *asmakiya*, which means "one belonging to the Asmaka country." He most likely went to Kusumapura at some point to pursue more education and lived there for a while. Aryabhata was mentioned in a verse as the head of an institution (*kulapa*) at Kusumapura. Since the University of Nalanda had an astronomical observatory and was located in Pataliputra during the period, there is conjecture that Aryabhata was also the head of the Nalanda University [11]. One of his most well-known works is the "*Aryabhatiya*". Indian mathematical literature cited the astronomical and mathematical book *Aryabhatiya*, which has persisted until the present day. This book covers algebra, trigonometry, arithmetic, continuous fractions, sum of power series, quadratic equations, and sine tables in its mathematical sections.

Aryabhata's treatment of zero is among his most important contributions to mathematics. Aryabhata created a positional number system with no zeros in approximately 500 AD. In his works, Aryabhata first conceptualized zero as a number and a placeholder in numerical notation. He did not specifically use a zero in his work, but his comprehension of the place-value system required the idea of zero. Aryabhata did not, however, use the Brahmi numerals but used letters of the alphabet to denote numbers, expressing quantities such as the table of sines in a mnemonic form. He introduced "kha" to denote void or absence in the place-value system; the purpose of this was similar to that of zero in positional notation. If the numbers aren't arranged in a way that follows the place value system or contains zero, Aryabhata cannot calculate the square and cubic roots. Furthermore, even though his computations did not directly state zero or the concept of emptiness, they still required a grasp of these ideas, especially in astronomical mathematics. Aryabhata's discovery of zero made it

possible to calculate the precise distance between Earth and Moon. Also, his methods of estimating planetary positions and eclipses could not have been as accurate without the mathematical understanding of 'shunya', the Sanskrit word for nothingness, which later evolved into the notion of zero. Therefore, the idea of zero revolutionised mathematics and laid the groundwork for contemporary numeral systems.

French mathematician Georges Ifrah argues in [7] that Aryabhata was familiar with both place value and number symbols. He stated in [7] as.

“it is extremely likely that Aryabhata knew the sign for zero and the numerals of the place value system. This supposition is based on the following two facts: first, the invention of his alphabetical counting system would have been impossible without zero or the place-value system; secondly, he carries out calculations on square and cubic roots which are impossible if the numbers in question are not written according to the place-value system and zero”.

Aryabhata was one of the few scientists who completed fulfilled an extraordinary amount of work throughout their lives. All across India, his efforts are acknowledged. He truly brought India to the attention of the world in terms of scientific knowledge and significance that impacted the entire planet. [5] *Bhaskara-I* who wrote a commentary on the *Aryabhatiya* a century later on *Aryabhatiya* says:

“Aryabhata is the master who, after reaching the furthest shores and plumbing the inmost depths of the sea of ultimate knowledge of mathematics, kinematics and spherics, handed over the three sciences to the learned world.

4. The contribution of the immense mathematician Brahmagupta

Among India's ancient mathematicians and astronomers, Brahmagupta held a special place in their hearts. In the areas of mathematics and astronomy, he created a new chapter. Brahmagupta was the first mathematician to develop the concept of zero as number and its arithmetical qualities. He claimed that shunya (zero) is a number that signifies nothing and said, "shunya is actually the result of subtracting a number from itself." Although everyone understands this concept today, in his time it was entirely new. He is known as *“the father of zero”*.



The great Indian Mathematician Brahmagupta was born in the city Bhinmal in Rajasthan, India, shortly after Aryabhata's demise in 598 AD. His father's name was Jishnu. Bhillamal Acharya is another name for Brahmagupta. Brahmagupta has provided very little personal information. The final two verses of 'Sgnadhyaya' of 'Brahmasphut-siddhant' contain Brahmagupta's brief introduction. He lived almost all of his life in [4]. He observed the work of many outstanding mathematicians while serving as the director of the astronomical observatory in Ujjain, the Indian centre of mathematics.

He wrote four books '*Durkeamynarda*', '*Khandakhadyaka*', '*Brahmasphutasiddhanta*' and '*Cadamakela*'. Though Brahmagupta added a large lot of new content, it is also believed that he corrected the *Siddhanta* text that he received. This treatise covers algebra, trigonometry, mathematics, and astronomy in addition to a great deal of other topics. The "Corrected Treatise of Brahma," meaning "Brahmasphutasiddhanta," is one of his most well-known publications. [12]. Additionally, Brahmagupta chastised contemporary Indian mathematicians and astronomers. The primary point of disagreement was over the opposing concepts and viewpoints; in fact, he used numerous chapters of the *Brahmasphutasiddhanta* to attack their mathematical ideas. The astronomer Muhammad al-Fazari translated Brahmagupta's writings into Arabic after the Arabs occupied a portion of India, which aided in the development and adoption of the Indian base ten number system [15].

In 624, at the age of just 26, he wrote the first mathematical text that was universally acknowledged. It was Brahmagupta who truly realised that mathematics needed a new number while expanding on the previously established concept of the placeholder in numbers. As a result, he established the idea of the number zero, one of the key discoveries in mathematics, in his work. The *Brāhmasphuṭasiddhānta* is the first known work to treat zero as a number itself, unlike the Babylonians who treated it as only a placeholder digit in representing another number or the Romans and Ptolemy who treated it as a symbol for lack of quantity. The most famous achievement of Brahmagupta was formulating the fundamentals of mathematics, namely the multiplication of positive, negative, and zero values. He recognized zero's role as a fundamental component of the numerical system, describing it as a "void" or "sunya" in Sanskrit. He introduced his revolutionary mathematical rules in "*Brahmasphutasiddhanta*" In this book, he represented positive number by *fortune* and negative number by *debts* and gave the following rules [7]:



A debt minus zero is a debt.

A fortune minus zero is a fortune.

Zero minus zero is a zero.

A debt subtracted from zero is a fortune.

A fortune subtracted from zero is a debt.

The product of zero multiplied by a debt or fortune is zero.

The product of zero multiplied by zero is zero.

The product or quotient of two fortunes is one fortune.

The product or quotient of two debts is one fortune.

The product or quotient of a debt and a fortune is a debt.

The product or quotient of a fortune and a debt is a debt.

Nevertheless, it appears that Brahmagupta miscalculated in some of his explanations of the zero division rules:

Positive or negative numbers when divided by zero is a fraction the zero as denominator.

Zero divided by negative or positive numbers is either zero or is expressed as a fraction with zero as numerator and the finite quantity as denominator.

Zero divided by zero is zero.

Although it is evident that rule do not follow the norms in modern mathematics, it is interesting to think about how Brahmagupta could have conceptualized those rules.

Numerous geometrical theories were included in the book as well, such as the "Pythagorean Theorem" for right angle triangles. He also discovered the area of a triangle and the key trigonometric formulas, including sine function values. He gave the value of ' π ' as square root ten to be accurate. In addition, he put forward guidelines for handling quadratic and simultaneous equations.

In fact, Brahmagupta was a great master of mathematical astrology. After Aryabhata, the first mathematician of India was 'Bhaskaracharya I'. Then there was Brahmagupta. Brahmagupta was also an astronomer and you discovered the rules for the use of 'zero'. After this there were many mathematicians who wrote on the subject of arithmetic and algebra.



Brahmagupta died in 668 AD. Even after so many centuries, Brahmagupta is remembered for his contributions to mathematics and astrology.

5. Conclusion

It is still unknown when and by whom zero was created, although it is well known worldwide that India is where it originated. Some researchers claim that zero was created twice, once by the Mayans and once by the Babylonians. Despite this, neither innovation had any impact on the numeral system. The invention of zero is believed to have been invented in India around the middle of the fifth century. The impact of the renowned Indian mathematician Brahmagupta's invention of zero on the advancement of human civilization can be likened to that of the discoveries of fire, the wheel, and computers. The majority of academics believe that the creation of the decimal number system and the number zero, which together form the great fundamental contribution of ancient India to the advancement of civilization.

In this regard the great scientist Einstein said–

‘we should be thankful to the Indians who taught us how to count, without which no worthwhile scientific discovery would have been possible!’

Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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Diversity of wall flora in Peri-urban areas of Thakurpukur, South 24 Parganas, West Bengal

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Abstract

The wall plants are the result of spontaneous colonization unassisted by human actions. In the trophic frameworks of ecosystems in rural, peri-urban, and urban areas, wall vegetation plays a significant role in representing an interesting group of stress-tolerant plant species, specifically adapted to thrive on thin nutritionally deficient substratum. The current investigation is an observational study to document the floral diversity of wall vegetation spreading over the brick, cemented, and mud construction walls in some selected peri-urban localities of Thakurpukur and Joka, South 24 Parganas, West Bengal. This work aimed to establish species diversity in conformities with the variability of the wall flora of the study sites. The wall vegetation was dominated by angiosperm species followed by Pteridophytes and Bryophytes. A total of 87 angiosperm plant species belonging to forty families have been recorded on the studied walls; among them, the most common members were Asteraceae, Amaranthaceae, Euphorbiaceae and Poaceae. Pteridophytes such as Pteris vitatta, Pteris longifolia, Chrystella dentata, Drynaria queercifolia and Adiantum cordatum are common occurrences. Only two species of Bryophytes (Cyathodium cavernarum, Semibarbula orientalis) were recorded. The current work revealed that the wall flora composition was dominated by plant species inhabiting the natural vegetation of the areas surrounding the study

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sites. This work may serve as a basic source of data for further ecological and systematic studies on the flora of this region.

Keywords: floral diversity, wall vegetation, peri-urban area, micro-environment.

1. Introduction

Walls represent a man-made micro-environment, partly resembling rocks and rock fissures (Woodell, 1979). They usually consist of binding materials of lower durability and chemical composition which is different from the building material used during the construction of the structure. These substances disintegrate and accumulate as fine-grain rubbles in crevices and thus, provide a substratum with a variable content of nutrients that generally initiate early succession of vegetation. The succession can be accelerated if soil is used as a binding or covering material. Due to repeated cleaning and fettling, walls represent a temporary habitat. Frequent disturbances of wall vegetation thus contribute to a high variation in species composition. Walls usually act as isolated objects of small dimensions. Therefore, wall microclimates are more strongly affected by the fluctuation of environmental factors, such as precipitation, temperature, and irradiation. Walls are characterized by a limited number of microhabitats and sidewalls have uniform slopes and microtopography (Nedelcheva, 2011). Nevertheless, their artificial origin, location in the urban and rural landscape, and wall-building technology influence a range of plant species, which can colonize these habitats (Duchoslav, 2002). Since walls are situated within urban and rural landscapes, the composition of wall flora is strongly influenced by the mass effects of the surrounding natural and seminatural vegetation types. Specific attributes principally characterize the wall habitats.

Because of the vertical orientation, walls generally represent three different zonation: (i) the basal part, (ii) the vertical wall surface with joints (fissures), and (iii) the top wall surface (Woodell, 1979). The wall habitat differs from natural habitat and rocks, depending on the multifarious properties of the wall structures. Buildings contain binding materials, which structurally and chemically differ from the original building materials. Wall surfaces resemble each other and have a uniform slope (generally right-angled) and micro-topographical characteristics with few microhabitats. As an artificial microenvironment conditioned by human beings, walls are inhabited only by plant species with specific adaptability for growth

and reproduction (Lisci and Pacini, 1993a; Lisci and Pacini, 1993b). The colonization of plants on walls is influenced by the age of the wall, its composition, and exposure to rain Altay et al. (2010). Most true wall species are only observed on vertical walls and along with the decrease in the angle of declination, a wide range of common species colonize. Propagules of the plants growing on the walls are carried to these habitats by natural agencies like, wind, birds, and animals and by stolon fragments (Yarci and Özçelik, 2002) and colonize there at random (Altay *et al.* 2010). There are habitats in which extreme conditions lead to the selection of species with morphological and physiological adaptations enabling them to survive. The study of wall flora provides a better understanding of the urban environment (Darlington, 1981; Francis, 2011; Nedelcheva, 2011).

The purpose of the present study was to document the floral diversity on brick, cemented, and mud construction walls in some selected sites of Thakurpukur and Joka, South 24 Parganas. The main aim of this study was to establish species diversity, conformities, and variability of the wall flora of the study sites. Till now information on wall flora in the present study area is meager. This work may serve as a basic source of data for further ecological and systematic studies on the flora of this region.

2. Materials and Methods

Site description

The present study was conducted in and around Thakurpukur, South 24 Parganas, mainly focusing on three different regions: Thakurpukur, Joka, and 3A bus stand. It is in the southern part of the state of West Bengal, Eastern India. The study sites were selected at random. This area is rich in floral wealth. The major part of the selected areas were vast wetlands. This region shows a tropical wet and dry climate. The annual mean temperature is 26.8°C; monthly mean temperatures range from 19–30°C. Summers are hot and humid with temperatures in the low 30°C and during dry spells, the maximum temperatures often exceed 40° C during May and June. Winter lasts only about two and a half months, with seasonal lows dipping to 9°C – 11° during December and January. On average, May is the hottest month, with daily temperatures ranging from 27–37°C, while January is the coldest month, temperatures varying from 12–23°C Often during early summer, dusty squalls followed by spells of thunderstorms or

hailstorms and heavy rains with ice sleet lash the city, bringing relief from the humid heat. These thunderstorms are convective and are locally known as *Kal Baisakhi* (*District survey report, 2018*). Thakurpukur spreads over 12000 acres of land area with well-maintained roads having extensive greenery all along and is composed of houses, buildings, educational institutions, temples, bridges, shops, etc. all around it. Few walls having cracks and crevices often favour the growth and development of plant species.

Table 1. Study sites

Sites	Location	Types of structures investigated
Thakurpukur (Gournagar, Majhi para, Thakurpukur Bazar)	22.26N 88.17E	Boundary wall, water reservoir, roadside bridge, Footpath
Joka	22.27N 88.17E	Boundary wall, roadside bridge, Footpath,
3A Bus stand	22.26N 88.17E	Boundary wall, water reservoir, Footpath

The current study is based on a yearlong intensive field survey conducted from July 2021 to June 2022 to record the vascular flora growing on the walls of the study area. During the field survey, every attempt was made to cover every corner of the region. The walls were thoroughly examined from the base to the top to record the plant species. One visit was made after every month at each location. Thus, a total of six visits were made for the field observations during the study period. The range of sampling stands included all types of walls (i.e. isolated walls in courtyards, fortifications, city walls, walls of dilapidated buildings, monuments, etc.). During the wall surveys, the plants from various types of old walls of residential compounds, parks, gardens, educational institutions, hospitals, temples, etc. were recorded and collected. The study was restricted to the wall tops, the wall joints, as well as, the flora and vegetation of the wall bases. Localities were selected by occasional walking through the area under study. Wall flora was studied and plants were collected during the study period with critical notes on habit, zones of vegetation, and seasonal occurrence. The observed plant specimens were photographed, collected, processed, identified, and preserved as herbarium sheets in the Department of Botany, Vivekananda College, Kolkata. In the enumeration of taxa, the Pteridophytic family is arranged after Dixit (1984) and the Angiosperms family according to

Bentham and Hooker’s natural system of classification. The plant species and Bryophytes were identified using taxonomic literature (Hooker, 1875-1897 and Duthie, 1903-1922) and Ray and Bhattacharya (2016), respectively.

3. Observation and Result

Plants Recorded from the study sites during the study period are furnished in tables 2 to 5.

Table 2. Group: Bryophytes

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer March- June	Monsoon July- October	Winter November- February
1	<i>Cyathodium cavernarum</i> Kunze ex Lehm.	Cyathodiaceae	Thallose -hepatic	-	+	-
2	<i>Semibarbula orientalis</i> (F. Weber) Wilk & Margad.	Pottiaceae	Moss	+	+	-

Table 3. Group: Pteridophytes

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer March- June	Monsoon July- October	Winter November- February
1	<i>Lygodium sp.</i> Sw.	Lygodiaceae	Herb	-	+	+
2	<i>Adiantum caudatum</i> L.	Pteridaceae	Herb	-	+	+
3	<i>Marsilea quadrifoliata</i> L.	Marsileaceae	Herb	+	+	-
4	<i>Pteris vittata</i> L.	Pteridaceae	Herb	+	+	+
5	<i>Pteris longifolia</i> L.	Pteridaceae	Herb	+	+	+
6	<i>Christella dentata</i> (Forssk.) Brownsey & Jermy	Thelypteridaceae	Herb	+	+	+
7	<i>Drynaria quercifolia</i> (L.) J. Sm.	Polypodiaceae	Herb		+	+

Table 4. Group: Angiosperm (Monocots)

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer March- June	Monsoon July- October	Winter November- February
1	<i>Eleusine aegyptiaca</i> Desf.	Poaceae	Herb	+	+	+
2	<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	Herb	+	-	+
3	<i>Commelina benghalensis</i> L.	Commelinaceae	Creepers	-	+	+
4	<i>Kyllinga monocephala</i> L.f.	Cyperaceae	Herb	+	-	+
5	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Herb	+	+	+
6	<i>Chloris barbata</i> Sw.	Poaceae	Herb	-	+	+
7	<i>Oplismenus burmanni</i> (Retz.) P.Beauv.	Poaceae	Herb	-	+	+
8	<i>Commelina diffusa</i> Burm.f.	Commelinaceae	Creepers	+	+	-
9	<i>Eragrostis tenella</i> (L.) P.Beauv.	Poaceae	Herb	-	+	+

Table 5. Group: Angiosperm (Dicots)

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer	Monsoon	Winter
1.	<i>Nicotiana glauca</i> Willd.	Solanaceae	Herb	+	+	-
2.	<i>Sonchus oleraceus</i> L.	Asteraceae	Herb	+	-	+

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer	Monsoon	Winter
3.	<i>Achyranthes aspera</i> L.	Amaranthaceae	Herb	+	+	+
4.	<i>Ziziphus jujube</i> Mill.	Rhamnaceae	Tree	+	+	+
5.	<i>Ipomoea nil</i> (L.) Roth	Convolvulaceae	Climber	-	+	+
6.	<i>Kalanchoe delagoensis</i> Eckl. & Zeyh.	Crassulaceae	Succulent Herb	+	+	+
7.	<i>Asystasia indica</i> H.J.Chowdhery & Av.Bhattacharjee	Acanthaceae	Herb	+	+	-
8.	<i>Mikania micrantha</i> Kunth	Asteraceae	Climber	+	+	+
9.	<i>Phyllanthus reticulatus</i> Poir.	Euphorbiaceae	Herb	+	+	+
10.	<i>Pouzolzia indica</i> (L.) Wight	Urticaceae	Herb	-	+	+
11.	<i>Peperomia pellucida</i> (L.) Kunth	Piperaceae	Herb	+	+	+
12.	<i>Cassia tora</i> L.	Caesalpinaceae	Herb	+	+	-
13.	<i>Ocimum sanctum</i> L.	Lamiaceae	Herb	+	+	+
14.	<i>Phyllanthus fraternus</i> G. L. Webster.	Euphorbiaceae	Herb	+	+	-
15.	<i>Euphorbia thymifolia</i> L.	Euphorbiaceae	Herb	--	+	-
16.	<i>Croton bonplandianus</i> Baill.	Euphorbiaceae	Herb	+	+	+
17.	<i>Allamanda cathartica</i> L.	Apocynaceae	Climber	+	+	+
18.	<i>Turnera ulmifolia</i> L.	Turneraceae	Herb	-	+	+
19.	<i>Cassia sophera</i> L.	Caesalpinaceae	Herb	+	+	-
20.	<i>Eclipta alba</i> Hassk.	Asteraceae	Herb	+	+	+

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer	Monsoon	Winter
21	<i>Coccinia grandis</i> (L.) Voigt	Cucurbitaceae	Scandent	+	+	-
22	<i>Momordica charantia</i> L.	Cucurbitaceae	Scandent	+	+	-
23	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Herb	+	+	-
24	<i>Mazus sp</i> Lour.	Mazaceae	Herb	+	-	-
25	<i>Nasturtium indicum</i> DC.	Brassicaceae	Herb	+	-	-
26	<i>Portulaca oleracea</i> L.	Portulacaceae	Herb	+	+	+
27	<i>Acacia auriculiformis</i> A.Cunn. ex Benth	Mimosaceae	Tree	+	+	+
28	<i>Desmodium triflorum</i> (L.) DC.	Papilionaceae	Herb	+	+	+
29	<i>Murraya koenigii</i> (L.) Spreng.	Rutaceae	Tree	+	+	+
30	<i>Psidium guajava</i> L.	Myrtaceae	Tree	+	+	+
31	<i>Scoparia dulcis</i> L.	Scrophulafacer	Herb	+	+	-
32	<i>Bacopa monnieri</i> (L.) Wettst.	Scrophulariaceae	Herb	+	+	-
33	<i>Hemigraphis hirta</i> (Vahl.) T.Anderson	Acanthaceae	Herb	-	+	+
34	<i>Lippia nodiflora</i> (L.) Michx.	Verbenaceae	Herb	+	+	-
35	<i>Alternanthera sessilis</i> (L.) DC.	Amaranthaceae	Herb	+	+	+
36	<i>Acalypha indica</i> L.	Euphorbiaceae	Herb	+	+	+
37	<i>Amaranthus viridis</i> L.	Amaranthaceae	Herb	-	+	+
38	<i>Amaranthus spinosus</i> L.	Amaranthaceae	Herb	+	+	+

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer	Monsoon	Winter
39	<i>Rivina humulis</i> L.	Phytolaccaceae	Herb	+	+	-
40	<i>Ficus religiosa</i> L.	Moraceae	Tree	+	+	+
41	<i>Cuscuta reflexa</i> Roxb.	Convolvulaceae	Parasitic climber	+	+	+
42	<i>Dentella repens</i> (L.) J.R.Forst. & G.Forst.	Rubiaceae	Herb	+	+	-
43	<i>Lindenbergia urticifolia</i> Lehm.	Orobanchaceae	Herb	-	+	+
44	<i>Ludwigia octovalvis</i> (Jacq.) P.H.Raven	Onagraceae	Herb	+	+	-
45	<i>Pilea microphylla</i> (L.) Liebm.	Urticaceae	Herb	+	+	+
46	<i>Ficus hispida</i> Linn.	Moraceae	Tree	+	+	+
47	<i>Blumea lacera</i> (Burm.f.) DC.	Asteraceae	Herb	+	+	-
48	<i>Argemone mexicana</i> L.	Papaveraceae	Herb	-	+	+
49	<i>Colocasia esculenta</i> (L.) Schott	Araceae	Herb	-	+	-
50	<i>Anthocephalus cadamba</i> (Roxb.) Miq.	Rubiaceae	Tree	+	+	+
51	<i>Vandellia crustacea</i> (L.) Benth.	Linderniaceae	Herb	+	+	-
52	<i>Cleome rutidosperma</i> DC.	Cleomaceae	Herb	-	+	-
53	<i>Cleome viscosa</i> L.	Cleomaceae	Herb	-	+	-
54	<i>Calotropis gigantea</i> (L.) W.T. Aiton	Apocyanaceae	Shrub	+	+	+

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer	Monsoon	Winter
55	<i>Parthenium hysterophorus</i> L.	Asteraceae	Herb	+	+	-
56	<i>Elephantopus scaber</i> L.	Asteraceae	Herb	-	-	+
57	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	Herb	-	+	+
58	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae	Herb	+	+	+
59	<i>Thevetia neriifolia</i> Juss. ex A. DC.	Apocynaceae	Shrub	+	+	+
60	<i>Oldenlandia paniculata</i> L.	Rubiaceae	Herb	-	+	+
61	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	Herb	-	+	+
62	<i>Trema orientale</i> (L.) Blume	Cannabaceae	Tree	+	+	+
63	<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Herb	-	+	+
64	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	Herb	-	+	-
65	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	Amaranthaceae	Herb	+	+	-
66	<i>Pyrostegia venusta</i> Ker Gawl.	Bignoniaceae	Climber	+	+	+
67	<i>Bauhinia purpurea</i> L.	Caesalpiniaceae	Tree	+	+	+
68	<i>Euphorbia tirucalli</i> L.	Euphorbiaceae	Shrub	+	+	+
69	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	Herb	+	+	-
70	<i>Tridax procumbens</i> L.	Asteraceae	Herb	+	+	+

Sl. No.	Scientific name	Family	Habit	Seasonal appearance		
				Summer	Monsoon	Winter
71	<i>Catharanthus roseus</i> (L.) G. Don	Apocynaceae	Herb	+	+	-
72	<i>Luffa acutangula</i> (L.) Roxb.	Cucurbitaceae	Scandent	+	+	-
73	<i>Punica granatum</i> L.	Lythraceae	Shrub	+	+	+
74	<i>Mollugo spargula</i> L.	Molluginaceae	Herb	+	+	+
75	<i>Leucas cephalotes</i> (Roth) Spreng.	Lamiaceae	Herb	-	-	+
76	<i>Vernonia cinerea</i> (L.) Less.	Asteraceae	Herb	+	-	+
77	<i>Azadirachta indica</i> A. Juss.	Meliaceae	Tree	+	+	+
78	<i>Ruellia tuberosa</i> L.	Acanthaceae	Herb	+	-	-

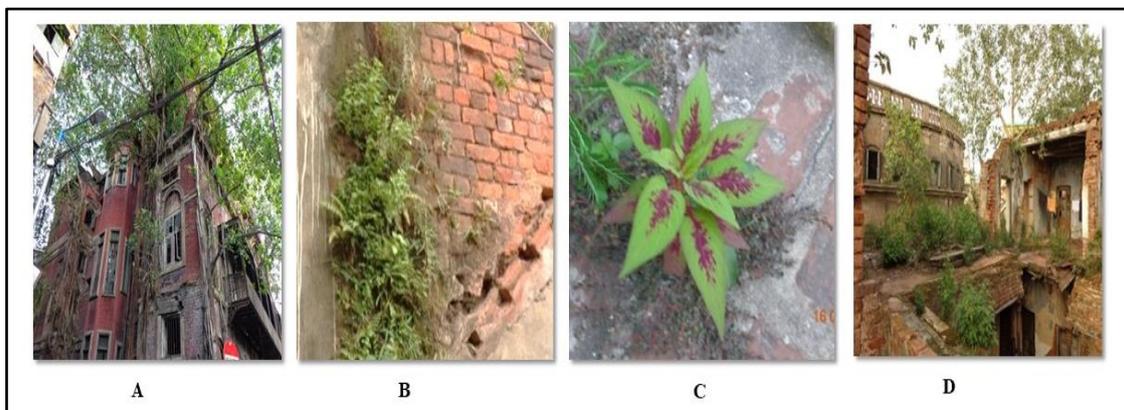


Figure 1. Habitat zones of wall Flora in various habitats. A. Roof and vertical wall of heritage building; B. Dilapidated vertical wall; C. Horizontal zone on a footpath; D. Dilapidated vertical and horizontal zone



Figure 2. Some plants observed in the study sites. A. *Pteris vittata*, B. *Commelina diffusa*, C. *Argemone mexicana*, D. *Lippia nodiflora* E. *Cleome viscosa*, F. *Coccinia grandis*, G. *Mirabilis jalapa*, H. *Boerhavia diffusa*, I. *Lindenbegia urticifolia*, J. *Calotropis gigantea* K. *Scoparia dulcis* L. *Kalanchoe delagoensis*

Table 6. Summary of wall vegetation recorded at Thakurpukur

Taxon	Bryophyte		Pteridophyte		Monocot		Dicot		Total no.
	No.	%	No.	%	No.	%	No.	%	
Species	2	4.45%	4	9.09%	7	15.90%	32	70.45%	44

Table 7. Summary of wall vegetation observed at Joka

Taxon	Bryophyte		Pteridophyte		Monocot		Dicot		Total no.
	No.	%	No.	%	No.	%	No.	%	
Species	1	2.12%	4	8.51%	9	19.14%	33	70.45%	47

Table 8. Summary of wall vegetation recorded at 3A bus stand

Taxon	Bryophyte		Pteridophyte		Monocot		Dicot		Total No.
	No.	%	No.	%	No.	%	No.	%	
Species	1	1.92%	7	13.46%	8	15.38%	36	69.23%	52

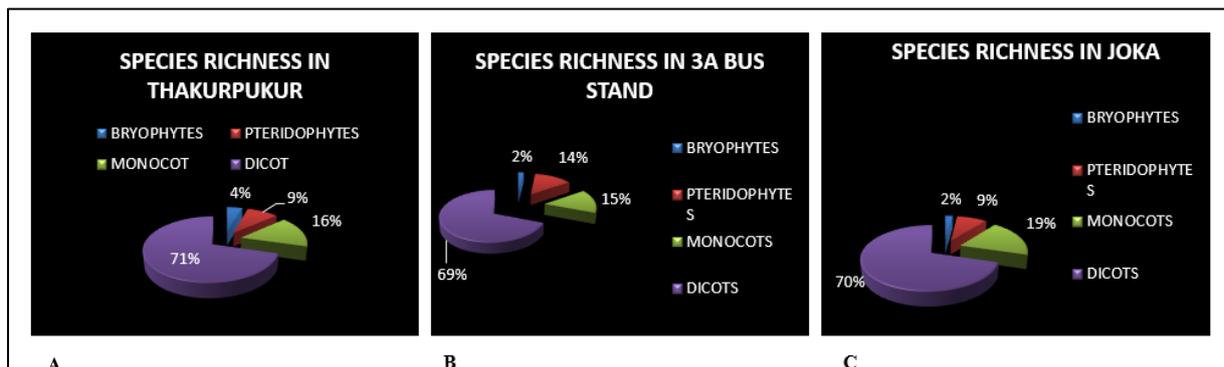


Figure 3. Comparison of the species richness of wall vegetation at different study sites. A. Thakurpukur, B. Joka, C. 3A bus stand.

Discussion

The wall plants are the result of spontaneous colonization unassisted by human actions. The present study revealed that the wall vegetation of the study area was dominated by angiosperm species followed by Pteridophytes and Bryophytes. During the present investigation 87 Angiosperm plant species, among which 9 monocot and 78 dicot species (Table 4, Table 5.), 7 species of Pteridophytes, and 2 species of Bryophytes (Table 3., Table 2.) were observed growing on pavements, and bricks inhabiting either the horizontal top and the vertical face or the basal zone or pavement of the wall. Comparative investigation of the study sites shows that the 3A bus stand area has maximum species diversity followed by the Joka and Thakurpukur regions. Furthermore, the basal zone (Pavement) represented the highest variability of plant species (Fig 4.) both in terms of kind and number. There was a remarkable variation regarding the seasonal distribution of different floral members as furnished in Table 2, Table 3, Table 4, and Table 5. The species diversity decreases and the percentage of typical xerophytes rises from the base to the top of the walls. This is due to the favorable environmental conditions in the basal zone with more humidity and nutrient-rich substratum.

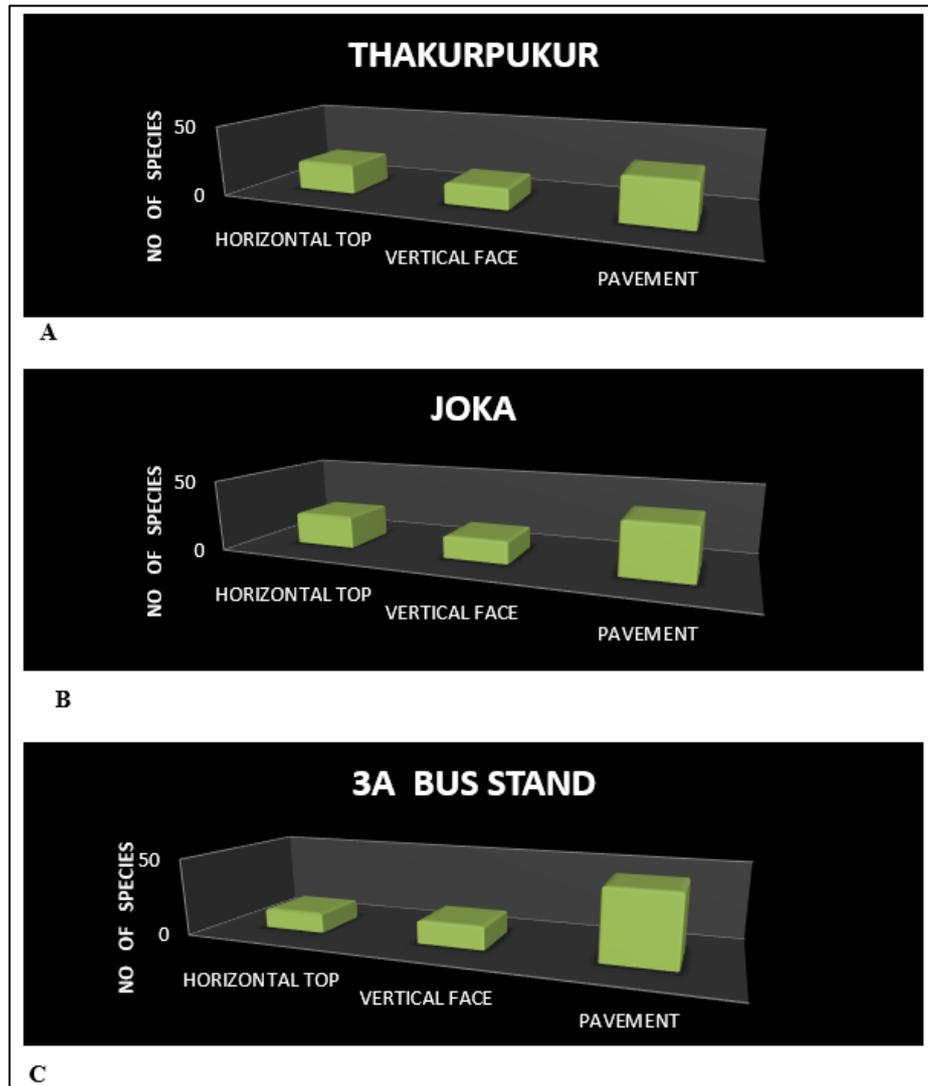


Figure 4. Comparison of the distribution of wall flora at different vegetation zones.

A. Thakurpukur, **B.** Joka, **C.** 3A bus stand.

Herbaceous plants were the dominant representatives of wall vegetation and our findings are in line with the observations of Nedelcheva (2011). Totally 87 angiosperm plant species belonging to 40 families have been recorded on the studied walls; among them, the most common members were *Asteraceae*, *Amaranthaceae*, *Euphorbiaceae* and *Poaceae* (Table 4, Table 5). The total no of vascular plants growing spontaneously on walls included nine monocotyledons and seventy-eight dicotyledons species. Monocot diversity is recorded to be maximum at Joka among the three different areas studied (Table 6, Table 7, and Table 8). Among monocots *Commelina benghalensis*, *Commelina diffusa*, *Eragrostis tenella*, *Cynodon*



dactylon, *Eleusine indica* were most frequent. Dicotyledons are the most prevalent group. In dicots *Vinca rosea* of Apocynaceae, *Pouzolgia indica*, of Urticaceae, *Cleome rutidosperma* of Capparidaceae, *Portulaca oleracea* of Portulecaceae, *Amaranthus viridis* and *Aspinosus* of Amaranthaceae, *Coccinea indica* of Cucurbitaceae, *Oldenlandia corymbosa* and *Oldenlandia paniculata* of Rubiaceae, *Vernonia cinerea* and *Eclipta alba* of Asteraceae, *Euphorbia hirta*, *Croton bonplundianum* and *Phyllanthus fraternus* of Euphorbiaceae, *Lindenbergia urticifolia* of Orobanchaceae, *Boerhavia diffusa* of Nyctaginaceae are the most common in occurrence. Other prevalent plants are *Heliotropium indicum* of Boraginaceae, *Ficus hispida*, *F. bengalensis*, *F. religiosa* of Moraceae and *Peperomia pellucida* of Piperaceae. The presence of *Mollugo spargula* of Aizoaceae, *Lippia nodiflora* of Verbenaceae, *Lindenbergia urticifolia* of Orobanchaceae are mention worthy. The family Asteraceae had high species richness, demonstrating the remarkable success of this family in terms of dispersal and establishment. Pteridophytes such as *Pteris vitatta*, *Pteris longifolia* of Pteridaceae, *Chrystella dentata* of Thelypteridaceae, *Microsorium punctatum* of Polypodiaceae, *Adiantum caudatum* (Adiantaceae) are of common occurrence. Comparative investigation of the study sites shows that the occurrence of bryophytes as reflected in species richness is highest in Thakurpukur area followed by 3A bus stand and Joka (Table 6, Table 7, and Table 8). Two species of Bryophytes recorded on walls are *Semibarbula orientalis* and *Cyathodium* sp (Table 2). These species inhabited both wall tops and vertical surfaces. Mosses generally occurred in well-lit places, but also in partially shady areas. Regarding moisture and reaction requirements, the mosses growing on the walls were indicators of dry to mesic sites on substrata with a pH higher than 5. Nirala and Singh (2019) observed that mostly the Asteraceae members colonize the walls in the winter season while the Poaceae members colonize the same in the rainy season (Nirala and Singh, 2019). A similar trend was also noticed in our investigation. The present study revealed that the wall flora composition was dominated by plant species inhabiting the natural vegetation of the areas surrounding the study sites.



Conclusion

In the trophic framework of rural, peri-urban, and urban areas, wall vegetation plays a significant role in the ecosystem. They represent an interesting group of stress-tolerant species specifically adapted to thrive on thin nutritionally deficient substratum. Providing shelter to the plant species that seek refuge in them, the walls of rural and urban localities contribute towards the conservation of some rare and threatened members of the plant kingdom. However, the woody plants damaging the walls must be uprooted. This work may serve as a basic source of data for further ecological and systematic studies on the flora of this region.

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Conflict of interest

The authors have no conflict of interest in publishing this paper

Data availability statement

Not applicable

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Global analysis of a diffusive predator-prey model with a competitor for the prey and fear effect

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Abstract

This article analyses a diffusive predator-prey model where the prey population faces a competitor, furthermore the prey population is affected by fear. The model incorporates inter-specific competition among the predator. Global asymptotic stability of the positive steady state is shown by forming a suitable Lyapunov function. The system admits of non-constant positive solution when we include cross diffusion. From the model analysis, we found non-constant positive steady states due to the presence of cross diffusion. Applying bifurcation result, we obtained non-constant positive solutions by considering the cross diffusion as a bifurcation parameter.

Keywords: Cross-diffusion; fear factor; global stability; priori estimates; bifurcation

1 Introduction

There is a considerable interest in investigating the dynamic behaviour between predator and their prey for several years and various aspects on predator-prey models have been noticed (see [1, 2, 3, 4], and the references therein). In the last few years, it is noticed that prey population changes its behaviour and physiological characteristics due to fear of predator. Furthermore, this fear effect affects the normal birth rate of the prey and sometimes exceeds the impact of direct predation [5]. This fact motivated some researchers to study the fear effect in predator-prey system [5, 6, 7, 8, 9, 10,

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11, 12, 13].

In the paper [6], the author investigated the system below:

$$\begin{aligned}\frac{dp}{dt} &= p \left(\frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r \right), \\ \frac{dq}{dt} &= q(r_2 - a_{21}p - a_{22}q) \\ \frac{dr}{dt} &= r(-d + c\beta p)\end{aligned}\tag{1}$$

where $p(t)$, $q(t)$ and $r(t)$ denote the densities of prey, competitor for prey and predator population respectively. r_1 and r_2 represent the intrinsic growth rate of prey and its competitor. a_{11} and a_{22} stand for intra-species competition rate of prey and its competitor. a_{12} and a_{21} measure the inter-specific competition between the prey and its competitor. d denotes the death rate of the predator. β stands for the per capita predator consumption rate. c is the conversion efficiency of the predator. k is the level of fear.

Under some appropriate restrictions on the model, in [6], the author obtained the conditions on the existence of equilibria, local and global stability, uniform persistence and Hopf bifurcation.

However, we note that when prey population faces fear, there may be competition among the predator population due to the scarcity of food [14, 15]. Hence, to account the above factor, we modify system (1) as follows:

$$\begin{aligned}\frac{dp}{dt} &= p \left(\frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r \right), \\ \frac{dq}{dt} &= q(r_2 - a_{21}p - a_{22}q) \\ \frac{dr}{dt} &= r(-d + c\beta p - hr)\end{aligned}\tag{2}$$

where h represents the intra-specific competition coefficient within the predator populations.

In the real world, species are not always homogeneous in space, so they have a tendency to shift to areas where population density is low, which will enhance its survivability in future time. This fact motivated some investigators to study reaction-diffusion in fear mediated predator-prey model. Wang and Zou [16] investigated a diffusive predator-prey model with fear effect. They developed the necessary and sufficient conditions of spatial pattern formation depending on the form of functional responses and concluded that fear factor as well as functional responses have a major impact producing pattern. Chen et al. [17] analysed fear induced a predator-prey model with diffusion and remarked that non-constant positive steady state cannot be obtained when conversion rate is high. Liu and Kang

[18] studied a predator-prey model with fear and diffusion. They derived some results for the nature of constant steady states. Also, they discussed about the non-constant steady states.

Motivated by the above works, we are interested to examine a fear induced diffusive predator-prey system when there is a competitor for the prey as follows:

$$\begin{aligned}\frac{\partial p}{\partial t} &= \delta_1 \Delta p + p \left(\frac{r_1}{1 + kr} - a_{11}p - a_{12}q - \beta r \right), \theta \in \Gamma, t > 0 \\ \frac{\partial q}{\partial t} &= \delta_2 \Delta q + q(r_2 - a_{21}p - a_{22}q), \theta \in \Gamma, t > 0 \\ \frac{\partial r}{\partial t} &= \delta_3 \Delta (r + \delta_4 pr) + r(-d + c\beta p - hr), \theta \in \Gamma, t > 0 \\ \frac{\partial p}{\partial n} &= \frac{\partial q}{\partial n} = \frac{\partial r}{\partial n} = 0, \theta \in \partial\Gamma \\ p(\theta, 0) &= p_0(\theta) > 0, q(\theta, 0) = q_0(\theta) > 0, r(\theta, 0) = r_0(\theta) > 0, \theta \in \Gamma\end{aligned}\tag{3}$$

where Γ is a bounded domain in \mathbb{R}^N ($N \geq 1$ is an integer), whereas for realistic applications $N = 2$ or 3 with a smooth boundary $\partial\Gamma$ and n is the outward unit normal vector. The homogeneous Neumann boundary conditions indicate that this system is self-contained with zero population flux over the boundary. The symbols δ_i ($i = 1, 2, 3$) represent the self diffusion coefficient, indicates the natural dispersive force of movement of an individual. The cross-diffusion pressure δ_4 or $\delta_3\delta_4$ denotes the tendency of predators to go away from a big group of preys.

In system (3), r diffuses with flux:

$$J = -\nabla(\delta_3 r + \delta_3 \delta_4 pr) = -\delta_3 \delta_4 r \nabla p - (\delta_3 + \delta_3 \delta_4 p) \nabla r.$$

We note that the part $-\delta_3 \delta_4 r \nabla p$ of the flux is directed toward the population p when its density is decreased which indicates that the prey species gather and form a large group so that the predator cannot attack the prey population.

The above type of non-linear diffusion was first initiated by Shigesada et al. [19] and after that several studies are made in different type of prey-predator models [20, 21, 22].

The emergence of stationary patterns in a predator-prey evolved due to the presence of cross-diffusion is pointed out by Pang and Wang [23]. There is now a considerable interest to examine the impact of cross-diffusion in reaction-diffusion systems [25, 26]. Here we point out that, no work has been done with diffusion and cross-diffusion in fear induced prey-predator system when there is a competitor for the prey.

In this work, we use degree theory to ascertain positive stationary solutions of (3), which will follow

from the system below:

$$\begin{aligned}
 -\delta_1 \Delta p &= p \left(\frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r \right), \theta \in \Gamma, t > 0 \\
 -\delta_2 \Delta q &= q(r_2 - a_{21}p - a_{22}q), \theta \in \Gamma, t > 0 \\
 -\delta_3 \Delta(r + \delta_4 pr) &= r(-d + c\beta p - hr), \theta \in \Gamma, t > 0 \\
 \frac{\partial p}{\partial n} = \frac{\partial q}{\partial n} = \frac{\partial r}{\partial n} &= 0, \theta \in \partial\Omega
 \end{aligned} \tag{4}$$

To examine the patterns due to cross-diffusion, we are interested to investigate the non-constant positive solutions of (4). For future usage, we designate

$$L = (r_1, r_2, a_{11}, a_{12}, a_{21}, a_{22}, c, \beta, d, h, k)$$

by direct computation, we can get a constant positive steady state of (4) (p^*, q^*, r^*) where p^* can be found by solving the following the equation

$$\begin{aligned}
 kc\beta(a_{11}a_{22}h + \beta^2a_{22}c - a_{12}a_{21}h)p^2 + (a_{11}a_{22}h^2 - a_{12}a_{21}h + \beta^2a_{22}hc - ka_{11}a_{22}hd + ka_{12}ha_{21}d + \\
 ka_{12}hr_2c\beta - 2k\beta^2a_{22}cd)p + a_{12}hr_2 \\
 + k\beta a_{22}d^2 - r_1a_{22}h^2 - \beta a_{22}hd - ka_{12}hr_2d = 0
 \end{aligned}$$

provided that

$$a_{11}a_{22}h + \beta^2a_{22}c - a_{12}a_{21}h > 0, \tag{5}$$

$$a_{12}hr_2 + k\beta a_{22}d^2 - r_1a_{22}h^2 - \beta a_{22}hd - ka_{12}hr_2d < 0, \tag{6}$$

$$\frac{d}{c\beta} < p^* < \frac{r_2}{a_{21}}. \tag{7}$$

The paper is structured in the following manner. Section 2 is dealing with the local and global stability of the constant positive equilibrium (p^*, q^*, r^*) . In Section 3, we derive a priori estimate for positive solutions of (4). We demonstrate whether the positive non-constant solutions exist or not for system (4). Section 5 establishes that the non-constant positive solutions may exist with the help of bifurcation analysis.

In the entire article, $0 = \nu_0 < \nu_1 < \nu_2 < \dots < \nu_n < \dots$ stands for the eigenvalues of $-\Delta$ in Γ with the homogeneous Neumann boundary condition. $m(\nu_j)$ represents the multiplicity of ν_j for any $j \geq 0$.

2 Dynamic behaviour of constant positive equilibrium

Now, we first consider system (3) without cross-diffusion and introduce the following system:

$$\begin{aligned}
 \frac{\partial p}{\partial t} &= \delta_1 \Delta p + p \left(\frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r \right), \theta \in \Gamma, t > 0 \\
 \frac{\partial q}{\partial t} &= \delta_2 \Delta q + q(r_2 - a_{21}p - a_{22}q), \theta \in \Gamma, t > 0 \\
 \frac{\partial r}{\partial t} &= \delta_3 \Delta r + r(-d + c\beta r - hr), \theta \in \Gamma, t > 0 \\
 \frac{\partial p}{\partial n} &= \frac{\partial q}{\partial n} = \frac{\partial r}{\partial n} = 0, \theta \in \partial\Gamma \\
 p(\theta, 0) &= p_0(\theta) > 0, q(\theta, 0) = q_0(\theta) > 0, r(\theta, 0) = r_0(\theta) > 0, \theta \in \Gamma
 \end{aligned} \tag{8}$$

2.1 Local stability

First we state the result on the stability character of the constant positive equilibrium point.

Theorem 1. *Suppose that (5-7) holds. If $a_{11}a_{22} > a_{12}a_{21}$ then X_0 is locally asymptotically stable.*

Proof. Let $X = (p, q, r)^T$, $X_0 = (p^*, q^*, r^*)$ and we denote

$$M(X) = \begin{pmatrix} p\left(\frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r\right) \\ q(r_2 - a_{21}p - a_{22}q) \\ r(-d + c\beta p - hr) \end{pmatrix}$$

Therefore,

$$M_X(X_0) = \begin{pmatrix} -a_{11}p^* & -a_{12}p^* & -p^*\left(\frac{r_1 k}{(1+kr^*)^2} + \beta\right) \\ -a_{21}q^* & -a_{22}q^* & 0 \\ c\beta r^* & 0 & -hr^* \end{pmatrix}.$$

Linearising (8) at X_0 , we get

$$X_t = (D\Delta + M_{X_0})X$$

where

$$D = \begin{pmatrix} \delta_1 & 0 & 0 \\ 0 & \delta_2 & 0 \\ 0 & 0 & \delta_3 \end{pmatrix}$$

The characteristic polynomial of $-\mu_i D + M_X(X_0)$ is given by

$$\phi_i(x) = x^3 + a_1 x^2 + a_2 x + a_3$$

where

$$\begin{aligned} a_1 &= \mu_i \delta_1 + a_{11} p^* + \mu_i \delta_2 + a_{22} q^* + \mu_i \delta_3 + h r^*, \\ a_2 &= (\mu_i \delta_1 + a_{11} p^*)(\mu_i \delta_2 + a_{22} q^* + \mu_i \delta_3 + h r^*) + (\mu_i \delta_2 + a_{22} q^*)(\mu_i \delta_3 + h r^*) \\ &\quad - a_{12} a_{21} p^* q^* + c \beta r^* p^* \left(\frac{r_1 k}{(1+k r^*)^2} + \beta \right), \\ a_3 &= (\mu_i \delta_1 + a_{11} p^*)(\mu_i \delta_2 + a_{22} q^*)(\mu_i \delta_3 + h r^*) - a_{12} a_{21} p^* q^* (\mu_i \delta_3 + h r^*) \\ &\quad + c \beta r^* p^* \left(\frac{r_1 k}{(1+k r^*)^2} + \beta \right) (\mu_i \delta_2 + a_{22} q^*). \end{aligned}$$

By the assumption of the theorem, a_1, a_2 and a_3 are all positive. Moreover, $a_1 a_2 - a_3 > 0$.

Using Routh-Hurwitz criterion, one can show that for each $i \geq 1$, all the three roots $x_{i,1}, x_{i,2}$ and $x_{i,3}$ of the characteristic equation $\phi_i(x) = 0$ can have negative real parts. Now we find a $\sigma > 0$ so that

$$\text{Re}\{x_{i1}\}, \text{Re}\{x_{i2}\}, \text{Re}\{x_{i3}\} \leq -\sigma, i \geq 1. \tag{9}$$

Suppose that $x = \mu_i \eta$, then we have

$$\phi_i(x) = \mu_i^3 \eta^3 + a_1 \mu_i^2 \eta^2 + a_2 \mu_i \eta + a_3 \triangleq \bar{\phi}_i(\eta).$$

Note that $\mu_i \rightarrow \infty$ as $i \rightarrow \infty$. We get

$$\lim_{i \rightarrow \infty} \frac{\bar{\phi}_i(\eta)}{\mu_i^3} = \eta^3 + (\delta_1 + \delta_2 + \delta_3) \eta^2 + (\delta_1 \delta_2 + \delta_1 \delta_3 + \delta_2 \delta_3) \eta + \delta_1 \delta_2 \delta_3 \triangleq \bar{\phi}(\eta)$$

Using the Routh-Hurwitz criterion again, we can see that all the three roots η_1, η_2 and η_3 of equation $\bar{\phi}(\eta) = 0$ have negative real parts. Thus, there exists a positive constant σ such that

$$\text{Re}\{\eta_1\}, \text{Re}\{\eta_2\}, \text{Re}\{\eta_3\} \leq -\sigma. \tag{10}$$

By continuity, we get $i_0 \in \mathbb{N}$ such that the three roots η_{i1}, η_{i2} and η_{i3} of $\bar{\phi}_i(\eta) = 0$ satisfy

$$\text{Re}\{\eta_{i1}\}, \text{Re}\{\eta_{i2}\}, \text{Re}\{\eta_{i3}\} \leq -\frac{\bar{\sigma}}{2}, i \geq i_0. \tag{11}$$

which implies that

$$\operatorname{Re}\{x_{i1}\}, \operatorname{Re}\{x_{i2}\}, \operatorname{Re}\{x_{i3}\} \leq -\frac{\mu_i \bar{\sigma}}{2}, i \geq i_0. \tag{12}$$

Suppose that $-\bar{\sigma} = \max\{\operatorname{Re}\{x_{i1}\}, \operatorname{Re}\{x_{i2}\}, \operatorname{Re}\{x_{i3}\}\}$;

then $\bar{\sigma} > 0$ and (5) holds for $\sigma = \min\{\bar{\sigma}, \frac{\bar{\sigma}}{2}\}$. Applying Theorem 5.1.1 in [24], we complete the proof.

2.2 Global stability

Now, we will derive condition for global behaviour of the equilibrium point (p^*, q^*, r^*) by applying the method used in [27].

Theorem 2. *If $a_{11} > \frac{r_1 k}{2(1+kr^*)} + \frac{a_{12}+a_{21}}{2}$, $a_{22} > \frac{a_{12}+a_{21}}{2}$ and $h > \frac{r_1 kc}{2(1+kr^*)}$ then all the solutions converge to (p^*, q^*, r^*) .*

Proof. Consider the following Lyapunov function

$$V(t) = \int_{\Gamma} \left[\int_{p^*}^p \frac{\tau - p^*}{d\tau} d\tau + \int_{q^*}^q \frac{\zeta - q^*}{d\zeta} d\zeta + \lambda \int_{r^*}^r \frac{\eta - r^*}{d\eta} d\eta \right] d\theta,$$

where $\lambda > 0$ will be selected afterwards.

$$\begin{aligned} \frac{dV}{dt} &= \int_{\Gamma} \left(\frac{p - p^*}{p} \frac{\partial p}{\partial t} + \frac{q - q^*}{q} \frac{\partial q}{\partial t} + \frac{r - r^*}{r} \frac{\partial r}{\partial t} \right) \\ &= \int_{\Gamma} (p - p^*) \left(\frac{r_1}{1 + kr} - a_{11}p - a_{12}q - \beta r - \frac{r_1}{1 + kr^*} + a_{11}p^* + a_{12}q^* + \beta r^* \right) d\theta \\ &+ \int_{\Gamma} (q - q^*) (r_2 - a_{21}p - a_{22}q - r_2 + a_{21}p^* + a_{22}q^*) d\theta \\ &+ \lambda \int_{\Gamma} (r - r^*) (-d + c\beta p - hw + d - c\beta p^* + hw^*) d\theta \\ &- \delta_1 p^* \int_{\Gamma} \frac{|\nabla p|^2}{p^2} d\theta - \delta_2 q^* \int_{\Gamma} \frac{|\nabla q|^2}{q^2} d\theta - \lambda \delta_3 r^* \int_{\Gamma} \frac{|\nabla r|^2}{r^2} d\theta \\ &\leq -\left[a_{11} - \frac{r_1 k}{2(1 + kr^*)} - \frac{a_{12} + a_{21}}{2} \right] \int_{\Gamma} (p - p^*)^2 d\theta \\ &- \left[\lambda h - \frac{r_1 k}{2(1 + kr^*)} \right] \int_{\Gamma} (r - r^*)^2 d\theta - \beta(1 - \lambda c) \int_{\Gamma} (p - p^*)(r - r^*) d\theta \\ &- \delta_1 p^* \int_{\Omega} \frac{|\nabla p|^2}{p^2} d\theta - \delta_2 q^* \int_{\Gamma} \frac{|\nabla q|^2}{q^2} d\theta - \lambda \delta_3 r^* \int_{\Gamma} \frac{|\nabla r|^2}{r^2} d\theta \\ &- \left[a_{22} - \frac{a_{12} + a_{21}}{2} \right] \int_{\Gamma} (q - q^*)^2 d\theta \end{aligned}$$

Choose $\lambda = \frac{1}{c}$, then

$$\begin{aligned} \frac{dV}{dt} &\leq -\left[a_{11} - \frac{r_1 k}{2(1 + kr^*)} - \frac{a_{12} + a_{21}}{2}\right] \int_{\Gamma} (p - p^*)^2 d\theta \\ &\quad -\left[a_{22} - \frac{a_{12} + a_{21}}{2}\right] \int_{\Gamma} (q - q^*)^2 d\theta - \left[\frac{h}{c} - \frac{r_1 k}{2(1 + kr^*)}\right] \int_{\Gamma} (r - r^*)^2 d\theta \\ &\quad -\delta_1 p^* \int_{\Gamma} \frac{|\nabla p|^2}{p^2} d\theta - \delta_2 q^* \int_{\Gamma} \frac{|\nabla q|^2}{q^2} d\theta - \frac{\delta_3}{c} r^* \int_{\Gamma} \frac{|\nabla r|^2}{r^2} d\theta \leq 0 \end{aligned}$$

which implies the desired assertion.

3 A priori estimates

In this part, we now estimate the positive solution of (4). We require two lemmas developed by Lou and Ni [28] and Lin et al. [29] respectively.

We now state the lemma on maximum principle.

Lemma 1. Assume that $f \in C(\bar{\Gamma} \times \mathbb{R})$.

(i) Suppose that $s \in C^2(\Gamma) \cap C^1(\bar{\Gamma})$ and fulfills

$$\Delta s(\theta) + f(\theta, s(\theta)) \geq 0 \text{ in } \Gamma,$$

$$\frac{\partial s}{\partial n} \leq 0 \text{ on } \partial\Gamma$$

If $s(\theta_0) = \max_{\bar{\Gamma}} s(\theta)$, then $f(\theta_0, s(\theta_0)) \geq 0$.

(ii) Suppose that $s \in C^2(\Gamma) \cap C^1(\bar{\Gamma})$ and fulfills

$$\Delta s(\theta) + f(\theta, s(\theta)) \leq 0 \text{ in } \Gamma,$$

$$\frac{\partial s}{\partial n} \geq 0 \text{ on } \partial\Gamma$$

If $s(\theta_0) = \min_{\bar{\Gamma}} s(\theta)$, then $f(\theta_0, s(\theta_0)) \leq 0$

Our next lemma is known as Harnack inequality.

Lemma 2. Assume that $c \in C(\bar{\Gamma})$. Let $s \in C^2(\Gamma) \cap C^1(\bar{\Gamma})$ and fulfills

$$\Delta s(\theta) + c(\theta)s(\theta) = 0 \text{ in } \Gamma,$$

$\frac{\partial s}{\partial n} = 0$ on $\partial\Omega$. Then we can find a $C > 0$, which is depended on B where $\|c\|_{\infty} \leq B$ so that

$$\max_{\bar{\Gamma}} s(\theta) \leq C \min_{\bar{\Gamma}} s(\theta).$$

Now we state result on upper bound.

Theorem 3 . Any positive solution $X(\theta) = (p(\theta), q(\theta), r(\theta))^T$ of (4) fulfills

$$\max_{\bar{\Gamma}} p(\theta) \leq K_1, \max_{\bar{\Gamma}} q(\theta) \leq K_2, \max_{\bar{\Gamma}} r(\theta) \leq K_3 \tag{13}$$

where $K_1 = \frac{r_1}{a_{11}}, K_2 = \frac{r_2}{a_{22}}, K_3 = \frac{c\beta r_1(a_{11} + \delta_4 r_1)}{a_{11}^2}$.

Proof. Let $\theta_0 \in \bar{\Gamma}$ such that $p(\theta_0) = \max_{\bar{\Gamma}} p(\theta)$. Using Lemma 1, one can get

$$\frac{r_1}{1+kr(\theta_0)} - a_{11}p(\theta_0) - a_{12}q(\theta_0) - \beta r(\theta_0) \geq 0 \text{ and } p(\theta_0) = \max_{\bar{\Gamma}} p(\theta) \leq \frac{r_1}{a_{11}} \triangleq K_1. \text{ Similarly,}$$

$$q(\theta_1) = \max_{\bar{\Gamma}} q(\theta) \leq \frac{r_2}{a_{22}} \triangleq K_2.$$

Let $\gamma = \delta_3 w + \delta_3 \delta_4 u w$.

Then from (4),

$$-\Delta\gamma = \frac{-dr + c\beta pr - hr^2}{\delta_3 r + \delta_3 \delta_4} \gamma \text{ in } \Gamma$$

$$\frac{\partial r}{\partial n} = 0 \text{ on } \partial\Gamma \tag{14}$$

Take $\theta_2 \in \bar{\Gamma}$ such that $r(\theta_2) = \max_{\bar{\Gamma}} r(\theta)$. Then $r(\theta_2) \leq \frac{c\beta}{h} p(\theta_2) \leq \frac{c\beta r_1}{ha_{11}}$.

$$\text{So } \max_{\bar{\Gamma}} r(\theta_2) \leq \frac{1}{\delta_3} \max_{\bar{\Gamma}} \gamma = \frac{\delta_3 r(\theta_2) + \delta_3 \delta_4 p(\theta_2) r(\theta_2)}{\delta_3} \leq \frac{c\beta r_1(a_{11} + \delta_4 r_1)}{a_{11}^2} \triangleq K_3.$$

Thus we obtained the bounds mentioned in (13).

Theorem 4 . There exist three positive constants C_1 (relying on $\frac{r_1}{d_1}, \Omega$), C_2 (relying on $\frac{r_2}{d_2}, \Gamma$), and C_3 (relying on $c, \beta, r_1, a_{11}, d_1, \Gamma$), so that any positive solution $(p(\theta), q(\theta), r(\theta))$ of (4) fulfills

$$\frac{\max_{\bar{\Gamma}} p(\theta)}{\min_{\bar{\Gamma}} p(\theta)} \leq C_1, \frac{\max_{\bar{\Gamma}} q(\theta)}{\min_{\bar{\Gamma}} q(\theta)} \leq C_2, \frac{\max_{\bar{\Gamma}} r(\theta)}{\min_{\bar{\Omega}} r(\theta)} \leq C_3. \tag{15}$$

Proof. It is easy to observed that $p(\theta)$ and $q(\theta)$ satisfy

$$\Delta p(\theta) + \frac{c_1(\theta)}{\delta_1} p(\theta) = 0 \text{ in } \Gamma$$

$$\Delta q(\theta) + \frac{c_2(\theta)}{\delta_2} q(\theta) = 0 \text{ in } \Gamma$$

$$\frac{\partial p(\theta)}{\partial n} = \frac{\partial q(\theta)}{\partial n} = 0 \text{ on } \partial\Gamma \tag{16}$$

where $c_1(\theta) = \frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r, c_2(\theta) = r_2 - a_{21}p - a_{22}q$.

Now $\|\frac{c_1(\theta)}{\delta_1}\|_{C(\bar{\Gamma})} \leq \frac{r_1}{\delta_1}, \|\frac{c_2(\theta)}{\delta_2}\|_{C(\bar{\Gamma})} \leq \frac{r_2}{\delta_2}$.

So by Lemma 1, the left hand side two inequalities of (15) follow.

Define $\phi(\theta) = \delta_3 r(\theta) + \delta_3 \delta_4 p(\theta) r(\theta)$. We have

$$\Delta\phi(\theta) + c_3(\theta)\phi(\theta) = 0 \text{ in } \Gamma$$

$$\frac{\partial\phi(\theta)}{\partial n} = 0 \text{ on } \partial\Gamma \tag{17}$$

where $c_3(\theta) = \frac{-d+c\beta p-hr}{\delta_3(1+\delta_4 p)}$.

Thus $\|c_3(\theta)\|_{C(\bar{\Gamma})} \leq \frac{c\beta r_1}{\delta_3 a_{11}}$.

Then Lemma 2 produces

$\frac{\max_{\bar{\Gamma}} \phi(\theta)}{\min_{\bar{\Gamma}} \phi(\theta)} \leq C_3^*$, for some positive constant $C_3^*(c, \beta, \delta_3, r_1, a_{11})$ and

$\frac{\max_{\bar{\Gamma}} r(\theta)}{\min_{\bar{\Gamma}} r(\theta)} \leq \frac{\max_{\bar{\Gamma}} \phi \max_{\bar{\Gamma}}(1+\delta_4 p)}{\min_{\bar{\Gamma}} \phi \min_{\bar{\Gamma}}(1+\delta_4 p)} \leq C_3^* \frac{\max_{\bar{\Gamma}} p}{\min_{\bar{\Gamma}} p} \leq C_3^* C_1 \triangleq C_3$.

Hence the theorem.

We now present result on lower bounds.

Theorem 5. Suppose $L, D_i, i = 1, 2, 3, 4$ be fixed positive constants. Assume that $r_1 c \beta > \min\{(1 + kK_3)(da_{11} + c\beta^2 K_3 + a_{11} h K_3, da_{11} + c\beta a_{12} K_2 + a_{11} h K_3)\}$ where K_2 and K_3 are defined in (13). Then there exists a positive constant $C = C(L, D_1, D_2, D_3, D_4)$ such that $(\delta_1, \delta_2, \delta_3) \in [D_1, \infty) \times [D_2, \infty) \times [D_3, \infty)$ and $\delta_4 \in [0, D_4]$, any positive solution $(p(\theta), q(\theta), r(\theta))$ of (4) satisfies

$$\min_{\bar{\Gamma}} p(\theta), \min_{\bar{\Gamma}} q(\theta), \max_{\bar{\Gamma}} r(\theta) \geq C. \tag{18}$$

Proof. Suppose that (18) does not hold. Then there exist sequences $\{\delta_{1i}, \delta_{2i}, \delta_{3i}, \delta_{4i}\}_{i=1}^\infty$ with $(\delta_{1i}, \delta_{2i}, \delta_{3i}) \in [D_1, \infty) \times [D_2, \infty) \times [D_3, \infty)$ and $\delta_{4i} \in [0, D_4]$ such that the corresponding positive solutions (p_i, q_i, r_i) of (4) satisfy

$$\max_{\bar{\Gamma}} p_i \rightarrow 0, \text{ or } \max_{\bar{\Gamma}} q_i \rightarrow 0, \text{ or } \max_{\bar{\Gamma}} r_i \rightarrow 0 \tag{19}$$

Using the maximum principle to the first two equations of (4), one obtains $p_i \leq \frac{r_1}{a_{11}}$ and $q_i \leq \frac{r_2}{a_{22}}$. Integrating the three equations in (4), we have

$$\begin{aligned} \int_{\Gamma} p_i \left(\frac{r_1}{1 + kr_i} - a_{11} p_i - a_{12} q_i - \beta r_i \right) d\theta &= 0, \\ \int_{\Gamma} q_i (r_2 - a_{21} p_i - a_{22} q_i) d\theta &= 0, \\ \int_{\Gamma} r_i (-d + c\beta p_i - hr_i) d\theta &= 0 \end{aligned} \tag{20}$$

for $i = 1, 2, \dots$. By applying a result on elliptic equations, we can get a subsequence of $\{p_i, q_i, r_i\}_i^\infty$, that are designated by $\{p_i, q_i, r_i\}_i^\infty$, and three non-negative functions $p, q, r \in C^2(\bar{\Gamma})$ so that $(p_i, q_i, r_i) \rightarrow (p, q, r)$ in $[C^2(\bar{\Omega})]^3$ as $i \rightarrow \infty$.

From (19), one has

$$p \equiv 0, \text{ or } q \equiv 0, \text{ or } r \equiv 0.$$

Again, we assume that $(\delta_{1,i}, \delta_{2,i}, \delta_{3,i}, \delta_{4,i}) \rightarrow (\delta_{-1}, \delta_{-2}, \delta_{-3}, \delta_{-4}) \in [D_1, \infty) \times [D_2, \infty) \times [D_3, \infty) \times [D_4, \infty)$. Let $i \rightarrow \infty$ in (20), we get

$$\begin{aligned} \int_{\Gamma} p \left(\frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r \right) d\theta &= 0, \\ \int_{\Gamma} q(r_2 - a_{21}p - a_{22}q) d\theta &= 0, \\ \int_{\Gamma} r(-d + c\beta p - hr) d\theta &= 0 \end{aligned} \tag{21}$$

There will be three cases to be examined now.

Case 1 ($p \equiv 0$). Note that $p_i \rightarrow p$, as $i \rightarrow \infty$. Then we have

$$-d + c\beta p_i - hr_i < 0 \text{ on } \bar{\Gamma}, \text{ for all } i \geq 1,$$

which contradict the third equation of (21).

Case 2 ($q \equiv 0, p \neq 0$ on $\bar{\Gamma}$). By applying Hopf boundary lemma, we get $p > 0$ on $\bar{\Gamma}$. So p and q obey the equations below:

$$\begin{aligned} -\delta_1 \Delta p &= p \left(\frac{r_1}{1+kr} - a_{11}p - \beta r \right), \\ \frac{\partial p}{\partial n} &= 0. \end{aligned} \tag{22}$$

Let $p(\theta_0) = \min_{\bar{\Gamma}} p(\theta)$. By Lemma 1 and (22), we obtain

$$\frac{r_1}{1+kr(\theta_0)} - a_{11}p(\theta_0) - \beta r(\theta_0) \leq 0$$

which implies that

$$p(\theta_0) \geq \frac{1}{a_{11}} \left(\frac{r_1}{1+kr(\theta_0)} - \beta r(\theta_0) \right) \geq \frac{1}{a_{11}} \left(\frac{r_1}{1+kK_3} - \beta K_3 \right).$$

By using the assumption $r_1 c\beta > (1+kK_3)(da_{11} + c\beta^2 K_3 + a_{11}hK_3)$ we have

$-d + c\beta p_i - hr_i > 0$ on $\bar{\Gamma}$, for all $i \geq 1$. After integration, the differential equation for r_i on Γ , reduces to

$$0 = \int_{\Gamma} r(-d + c\beta p_i - hr_i) d\theta > 0 \text{ for all } i \geq 1 \text{ which is not true.}$$

Case 3 ($w \equiv 0, u \neq 0$ and $v \neq 0$ on $\bar{\Omega}$). Again applying the same lemma as in case 2, we get $p > 0$ and $q > 0$ on $\bar{\Gamma}$. Then p and q obey the following equations:

$$\begin{aligned} -\delta_1 \Delta p &= p(r_1 - a_{11}p - a_{12}q) \text{ in } \Gamma, \\ \frac{\partial p}{\partial n} &= 0 \text{ on } \partial\Gamma. \end{aligned} \tag{23}$$

Let $p(\theta_1) = \min_{\bar{\Gamma}} p(\theta)$. Lemma 1 and (23) yield $r_1 - a_{11}p(\theta_1) - a_{12}q(\theta_1) \leq 0$

which implies that $p(\theta_1) \geq \frac{1}{a_{11}}(r_1 - a_{12}q(\theta_1)) \geq \frac{1}{a_{11}}(r_1 - a_{12}K_2)$.

By using the assumption $c\beta r_1 > da_{11} + c\beta a_{12}K_2 + a_{11}hK_3$ we know that

$-d + c\beta p_i - hr_i > 0$ on $\bar{\Gamma}$, for all $i \geq 1$. After integration, the differential equation for r_i on Γ produces $0 = \int_{\Gamma} r(-d + c\beta p_i - hr_i)d\theta > 0$ for all $i \geq 1$ that is not true.

The proof is completed.

4 Presence of non-constant positive solution

In this paragraph, we shall provide the validity of non-constant positive solution of (4) in case of cross-diffusion.

Let $X = (p, q, r)^T, X_0 = (p^*, q^*, r^*), \Psi(X) = (\delta_1 p, \delta_2 q, \delta_3(r + \delta_4 p r))^T$, then system (4) becomes

$$-\Delta \Psi(X) = M(X), \text{ with } M(X) = \begin{pmatrix} p(\frac{r_1}{1+kr} - a_{11}p - a_{12}q - \beta r) \\ q(r_2 - a_{21}q - a_{22}q) \\ r(-d + c\beta p - hr) \end{pmatrix}.$$

Clearly, the solution X of (4) may be positive whenever

$$F(X) = X - (I - \Delta)^{-1}\{\Psi_U^{-1}(X)[M(X) + \nabla X \Psi_{XX}(X) \nabla X^T] + X\} = 0 \tag{24}$$

Using a result on index of fixed point in [30] and the similar reasoning developed in [23], we realize that to simplify our calculation regarding index $(I - F, X_0)$, we require to find out the sign of $N(\rho)$, where $N(\rho)$ is described by

$$N(\rho) = \det\{\Psi_X^{-1}(X_0)\} \det\{\rho \Psi_X(X_0) - M_X(X_0)\} \tag{25}$$

After some calculation, we can show that $\det\{\Psi_X^{-1}(X_0)\}$ cannot be negative and

$$\det\{\rho \Psi_X(X_0) - M_X(X_0)\} = Q_3(\delta_3)\rho^3 + Q_2(\delta_3)\rho^2 + Q_1(\delta_3)\rho + Q_0(\delta_3) = Q(\delta_3; \rho)$$

where

$$Q_3(\delta_3) = \delta_1 \delta_2 (\delta_3 + \delta_3 \delta_4 p^*),$$

$$Q_2(\delta_3) = a_{11} p^* \delta_2 \delta_3 (1 + \delta_4 p^*) + \delta_1 \{ \delta_2 h r^* + a_{22} q^* \delta_3 (1 + \delta_4 p^*) - \delta_2 \delta_3 \delta_4 r^* (\beta + \frac{r_1 k}{(1+kr^*)^2}) \},$$

$$Q_1(\delta_3) = \delta_1 a_{22} q^* h r^* + a_{11} p^* \{ \delta_2 h r^* + a_{22} q^* \delta_3 (1 + \delta_4 p^*) \} - a_{12} a_{21} p^* q^* \delta_3 (1 + \delta_4 p^*) - a_{22} \delta_3 \delta_4 q^* r^* (\beta + \frac{r_1 k}{(1+kr^*)^2}),$$

$$Q_0(\delta_3) = h p^* q^* r^* (a_{11} a_{22} - a_{12} a_{21}).$$

Assume that three roots of $Q(\delta_3; \rho) = 0$ be $\bar{\rho}_1, \bar{\rho}_2$ and $\bar{\rho}_3$ respectively with $\text{Re}(\bar{\rho}_1) \leq \text{Re}(\bar{\rho}_2) \leq \text{Re}(\bar{\rho}_3)$. Note that $Q_0 > 0$ when $a_{11}a_{22} > a_{12}a_{21}$ and $Q_3 > 0$. Hence $\bar{\rho}_1\bar{\rho}_2\bar{\rho}_3 = -\frac{Q_0}{Q_3} < 0$. So the equation $Q(\delta_3; \rho) = 0$ has one real and negative root while the product of the other two roots is positive.

Consider the following limits:

$$\begin{aligned} \lim_{\delta_3 \rightarrow \infty} \frac{Q_0(\delta_3)}{\delta_3} &= 0, \\ \lim_{\delta_3 \rightarrow \infty} \frac{Q_1(\delta_3)}{\delta_3} &= p^*q^*(1 + \delta_4p^*)(a_{11}a_{22} - a_{12}a_{21}) - a_{22}\delta_4q^*r^*(\beta + \frac{r_1k}{(1+kr^*)^2}) \triangleq b_1, \\ \lim_{\delta_3 \rightarrow \infty} \frac{Q_2(\delta_3)}{\delta_3} &= (1 + \delta_4p^*)(a_{11}p^*\delta_2 + \delta_1a_{22}q^*) - \delta_2\delta_4r^*(\beta + \frac{r_1k}{(1+kr^*)^2}) \triangleq b_2, \\ \lim_{\delta_3 \rightarrow \infty} \frac{Q_3(\delta_3)}{\delta_3} &= \delta_1\delta_2(1 + \delta_4p^*) \triangleq b_3. \end{aligned}$$

It is easy to see that $b_3 > 0$.

Note that

$$\lim_{\delta_3 \rightarrow \infty} \frac{Q(\delta_3; \rho)}{\delta_3} = b_3\rho^3 + b_2\rho^2 + b_1\rho = \rho(b_3\rho^2 + b_2\rho + b_1)$$

The equation $b_3\rho^2 + b_2\rho + b_1 = 0$ possesses exactly two positive solutions whenever the following conditions hold:

$$b_1 > 0, b_2 < 0, b_2^2 - 4b_1b_3 > 0. \tag{26}$$

For sufficiently large value of δ_3 , we see that $\bar{\rho}_1$ is real and negative while $\bar{\rho}_2$ and $\bar{\rho}_3$ are real and positive since the product $\bar{\rho}_2\bar{\rho}_3$ is positive. Also, we have

$$\begin{aligned} \lim_{\delta_3 \rightarrow \infty} \bar{\rho}_1 &= 0, \\ \lim_{\delta_3 \rightarrow \infty} \bar{\rho}_2 &= \frac{-b_2 - \sqrt{b_2^2 - 4b_1b_3}}{2b_3} \triangleq \rho_2^* > 0, \\ \lim_{\delta_3 \rightarrow \infty} \bar{\rho}_3 &= \frac{-b_2 + \sqrt{b_2^2 - 4b_1b_3}}{2b_3} \triangleq \rho_3^* > 0. \end{aligned} \tag{27}$$

It is possible to find a $\delta_3^* > 0$ whenever $\delta_3 > \delta_3^*$, we have:

$$-\infty < \bar{\rho}_1 < 0 < \bar{\rho}_2 < \bar{\rho}_3;$$

$$Q(\delta_3; \rho) < 0 \text{ if } \rho \in (-\infty, \bar{\rho}_1) \cup (\bar{\rho}_2, \bar{\rho}_3)$$

$$Q(\delta_3; \rho) > 0 \text{ if } \rho \in (\bar{\rho}_1, \bar{\rho}_2) \cup (\bar{\rho}_3, \infty).$$

Since $\bar{\rho}_2^* \in (\rho_i, \rho_{i+1})$ and $\bar{\rho}_3^* \in (\rho_j, \rho_{j+1})$ for some $j > i > 0$, we have $Q(\delta_3; \rho_k) < 0$ when $i + 1 < k < j + 1$. Thus from previous analysis, we have the following theorem.

Theorem 6. Suppose that δ_1, δ_2 and δ_4 are fixed and the assumption of Theorem 4 and (18) be hold and where ρ_2^* and ρ_3^* are given in (27). If $\bar{\rho}_2^* \in (\rho_i, \rho_{i+1})$ and $\bar{\rho}_3^* \in (\rho_j, \rho_{j+1})$ for some $j > i \geq 1$,

and the sum $\sum_{n=i+1}^j m(\mu_n)$ is odd, then it is possible to find a $\delta_3^* > 0$, so that (4) possesses at least one non-constant positive solution provided $\delta_3 \geq \delta_3^*$.

Proof. We show the result by the method of contradiction. Suppose that for specific choice of $\delta_3 = \bar{\delta}_3 \geq \delta_3^*$, system (4) has no non-constant solutions. Next, we choose $\delta_3 = \bar{\delta}_3 \geq \delta_3^*$.

For $t \in [0, 1]$, consider

$$\Psi(t; X) = (\delta_1 p, \delta_2 q, \delta_3 r + t\delta_4 pr)^T,$$

Then (4) becomes

$$\begin{aligned} -\Delta\Psi(t; X) &= M(X), \quad \theta \in \Gamma \\ \frac{\partial X}{\partial n} &= 0, \quad x \in \partial\Gamma \end{aligned} \tag{28}$$

Clearly, for $t \in [0, 1]$, there exists exactly one positive solution of system (28) and X is a positive solution of system (4) whenever if X is a positive solution of system (28) when $t = 1$. X is a positive solution of system (28) whenever

$$F(X) = X - (I - \Delta)^{-1} \{ \Psi_X^{-1}(X) [M(X) + \nabla X \Psi_{XX}(X) \nabla X^T] + X \} = 0.$$

By a priori estimates, it can be shown that the solutions of system (28) which are positive will remain in E defined by

$$E = \{(p, q, r) : C < p, q, r < D\}$$

where

$D = \max\{K_1, K_2, K_3\}$ and $F(t; X) \neq 0$ on ∂E . So $\deg(F(t; X), E, 0)$ is well defined. Using degree theory related to homotopy of invariance, one can get

$$\deg(F(1, \cdot), E, 0) = \deg(F(0, \cdot), E, 0). \tag{29}$$

Note that

$$N(t; \rho) = \det\{\Psi_X^{-1}(t; X_0)\} \det\{\rho\Psi_X(t; X_0) - M_X(X_0)\} \tag{30}$$

and when $t = 0$, $N(0; \rho) > 0$ by the assumption (26). By means of the result $\text{index}(I - F(t, \cdot), X_0) = (-1)^\sigma$ where $\sigma = \sum_{n \geq 1, N(\rho_n) < 0} m(\rho_n)$. We get

$$\text{index}(I - F(0, \cdot), X_0) = (-1)^0 = 1. \tag{31}$$

As we have already assumed that that system (4) has no non-constant positive solution and $\sum_{n=i+1}^j m(\mu_n)$, is odd, so we get

$$\text{index}(I - F(1, \cdot), X_0) = (-1)^{\sum_{n=i+1}^j m(\rho_n)} = 1.$$

Moreover, $F(1; 0) = 0$ and $F(0; X) = 0$ have a unique positive solution X_0 on E follows from the assumption. So

$$\deg(F(0, \cdot), E, 0) = \text{index}(I - F(0, \cdot), X_0) = 1, \quad (32)$$

$$\deg(F(1, \cdot), E, 0) = \text{index}(I - F(1, \cdot), X_0) = -1 \quad (33)$$

Thus (32)-(33) contradict with (29). Hence the theorem.

5 Bifurcation 5.

In this paragraph, we will address the validity of non-constant positive solutions of system (4) by applying bifurcation. Keeping the parameters $r_1, r_2, k, a_{11}, a_{12}, a_{21}, a_{22}, \beta, d, h, \delta_1, \delta_2, \delta_4$ fixed and taking δ_3 as a bifurcation parameter, we develop the result.

Definition 1. (δ_3^*, X_0) is known as a bifurcation point of system (4) given any $\delta \in (0, \delta_3^*)$, one can find a $\delta_3 \in [\delta_3^* - \delta, \delta_3^* + \delta]$ so that system (4) possesses a non-constant positive solution. If not, (δ_3^*, X_0) becomes a regular point.

Consider $P = \{\rho > 0 \mid h(\rho) = 0\}$ and $S_p = \{\rho_2, \rho_3, \rho_4, \dots\}$, where $N(\rho)$ is defined by (25). To highlight the role of δ_3 on $P(\rho), F(\rho)$ and P , we designate these by $N(\delta_3; \rho), F(\delta_3; \rho)$ and $P(\delta_3; X)$ respectively, where $F(X)$ is defined by (24).

The proof of the result below is similar to a result in [23] and the proof is not given here.

Theorem 7. Suppose that $\delta_3^* > 0$.

(1) If $S_p \cup P(\delta_3^*) = \phi$, then (δ_3^*, X_0) is a regular point of system (4).

(2) Suppose $S_p \cup P(\delta_3^*) \neq \phi$, and $N(\delta_3^*; \rho) = 0$ has only simple positive roots.

If $\sum_{\rho_j \in P(\delta_3^*)} m(\rho_j)$ is odd, then (δ_3^*, X_0) is a bifurcation point of system (4).

6 Discussion

In the present work, we have investigated a predator-prey system with a competitor for the prey and fear effect. We assume that prey and predators are not spatially homogeneous and to examine the impact of diffusion, we consider a reaction-diffusion system equipped with homogeneous Neumann boundary conditions. This means that there is no population flux over the natural surroundings.

Basic results include local as well as global behaviour of the interior steady state and pattern formation when system allows cross-diffusion.

From Theorem 1, we note that if the intra-specific competition dominates the inter-specific competition then the constant positive steady state is locally asymptotically stable. This finding shows that, if there is no cross-diffusion then the diffusion driven instability cannot occur. If the condition of the Theorem 1 is reversed, local stability can be achieved under the influence of self-diffusion of the interacting species. We have further derived the condition for the global stability of the constant positive steady state by forming an appropriate Lyapunov function. With the help of maximum principle and Harnack inequality, it is possible to find the priori estimate to the positive solutions which are reflected in Theorems 3 and 4. We have found certain conditions for which the system induces spatial pattern as long as system admits cross-diffusion. This fact may be considered as the modified form of Turing pattern. Lastly, we have identified the parameter δ_3 to obtain bifurcation of the system.

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