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Home > Arabian Journal of Geosciences > Article					
Original Paper   Published: 26 July 2022	Access via your institution $\rightarrow$				
Projections of atmospheric changes over Iran in 2014–					
2050 using the CMIP6-HighResMIP experiment	Access options				
David Francisco Bustos Usta, Maryam Teymouri, Uday Chatterjee 🖂 & Nairwita Bandyopadhyay					
Arabian Journal of Geosciences 15, Article number: 1335 (2022) Cite this article	Buy article PDF				
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Abstract	Price includes VAT (India)				
It was evident from observations in the recent past that atmospheric variables are changing at	Instant access to the full article PDF.				
regional scale and may continue to impact the regional weather in the coming future. An 8-					
member ensemble from the HighResMIP experiment is used to analyze projected changes in					
temperature, atmospheric pressure, precipitation, and surface wind over Iran during 2015–	Rent this article via DeepDyve.				
2050 period. A considerable increase of temperature between 2 and 2.5 °C by 2050 with					
respect to the baseline period (1979–2014) is expected with a higher rate towards	Learn more about Institutional subscriptions				
southwestern and southeastern of Iran. From the seasonal analysis, an increase of $\sim$ 4 $^{\circ}\mathrm{C}$					
(2 °C) by 2050 would be maintained in summer (winter) season over the country.	Sections Figures References				
Furthermore, a reduction in atmospheric pressure between 0.2 and 1 hPa by 2050 with respect	Sectors rights rights				
to the baseline period towards the northwestern region of the country is foresaw; however, no	Abstract				
consistent changes are expected in the remain regions where lack of coherence between	Data availability				
models is recognized. Besides, precipitation changes are expected to be significant towards the	References				
northwestern Iran region with values between 0.1 and 0.3 mm day <sup>-1</sup> by 2050 with respect to					
the baseline period, contrary to the results obtained in the eastern region with changes	Acknowledgements				
between – 0.1 and 0.1 mm day <sup>-1</sup> towards the Lut and the Kavir deserts. Additionally, an	Author information				
interesting behavior was noticeable in all the models selected with a reduction in precipitation	Ethics declarations				
🗩 10°C Cloudy 🗧 🔍 Search 📘 🖸 😋 🖬 🔹 🗖	💼 🧬 🦕	へ 🔿 ENG 日 🖓 23 IN 日 🖓 24-02-20			

Vulnerability assessment of envir x +	
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Home > Arabian Journal of Geosciences > Article Original Paper   <u>Published: 22 July 2022</u> Vulnerability assessment of environmental degradation due to coastal hazards using geospatial technology—a study of Puri coast along the Mahanadi Delta, India Gopal Krishna Panda, Uday Chatterjee S. Monalisha Mishra & Ashutosh Mohanty Arabian Journal of Geosciences 15, Article number: 1322 (2022)   <u>Cite this article</u> 158 Accesses   <u>Metrics</u> Abstract	Access via your institution → Access options Buy article PDF 39,95 € Price includes VAT (India) Instant access to the full article PDF.
Inis study makes an assessment of the risk of environmental degradation due to coastal hazards along Puri coast of the Mahanadi delta across Bay of Bengal, India, using geospatial technology. It analyses the vulnerability profile of environmental degradation by assessing the inherent hazards of the coastal zone such as ecosystem disruption, gradual coastal inundation, intrusion of salt water, coastal flooding, and erosion. The study uses Coastal Hazard Wheel model which is a multi-hazard assessment and management tool in a changing global climate	Rent this article via DeepDyve.
using the biogeophysical parameters of the coast such as geomorphological layout, nature of wave exposure, range of tidal amplitude, coastal vegetation, balance and deficit of coastal sediments, and presence or absence of storm climate. The model uses multi-date remote sensing data from the open sources and a GIS framework to assess the problem and fieldwork for validation of its results. The study has generated data and maps about the degree to which environmental degradation is inherent to a particular location along the Puri coast. Taking together the data from the high and very high category, this study has identified that 86% of the coastline is highly vulnerable to coastal erosion, 72% to coastal flooding, 79% to salt water intrusion, and 92% moderately vulnerable to ecosystem disruption. But taking together all the	Sections     Figures     References       Abstract     Data availability       Data availability       References       Acknowledgments       Author information       Ethics declarations
→ 10°C Cloudy	▲

Home > GeoJournal > Article

Published: 11 June 2022

Solid waste management through multi-criteria decision making: using analytic hierarchy process as an assessment framework for the Hooghly district, West Bengal

Amit Kumar Das 🖾, Uday Chatterjee & Jenia Mukherjee

GeoJournal 87, 911–930 (2022) Cite this article 276 Accesses 2 Citations 1 Altmetric Metrics

## Abstract

Solid waste management (SWM) is a crucial service governed by urban local bodies (ULB). Hence, it is essential to identify challenges and opportunities in the SWM procedures and practices towards improved delivery of services. In this study, analytic hierarchy process (AHP) has been applied in the three sub-divisional towns of the Hooghly district, West Bengal (India), namely Chandannagar, Hooghly-Chinsurah and Serampore to analyze the existing SWM scenario. As AHP is a Multi-Criteria Decision Making tool, hence, it has been deployed by experts to come up with SWM performance index, clearly demonstrating the strengths and weaknesses of management strategies in selected study sites. This article further advances the significance of the AHP method by carving out multi-layered realities through the quantification of qualitative insights across various segments of waste management in the three towns. While interviews with waste management officials led to the formulation of key performance indicators and sub-indicators matrix, the obtained normalized weights brought to the fore the real engagement and actions executed by each of these towns in managing solid wastes. The application of this innovative AHP method ensured accuracy in the ranking system across performance of the specified ULBs. This AHP-induced situational analysis of SWM is not only significant in terms of policy formulation in the ULBs of the Hooghly district but has potentials to work at scales.

## Graphical abstract



Home > Innovative Infrastructure Solutions > Article

Case study Published: 18 March 2022

# Importance–Performance Analysis to assess community role in solid waste management in the Hooghly District, West Bengal

<u>Amit Kumar Das</u> ⊠, <u>Jenia Mukherjee</u> & <u>Uday Chatterjee</u>

Innovative Infrastructure Solutions 7, Article number: 187 (2022) Cite this article
151 Accesses 1 Altmetric Metrics

## Abstract

Solid Waste Management (SWM) is a major concern in developing cities. Small cities and peripheral towns lack adequate hard infrastructural facilities to systematically manage solid wastes from generation to disposal. It can be argued that through soft intervention measures such as local community's awareness, participation, involvement and engagement in tackling solid wastes, the infrastructural challenges of small towns can be met to a great extent. In this article, the three sub-divisional towns of the Hooghly District, West Bengal: Hooghly-Chinsurah, Chandannagar and Serampore, have been selected to assess community perception and performance in managing solid wastes through Importance–Performance Analysis (IPA). The Importance and Performance (IP) quantitative scores and the "G"-value (i.e., the gap between I and P) have been enumerated for different social groups classified across age, income, education and gender. Furthermore, the concordance levels (CL) have been calculated by quantifying the ratio between mean performance score (MPS) and mean importance score (MIS) against each SWM component specifically identified for the study area. Through the research findings, it can be mentioned that the IPA assessment tool is significant in terms of designing innovative and low-cost action strategies for municipalities, complementing (inadequate) hard infrastructures for developing cities. This study finally argues that this methodology can be applied across scales through which local ULBs can design efficient and effective SWM mechanisms reliant upon capacitating local communities.

Contents lists available at ScienceDirect

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## **Research Article**

## Impact of land use change and rapid urbanization on urban heat island in Kolkata city: A remote sensing based perspective

Uday Chatterjee<sup>a,\*</sup>, Sushobhan Majumdar<sup>b</sup>

<sup>a</sup> Assistant Professor of Geography, Bhatter College, Dantan, Vidyasagar University, West Bengal, 721101, India
<sup>b</sup> Former Research Fellow, Department of Geography, Jadavpur University, Kolkata, 700032, West Bengal, India

#### ARTICLE INFO

Keywords: Surface temperature Heat island Urbanization Normalized difference vegetation index and normalized difference built up area index

#### ABSTRACT

Kolkata is one of the cities located in the eastern parts of India and experiences rapid urban growth. Because of the rapid urbanization, land use and land cover are changing very rapidly in which impacts on the local land resources and the surface temperature of Kolkata are much higher than its surroundings. In this study, an effort has been done to find out how the vegetation cover is affected by urban growth and how the built up area grew over time. Except this, the attempt has also been made to scrutinize the trends of surface temperature in Kolkata city. This study was done between 2005 and 2019. To find out the vegetation cover and built up area of Kolkata city, Normalized Difference Vegetation Index and Normalized Difference Built up Area Index and Landsat satellite images between the year 2005 and 2019 have been used. This study reveals that vegetation area is declining towards the city core areas and percentages of built up areas are increased towards the urban area. Surface temperature is high in the city core areas which records 41 °C temperature in 2019. This study will throw new light in case of urban heat island studies.

#### 1. Introduction

Urbanization means the process of an area to be urbanized. Urbanization is very rapid in the case of developing countries and it decreases towards developed countries. In the case of developing countries, metropolitan cities have been playing a vital role in the high growth rate of urbanization. According to various researchers, urbanization has been categorized as a process of urbanization (He et al., 2006; Wang et al., 2014; Song et al., 2012; Shahbaz et al., 2014). Many International Organizations like the United Nations, FAO have been tried to project future populations. According to the report of the United Nations (2019), global population will be increased by 8.5 billion in 2030, 9.7 billion in 2050 and 10.9 billion in 2100. According to the latest report of the United Nations (2018), 55% percentage of the population will be lived in urban areas which will be 68 percent in 2050. The population of India will be increased by 273 million between 2019 and 2050 (United Nations, 2019). Urbanization means the expansion of urban area (Seto et al., 2011). Angel et al. (2011) makes an attempt for the projection of urban area which was 3,00,000 km<sup>2</sup> in 2000and will be increased into 1,200,000 km<sup>2</sup> in 2050. Types of urbanization in the world vary from country to country (Pannell, 2002) and they also cause threat to resources and environmental issues among the many countries like China (Fang, 2009). It also leads to the problems of soil erosion, desertification, scarcity of water resources, etc. (Wang & Fang, 2011). It also threatens to natural and semi natural habitats because of the indirect impacts of urbanization (Ruppert et al., 2012).

With the rates of urban expansion urban land use and land cover pattern hugely change with the time. The environmental impacts of

\* Corresponding author. *E-mail address:* raj.chatterjee459@gmail.com (U. Chatterjee).

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Fig. 1. The study area.

land use change are the results of the urbanization process (Carlson & Traci Arthur, 2000; Xiao et al., 2006). According to the various researchers, urban area occupies only four per cent of the total land surface but it impacts on the physical environment and social environment (Tang, 2011, Van Delm & Gulinck, 2011; Su et al., 2014, Lee & Choe, 2011). The urban expansion also causes habitat destruction, resource destruction, loss of biodiversity and fragmentation of landscape (Sala et al., 2000; Song, 2014; Song & Liu, 2014; Batisani & Yarnal, 2009; Rebele, 2009; Su et al., 2011; Seto et al., 2012). Extreme impact of urban expansion leads to the scarcity of the water resources (Guttikunda et al., 2003; Wang et al., 2013) and bad impact on public health (Khoo et al., 2003).

#### 1.1. Urbanization and land use change

The population has been playing a dominant role in the process of urbanization from the beginning of civilization (Seto et al., 2011). Food, clothing and human employment are the basic requirements of human life. Urban areas are the hub of these things. People of the surrounding areas want to settle down in urban areas to fulfill their essential requirements. These are the causes of the process of urbanization. Tremendous demand for land in urban areas creates a huge problem for the city officials as the supply of the land is limited. TheLack of open space and overpopulation of cities creates an adverse impact on the environment (Wei, 2015).

#### Journal of Urban Management 11 (2022) 59-71

#### Table 1

Detailed information about satellite images.

Acquisition Date	Sensor	Spatial Resolution	Projection
08-03-2019	OLI-TIRS	30m	WGS 84 UTM 45 N
21-01-2010	TM	30m	WGS 84 UTM 45 N
17-11-2005	TM	30m	WGS 84 UTM 45 N
14-11-2000	TM	30m	WGS 84 UTM 45 N

#### 1.2. Increase in land surface temperature

Decrease in vegetation and an increase in the urban area or built up area increases the surface temperature of the area. Temperature is high in the central areas of the city which gradually decreases towards the peripheral areas. It creates serious causes to the global biosphere (Turner et al., 1994). It is also responsible for the local climate, habitat destruction and loss of biodiversity (Foly et al., 2005; Kalnay and Cai, 2003). The magnitude of UHI is particularly enhanced in China, which has experienced a rapid urbanization during the last three decades (Sun et al., 2016; Zhou et al., 2016). Yao et al. examined the impacts of urbanization on the vegetation coverage of 59 large cities in Africa, and vegetation decreased significantly in 44 of the 59 cities. At present, India and China experience high rates of urban land expansion in the last 30 years (Bai et al., 2014; Seto et al., 2011).

Land surface temperature can be estimated both in the day time and in night time. According to the Jusuf et al. (2007), surface temperature is relatively high in the commercial and airport areas than the other areas. Bokaie et al. (2019) opined that there is a significant relationship between the land surface temperature and land use-land cover change of an area. Van and Bao (2010) also showed that surface temperature will be high in the industrial and urban areas than the other urban vegetative areas. According to (Oke, 1981, 1982; Nunez & Oke, 1977) geometry of the urban areas also regulate temperature of the surface by absorbing incoming solar radiation. Chow (2006); Lan and Zhan (2017) opined that building geometry also controlled the temperature of the area i.e. dense building structure reduce the temperature by shading effect but it increases temperature during the nighttime. Lan and Zhan (2017) also suggested that high rise buildings may reduce the temperature in day time, but it increases temperature in nighttime.

Recently, Kolkata city has been experienced with rapid destruction of vegetation cover and increase in the built up area within a shorter period. So, in this study, an effort has been done to investigate the nature of vegetation cover and increase of built up area in Kolkata. From the field visit, it has also been done that the surface temperature of Kolkata city has been increasing day by day. The person inhabited in the surroundings of Kolkata enjoys better weather than the people in the city core area. So, in this study, an effort has been done to measure the land surface temperature of Kolkata. The objective of this study is as follows-

#### 1.3. Objectives

The objective of this study is to investigate the vegetation cover and built up area of Kolkata city between 2005 and 2019. Except this effort has also been done to find out the surface temperature of Kolkata city between these periods.

#### 2. Study sites

Kolkata is one of the oldest metropolitan cities in India which is located in the eastern part of India over a large alluvial plain. It is situated over the moribund delta of the Hooghly river. From the topographical sheet or from the geological map of Kolkata it has been found that the height of Kolkata ranges from 1.5 to 9 m from mean sea level. Kolkata is under the jurisdiction of Kolkata Municipal Corporation. The total number of wards in Kolkata is 144 which aresubdivided into 16 boroughs. This study has been done after the addition of 2 g panchayats with KMC. For this study, the area of Kolkata Metropolitan Area has been considered which is delineated by Kolkata Metropolitan Development Authority or KMDA. Kolkata city recently has experienced a negative growth rate of population between 2001 and 2011. Six districts partially are under Kolkata those are likely Kolkata, Howrah, North 24 Parganas, Hooghly, South 24 Parganas and Nadia. Among them, only the entire Kolkata district is under KMDA (Fig. 1).

Among the total areas of KMA, Kolkata district covers 10.78 per cent of the total area, whereas Hooghly, Howrah, Nadia, North 24 Parganas and South 24 Parganas district covers 19.13 per cent, 14.67 per cent, 6.90 per cent, 25.63 per cent and 22.89 per cent of the total area. Among the total population of KMA, Kolkata comprises 28.66 per cent of the total population. Hooghly, Howrah, Nadia, North 24 Parganas and South 24 Parganas district covers 12.83 per cent, 16.12 per cent, 1.79 per cent, 30.14 per cent, 10.46 per cent of the total population. According to the latest census, population growth of Kolkata city is quite high which experiences 10.30 percent. The rate of land use change is very high in Kolkata city and the rate of land use change is relatively high towards the peripheral areas of the city.

#### 3. Data and methods

#### 3.1. Collection of data (images and information)

This study is based on satellite images. Satellite images have been collected from the United States Global Survey on various dates. Table 1 shows detailed information about the satellite images used for this study. For the analysis cloud, free images of the same time

Table 2           Index values for NDVI.	
Categories	Values
Low	-0.51-0.0
Medium	0.01-0.25
High	0.26-0.50
Very High	0.51-0.75
Table 3         Index values for NDBI.	
Categories	Values
Very Low	_0.600

Very Low	-0.600.30
Low	-0.30-0.00
Medium	0.01-0.30
High	0.31-0.60

period have been chosen to minimize the errors. For the analysis, ground verification has been done for some ground truth information. Some information regarding the growth and development of Kolkata city and its surrounding information has been collected from the various offices like Kolkata Municipal Corporation, Kolkata Municipal Development Authority etc. This study has been done after the addition of several rural mouzas with Kolkata Municipal Corporation.

#### 3.2. Image processing

For the analysis, both the remote sensing and GIS techniques have been used. For mapping purposes, various cartographic techniques have been used. For the mapping purposes, Arc GIS 10.3 and Erdas Imagine 2014 software have been used. To scrutinize the demographic growth and surface temperature prediction, statistical analysis has been done. For the calculation of NDVI and NDBI index, Erdas Imagine 2014 software has been used. For the mapping of land surface temperature,Arc GIS 10.3 software has been used.

#### 3.3. NDVI index

NDVIIndex (Normalized Difference Vegetation Index) is a graphical indicator of satellite images, mainly used for the remote sensing measurements especially vegetation mapping. Mainly two bands have been used for the calculation of NDVI Index. Those are Near Infrared (which vegetation reflects) and Red Band (which vegetation absorbs most). It always ranges from -1 to +1.

NDVI Index = 
$$\frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}$$

It is mainly used to measure healthy vegetation where a positive value indicates healthy vegetation and vice versa. NDVI can also be used for farmland mapping (Majumdar, 2019). Table 2 showing index values for NDVI in Kolkata city.

### 3.4. NDBI index

**NDBI** Index is another graphical indicator, used for measuring the urban areas specially built up areas or artificial structure areas. Mainly, two bands are used for the NDBI mapping purposes, those are likely Short wave Infrared and Infrared Band. Like NDVI and other indices, it also ranges from -1 to +1.

NDVI Index = 
$$\frac{SWIR - NIR}{SWIR + NIR}$$

This index is mainly used for the built up index mapping where a positive value indicates the presence of artificial structure or built up areas and the lower value indicates the availability of physical features. Table 3 showing values of NDBI index in Kolkata city.

#### 3.5. Land surface temperature

For the analysis, Landsat satellite images (Landsat 5 TM and 8 OLI) of 2005, 2010, 2015 and 2019 have been used (same period). For the surface temperature analysis at the time of layer stacking thermal bands were stacked. For measuring the LST and Normalized Difference Built up Area Index (NDBI), various statistics have been used. For the LST mapping, first radiance values have been calculated using this formula.

$$CVR1 = \frac{LMAX\lambda - LMAX\lambda}{(QCALMAX - QCALMIN)^*(QCAL - QCALMIN)} (For Landsat 5 TM)$$



Fig. 2. Normalized difference vegetation index of Kolkata city.

Table 4

NDVI values for Kolkata.

Index Values	2005		2010	2010		2015		2019	
	Area (SQ.KM).	Percent							
Very Low	537	29.17	616	33.46	658	35.74	687	37.32	
Low	456	24.77	527	28.63	578	31.40	613	33.30	
Medium	103	5.59	69	3.75	54	2.93	49	2.66	
High	273	14.83	226	12.28	198	10.76	184	9.99	
Very High	472	25.64	403	21.89	353	19.17	308	16.73	

Where, CVR1 indicates cell value as radiance, QCAL is the Digital Number, LMIN indicates Spectral radiance scales to QCALMIN, LMAX indicates Spectral radiance scales to QCALMAX, QCALMIN = the minimum quantized calibrated pixel value of the images and QCALMAX is the maximum quantized calibrated pixel value of the images. From the radiance value of the temperature of the image of the Kolkata, the city has been measured.

 $L\lambda = MLQcal + AL - 0i$  (For Landsat OLI 8)

Where,  $L\lambda = TOA$  spectral radiance (Watts/(m2 × srad × µm)), ML = Band-specific multiplicative rescalingfactor from the metadata (RADIANCE\_MULT\_BAND\_x, where x is the band number), AL = Band-specific additive rescaling factor from the metadata (RADI-ANCE\_ADD\_BAND\_x, where x is the band number), QCal = Quantized and calibrated standard product pixel values (DN) and is the correction for band 10. From the radiance value, LST has been collected applying these statistics (Mallick and Bharath, 2008; Barsi et al., 2014). LST has been calculated in degree Celsius.

#### 3.6. Mapping techniques and Software's

For the analysis, both the remote sensing and GIS techniques have been used For the mapping purposes, various cartographic techniques have been used. For the mapping purposes, Arc GIS 10.3 and Erdas Imagine 2014 software have been used. To scrutinize the demographic growth and surface temperature prediction statistical analysis has been done. For the calculation of NDBI and NDVI indices, Erdas Imagine 2014 has been used. For the mapping of land surface temperature, Arc GIS 10.3 software has been used. For the future prediction of the surface temperature, Microsoft Excel 2019 has been used.

#### 4. Results and analysis

#### 4.1. Changes in vegetation and built up area

Among the natural Land Use and Land Cover (LULC), vegetation and water body are the major features in KMA. Among these two LULC types, vegetation is more dynamic in nature. Vegetation is mainly high in the peripheral areas of the city which gradually decreases towards the central part of Kolkata city.

To investigate the nature and patterns of vegetation cover in Kolkata city, NDVI indices have been done (Fig. 2). NDVI indices have been done over the years 2005, 2010, 2015 and 2019. Table 4 showing NDVI values for Kolkata. Table 4 shows the distribution of theNDVI index in Kolkata between 2005 and 2019. In 2005, 29.17 percent of the total KMA experiences very low NDVI values and 25.64 percent experiences very high NDVI values. In 2010, because of the destruction of vegetation cover areas of high vegetation cover completely disappears. Both in the years 2015 and 2019, vegetation cover hugely decreased. In 2019, only 16.73 per cent of the area is under good vegetation cover and nearly 70 percent of the area experiences low density of vegetation which creates an adverse impact on vegetation (Fig. 3).

From the NDVI images of Kolkata city of 2005, it has been found that values for NDVI ranges from +0.71 to -0.89. In 2005, the amount of vegetation is very low in the Central Business part of the area which isslightly high in the northern parts of KMA i.e. towards Kalyani city, but it experiences very high in the western parts (rural blocks of Hooghly district) and northern parts (rural blocks of Nadia district). Percentage of vegetation cover in this area is comparatively higher than the other areas. In 2010, the percentage of vegetation cover is very less in the CBD areas. These areas are totally vegetation less areas. The percentage of vegetation cover is also slightly high in the northern and eastern peripheral areas of the city. In 2010, the values of NDVI in Kolkata city ranges from +0.61 to -0.59. In 2015, values of NDVI in Kolkata city ranges from +0.54 to -0.57. In this time period, the percentage of vegetation cover in the northern parts slightly decreased, but the percentage of vegetation cover was also high in the western parts of KMA. In 2019, the values of vegetation indices ranges from +0.43 to -0.51. Vegetation cover is very less in the CBD, Central Kolkata area and Esplanade area and it was high in the western parts of KMA. Table 5 showing NDVI values in the different parts of KMA.

Among the cultural features of LULC types, built up area is one of the important features which can be used as a parameter to measure the pace of the urbanization and the process of urbanization of an area. In this study, NDBI indices have been used to find out the growth of urban areas or built upareas. For this study, any type of concrete structures, artificial surfaces, buildings, houses have been considered as a built up area.



Fig. 3. Normalized difference built up area index of Kolkata city.

#### Table 5

NDVI values in KMA.

Index	2005	2010	2015	2019
Values	Location	Location	Location	Location
Low	CBD areas, South Kolkata i.e. Garia, Tollygunge	CBD Areas, Central Kolkata area, South Kolkata i.e. Garia, Tollygunge, North Kolkata i.e. Hatibagan, Baghbazar	CBD Areas, Central Kolkata area, Dharmatala area, South Kolkata i.e. Garia, Tollygunge, North Kolkata i.e. Hatibagan, Baghbazar, Eastern Kolkata	CBD Areas, Central Kolkata area, Dharmatala area, Esplanade adjacent area, South Kolkata i.e. Garia, Tollygunge, North Kolkata i.e. Hatibagan, Baghbazar, Eastern Kolkata
Medium	Howrah Municipal Corporation Area	Howrah Municipal Corporation Area and Western Kolkata and South Kolkata	Howrah Municipal Corporation Area and Western Kolkata and South Kolkata	Howrah Municipal Corporation Area and Western Kolkata and South Kolkata, North Eastern part of Kolkata
High	Northern part of KMA towards Kalyani area	Northern part of KMA towards Kalyani area	Northern part of KMA towards Kalyani area and Western parts of KMA i.e. western bank of Hooghly river	Northern part of KMA towards Kalyani area and Western parts of KMA i.e. western bank of Hooghly river
Very High	Rural Blocks of Hooghly District and Nadia District	Rural Blocks of Hooghly District and Nadia District	Rural Blocks of Hooghly District	Rural Blocks of Hooghly District

#### Table 6

NDBI values for Kolkata.

Index Values	2005		2010	2010		2015		2019	
	Area (SQ.KM).	Percent							
Very Low	732	39.76	657	35.69	616	33.46	563	30.58	
Low	630	34.22	587	31.88	533	28.95	491	26.67	
Medium	156	8.47	199	10.81	235	12.76	267	14.50	
High	323	17.54	398	21.62	457	24.82	520	28.25	

#### Table 7

NDBI values in KMA.

Index	2005	2010	2015	2019
Values	Location	Location	Location	Location
Very Low	Rural Blocks of Hooghly District and Nadia District	Rural Blocks of Hooghly District and Nadia District	Rural Blocks of Hooghly District	Rural Blocks of Hooghly District
Low	Howrah Municipal Corporation Area and Western Kolkata and South Kolkata	Howrah Municipal Corporation Area and Western Kolkata and South Kolkata, North Eastern part of Kolkata	South Eastern part (Sonarpur area) South Kolkata i.e. Santoshpur, Garia, Tollygunge	South Eastern part (Sonarpur area), South Kolkata i.e. Garia, Tollygunge, North Kolkata i.e. Hatibagan, Baghbazar
Medium	South Eastern Part of Kolkata	South Eastern Part of Kolkata	South Eastern and North Eastern Part of Kolkata	South Eastern, South western, North Eastern, Part of Kolkata
High	CBD areas, Central Kolkata, North Kolkata	CBD Areas, Central Kolkata area, North Kolkata	CBD Areas, Central Kolkata area, Dharmatala area	CBD Areas, Central Kolkata area, Dharmatala area, Esplanade adjacent area

Table 6 shows the values of NDBI in Kolkata from 2005 to 2019. From the NDBI indices, it has been found that the percentage of urban areas hugely increased between this time period. The percentage of the built up area or urban core area increases from 17.54 percent into 28.25 per cent of the area, where other areas hugely decreased between this time period.

In 2005, the values of the NDBI index ranges from 0.42 to -0.76. The lowest values of the NDBI index can be found in the rural blocks of Hooghly and Nadia districts as most of the lands in this area are agricultural lands and vegetation areas. So, NDBI value experiences low in this area. In 2005, NDBI values are high in the CBD areas, Northern Kolkata and Central Kolkata areas. In 2010, NDBI values are low in the villages of Hooghly and Nadia district and high towards the Kolkata city areas. Values of NDBI in this time period ranges between +0.48 and -0.61. In 2015, NDBI value slightly increases in the south and south eastern part and north eastern part of Kolkata. Between this time period, it ranges between +0.53 and -0.52. In 2019, the values of NDBI index ranges between +0.59 and -0.43. From the overview of the NDBI indices between 2005 and 2019, it has been found that NDBI value increases towards the city area which gradually decreases towards the peripheral areas like CBD area, Dharmatala area, Rajabazar area, Garia, Santoshpur, Baghbazar etc. The values of this index is very high throughout the time period (Table 7).

Table 8 and Table 9 showing changes in NDVI and NDBI values of Kolkata city. From the NDVI values of Kolkata from 2005 to 2019 it has been found that the areas of very low indices have been increased very fast and very high indices decrease very rapidly between 2005 and 2010 which indicates the vegetation cover of Kolkata decreasing very rapidly between this time period. Between 2010 to 2015 and 2015 to 2019, very high indices have been decreasing very faster than the very low indices. This tendency indicates the vegetation

Changes in NDVI values.

Index Values	2005–2010		2010-2015		2015-2019	2015–2019		
	Area (SQ.KM).	Percent	Area (SQ.KM).	Percent	Area (SQ.KM).	Percent		
Very Low	79	4.29	42	2.28	29	1.58		
Low	71	3.86	51	2.77	35	1.90		
Medium	-34	-1.85	-15	-0.81	-5	-0.27		
High	-47	-2.55	-28	-1.52	-14	-0.76		
Very High	-69	-3.75	-50	-2.72	-45	-2.44		

#### Table 9

Changes in NDBI values.

Index Values	2005–2010		2010-2015		2015–2019		
	Area (SQ.KM).	Percent	Area (SQ.KM).	Percent	Area (SQ.KM).	Percent	
Very Low	-75	-4.07	-41	-2.23	-53	-2.88	
Low	-43	-2.34	-54	-2.93	-42	-2.28	
Medium	43	2.34	36	1.96	32	1.74	
High	75	4.07	59	3.20	63	3.42	

cover of Kolkata has been transforming into other land cover types very rapidly which possesses serious threat to natural ecosystems. By overviewing the NDBI values of KMA, it has been found that high and very low indices experience very high between 2005 and 2010, as both experience high percentage of changes between this time period. But after this time period, the areas with high NDBI values rapidly increased than the other categories. This tendency indicates that the demand for open space or vacant land in Kolkata city has been increasing very fast which accelerates the growth of built up area.

#### 4.2. Increase in land surface temperature

From the field verification, it has been found that the surface temperature in the core areas of Kolkata city is quite higher than the other peripheral areas. In this study, Landsat satellite images have been used to scrutinize the land surface temperature of the area.

Fig. 4 shows the surface temperature of Kolkata city between 2005 and 2019. From the surface temperature image of 2005, it has been found that maximum and minimum temperature during that time period are 26 °C and 14 °C. By analyzing this image, it has been found that temperature is higher in the city core areas than in the peripheral areas. In 2019, maximum and minimum temperatures experienceare 41 °C and 23 °C. By analyzing the surface temperature between these four time period, it has been found that the average temperature of this city has been increased nearly 20 °C and 32 °C between 2005 and 2019. For this reason, Kolkata city has been suffered from heat island like situation.

Table 10 shows the distribution of surface temperature in Kolkata city between 2005 and 2019. From the temperature distribution in Kolkata city, it has been found that in 2005, nearly 1780 sq. Km. of the area is under the 11 °C and 25 °C which experiences nearly 96 per cent of the area. Only 3 per cent of the area has been experienced with high surface temperature i.e. 26 <sup>0</sup> C and 40 °C. From 2005, the area of low surface temperature has been decreased very rapidly and high temperature increases very fast which converts Kolkata into heat island like situation. In 2019, the temperature in the core areas of Kolkata (CBD area, Central Kolkata area etc.) has been reached into 41 °C which may be causes of concern among the environment researchers and urban planners. Table 11 shows the distribution of surface temperature in Kolkata city.

Table 12 showing changes in LST values in Kolkata. From the table, it has been found that the area with low temperature has been decreased and the area between 26 °C and 40 °C has been increasing very rapidly which creates lots of problem to the urban planners and decision makers.

#### 4.3. The relationship among NDVI, NDBI and LST values

From the overview of the NDVI, NDBI and LST maps, it has been found that Kolkata city high NDVI values are declining very fast and NDBI values are increasing very fast which accelerates the increase in surface temperature. The highest temperature estimated in Kolkata city has found that it records 41 °C in 2019. Fig. 5 shows the projection of surface temperature in Kolkata city up to 2030. From this analysis, it has been found that the temperature of Kolkata city will be increased up to 53 °C in 2030. Because of the high temperature increase in Kolkata city, the inhabitants of Kolkata city will face lots of problems. To solve this problem, policy makers and decision makers will formulate new policies to minimize the surface temperature of Kolkata city.

#### 5. Discussion

Kolkata is one of the metro cities in the eastern parts of India. Kolkata city has been developingvery fast because of the influx of refugees from the former East Pakistan and migration from the rural areas because of the employment facilities, good healthcare



Fig. 4. Land surface temperature of Kolkata city from 2005 to 2019.

#### Table 10

Land surface temperature of Kolkata city.

Temperature in Celsius	2005		2010		2015		2019	
	Area (SQ.KM).	Percent						
11 to 25	1780	96.69	1535	83.38	1384	75.18	1237	67.19
26 to 40	61	3.31	306	16.62	457	24.82	568	30.85
41 to 55	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	36	1.96

#### Table 11

Land surface temperature in KMA.

Temperature in Celsius	2005	2010	2015	2019			
	Location	Location	Location	Location			
11 to 25	The whole part of KMA	Whole part of KMA	Whole part of KMA	Whole part of KMA			
26 to 40	CBD areas	CBD areas, Central Kolkata, North Kolkata	CBD areas, Central Kolkata, North Kolkata, Howrah	CBD areas, Central Kolkata, North Kolkata, South, Kolkata and Howrah			
41 to 55	N.A.	N.A	N.A	CBD areas, Central Kolkata, North Kolkata, South, Kolkata, Eastern Kolkata and Howrah			

#### Table 12

Changes in LST values.

Temperature in Celsius	2005–2010		2010-2015		2015-2019	2015–2019	
	Area (SQ.KM).	Percent	Area (SQ.KM).	Percent	Area (SQ.KM).	Percent	
11 to 25	-245	-13.31	-151	-8.20	-147	-7.98	
26 to 40	245	13.31	151	8.20	111	6.03	
41 to 55	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	



Fig. 5. Surface temperature prediction of Kolkata city.

facilities etc. Presently, Kolkata city has been growing in a south-easterly and south-westerly direction from the city core area as it has been found during the analysis of the satellite images (Majumdar, 2019). The demand for the land of Kolkata city is very high in recent decades. To meet the needs vegetation area has been declining very fast and built up area has been increased a lot which is also the main reason for increasing land surface temperature (Majumdar, 2019).

From the overview of the analysis, it has been found that the temperature of Kolkata city has been increasing very fast. Temperature is high in the central city or city core areas. From the field verification, it has been found that most of the agricultural lands, vegetation areas, water body areas have been converted into the urban area or built up area. The transformation of land i.e. non urban area or semi urban area to an urban area is high in the peripheral areas than the city areas as the availability of land is very high in those areas. Low prices of land are also another factor behind the rapid transformation of land in Kolkata city.

#### 6. Recommendations

The temperature of Kolkata city has been increasing very fast. To minimize these problemsurban planners should formulate policies for the reduction of temperature. The policy makers should formulate new laws or regulations to stop the illegal or unplanned conversion of land. Awareness among the people should be increased to combat with this problem. There is no master plan for Kolkata city. To minimize this problem, new master plan should be developed. Another noticeable fact is that there is no coordination among the developmental agencies (Like KMDA, KMC, KIT etc.).Coordination among the agencies should be increased to eradicate this problem.

#### 7. Conclusion

Kolkata is one of the cities with 15.89 million people with the coordination of various constituent units like Municipal Corporations, Municipalities, Census Towns, Outgrowths and Rural areas. The total number of the constituent units 594. From the study, it has been found that vegetation in Kolkata city has been decreased very fast with the rapid increase in the urban area. NDVI maps show that vegetation area is high in the peripheral areas than the city areas or urban areas. Encroachments of the urban area over the vegetation area are high in the outer peripheral areas. On the other hand, NDBI index is higher towards the city areas than the outwards of Kolkata city. The temperature in the central part is very high than in the other areas. To minimize these problems city authorities should take immediate measures. This research work will not only help the city authorities but also the decision makers and policy planners for the construction of new policies. This study which has been done over Kolkata, can be performed in any other cities in India. This study will throw new light over the urban heat island studies.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Assessment of temperature changes over Iran during the twenty-first century using CMIP6 models under SSP1-26, SSP2-4.5, and SSP5-8.5 scenarios

David Francisco Bustos Usta, Maryam Teymouri & Uday Chatterjee 🖂

Arabian Journal of Geosciences **15**, Article number: 416 (2022) Cite this article **385** Accesses **3** Citations Metrics

## Abstract

A 22-member ensemble from CMIP6 is used to analyze the Iran future climate in terms of surface air temperature, identifying when anomalies of 1.5 °C, 2.0 °C, and 2.5 °C would be achieved with respect to the preindustrial period (1861–1900). Validation was conducted using data from 97 stations of IRIMO around Iran in the 1990–2014 period, and the following range metrics were obtained: 1.45-3.49 (MAE), 1.82-3.99 (RMSE), and 16.51-38.04 (MAPE); however, ACCESS-ESM1.5, ACCESS-CM2, CESM2-WACCM, BCC-CSM2-MR, FGOALS-g3, INM-CM5-0, and CNRM-CM6-1-HR models display the best performance. The global warming targets  $(D_{1.5}, D_{2.0}, D_{2.5})$  are attained by the 2019, 2029, and 2047 under SSP1-2.6 scenario; 2017, 2031, and 2043 under SSP2-4.5 scenario; and 2016, 2028, and 2039 under SSP5-8.5 scenario; on the other hand, the respectively attained years for Iran are 2007, 2019, and 2030 under SSP1-2.6 scenario; 2007, 2016, and 2028 under SSP2-4.5 scenario; and 2006, 2015, and 2027 under SSP5-8.5 scenario, an evidence of a higher mean increase in surface air temperature with respect to the global behavior. We identified important aspects regarding the temperature anomalies in the Iran region: (1) a mean warming of 0.64 °C (SSP1-2.6), 1.47 °C (SSP2-4.5), and 0.74 °C (SSP5-8.5) for the 2000–2024 period with respect to the preindustrial baseline; (2) a mean warming of 0.82 °C (SSP1-2.6), 2.06 °C (SSP2-4.5), and 0.76 °C (SSP5-8.5) for the 1960–2014 period with respect to the preindustrial period; (3) a warming trend of 2.88  $^{\circ}Ccy^{-1}$  for the 1960–2014 period, more than the triple of the trend for the 1850–2014 period of  $0.54^{\circ}$  Ccy<sup>-1</sup>; and (4) for the 2014–2100 period, it was possible to see warming trends of  $1.34^{\circ}$ Ccy<sup>-1</sup>(SSP1-2.6),  $3.36^{\circ}$ Ccy<sup>-1</sup>(SSP2-4.5), and  $7.46^{\circ}$ Cyr<sup>-1</sup>(SSP5-8.5), which represent trends above double the trend observed in the 1960-2014 period under the SSP5-8.5 projection scenario. All of these indicators show an intensification of the warming over the Iran region with respect to the global trends. From the spatial analysis of surface air temperature trends over five regions of Iran for the 1850-2014, 1960-2014, 2014-2050, and 2014–2100 periods, it was possible to identify a significant increase in all the trends over Iran but specially in the central part of the country.

Home > GeoJournal > Article

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## Assessment of spatial distribution of rain-induced and earthquake-triggered landslides using geospatial techniques along North Sikkim Road Corridor in Sikkim Himalayas, India

<u>Bappaditya Koley</u> ⊠, <u>Anindita Nath, Subhajit Saraswati, Uday Chatterjee</u>, <u>Kaushik Bandyopadhyay</u>, <u>Basudeb Bhatta</u> & <u>Bidhan Chandra Ray</u>

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## Abstract

The spatial distribution of landslides is analyzed to understand landslide incidences and triggering factors along North Sikkim Road Corridor in the parts of Sikkim Himalayas. The present study area is also highly prone to landslide which mainly occurred due to heavy rainfall and earthquake. The present study highlights the spatial distribution of rain-induced and earthquake triggered landslides based on various preparatory factors. In this study 58 rain-induced landslide locations were identified and assessed the spatial distribution. Earthquake triggered landslides were assessed based on the interpretation of pre and post satellite images on 2011 Sikkim earthquake. Therefore, the study attempts to (i) show the inventory map of rain-induced and earthquake-triggered landslides (ii) evaluate the spatial distribution pattern of rain-induced and earthquake-triggered landslides basis of their event controlling parameters (iii) Finally, to show the characteristics of spatial distribution of raininduced and earthquake triggered landslides in the study area. Global Positioning System (GPS) and Ground Control Points (GCP) were used for verification of rainfall induced landslide locations and the improvement of the planimetric accuracy of the Landsat 7 ETM+ satellite images from the Google Earth. For the spatial distribution analysis, all raster maps were prepared using GIS techniques. After that, location wise spatial values were extracted both rain-induced and earthquake triggered landslides using multi-data extraction technique in GIS environment. From the present study, it has been observed that the co-seismic landslides initiating under dry conditions could account for steeper slope angles than the raininduced landslides. It has been also observed that rain-induced landslides on southerly slope facing is maximum, and it decreases with the angle orientation on the northerly slope facing is relatively low. The study also reveals that rain induced and earthquake triggered landslides could be found in the sparsely vegetated areas. The present study is a pathway to develop landslide hazard zonation map, landslide control measures, disaster management, tourism planning and sustainable development in this area.

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## Risk assessment of coastal erosion for Odisha coast along Bay of Bengal, India using coastal hazard wheel model

<u>Gopal Krishna Panda</u>, <u>Monalisha Mishra</u> & <u>Uday Chatterjee</u>

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## Abstract

This paper makes an assessment of the coastal erosion hazard of the Odisha state with the use of 'Coastal Hazard Wheel' methodology which is a multi-hazard assessment as well as a management tool in a changing global climate. This study analyses the coastal environment to assess the vulnerability profile of coastal erosion by using bio-geophysical parameters such as geological layout, tidal range, exposure to waves, balance or deficit of sediments, characteristics of flora and fauna and exposure to storm climate. These are also used in analysing climate change hazards of the coast which are inherent to an area like saline flooding, gradual inundation, ecosystem disruption and salt water intrusion. CHW framework has generated information about the degree to which coastal erosion is inherent in a particular coastal location along the coast. This application has used remote sensing data from the public domain and a GIS approach to screen the problem with an appropriate scale as suitable for regional and national planning purposes with a management perspective because of limited data availability. The study has generated coastal erosion data and maps for the 480 km of the coastline dividing the coast in to 14 different morphological segments. Assessment of this hazard shows that 50 percent of Odisha's coastline is vulnerable to a high or very high inherent hazard of erosion, 45 percent exhibits a lower level of erosion presence and 5 percent is moderately vulnerable to erosion. This study has revealed increasing magnitude of coastal erosion than previous assessments by different researchers which were mostly based on coastal vulnerability indices. The study also identifies a number of possible erosion hazard management and mitigation options which can be used depending on their location specific field data and coastal characteristics. The finding of the study is significant in view of its contribution towards a first step in understanding coastal erosion at the regional level for their management. However, input of local data and manmade structures along the coast in the model would enhance the results for the site-specific mitigation measures.





## Article Studies on Reproductive Development and Breeding Habit of the Commercially Important Bamboo Bambusa tulda Roxb

Sukanya Chakraborty<sup>1</sup>, Prasun Biswas<sup>1,2</sup>, Smritikana Dutta<sup>1</sup>, Mridushree Basak<sup>1</sup>, Suman Guha<sup>3</sup>, Uday Chatterjee<sup>4</sup> and Malay Das<sup>1,\*</sup>

- <sup>1</sup> Department of Life Sciences, Presidency University, Kolkata 700073, India; sukanya.rs@presiuniv.ac.in (S.C.); prasun.biswas.22@gmail.com (P.B.); duttasmritikana@gmail.com (S.D.); mridushree.rs@presiuniv.ac.in (M.B.)
- <sup>2</sup> Department of Botany, Kalna College, Kalna 713409, India
- <sup>3</sup> Department of Statistics, Presidency University, Kolkata 700073, India; suman.stat@presiuniv.ac.in
- <sup>4</sup> Department of Geography, Bhatter College, Kharagpur 721426, India; raj.chatterjee459@gmail.com
- Correspondence: malay.dbs@presiuniv.ac.in

Abstract: Compared to other grasses, flowering in bamboo is quite divergent, yet complex with respect to time to flower, number of individual culms in a population that have been induced at a time (sporadic vs. gregarious), nature of monocarpy, morphology of inflorescences (solitary spikelet vs. pseudospikelet), biology of pollen and nature of genetic compatibility. Wide diversity exists even across species and genotypes. However, due to the rarity of flowering and inaccessibility, few studies have been done to systematically analyse diverse aspects of the reproductive behaviour of bamboo. In this study, four recurrently occurring, sporadic flowering populations of Bambusa tulda have been closely observed over the last seven years. Detailed inflorescence and floral morphology and development of reproductive organs have been studied. Pollen viability was assessed by staining and in vitro germination. Self and cross pollination experiments were performed in a plantation site to assess the genetic nature of pollen-pistil interaction. The study identifies interesting reproductive features, that are not common in other grasses. A few important observations include the early appearance of a solitary spikelet vs. late appearance of a pseudospikelet in the flowering cycle, low rate of pollen germination, protandry, self-incompatibility and higher rate of seed setting by the pseudospikelet as compared to the solitary spikelet. The findings will not only be useful to understand the reproductive behaviour of this non-woody timber plant, but will also be useful for forest management and sustainable use of bamboo bioresources.

**Keywords:** bamboo; sporadic flowering; protandry; pollen germination; cross pollination; self incompatibility; seed setting

### 1. Introduction

Bamboos belong to the monocotyledonous plant family Poaceae and subfamily Bambusoideae. They are globally distributed from 51° North to 47° South except in the polar regions [1]. There are ~125 genera and 1670 species of bamboos identified so far [1,2]. Herbaceous bamboos are found in Brazil, Mexico, Paraguay and West Indies; paleotropical woody bamboos are distributed in Africa, India, Japan, Madagascar, Oceania, South China and Sri Lanka; neotropical woody bamboos are found in Argentina, Chile, Southern Mexico and West Indies; whereas north temperate woody bamboos are observed in Africa, India, Madagascar and Sri Lanka [2]. With respect to species diversity, Asia is at the top, followed by South America and Africa [3]. Among Asian countries, China contains ~6.01 million hectares of bamboo vegetation [4], followed by India having with ~160,037 sq km (India State of Forest Report 2019, https://fsi.nic.in/forest-report-2019?pgID=forest-report-2019 accessed between the period of October 2017 to February 2018). Worldwide ethnic populations are heavily dependent on bamboo bioresources, due to their various uses, such as food and beverage, fodder, medicine, fishing gear, handicrafts and artefacts [5–8].



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The flowering behaviour of bamboo is distinctive. Four diverse flowering types have been identified in bamboos. They are (i) sporadic, (ii) massively synchronised (gregarious), (iii) sporadic followed by massively synchronised, and (iv) partial [9,10]. The sporadic flowering events occur in few culms of a population and have been observed in Bambusa bambos [11], Bambusa pallida [12], B. tulda [13], Dendrocalamus asper [14], and Dendrocalamus longispathus [15]. In contrast, gregarious flowering happens in a synchronised manner in almost every culm growing over a large geographical area and had been observed in many species, such as Bambusa nutans [16], B. tulda [12,17–22], Dendrocalamus racemosa [22], Melocanna baccifera [21], Thamnocalamus spathiflorus [23] and Thamnocalamus aristatus [24]. Quite often, sporadic events may be followed by mass flowering in subsequent years and are defined as sporadic-massively synchronised flowering. It has been observed in B. tulda [23], Chusquea culeou, Chusquea montana, M. baccifera, Phyllostachys heteroclada, Phyllostachys reticulata and Sasa cernua [10]. Partial flowering events take place in small, discrete populations, and it is neither extended like gregarious, nor restricted like the sporadic type concerning the number of culms flowered. It had been observed in *Pleioblastus simonii* [10]. The flowering time varies between 1–120 years across different species [10]. Another complexity of bamboo flowering is related to the nature of monocarpy, which differs between sporadic and gregarious flowering types. Mass death of the entire population takes place in cases of gregarious flowering, which is not common for sporadic and partial flowering.

Studies of bamboo flowering have traditionally been focused on ecological aspects [2,25–27], which have recently moved towards molecular and genetic aspects [28–31]. In contrast, very few studies have focused on understanding the reproductive behaviour and specialities of bamboo [32–35]. More studies need to be conducted to understand the reproductive diversity adopted by different bamboo species. In this study, *B. tulda* was selected for many reasons, such as their enormous economic importance, wide distribution, occurrence of diverse flowering types and woody habitats. Four recurrent and sporadically flowering populations of *B. tulda* were observed for seven years to analyse diverse aspects of reproductive development, such as types of inflorescences observed in a flowering cycle, development of reproductive organs, rate of pollen germination, nature of genetic compatibility and amount of seed set.

### 2. Results

### 2.1. Observations on Recurrent, Sporadic Flowering Cycle of B. tulda for Seven Years

The number of flowering clumps (=genet) varied from 1–4 among four studied populations (Table 1; Figure 1). Similarly, the number of flowering culms (=ramet) also varied among the clumps. For instance, 1–8 out of 33–59 culms flowered sporadically for four consecutive years in the case of SHYM7. Whereas, it was 2–8 out of 24–41 culms in SHYM16, 1–17 out of 43–93 culms in BNDL23 and 6–11 out of 29–84 culms in the case of BNDL24 (Table 1).

All these populations were closely observed for seven years to study the flowering cycle. During the initiation of the flowering cycle in spring (February to March, Light 11 h: Dark 13 h), solitary spikelets started emerging in only a few culms of each population (Figure 2). However, by summer, i.e., from April to May (Light 13 h: Dark 11 h), the number of solitary spikelets increased and pseudospikelets started emerging. The maximum number of pseudospikelets emerged from the nodes of flowering branches during July (Figure 2). Subsequently, from August, both solitary and pseudospikelets decreased in numbers and withered by October (Figure 2). Flowering was always followed by the death of the flowered branches, but the flowering culm remained alive until 2-3 recurrent flowering cycles and subsequently underwent senescence.

However, rhizomes of the flowering clump remained active and young culms sprouted from the rhizomes. These sprouted culms attained maximum height before winter (Figure 2). New leaves, as well as branches emerged from old culms from August to October.

Population Number	Duration of Flower- ing	Clump and Culm	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
SHYM7	2013–16	Number of flowering clumps	1	1	2	1	0	_	-
		Total culm number in a flowering clump	42	45	59	33	-	_	_
		Number of flowering culms	3	5	8	1	_	_	_
		Number of withered culms	0	1	2	7	_	_	-
SHYM16	2016–19	Number of flowering clumps	2	2	2	1	0	_	-
		Total culm number in a flowering clump	38	41	40	24	-	-	-
		Number of flowering culms	7	8	5	2	-	-	_
		Number of withered culms	0	0	5	9	-	-	_
BNDL23	2013–19	Number of flowering clumps	4	4	3	3	3	3	1
		Total culm number in a flowering clump	77	93	86	87	79	55	43
		Number of flowering culms	11	14	17	15	6	5	1
		Number of withered culms	2	5	9	6	11	12	8
BNDL24	2017–to date	Number of flowering clumps	1	1	2	1	2	_	_
		Total culm number in a flowering clump	31	33	71	29	84	_	_
		Number of flowering culms	6	10	9	8	11	_	-
		Number of withered culms	1	0	5	2	1	-	-

**Table 1.** Comparison between numbers of flowering vs. non-flowering clump and culm observed for seven years in four populations of *B. tulda* studied. Absence of flowering was indicated by (–).

### 2.2. Macro- and Micro-Morphology of Solitary Spikelet and Pseudospikelet

Solitary spikelets were observed either on top of the young growing branches or tillers arising from the rhizome of the flowering culm (Figure 3A–D). It was initially bright green in colour and became pale, straw-coloured on withering, 4.5–9.3 cm long, 0.5–1 cm wide. Each solitary spikelet was subtended by a flag leaf, which was smaller in size than other vegetative leaves (Figure 3A,C). They usually developed in a basipetal manner. Mature inflorescences were observed at the top, whereas young ones were located at the base and remained covered by the leaf sheath. The SEM analysis of inflorescence bud revealed a single apical inflorescence meristem (IM, Figure 3D). In contrast, pseudospikelets grew in clusters on the nodes of flowering branches and were devoid of flag leaves (Figure 3E–H).

They were 4.3–9.5 cm in diameter and comprised of ~3–34 spikelet units. Here, each inflorescence unit develops on an axis (rachis), which may bear secondary axes (rachilla; Figure 3G). Rachilla bears several bracts. The basal bracts subtended multiple inflorescence buds, while the bracts in the upper region of the rachilla subtended single spikelet units (Figure 3G). The SEM analysis of inflorescence bud revealed multiple inflorescence meristems arranged in a capitate manner (Figure 3H).



**Figure 1.** Gregarious and sporadic flowering incidents of *B. tulda* previously reported from different regions of India and the study sites used in these analyses. Data sources for Map: Esri, Maxer, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN and the GIS user Community. Blue bubbles represent gregarious flowering, and green bubbles represents sporadic flowering events (Troup, 1921; Perry, 1931; Mohan Ram and Gopal, 1981; Rawat, 1987; Gupta, 1987; Naithani, 1993; Bhattacharya et al., 2006; Sarma et al., 2010; Naithani et al., 2013). Those with a flowering cycle that continued until June, 2021, have been marked with asterisks. Flowering year marked in red font identified in this study.



**Figure 2.** Induction of sporadic flowering and seasonal effect on emergence of solitary spikelet and pseudospikelet in *B. tulda*. Abbreviations used: SB—Senesced flowering branch, SL—Solitary spikelets, PSL—Pseudospikelets, NL—New leaf, DFC—Dead flowering culm.

Both solitary spikelets and pseudospikelets were composed of indistinguishable spikelet units, which were subtended by 17–50 mm long, distichous, shining, chaffy bracts. The lower most 2–4 florets were reduced to empty glumes, whereas 4–18 fertile florets were located on the top (Figure 4A).

### 2.3. Morphology of Florets and Micro Morphology of Floral Bracts

In a spikelet unit, florets matured in an acropetal manner. Florets were bisexual, 15–19 mm long and 4.5–7 mm broad at the base (Figure 4A–H). Lemmas were broadly acuminate, mucronate, concave, glabrous, many nerved, bright green, 14.5–21.5 mm long and 4.5–6.5 mm broad (Figure 4B). They were overlapping with paleas. Paleas were membranous, penicillate, 2-keeled, 5–7 nerved, 9–14 mm long, 3–5 mm broad at the base and ciliated at the top (Figure 4C). Lodicules were three in numbers, 1.5–2.5 mm long and fleshy. It was they were pale green, waxy, cuneate, oblong, hyaline at the base and whitish fimbriate at the apex (Figure 4D).



**Figure 3.** Morphological observation and Scanning electron microscopy (SEM) of the inflorescence of *B. tulda*. (**A**) Solitary spikelet from the lateral branch. (**B**) Organisation of a solitary spikelet. (**C**) Solitary spikelet from a rhizome as a tiller. (**D**) SEM images of spikelet with single inflorescence meristem. (**E**) Pseudospikelet. (**F**) Pseudospikelet in a capitate form. (**G**) Rachis (RCS) and rachilla (RCL) of pseudospikelet. (**H**) SEM images of pseudospikelet with multiple inflorescence meristem. Abbreviations used: FL—Flag leaf, IM—Inflorescence meristem.

Since palea and lemma contain many species diagnostic characters, SEM analyses were performed. The abaxial surface of paleas contained dumbbell-shaped silica cells (SC, Figure 4I) and long cells (LC) with dense prickles in between (Figure 4J). In the middle part of the palea, prickles were higher in number than were SC. On the contrary, SC were dominant in margins (Figure 4K). However, the abaxial surface of the lemma was comparatively smoother. LC were observed, and prickles were lower in abundance (Figure 4K). Both lemma and palea contained trichome-like macro hairs on the margin (Figure 4L). Also, stomatal guard cells were observed in both lemma and palea.

Mature florets of *B. tulda* contained six stamens. Anthers were basifixed, purple or yellow at maturity (Figure 4E). Each anther had two lobes, and the tip of the anther lobes were emarginated (Figure 4E). At the apical part of an anther, a pore-like linear dehiscence suture was observed (Figure 4F). Anther filaments were thread-like and attained 10–17 mm length during anthesis. The ovary was pear-shaped, 2–2.6 mm long; style 2–3 mm long, hairy. Stigma was trifid, 2–3 mm long, having whitish stigmatic papillae (Figure 4G,H).

Studies on developing florets (F1–F9) within a spikelet revealed different rates of developmental progression between androecium and gynoecium (Figure 5A–H). Initially, androecium and gynoecium primordia grew simultaneously in the most immature floret (F1, Figure 5B). Subsequently, differentiation of androecium primordia was initiated in the floret F2 (Figure 5C), while the gynoecium differentiation started in the F3 (Figure 5D). Eventually, the mature anthers protruded ~3 h earlier than gynoecium (F6, Figure 5G). In contrast, gynoecium attained maturity after completion of anthesis and subsequent senescence of anthers (F9, Figure 5H).



**Figure 4.** Morphological observation of different floral parts of *B. tulda* and Scanning electron microscope (SEM) images of the abaxial epidermis of palea and lemma; (**A**) Single floret with six basifixed anthers. (**B**) Dorsal view of a lemma. (**C**) Dorsal view of a palea. (**D**) Lodicule. (**E**) Anther showing two lobes. (**F**) Apical suture of the anther. (**G**) Gynoecium with trifid stigma. (**H**) Longitudinal section of ovary. (**I**) Presence of prickles (P) and silica cells (SC). (**J**) Presence of macro hair (MH) and long cells (LC; magnified view inset). (**K**) Presence of SC and LC, (LC; magnified view inset). (**L**) Presence of macro hairs (MH). Abbreviations used: F—Floret, G—Glume, AL—Anther lobes, AS—Apical suture, DL—Dehiscence line, OV—Ovary, O—Ovule, MH—Macro hair, LC—Long cells, SC—Silica cells, P—Prickles.

## 2.4. Morphology, Cytology and Germination of Pollen Grains

Microscopic observations revealed that pollen grains were globose, mono-ulcerate and their diameter ranged from 22.37–43.2  $\mu$ m (Figure 6A). SEM analyses revealed that pollen grains were monoporate, with a distinct annulus and granular exine with regulated ridges (Figure 6A). Cytological studies revealed that the dividing microspores exhibited various meiotic stages that included metaphase I, late anaphase I, late telophase I, metaphase

II, anaphase II and late telophase II (Figure S1). In many instances, microspores having multiple nuclei were observed. However, no meiotic abnormalities were recorded. To assess the viability of pollen grains, a 2,3,5 triphenyl tetrazolium chloride (TTC) assay was performed. Viable pollen grains appeared red, whereas non-viable ones remained unstained (Figure 6B). Among 2460 pollen grains obtained from *B. tulda*, 602 were viable, and the rate of viability varied from  $23.94 \pm 4.28\%$  to  $25.35 \pm 1.87\%$ . This finding was further supported by an in vitro pollen germination assay, although the absolute values were lower in in vitro germination than the TTC assay (Figure 6C–D). This could be due to a higher false positivity rate for the TTC assay. The maximum percentage (14.29  $\pm$  0.8%) of pollen germination was observed in Brewbaker and Kwack's medium supplemented with 15% sucrose [Table S1]. Among 396 pollen grains, 57 germinated and the germination percentage varied from 13.48  $\pm$  4.05% to  $15.16 \pm 5.49\%$  across *B. tulda* populations.



**Figure 5.** Developmental progression of androecium and gynoecium in florets of *B. tulda*. Floret numbers are marked from apex to base in order of maturity (F1—youngest, F7—oldest floret). (**A**) Arrangement of florets in a spikelet. (**B**–**E**) Developmental stages of androecium and gynoecium primordia. (**F**) Unopened flower with matured anthers and immature gynoecium. (**G**) Open floret with matured anthers and immature stigma. (**H**) Floret with anther filaments and developed stigma. Abbreviations used: AP—Androecium primordia, GP—Gynoecium primordia, A—Androecium, G—Gynoecium, MA—Mature anther, AF—Anther filament, S—Stigma.

#### 2.5. Self-Incompatibility in B. tulda

To understand the nature of genetic interaction between pollen and pistil, the pollenpistil interaction was studied in vivo in two geographically distant (BNDL 23, BNDL 24; ~340 m) populations of *B. tulda* (Figure 7A–C). The florets started opening at 6:00 a.m., and the maximum number of open florets were observed at 10:00 a.m. AM (Figure 7B). The florets remained open for at least 4 h after anthesis, and the frequency of open florets gradually declined. The rate of pollen germination was almost equal among the four different times investigated. Maximum pollen germination was observed within 2 h postpollination. Therefore, 10:00 a.m. was selected as the optimum time to perform the self vs. cross pollination experiments. Pollinated stigmas were stained, and attached pollen grains obtained blue colour, whereas the germinated pollen tubes were hyaline (Figure 7D–G). In the case of self pollination, the number of pollen grains germinated was 62 out of 834; whereas, it was 300 out of 802 for cross pollination. Therefore, the percentage of pollen germination was significantly higher (p < 0.000) in the case of cross pollination (32.9–41.3%) than self pollination (4.2–8.6%; Figure 7F).



**Figure 6.** Studies on pollen morphology and viability. (**A**) SEM image of a monoporate pollen having granular exine. (**B**) Pollen grains stained using 2,3,5 triphenyl tetrazolium chloride (TTC) and (**C**) Germinated pollen grain. (**D**) Bargraph of the pollen viability based on TTC staining (black bar) and germination assay (grey bar). Pearson's chi-squared test revealed that the differences in proportion were statistically not significant across *B. tulda* populations for both TTC and germination assay. Abbreviations used: AN—Annulus, NP—Non-viable pollen, VP—Viable pollen, PT—Pollen tube.

### 2.6. Higher Rate of Seed Setting in Pseudospikelet Compared to Solitary Spikelet Inflorescences

To understand the importance of two different types of inflorescences and their impact on overall seed setting, the total number seeds of obtained from solitary spikelets and pseudospikelets were counted and compared (Figure 8A–C). To avoid any confounding effect, due to the different number of spikelet units present in solitary vs. pseudospikelets on the number of total seeds observed, single spikelet units having 7–9 florets were selected from each inflorescence type. The percentage of seed settings in pseudospikelet was significantly higher at p < 0.050 (17.3–25.7%) than solitary spikelets (3.2–9.6%; Figure 8D).



**Figure 7.** Experimental design and microscopic observation to study *in vivo* pollen-pistil interaction in *B. tulda.* (A) Time course experiment was conducted to identify the optimum time point for pollination. (B) Line graph demonstrating the optimum time point for opening of the *B. tulda* flower. (C) Schematic representation of the experimental set up. (D) Magnified view of stained stigma after self pollination. Pollen tubes are marked by an arrow. (E) Magnified view of stained stigma after cross pollination. Pollen tubes are marked by an arrow. (F) Histogram demonstrating the relative abundance of self vs. crossed pollination in two populations of *B. tulda*. Two-sample approximate *z*-test was performed to test statistical significance at p < 0.000. While performing the test of significance, data for cross pollination obtained from BNDL23 and BNDL24 were pooled and compared to the pooled data obtained for self pollination. (G) Scanning electron microscopic (SEM) image of stigma after cross pollination. Abbreviations used: h—Hour, S—Stigma, PT—Pollen tube, P—Pollen.



**Figure 8.** Studies on the rate of seed setting between solitary spikelets and pseudospikelets. (**A**) Solitary spikelet inflorescence with single seed-bearing floret. (**B**) Pseudospikelet inflorescence with multiple seed-bearing florets. Seeds are marked by an arrow. (**C**) Newly emerged young seedling. (**D**) Histogram demonstrating differential seed set observed between solitary spikelets vs. pseudospikelets. Two-sample two-sided *t*-test was performed to test statistical significance at *p* < 0.050. While performing the test of significance, data for pseudospikelets obtained from the three populations were pooled and compared to the pooled data obtained for solitary spikelets.

### 3. Discussion

### 3.1. Flowering Time, Cycle and Inflorescence Types: Why So Much Diversity?

In B. tulda three kinds of flowering cycles, such as (i) gregarious (massively synchronised), (ii) sporadic, and (iii) sporadic-massively synchronised, had been observed [9,10]. This indicates that even within one species, wide diversity exists with respect to flowering time, which may be regulated by genotype, as well as environment [10,36]. Gregarious flowering generally extends over a large area, while sporadic remain restricted in a few culms. Sporadic events may or may not be followed by mass flowering. When a sporadic cycle is converted into gregarious in subsequent years, it is referred to as sporadic-massively synchronised. This study identified seven sporadic flowering incidents of *B. tulda* over the last seven years (Table 1 and Table S2). In addition, noticeable differences were also observed with respect to the rate of seed setting and senescence patterns between sporadic and mass flowering [33,37,38]. In mass flowering, the rate of seed production is usually higher, and flowering culms wither after each cycle, which was not the case for sporadic flowering. Since the ecological impact of gregarious flowering is huge, studies have been conducted, and many hypotheses put forward, such as habitat modification, seed predator and resource allocation [26,39]. In contrast, much less attention has been paid to sporadic flowering, and it has mostly been considered an early indicator of future

large scale flowering [40]. Our study indicates that sporadic flowering is more frequent in smaller, fragmented populations, and may not necessarily be followed by synchronous flowering.

Apart from the diverse extent of synchrony in flowering time, *B. tulda* also demonstrates diversity in inflorescence morphology and appearance in sporadic flowering (Figure 2). In this study, two types of inflorescences, referred to as solitary spikelet and pseudospikelet, have been identified in *B. tulda* (Figure 3A–H). Although such types of inflorescences were also reported from *Guadua inermis, Phyllostachys aurea, Dendrocalamus menghanensis* [41–43], no studies have aimed to understand their relative abundance in a flowering cycle, particularly with reference to seasonal changes. This study identified that solitary spikelets were more abundant during the early stages of the flowering cycle (March–May) in *B. tulda*, whereas pseudospikelets were more abundant in the later stage (May–July; Figure 2). The differential rate of inflorescence abundance might have occurred, due to the following reasons- firstly, solitary spikelets developed from the apical meristem of a flowering branch, and after their senescence, pseudospikelets emerged in clusters from axillary meristems (Figure 3D,H). Secondly, during the late stage of flowering, the culm initiated to shed off vegetative leaves and mobilised stored photosynthate towards reproductive growth.

# 3.2. Fragmented Flowering Population, Low Pollen Viability and Dispersal Lead to Reduced Seed Setting

The rate of pollen viability was apparently low in *B. tulda*, as evidenced by TTC and the in vitro pollen germination assay. These are effective, yet sensitive methods, which can be affected by many factors, such as temperature, humidity, time of pollen collection, maturity of the florets and composition of assay medium [44–47]. Although sufficient precautions were undertaken to employ optimum conditions during pollen collection and assay, there could have been issues like time to transport them to the laboratory and small populations frequently subjected to anthropogenic impact, which might also have affected overall pollen quality. Nevertheless, in *Bambusa vulgaris*, pollen germination was only 4.5%, which was linked to chromosomal abnormalities [48]. However, in B. tulda no such chromosomal aberrations were observed (Figure S1). In contrast, a very high rate of pollen viability (85%) was observed in *M. baccifera* [48]. Other than viability, successful dispersal of pollen from the anther is also required for efficient dispersal. Also, population size and physical distance between populations are other important factors that determine mating success [35]. All the three populations used in this study were small, consisting of approximately 10–50 clumps and each clump comprising of 7–52 culms. Moreover, anthers of B. tulda display narrow apical suture, causing limited liberation of pollen grains (Figure 4F). The optimum mating distance was ~0–50 m for Dendrocalamus membranaceus and 0–1500 m for Dendrocalamus sinicus [35]. It has been observed that the optimum distance for horizontal dispersal of pollen was ~55 m, and maximum dispersion could be up to  $\sim$ 370 m in maise [49]. The relatively long spatial separation between flowering populations of *B. tulda* (BNDL23, BNDL24; ~340 m) might have resulted in a lower abundance of pollen grains required for successful cross pollination (Figure 7C).

Other factors, such as the activity and abundance of pollinators, also influence the pollination process [33]. In *D. membranaceus* and *D. sinicus*, mating success was not only dependent on clump density, but also on pollinator abundance [33,37,50]. In this study, few insect visitors were observed, suggesting wind pollination as the primary mode of pollen dispersal in *B. tulda*. This is in accordance with previous observations made in Arundinaria gigantea, *Ochlandra travancorica, Phyllostachys pubescens, D. membranaceus, D. sinicus* and *Dendrocalamus strictus* [33,51–54]. However, insect pollination has been observed in few bamboo species, such as *D. membranaceus, D. sinicus, Phyllostachys nidularia, Guadua paniculata* and *G. inermis* [33,34,55]. The size of pollen grains also influences the rate of pollen dispersal by air. The pollen of *B. tulda* falls into category 3, which includes small pollen having sizes ranging from 33.1–43.9  $\mu$ m [56], conferring higher buoyancy. Although most grass pollen are known to be air-borne and allergenic, no such observations have been reported for bamboo [57].

A higher rate of seed setting was found to be correlated with flowering area in *Sasa senanensis*, *Sasa kurilensis* and *Sasa palmata*, where the main determining factor was the availability of sufficient pollen [32]. A larger flowering area implies a higher capacity for pollen dispersal. The small size of a population, due to fragmentation is significantly associated with a low seed set [Morgan, 1999]. Availability of pollen grains and pollinators were two primary reasons behind higher amounts of seed setting, due to gregarious flowering in *D. membranaceus* [37] and *Schizostachyum zollingeri* [58]. In contrast, this study and others have recorded a very low amount of seeds in *B. tulda* (Figure 8A,D; [13]). Since the studied populations (BNDL23, BNDL24 and SHYM7) were small and isolated, low availability of pollen might be associated with low seed setting. This reduced seed setting can also be linked to low pollen viability [59]. Similar findings were observed in *B. vulgaris*, where a low rate of pollen viability was responsible for the lack of seed set [44].

Although the total amount of seeds produced, due to sporadic flowering, is low, and their relative abundance is different between solitary spikelets and pseudospikelets (Figure 8B,D). Pseudospikelets were more predominant during the later phase of the flowering cycle, i.e., from May to July, which was right before the promotion of vegetative growth. Therefore, it could be an adaptive strategy for *B. tulda* to ensure reproductive success by maximising seed production preceding the monsoon season.

#### 3.3. Protandry and High Rate of Genetic Incompatibility to Ensure Genetic Variability

Since flowering time is unusually extended in bamboo, the occurrence of genetic variability, due to sexual reproduction is less frequent. Therefore, the plant group may adopt diverse morphological and reproductive mechanisms to promote self-incompatibility over self-compatibility. Differential development of reproductive organs, known as protandry and protogyny, increases the possibility of cross pollination. This study identified protandry in *B. tulda*, where the androecium matured before the gynoecium, promoting the primarily outcrossing nature of the plant (Figure 5A–H). This observation was similar to findings in *G. paniculata*, *G. inermis* and *Aulonemia aristulata* [34]. Similarly, protogyny, i.e., earlier development of the gynoecium than the androecium has been observed in other bamboos, such as *D. membranaceus*, *D. sinicus*, *Dendrocalamus sikkimensis*, *P. nidularia*, *P. heteroclada* and *Phyllostachys nuda* [33,55,60]. Even in some rare instances, e.g., in M. baccifera, both protandrous and protogynous flowers have been observed [48].

Another strategy to ensure genetic variability is by maintaining a high rate of cross pollination. In this study, the in vivo pollination experiment performed on two populations of *B. tulda* (BNDL23, BNDL24; ~340 m) suggested predominance of cross pollination over self pollination (Figure 7C–F). Wide variations exist across bamboo species with respect to the predominance of self vs. cross pollination. For example, *M. baccifera* is primarily a cross pollinated species [48]. In contrast, *S. senanensis, S. kurilensis, S. palmata, S. cernua* and *Phyllostachys edulis* and *P. pubescens* are primarily self pollinated [32,61,62]. A few others, e.g., *D. membranaceus* and *D. sinicus*, are predominantly cross pollinated, but may undergo self pollination in unusual situations, such as spatial separation of flowering culms and abundance of pollinators [35]. Consequently, the rate of self pollination is higher in sporadic flowering, whereas it is much less in the case of gregarious one [63,64].

In grasses, the Gametophytic Self Incompatibility (GSI; [65]) is maintained by the two unlinked, multiallelic loci S and Z, whereas in dicotyledonous plants, it is regulated by the single S locus [66]. Since both S and Z loci are multiallelic, their allelic diversity can be an important factor that determines the interaction between pollen and pistil during a compatibility reaction [65,67]. In the case of cross pollinated species, self pollination may occur, due to the unavailability of compatible pollen grains. This may result in the rejection of majority pollen, due to lower allelic diversity during their interaction with the pistil. This may lead to a lower rate of fertilisation, and consequently, low seed set. Although the two loci based gametophytic SI (GSI) is known in grasses, molecular information regarding the genes and their regulation are scanty, and in Bambusoideae they are even rarer. Since diverse mating behaviour is observed in bamboos and an individual species can determine its mating nature based on the availability of pollen grains, pollinators and environmental factors, it would be interesting to know if the S-Z loci based GSI system exists in bamboo.

# 3.4. Semelparous Gregarious Flowering vs. Iteroparous Sporadic Flowering: Ecological Benefits and Costs

Most bamboos are monocarpic, and therefore, culm death is followed by flowering. This has been corroborated by observing the induction of programmed cell death-related genes in Bambusa arundinacea [68]. However, the extent of semelparity varies between sporadic vs. gregarious types and even among populations. For example, in the case of gregarious flowering, a single flowering cycle generally persists for two to three years, which is followed by the death of whole flowering populations [14]. This reflects the semelparous nature of gregarious flowering [38]. In contrast, sporadic flowering is predominantly iteroparous, i.e., multiple flowering cycles may recur in a single flowering culm until death [38]. Our observations on sporadic flowering in B. tulda revealed that rhizomes of the flowering clump usually remained alive, and new culms may emerge every season (Table 1, Figure 2). In contrast, the death of both culm and rhizome takes place in the case of gregarious flowering, but is compensated by enormous production of seeds. Such mass death causes a sudden decline in forest populations, leading to drastic changes in forest dynamics [69–71], due to increased availability of light, deposition of extra organic matters, interactions among species for survival of seedlings (Figure 8C) [69,72–75]. For example, drastic changes in light intensity after mass death of bamboo culm results in quick growth of new bamboo seedlings along with many tall tree species.

Sporadic flowering may or may not be followed by mass flowering events. Recurrent death of only a limited number of clumps may have much less impact on population dynamics. Yet, it may still cause habitat loss for several endangered species, particularly in fragmented forest areas [26,70]. Additionally, solely sporadic events in *D. strictus* and *D. membranaceus* revealed the consistently low frequency of seed setting [37,60]. However, sporadic events, which resulted in gregarious flowering (sporadic-massive synchronised type), may have a much more severe impact on forest populations [10]. One such study revealed that high rates of seed setting in initial sporadic cycles before the onset of mass flowering potentially initiated regeneration of bamboo population before mass death in *Sasa veitchii* var. *hirsuta* [76]. Such an initial regeneration process may prevent the sudden changes in interaction among the organisms present at diverse trophic levels [77]. It also helps in continuous nutrient cycling and litter production to maintain soil fertility [74].

#### 4. Materials and Methods

#### 4.1. Population of B. tulda Studied

To study reproductive developments of bamboo, three populations of *B. tulda*, i.e., SHYM7 (Rahuta, Shyamnagar, West Bengal, India, 22.830829° N, 88.405029° E), SHYM16 (Rahuta, Shyamnagar, 22.829591° N, 88.409095° E) and BNDL23 (Rajhat, Bandel, West Bengal, India, 22.934348° N, 88.353255°E, Figure 1), which flowered sporadically were monitored for seven years from 2013–2020 (Figure 2). For the purpose of pollination experiments, BNDL23 and BNDL24 (Rajhat, Bandel, 22.932155° N, 88.355551° E) populations were used. Each population was separated by a distance of at least 300 m and were composed of ~10–50 clumps (=genets) [78], out of which flowering was recorded in 1–5 clump. Each clump was comprised of ~7–52 culms (=ramets), and in few rare incidents >70 culms were present. The height of an individual culm ranged from 15–20 m and diameter from 49–55 mm. All these populations were of mixed type and composed of *B. tulda* along with other bamboo species (~1:3). The number of flowering clumps and culm in each studied population were recorded for seven consecutive years (Table 1).

### 4.2. Studies on Inflorescence and Floral Morphology and Pollen Cytology of B. tulda

To study the morphology of inflorescences and floret, 20 intact inflorescences of each type were obtained from different positions of flowering branches. Inflorescence having

ready to open florets were collected from the field in an airtight plastic bag at 6:00 AM in the morning and brought to the laboratory. Numbers of solitary spikelet vs. pseudospikelet and florets per spikelet were obtained from three randomly selected flowering culm per population (Figure 3A–H). Fresh florets and individual floral parts, such as glume, lemma, palea, androecium and gynoecium, were dissected, observed and measured by a stereo zoom microscope (50X, Carl Zeiss, Germany, Figure 4A–I). Florets located at the apex of each spikelet was labelled as F1, and the subsequent florets towards the base were labelled in increasing order. Florets in each of these positions were collected to study the developmental progression of androecium and gynoecium (Figure 5A–H). Pollen grains were collected from anthers during post-anthesis of florets and observed in a bright field microscope (Carl Zeiss, Axiostar Plus, Germany). To study the meiotic cell division in pollen, young spikelets were fixed in Carnoy's solution between 6:30–7:00 a.m. on the plantation site. The pollen were stained with 2% acetocarmine and were observed under a bright field microscope.

# 4.3. Scanning Electron Microscopy (SEM) Analyses of Inflorescence Buds, Floral Bracts and Pollen Grains

To perform the SEM analyses of inflorescence buds, young buds (>3 mm) of both solitary and pseudospikelets were collected. Outer protective layers were carefully removed to expose the meristem tip prior to SEM analyses (Figure 3D,H). Lemma and palea were obtained from freshly collected florets to observe both dorsal and ventral surfaces (Figure 4I–L). Similarly, pollen grains were collected from anthers during post-anthesis (Figure 6A). Each sample was coated by platinum using POLARON-SC7620, Carbon Accessory (Model-CA76) and were scanned with ZEISS EVO 18 SEM (Carl Zeiss SMT, Germany) having a maximum acceleration voltage of 30 kV.

### 4.4. Test of Pollen Viability by Tetrazolium Staining and In Vitro Pollen Germination Assay

Viability of *B. tulda* pollen was assessed by staining with 2,3,5 triphenyl tetrazolium chloride (TTC) and performing in vitro pollen germination assay (Figure 6B–D). For each of the three populations studied (SHYM7, SHYM16, BNDL24), florets were collected from three randomly selected culms between 8:00–9:00 AM during May, 2015 (~34–37 °C). For each culm, three florets were obtained from randomly selected flowering branches. Anthers from fresh florets were collected during post-anthesis when the anthers were bright yellow or purple. Collectively 18 anthers obtained from 3 florets from each culm were pooled together and were subjected to TTC, as well as in vitro germination assay.

Anthers were immediately kept in micro centrifuge tubes containing ~1.0 mL of TTC solution, incubated in the dark for 30 min and observed under a bright field microscope (Figure 6B,D) [79]. A total of 2460 pollen were used for this analysis. Percentage of pollen viability was calculated by counting stained (viable) vs. non-stained (non-viable) pollen observed in three randomly selected microscopic fields (Figure 6D) and then dividing the number of stained pollen by the total number of pollen and multiplying the proportion, thus, obtained by 100.

For in vitro germination analyses, pollen were collected similarly as described in the case of TTC assay and were immediately dusted in a 0.5 mL pollen germination medium (PGM, Brewbaker and Kwack's medium). To identify the ideal concentration of sucrose for optimum germination, media were supplemented with 10, 15, 20, 25 and 30% sucrose (w/v), incubated for 30 min and observed under a bright field microscope in their natural habitat itself. A total of 1175 pollen were used for this analysis. The optimum percentage of germination was observed in media supplemented with 15% sucrose, and hence, was used for in vitro germination assay. Pollen were incubated in PGM for ~2 h. A total of 396 pollen were observed under a bright field microscope to score numbers of germinated vs. non-germinated pollen (Figure 6C) [80]. Pollen grains were considered as germinated, if the length of pollen tube was greater than the diameter of the pollen grain as per the recommended procedure [81]. Percentage of pollen viability was determined by dividing the number of germinated pollen grains by the total number of pollen grains and multiplying the proportion, thus, obtained by 100 (Figure 6D).

### 4.5. Artificial Pollination Conducted in Situ

To understand the nature of pollen-pistil interaction in *B. tulda*, self and cross pollination experiments were performed in their natural habitat (Figure 7A–C). Two individual flowering populations located in Bandel, West Bengal, India (BNDL23 and BNDL24) separated by ~340 m were selected for this study (Figure 7C). Since bamboos primarily propagate via rhizomes, this experiment was performed in populations, which were distanced by at least 300 m to ensure genetic diversity. However, to ensure maximum pollen viability during artificial pollination, population pairs (BNDL23 and SHYM16), which were distanced by ~33 km. could not be considered (Figure 1). For an individual population,  $\sim$ 7–8 culms were used for this study. Approximately 30 spikelets obtained from each population were used for pollination experiments. This was conducted during March, 2019. Selected florets were emasculated prior to pollination, and pollen were dusted within 15 min to ensure viability. The time for maximum floret opening was monitored for three consecutive days at five different time points (6:00 a.m. AM, 8:00 a.m., 10:00 a.m., 12:00 p.m. PM and 2 p.m.) in both populations (Figure 7B). In addition, to identify the optimum time for pollen germination, pollination experiments were performed at four distinct time points (8:00 a.m., 10:00 a.m., 12:00 p.m. and 2 p.m.; Figure 7A). Pollinated stigmas were collected at 2 and 4 h post-pollination and were immediately fixed in formaldehyde, alcohol, acetic acid solution (FAA, 1:5:0.5). Subsequently, they were treated with 70% alcohol followed by 4 M NaOH and finally washed with distilled water. Pistils were stained with 0.001 mg/mL aniline blue (Merck, Germany) and observed under a bright field microscope (Figure 7D,E). Pollen grains that germinated on stigma were counted. For self and cross pollination experiments, pollination was performed at 10:00 a.m., and the pollinated pistils were collected at 12:00 p.m. In the case of self pollination, pollen from mature anthers obtained from one population were dusted on the stigma of an open flower located on the same clump (geitonogamy). On the contrary, cross pollination was performed by dusting pollen collected from one population to the stigma in another population (xenogamy). Immediately after pollen dusting, pollinated flowers were covered with plastic bags to prevent any subsequent pollination. The percentage of germination was determined by dividing the total number of germinated pollen to the total number of pollen and multiplying the proportion, thus, obtained by 100 (Figure 7F).

#### 4.6. Seed Numbers Obtained from Solitary Spikelet vs. Pseudospikelet

To compare between the number of seeds obtained from solitary spikelet and pseudospikelet, both the inflorescences were collected from ~7–12 culms from each of the three populations from March to July, 2018 (SHYM7, SHYM16, BNDL23, Figure 8A–D). Seeds were counted from 96 solitary spikelets and 99 spikelet units obtained from 120 pseudospikelet. Both solitary and pseudospikelets were randomly selected from the flowering branches of ~6–7 culms from a clump. To make the analysis comparable, only spikelets containing 7–9 florets were selected from both the inflorescence types. In the case of solitary spikelet, the total number of seeds produced by all the florets in that inflorescence was counted. On the other hand, for pseudospikelet, only the fully developed mature spikelets with a similar number of florets located in that cluster were selected, and the total number of seeds were counted.

#### 4.7. Statistical Analyses

For pollen viability assessed by staining, as well as in vitro pollen germination assay, a Pearson's chi-squared test was performed to analyse whether the differences in proportion were statistically significant across *B. tulda* populations. A two-sample t-test of mean was performed to test whether seed setting percentage for solitary spikelet and pseudospikelet were significantly different. Similarly, a two-sample approximate Z-test t-test was per-
formed to analyse the statistical difference between the proportion of pollen germination in the case of self vs. cross pollination for *B. tulda*.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/article/ 10.3390/plants10112375/s1, Figure S1: Cytological observation on dividing pollen mother cells of *B. tulda*. (A) Metaphase I (B) Late anaphase I (C) Late telophase I (D) Metaphase II (E) Anaphase II (F) Telophase II (G) Pollen tetrad (H) A multinucleate (marked with arrow) microspore, Table S1: Percentage of pollen germination of *Bambusa tulda* in Brewbaker and Kwack's medium supplemented with 10, 15, 20, 25 and 30% sucrose (*w*/*v*), Table S2: Various flowering events recorded in *Bambusa tulda* in India.

**Author Contributions:** M.D., P.B., S.C. and S.D. conceptualised the outline of the manuscript. P.B., S.C. and S.D. performed the filed survey. P.B. performed the floral morphology and pollen viability experiments. S.C. and S.D. performed the SEM imaging and in vivo artificial pollination experiments. S.C. performed the seed setting analysis. P.B., S.C., S.D. and M.B. prepared the figures. U.C. calculated geographical distance between populations. S.G. performed the statistical analyses. M.D. drafted the final version of the manuscript with input from all the authors. All authors have read and agreed to the published version of the manuscript.

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Published: 30 October 2021

# Projections of temperature changes over South America during the twenty-first century using CMIP6 models

David Francisco Bustos Usta, Maryam Teymouri & Uday Chatterjee 🖂

GeoJournal 87, 739–763 (2022) Cite this article 311 Accesses 1 Citations Metrics

## Abstract

A 22-member ensemble from CMIP6 is used to analyze the projected changes and seasonal behavior in surface air temperature over South America during the twenty-first century. In the future projections, CMIP6 models shown a high dependency to the socioeconomic pathway over each country of South America. The multimodel ensemble projects a continuous increase in the annual mean temperature over South America during the twenty-first century under the three future scenarios (SSP1-2.6, SSP2-4.5 and SSP5-8.5). Besides, it was possible to identify consistent positive trends across all the models, with values between 0.45  $\pm$  0.05 and 2.05  $\pm$ 0.31 °C cy<sup>-1</sup> under the historical experiment, however largest trends occurs for the projection periods (near, mid and far future), with values between  $-0.87 \pm 0.84$  to  $2.88 \pm 0.60$  °C cy<sup>-1</sup> (SSP1-2.6), 1.41  $\pm$  0.88 to 5.32  $\pm$  0.81 °C cy<sup>-1</sup> (SSP2-4.5) and 4.75  $\pm$  0.58 to 8.76  $\pm$  0.74 °C cy<sup>-1</sup> (SSP5-8.5) with maximum values at Bolivia, Brasil, Paraguay and Venezuela whilst minimum values for Argentina and Uruguay, regardless of the SSP scenario used. From the seasonal behavior analysis was possible to identify maximum values between January and March whilst minimum between June and July, except in Brasil, Venezuela and Guyana-Surinam-French Guayana, with annual range decreasing as the latidude decreases. By the end of the twentyfirst century the annual mean temperature over South america is projected to increase between 0.92-2.11 °C, 0.97-3.37 °C and 1.27-6.14 °C under SSP1-2.6, SSP2-4.5 and SSP5-8.5 projection scenarios respectively. This projected increase of temperature across the continent will produce negative repercussions in the social, economic and political spheres. The results obtained in this study provide insights about the CMIP6 performance over this region, which can be used to develop adaptation strategies and might be useful for the adaptation to the climate change.

#### Springer Link

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Published: 24 September 2021

Dwellers' perception toward the Urban services of Panskura Municipality, India: an application of importance-performance models

Subhrangsu Das 🖂, Nirmalya Das, Uday Chatterjee & Santu Guchhait

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#### Abstract

The provision of urban service and citizens' satisfaction is an important key issue in urban planning. Importance-performance analysis (IPA) is an effective and widely applicable technique to explore consumer's satisfaction. IPA helps to prioritize the management strategies for urban services using the IPA. Purpose of the present study is to assess the performance of urban services and citizen's satisfaction level of Panskura municipality using IPA models and improvement index. A total of 629 valid household responses are collected with the help of the door-to-door primary survey technique. The study reveals that all the selected seven urban services have significant importance-performance gap except water supply. Residents of the Panskura municipality are very much satisfied with the water supply service because of the very minimum improvement score. The combined result of IPA matrices and improvement index suggests residents are dissatisfied to a great extent with the performance of four urban services, i.e. health, economy, transportation and sanitation. These urban services require a problem-solving urgent action for restoration of the performance status. The improvement and prioritization of urban service are also required to fulfil the demand of target groups.

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### Published: 26 August 2021

# Control and maintenance of borders due to the expansion of the Kurdish ethnic group on both sides of the Iranian-Iraqi border

Mohsen Janparvar ⊠, Sajed Bahrami Jaf, Mahboubeh Shahbazi & Uday Chatterjee

<u>GeoJournal</u> 87, 4161–4177 (2022) Cite this article 139 Accesses Metrics

## Abstract

Borders are part of countries that are the end of national sovereignty and the starting of interaction to enter the international arena, and can play a role as a factor in creating war or in establishing friendship and interaction. Therefore, border control causes internal security and not cause problems with the neighboring country, but also reduces the problems. The present study investigates the effect of establishing a single ethnic group on both sides of the border for controlling it with emphasis on the Kurdish ethnic group. The method of the present research was descriptive-analytical and the data collected in two sections: library and field (questionnaire). The findings of the theoretical part of the research showed that based on theories related to border control and ethnicity, 29 variables selected totally as the main items of the research. In the field section, the results of the questionnaire analyzed by sending the questionnaire electronically to 35 border experts and in this way MicMac software used. The results of the present study show that 10 variables are the most important factors that influence border control on the areas of establishment of Kurdish ethnic group on both sides of the border. Lack of cultural cohesion on both sides of the border with the center, concentration of threats, unemployment, border planning, political instability, population size, terrorism, independence aspirations, political discrimination, the topographic situation of the border area, and the importance of political and security components in controlling the borders of Kurdish areas are those variables.

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## Data availability statement

The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

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#### Published: 25 April 2021

## Analysis of kulbari's economic position in the northwest border villages of Iran (a study of paveh border villages)

<u>Mohsen Janparvar, Akbar Heydari, Sajed Bahrami Jaf, Uday Chatterjee</u> <sup>IM</sup> & <u>Uttara Singh</u> <u>GeoJournal</u> 87, 3219–3229 (2022) | <u>Cite this article</u> 116 Accesses | <u>Metrics</u>

#### Abstract

One of the most important issues along the Iran-Iraq border (Kurdistan) is the Kulbari phenomenon. The phenomena have forced the inhabitants of these border regions, whether old or young, men or women, to some extent be involved. Problems of life and finances of this phenomenon cannot be ignored by any viewer. The present paper is an attempt to study the economic position of Kulbari's in the north-western border villages of Iran more specifically the border villages of Paveh. For the same purpose the library documentary and field study methods have been used. A questionnaire was prepared keeping the statistical population in mind, of which 113 questionnaires were answered. Results thus obtained shows that the most important parameter affecting the political dimension of the Kulbari phenomenon in the border villages is the communication policy between the two border states, the ideology, and strategies of the two border states, and the border policy. In the economic dimension, the most important parameter includes the supply of necessities of life, employment and unemployment in the border region, the absence of agricultural and pasture land; and in the geographical dimension the most important parameters affecting the stability of the Kulbari phenomenon is the development level of the border region relative to the center. Finally, the paper also provides some suggestions to solve the Kulbari issue in the study area.

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## Russia's Invasion of Ukraine & India-Russia Ties

Dr. Prafulla Kumar Das \* & Kamal Sarkar\*\*

[While taking a brief look at the pattern of India's relationship with the erstwhile Soviet Union during the Cold War, authors endeavour to focus on India-Russia relations in its multiple manifestations in the post-Cold War along with specific reference to the geopolitical developments obtaining in the aftermath of the Russian invasion of Ukraine in February this year.]

The state of Russia emerged in 1991 with the breakup of the former communist state of the Soviet Union. Even after the breakup, Russia is the largest country in the world with a total area of 17,098,242 Km<sup>3</sup> and a land area of 16,376,870 Km<sup>3</sup>, equivalent to 11% of the total world's landmass. After the dissolution of the Soviet Union, Russia inherited its close relationship with India which resulted in both nations sharing a special relationship. The political relationship was bolstered by a close economic relationship and an even closer defence link. The Indo-Soviet ties were an important factor in Asia. They could counter any other equation in the region and, from India's point of view, contributed to the maintenance of peace, security and balance in the region.

#### India-Russia relations during India's Independence

Before reviewing India-Russia relations, it is important to know how India's relations with the erstwhile Soviet Union were. In the years following India's independence in 1947. India's relations with the Soviet Union were far from cordial. Because at that time the Soviet Union was mainly governed by Stalin's vision. The main features of Stalin's policy were non-cooperation with Western capitalist countries and their allies and the expansion of the Soviet Union's influence around the world was an important objective of its diplomacy. In view of the erstwhile Soviet Union India achieved independence as per the Mountbatten Plan, India, in fact, remained under the control of the Western imperialists. Apart from that, the way in which India established various relations with the Western countries for the sake of development that displeased the Soviet Union.

#### Unforgettable Past of Indo-Russian (Soviet) Friendship

Within a few days of Independence of India, Soviet Union changed a lot and the attitude of the Soviet Union towards India became positive. India has been at loggerheads with Pakistan over Kashmir issue since independence. India's relations with the United States deteriorated when the US sided with Pakistan in this dispute. Second, India remained non-aligned in the Korean crisis rather than joining with the Western alliance. These two incidents changed the Soviet Union's perception of India. Apart from that, the policy makers of India at that time urgently needed the country's economic development, not getting involved in alliance politics.

India at that time thought that it was best to be close with the Soviet Union. The then Prime Minister of India Jawaharlal Nehru's influence again worked behind India's reliance on the Soviet Union rather than the United States. Nehru was a supporter of the Soviet Union's planned economy. India's Five-Year Plan was modelled after the Soviet planning system. On the other hand, the Soviet leaders also saw the direction of India's economic and foreign policy and understood that India would not at least become a partner of the US alliance because of its being a pioneer of the non-aligned movement. Besides, Prime Minister Nehru's anti-colonialism and anti-imperialism policy attracted the Soviet Union to India.

In view of these, India and the Soviet Union started getting closer. In 1953 this friendship was further strengthened by the conclusion of an important trade agreement between the two countries. Along with this, mutual foreign visits between the leaders of both countries continued. Among those visits, the Indian Prime Minister's visit to Moscow in 1955 and Soviet Prime Minister Nikolai Bulganin and Communist leader Khrushchev's visit to India in November of that year are particularly notable. During these visits, several economic technical and political cooperation plans were taken up between the two countries. For example, the Soviet Union promised all possible help to build iron and steel factories in India. Apart from that, the Soviet Union recognized Kashmir as an integral part of India. So every time Pakistan tried to raise the Kashmir issue

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Asst. Prof. & Head, Dept. of Pol. Sc., Bhatter College, Dantan, Paschim Medinipur.

<sup>\*\*</sup> Asst. Prof., Dept. of Pol. Sc., Bhatter College, Dantan, Paschim Medinipur

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## रूपगोस्वामिनः कालकृतिनिरूपणं नाटकचन्द्रिकारचनाकालविमर्शनञ्च

सनातन-दासः, पश्चिमवङ्गः

## १. रूपगोस्वामिनः कालकृतिनिरूपणम्

## १.१. आविर्भावकालः

गौडीयवैष्णवपरम्परासु ये तावत् गोस्वामिसम्प्रदायिनः दार्शनिकाः प्रसिद्धाः आसन् तेष्वन्यतमः खलु रूपगोस्वामी। प्रामाण्यतथ्याभावात् रूपगोस्वामिनः आविर्भावतिथिः यथार्थरूपेण निर्णेतुं न शक्वते। तथापि गौणतथ्यादिभिः कल्पितकालनिरूपणं कियतेऽत्र। श्रीचैतन्यदेवः सच्न्यासग्रहणस्य पञ्चमवर्षादनन्तरं १५१४-१५ ईशवीयाब्दे रामकेलिग्रामं समागतवान्। तदा रूप-सनातनौ गौडाधिपतेः हुसेनशाहस्य मन्त्रिणावस्ताम्। श्रीचैतन्यदेवस्य वयस्तदा अष्टाविंशतिः नवविंशतिर्वति। आचार्येण सतीशचन्द्रमित्रमहोदयेनोक्तं यत् १४६५ ईशवीयाब्दे सनातनः १४७० ईशवीयाब्दे रूपश्च अजायेताम्।<sup>1</sup>अतः चैतन्यदेवस्य रामकेलिग्रामागमनसमये रूपस्य वयः पञ्चचत्वारिंशदित्यनुमीयते। वयसि अस्मिन् राजमन्त्रित्वं यथार्थमेव। पुनः १५४१ ईशवीयाब्दात् प्राग्रयितस्तवमालायामुक्तं श्रीरूपेण-

"पलितंकरणीदशा प्रभो मुहुरन्धंकरणी च मां गता। शुभगंकरणी कृपा शुभैर्नतवाढ्यंकरणी च मय्यभूत्॥" [गोविन्दविरुदावली २२] अनेन ज्ञायते यत् यदा स्तवमाला विरचिता तदा रूपगोस्वामी वयोवृद्धो जातः इति। स्तवमालायाः रचनाकालः १५४० ईशवीयाब्दः इति स्वीक्रियते चेत्तदा रूपगोस्वामिनः वयः उपसप्ततिरिति स्यात्। वयसि अस्मिन्पक्वकेशत्वं दृष्टिद्दीनत्वञ्च स्वाभाविकमेव। अतः रूपगोस्वामिनः जन्मः १४७० ईशवीयाब्दः इत्यनुमीयते।

## १.२. तिरोभावकालः

डॉ दीनेशचन्द्रसेनमहोदयेन भणितं यत् १५९१ ईशवीयाब्दे रूपगोस्वामिनः प्रयाणमभवत्।<sup>2</sup>जगद्वन्धुभद्रेण गौरपदतरङ्गिन्यामुक्तं १४८० शकाब्दे (१५५८ ईशवीयाब्दे) रूपस्य प्रयाणमभूत्। डॉ सुकुमारसेनमहोदयः १५५९ ईशवीयाब्दे<sup>3</sup>, राधागोविन्दनाथमहोदयः १५९१-९२ ईशवीयाब्दे<sup>4</sup>तथा गिरिजाशंकररायचौधुरीमहोदयः १५६३ ईशवीयाब्दे<sup>5</sup> रूपगोस्वामिनः मृत्युरभवदित्युक्तवान्। बाबूलालशुक्ठमहोदयेनोक्तं यत् १५५३ ईशवीयाब्दस्य मध्ये रूपगोस्वामी जीवितः आसीदिति। यद्वा भवतु षोडशशतकस्य मध्यभागपर्यन्तं रूपगोस्वामी जीवितः आसीदिति तु निर्विवादमेव।

## १.३. साहित्यकृतिः

चैतन्यदेवप्रवर्तितां प्रेमभावनां शास्त्रीयरूपप्रदातृषु श्रीरूपः अग्रणीः आसीत्। केवलं प्रचारेण धर्मस्य स्थितिर्न सुदृढा भवति। अनन्तकालं यावत् धर्मरक्षणाय धर्मप्रसाराय च ग्रन्थरचनां व्यतिरिच्य नास्ति किमप्युपायान्तरम्। तस्माद्वैष्णवसम्प्रदायस्य नवसिद्धान्तस्थापनाय रूपगोस्वामिना नैके ग्रन्था विरचिताः। तद्रचितानां ग्रन्थानां पूर्णाङ्गविवरणं भ्रातुष्पुत्रेण जीवगोस्वामिना लघुवैष्णवतोषण्यामुक्तम्। लघुतोषणीविवरणानुसारेण उत्कलिकावछरी, गोविन्दविरुदावली प्रेमेन्दुसागरश्चैते ग्रन्थाः स्तवमालान्तर्गताः, न तु पृथवभूताः इति। तत्रोक्तं पृथक् पुस्तकं छन्दोऽप्टकमित्यपि स्तवमालान्तर्गतम्। अतः रूपगोस्वामिरचितानां ग्रन्थानां संख्या प्रायः षोडशेति। ताश्च ग्रन्थाः- १. हंसदूतम् २. उद्धवसन्देशः ३. कृष्णजन्मतिथिविधिः ४. बृढद्रणोदेशदीपिका ५. लघुगणोदेशदीपिका ६. स्तवमाला ७. विदग्धमाधवम् ८. ललितमाधवम् ९. नाटकचन्द्रिका १०. दानकेलिकौमुदी ११. भक्तिरसामृतसिन्धुः १२. उज्वलनीलमणिः १३. मथुरामहिमा १४. पद्यावली १५. श्रीभागवतामृतम् १६. आख्यातचन्द्रिका इति।

## २. नाटकचन्द्रिकायाः रचनाकालविमर्शनम्

गौडीयवैष्णवालङ्कारशास्त्रेषु नाट्यतत्त्वमूलको ग्रन्थः खलु नाटकचन्द्रिका। रूपगोस्वामिप्रणीतेषु उपविंशतिग्रन्थेषु अन्यतमेयं नाटकचन्द्रिका नामापूर्वा रचना। ग्रन्थस्यास्य रचनाकालविषये किमपि सुनिर्दिष्टं तथ्यं न प्राप्तम्। ग्रन्थस्य पुष्पिकादावपि न लभ्यते तादृशं किमपि तथ्यम्। अपि च विषयेऽस्मिन्विद्यते एव विदुषां विप्रतिपत्तिः। न केवलं नाटकचन्द्रिकायाम्, रूपविरचितेषु चन्द्रिकेतरग्रन्थेष्वपि

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## Sanatan Das

Assistant Professor & HOD of Sanskrit Bhatter College, Dantan- 721426 Paschim Medinipur, West Bengal Phone- 8910208399 ; Whatsapp- 9547163741 E-mail- dassanatan147@gmail.com

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## Post-Partition Migration and Transgenerational Trauma: A Study of "Folie à Deux" in Anirudh Kala's *The Unsafe Asylum: Stories of Partition and Madness*

MIR AHAMMAD ALI

#### Abstract

Recent exploration in the field of 'Migration Studies' tends to uncover the psychological depths of the trauma of the migrants. The act of readjustment of the dislocated refugees in an entirely new geopolitical space is never an easy and unproblematic one. Some of the involuntary migrants have to suffer bouts of panic attacks, fear psychosis, and an acutesense of dislocation which lead to pathological disorders. This new interface between 'Migration' and 'Mental Health' is a space which requires to be explored. The Partition of India leftsome 15 million people homeless and was undoubtedly thelargest mass migration in human history. A few well-known Indian psychiatrists like Sanieev Jain and Alok Sarin observe that the trauma in some partition victims leads to certain post- traumatic stress disorders (PTSD) and in some cases, this trauma-induced pathology can pass on to the next generation/sepigenetically. This can be termed as transgenerational/ intergenerational trauma. Anirudh Kala's verv recently released monumental text. The Unsafe Asylum: Stories of Partition and Madness (2018), deals with these issues. This collection of interlinking short stories by the famous Indian psychiatrist from Ludhiana, Punjab opens up new horizons of Migration Studies where the victims are seen to be troubled by the inner psychological trauma. At times, the buried trauma haunts them many years after the actual Partition took place and as they 're-experience' the past traumatic events, they become disturbed mentally and physically. A good number of characters in this anthology like Rulda and Fattu, Iqbal JunaidHussain's son Asif in the story "No Forgiveness Necessary",

Prakash Singh Kohli in "Belly Button", Harpreet Cheema/Firdaus in "Sits's Bus", Venky in "Partitioning Madness" suffer from trauma-induced pathological disorders. In another story "Folie à Deux", the fear psychosis of an unnamed female narrator is transferred to her three offspring, which is 'transgenerational' in nature. This paper seeks to engage in a psychoanalytic exploration of the transgenerational transmission of the trauma of the post- partition migrants. It also tries to analyse the "Folie à Deux" syndrome in the titular story and to see how the delusional disorder of a partition victim is shared by her offspring.

**Keywords:** Trauma-induced Pathology, Madness and Partition, Folie à Deux syndrome, Transgenerational Trauma, Posttraumatic Stress Disorder (PTSD), Trauma Studies, Partition Studies.

### I

"There has almost never been a society which has not experienced migration in some form or the other, and currently no such society exists."

- Levent Küey

Levent Kuey rightly pointed out that there had hardly beenany society that had never faced migration in one way or the other. What Kuey wanted to suggest is that "Migration has been a collective experience for humankind throughout history."<sup>1</sup> Questions generally arise then how to study this human migration? Over the last few decades, there is invariably an increase in scholarship in the field of Migration Studies. The conventional approaches to Migration Studies

<sup>&</sup>lt;sup>1</sup> Levent Küey pointed out the traumatic aftereffects of migration in his essay "Trauma and Migration: The Role of Stigma" in *Trauma and Migration: Cultural Factors in the Diagnosis and Treatment of Traumatised Immigrants.* 

also underwent a momentous change over time. The traditional approaches primarily sought to understand and analyse the causes, nature and flows of migration. Recent scholarship, on the other hand, tends to focus more on the 'human dimension'<sup>2</sup> of migration and tries to listen to the voices of affected ones from beneath which had long been silenced. How do common people suffer due to involuntary or forced migration? How do the migrants readjust themselves in a new space when they are forcibly relocated? What are the psychosocial effects of migration upon its victims? What roles does the buried memory play in their lives? Do the memories of their traumaticpasts affect their present situation? Can trauma-inducedpathology be transmitted to the next generation? There are several other questions like the ones mentioned above that deserve critical attention in this regard. This paper aims to explore such issues.

Recent exploration in the field of 'Migration Studies'<sup>3</sup> tends to uncover the psychological depths of the trauma of the migrants. The act of readjustment of the dislocated refugees in an entirely new geopolitical space is never an easy and unproblematic one. Some of the involuntary migrants have to suffer bouts of panic attacks, fear psychosis, and an acute sense of dislocation, leading them to certain pathological disorders

<sup>&</sup>lt;sup>2</sup> Ian Talbot talked about the 'human dimension' of post-partition forced migration in his essay, "A Tale of Two Cities: The Aftermath of Partition for Lahore and Amritsar 1947-1957." *Modern Asian Studies*, vol. 41, no. 1, 2007, pp. 151–185. *JSTOR*, www.jstor.org/stable/4132347. p. 153

<sup>&</sup>lt;sup>3</sup> The psychological effects of migration, especially the traumatisation of the migrants from a psychoanalytical point of view, have been discussed in greater detail in two recently published books. Interested readers may look at them. *Trauma and Migration Cultural Factors in the Diagnosis and Treatment of Traumatised Immigrants*. Ed. by Meryam Schouler-Ocak. Switzerland: Springer, 2015 and *Migration Trauma, Culture, and Finding the Psychological Home Within: Views From British Object Relations Theory* by Grace P. Conroy, London: Rowman and Littlefield, 2016.

such as madness, chronic depression, and behavioural disorders obsessive compulsion, delusion, paranoia and so on. This new interface between Migration and Mental Health, or more specifically, between Migration-induced Trauma and Literary Fiction is a space which I would like to explore in this essay. Hence, the prime focus would be on the post-partition migration that had affected millions' lives.

The Partition of India left some fifteen million people homeless and is possibly the largest mass migration in human history. The Radcliffe Line had carved a deep scar not only on the Indian Territory but also on the minds of millions. Large *kafilas*<sup>4</sup> of dislocated refugees began to cross the new border due to the fear of persecution. After their involuntary migration, they found themselves usually on the wrong side of the border. The territorial politics of the nation-state madethem refugees which often led them to traumatic moorings. Such unprecedented, lifethreatening, disturbing events evoke trauma in the victims and this continues to haunt them later in their lives. Its manifestations can be seen in the victim's psychological and behavioural disorders in their developmental years.

Some well-known Indian psychiatrists like Sanjeev Jain of NIMHANS, Bengaluru and Alok Sarin of SBISR, New Delhi, observed that the trauma experienced by the partition victims leads to certain post-traumatic stress disorders (PTSD) and in some cases, this trauma-induced pathology can pass onto the next generation/s epigenetically. This can be termed as 'transgenerational/intergenerational trauma'<sup>5</sup> in which different types of psychic disorders can be found in their behaviour. For

<sup>&</sup>lt;sup>4</sup> Large scale convoy or mass procession.

<sup>&</sup>lt;sup>5</sup> The very idea of 'transgenerational/ intergenerational trauma' was popularised by several child trauma researchers like Byron Egeland, Inge Bretherton, and Daniel Schechter around 1990s.

example, long-term depression, disruptive thoughts, anxiety, amnesia, insomnia, hallucination and delusions, dissociative identity disorder, self-annihilation and suicidal tendency are some of the well-known symptoms of Post Traumatic State Disorders (PTSD) that have been found in some post-partition migrants. The classic example of this kind of victim, suffering from territorial anxiety is Saadat Hasan Manto's protagonist Bhisan Singh in "Toba Tek Sing."<sup>6</sup> In this story, Bhisan Singh is not merely a fictional lunatic but represents thousands of other lunatics of the time who suffer from post-partition stress disorders.

Alongside Manto's story, there are a few more narratives which represent this psychological aspect of migration caused by partition. Very recently, Anirudh Kala's monumental text, The Unsafe Asylum: Stories of Partition and Madness (2018) deals with some of the above-highlighted issues. For example, Anirudh Kala's The Unsafe Asylum opens up new horizons of Migration Studies where the victims are seen to be troubled by the inner psychological trauma. It can considerably be categorised as a vital specimen of 'Trauma Fiction.'<sup>7</sup>. a relatively new genre or an interdisciplinary field of engagement with literary fictions taking both trauma studies and literary texts together. Anne Whitehead rightly points out that "Trauma fiction overlaps with and borrows from bothpostmodern and postcolonial fiction in its self-conscious deployment of stylistic devices as modes of reflection or critique" (Whitehead 2004:3). Thinking from this perspective, Kala's postcolonial text could be seen as a critique of the territorial politics responsible for such a large-scale human

<sup>&</sup>lt;sup>6</sup> Find the story written by Saadat Hasan Manto, pp. 9-15, in the anthology *Bitter Fruit: The Very Best of Saadat Hasan Manto*. Trans. & ed. Khalid Hasan. New Delhi: Penguin Books India, 2008. Print.

<sup>&</sup>lt;sup>7</sup> Interested readers may look at Anne Whitehead. *Trauma Fiction*. Edinburgh: Edinburgh University Press, 2004.

migration. A good number of characters in this anthology like Rulda and Fattu. Iabal Junaid Hussain's son Asif in the story "No Forgiveness Necessary", Prakash Singh Kohli in "Belly Button". Harpreet Cheema/Firdaus in "Sita's Bus", and Venky in "Partitioning Madness" suffer from trauma-induced pathological disorders. In another story "Folie à Deux", thefear psychosis of an unnamed female narrator is transferred to her three children, which is transgenerational in nature. DrKala's profession as a Ludhiana-based psychiatrist who had encountered a good number of patients-cum-victims of postpartition violence and migration helped him in shaping these stories of madness and maladies. Dr Kala's own family had to migrate from Kala Shah Kaku, a village in Sheikharpura (now in Pakistan) to Ludhiana in December 1947. In one of his interviews, Anirudh Kala mentions,

Mental health is still not a priority in our country, so we can imagine how things would have been 70 years ago. What people went through is so painful that they fail even to describe it. They have chosen to suppress it. Numbness follows when the pain gets unbearable. People who went through this great tragedy decided to bury their feelings and fears, for it was just too painful torevisit. The impact of the partition on people's mental health is the least talked about aspect of this tragedy.<sup>8</sup>

The characters in this trauma fiction are representative of the millions of actual migrants who had suffered from, what Dominica LaCapra (1999) called, 'founding trauma', a unique

<sup>&</sup>lt;sup>8</sup> See the reporting "Partition of the Minds" by Divya Goyal published on December 1, 2019 published in *The Indian Express*.

https://indianexpress.com/article/lifestyle/books/partition-of-the-mindsanirudh-kala-the-unsafe-asylum-stories-of-partition-and-madness-5291163/

sort of trauma, (either situational<sup>9</sup> or historical<sup>10</sup>) "that paradoxically becomes the basis for collective and/or personal identity."<sup>11</sup> In recent times, several geneticists like Nathaniel Vincent Mohatt, Azure B. Thompson and Nghi D. Thai explored that this situational or historical trauma can travel to the survivors' offspring. So, I intend to examine in my paper the transgenerational transmission of trauma among the partition victims by closely analysing the text itself.

## II

According to *The International Dictionary of Psychoanalysis*, trauma essentially refers to certain horrific events of "violence and suddenness" that lead the victims to an "inflow of excitation" to such an extent that it "stuns the subject" (Alain De Mijola 2005:1800). There has always been a significant debate among psychoanalysts and trauma theorists regarding the transgenerational transmission of trauma. Can trauma be transmitted to the offspring of the victims? What are the

<sup>&</sup>lt;sup>9</sup> Trauma arising out of a particular situation or phenomena, whether natural or artificially created can be termed 'Situational Trauma'. Epidemic natural disaster, catastrophic war, sexual abuse, routine violence, major accidents etc. could give birth to situational trauma.

<sup>&</sup>lt;sup>10</sup> Originated with the study of Holocaust survivals, the 'Historical Trauma' refers to "the complex and collective trauma experienced over time and across generations by a group of people who share an identity, affiliation, or circumstance". (Nathaniel Vincent Mohatt, Azure B. Thompson, Nghi D. Thai, and Jacob Kraemer Tebes). This trauma can be transmitted across generations. For more information, see the article "Historical trauma as public narrative: A conceptual review of how history impacts present-day health" by Nathaniel Vincent Mohatt, Azure B. Thompson, Nghi D. Thai, and Jacob Kraemer Tebes, 2014. Published in Social Science & Medicine. 128 - 136Published online 2014 Ian 31  $106^{\circ}$ DOI 10.1016/j.socscimed.2014.01.043. Weblink: https://www.ncbi.nlm.nih.gov/ pmc/articles/PMC4001826/

<sup>&</sup>lt;sup>11</sup> See p. 724 of LaCapra, Dominick, 1999. "Trauma, Absence, Loss." *Critical Inquiry*, Volume 25(4), pp. 696–727. *JSTOR*, www.jstor.org/stable/1344100.

mechanisms for doing so? Or more specifically, can trauma be intergenerational or transgenerational? A small number of trauma theorists have recently explored that a certain kind of trauma is "subtle but pervasive"<sup>12</sup> and can be transmitted from its direct victim/s to the later generation/s of trauma survivors. This could be termed as transgenerational trauma or intergenerational trauma. Studies related to this field are relatively new. Ronald M Doctor and Frank N Shiromoto have rightly pointed out in their *The Encyclopedia of Trauma and Traumatic Stress Disorders* that "This type of trauma occurs in children of traumatised individuals, but it is usually subliminal or less obvious than trauma due to a firsthand experience." (Doctor & Shiromoto 2009:276)

Although Cathy Caruth has largely popularised the discipline of 'Trauma Studies'<sup>13</sup>, there are several other trauma theorists who have popularised the idea of transgenerational trauma. Dr Vivian Rakoff first studied the transgenerational transmission of trauma<sup>14</sup> while working at the Jewish General Hospital in Montreal in the case of some Brazilian offspring of Holocaust survivors (OHS) (Braga 2012:134). Soon this approach attracted global attention and many trauma theorists tried to link it with the racial discrimination against African Americans. Further, trauma theorists continued linking this with the World War veterans, Vietnam War veterans, the Armenians survivors of Turks attacks, survivors of the Atomic

<sup>&</sup>lt;sup>12</sup> See Ronald M Doctor and Frank N Shiromoto, 2009. *The Encyclopedia of Trauma and Traumatic Stress Disorders*. New York: *Facts on File Library of Health & Living*, P. 276

<sup>&</sup>lt;sup>13</sup> See the book by Cathy Caruth, 2016. *Unclaimed Experience: Trauma, Narrative, and History*. Johns Hopkins University Press.

<sup>&</sup>lt;sup>14</sup> For more details see Braga, L.L., Mello, M.F. & Fiks, J.P. Transgenerational transmission of trauma and resilience: a qualitative study with Brazilian offspring of Holocaust survivors. *BMC Psychiatry* 12, 134 (2012) DOI:10.1186/1471-244X-12-134

bombings of Hiroshima and Nagasaki by the US, and Cambodian and Iraqi victims of war, 9/11 terror survivors and so on. Later on, some child trauma theorists like Byron Egeland, Inge Bretherton, and Daniel Schechter have advanced the idea of transgenerational trauma, based on the findings and clinical observations of Selma Fraiberg.<sup>15</sup>

Under the umbrella of Transgenerational Trauma, one significant disorder is 'shared delusional disorder', a psychiatric syndrome generally known as 'Folie à deux'. Inthis type of disorder, the delusion or hallucinations caused by a certain traumatic event is transmitted to the next generation/s and somewhere the offspring 'shares' his/her post-traumatic disarray. Two French psychiatrists, Charles Lasègue and Jean-Pierre Falret first coined the term 'Folie à deux', and conceptualised it as "a relatively rare syndrome that has long since attracted much clinical attention."<sup>16</sup> According to The ICD-10 Classification of Mental and Behavioural Disorders<sup>17</sup>, this syndrome is generally known as 'Induced delusional disorder'; whereas the Diagnostic and Statistical Manual of Mental Disorders 4 (DSM IV)<sup>18</sup> terms it as 'Shared psychotic disorder.'<sup>11</sup>

This is no less evident in our present discussion of the story, "Folie à Deux" by Anirudh Kala in *The Unsafe Asylum: Stories of Partition and Madness* (2018). The story rightly chronicles the trauma-induced psychopathology of an unnamed woman, a post-partition migrant, whose PTSD is transmitted epigenetically to her offspring. Her delusional disorder is

<sup>&</sup>lt;sup>15</sup> Her monumental work "Ghosts in the Nursery" is the foundational text of trans/intergenerational trauma.

<sup>&</sup>lt;sup>16</sup> Arnone, Danilo et al, 2006. The Nosological Significance of Folie à Deux: A Review of the Literature. *Annals of General Psychiatry*, Vol. 5(11). DOI:10.1186/1744-859X-5-11

<sup>&</sup>lt;sup>17</sup>, World Health Organization.

<sup>&</sup>lt;sup>18</sup> The standard American Psychiatric Association's criteria.

somewhat shared by her children who suffer recurring panic attacks, chronic suicidal tendencies, and schizophrenic aberrations of their mother.

The story very minutely portrays a couple who had forcibly migrated from Multan. Pakistan to Patiala, Puniab in 1948. The migrant woman, later on, became a patient of Dr Kohli. The first panic attack of its kind was felt immediately after she had migrated from Multan. Such sort of complex stress disorder arising out of a particular situation can be termed as situational trauma. All the significant symptoms of paranoid schizophreniaauditory hallucination, paranoia, neurobiological like dysfunction of the brain, and delusion could be seen in the patient. She could hear the auditory hallucination of the "whisperings of a mob" (113) of some "bearded" men froma rival community threatening to "carve her to pieces" and "amputate her breasts". In an utter sense of paranoid schizophrenia, she "ran out into the rain" to avoid her persecutors. Later on, she was taken to an exorcist, and it is with the help of certain herbs as part of his treatment, that she began to recover slowly in the next few months. This continued for the next twenty years.

Meanwhile, she had lost her husband and given birth to three children. Suddenly a second attack, though more severe followed. She suffered from a delusion that "there was another person sleeping inside her" (114). The woman then began to suspect each and everyone close to her, and she used to hear confused noises which did not exist in reality. The trauma returned in the form of delusional disorder and to her alternative reality, that not only she, but her daughters too wereunder the threat of sexual assault. She could see some men "threatened to rape" her daughters because "they have grown up nicely" (114). Her pathological neurosis reached its culmination when she began to hide from her own family in an utter paranoid psychosis.

Suddenly, one night as a certain wedding procession was marching on the street nearby with firecrackers, a music band and dholwallas<sup>19</sup> the woman had another panic attack. She had developed a delusion that somebody was approaching to capture her and other members of the family and she started shouting that some attackers "were battering down the front door and shots were being fired" (116). One could easily guess the past traumatic events of the partition (like sexual assault) that the woman might have undergone. The fear psychosis returned to her time and again through different symbolic structures, and sometimes suicide attempts were followed. Finally, in utter desperation and a confused delusional state, she jumped over the roof of her house to death. This incidentof her suicide happened to be another source of trauma for the rest of the family members. Many of the traumatic traits of the Folie imposée (the primary inducer) could be seen to have transferred to her offspring, who are the secondary receptor. This phenomenon has its explanation in the discipline of Trauma Studies. One may be reminded of Cathy Caruth's notion of trauma as a "profound crisis of history."<sup>20</sup> According to Caruth,

If PTSD must be understood as a pathological symptom, then it is not so much a symptom of the unconscious, as it is a symptom of history. The traumatised, we might say, carry an impossible history within them, or they become themselves the symptom of a history that they cannot entirely possess (Caruth 1995:5).

<sup>&</sup>lt;sup>19</sup> Drummers that play the drum at specific occasions

<sup>&</sup>lt;sup>20</sup> See Anne Whitehead p. 5

It is evident in the text itself that the pathological symptoms seen in the woman protagonist are not merely products of the disturbed psyche/"unconscious" instead, they are the products of the troubled history, and it is in this way, that the traumatised subject, here, the victimised woman became a symptom of a history that she cannot entirely possess. The distressing symptoms of the troubled history could be located within her and in her progeny later on.

#### III

The title "Folie à Deux" actually means shared delusional disorder. I shall now discuss how the mother's delusional disorder is shared by her offspring transgenerationally in the second half of the story. The story relates to a similar sort of panic attack in the character of Om (the only boy in the family) who after his mother's death unexpectedly began to behave "very strange" (117). Some schizophrenic disorders like the auditory hallucinations of hearing the horrible murmurings like her mother used to could be seen in him. His condition deteriorated drastically, and he was taken to the mental hospital by his elder sister to be investigated by Dr. Kohli.

The common symptoms that his mother had been suffering from could be traced in him and a similar sort of delusion of the bearded men with green armbands and their sickles comingto capture him could be seen in him. The auditory hallucinations of confused and chaotic murmurings that he heard were epigenetically transmitted from his mother. It couldbe marked out when he "plugged his ears with his fingers, and seemed baffled that this did not muffle the obscenities" (117- 118), the same way his mother did. The major disorders of his mother like delusion, hallucination, and paranoia came unto him. On one of his bus trips, he found (in his alternate reality) that all the passengers inside the bus turned to be ISI agentsand were planning to detain him. This repetitive compulsion
was inherited from the mother that resurfaced at a different symbolic level. Here the ISI agents represent the other for whom her mother had developed a phobia. Om believed in his 'alternate reality' that the ISI agents jeered at his "manliness" (119) and in utter delusion, he considered that his mind was being controlled by "a man named Jeevanditta who had been dead for two hundred years but worked through a proxy in Pakistan" (120). Her mother's fear of "Muslims with sickles" (120) had resurfaced as the fear of ISI in Om. Later he stayed there in the hospital for nearly a month and with heavy doses of sedative, slowly began to recover.

### IV

After Om, the story takes us to Chitra, the youngest daughter of the family, who suddenly began to behave "oddly, over and above her regular fiery temper" (121). Somewhere she also began to share the similar sort of malady of her mother much like Om. Like her mother, she also suffered from obsessivecompulsive disorder and visualised an 'alternate reality'. Like her mother, Chitra began to believe that a 'Mussalman' doctor had killed her mother. We can see pretty clearly how a similar kind of traumatic disorder re-emerged at a different symbolic level. The bouts of a panic attack and depression, delusion disorder, anxiety and social withdrawal of Chitra and Om were analogues to each other that they have primarily derived from their mother. It became challenging for their elder sister to continue the family as she is the only earning member in the house and the only sane person.

Then, the story rapidly takes us to Dr. Kohli's chamber, who was busy writing an abstract of a paper for his next conference. Suddenly, the elder sister of the house came with her "hair open and dupatta trailing, sobbing, loudly" (123). Dr. Kohli was shocked by her abrupt appearance of this kind. His initial thought was that perhaps Om had committed suicide. But the Contextualising Migration...

condition was much more gruesome and pathetic than he could imagine. The girl shouted at Dr. Kohli and accused him saying,

Om and Chitra are not mentally ill, nor was my mother. There are real bearded Mussalman men out there, hundreds of them, carrying swords, shouting that they will kill us. I [the elder sister said] heard them! They can become small like Lilliputians, and crawl through the ventilators. *I saw them. You* [Dr. Kohli] *bastard! You have been pumping drugs into my brother and sister. Youare on their side. You killed my mother too. You are a psycho yourself a killer* (123). [Emphases mine]

It took no time for Dr. Kohli to understand that the only remaining sane family member was also affected by the transgenerational trauma. She also, much like others, began to believe in an alternate reality. In her delusional state, she held that Dr. Prakash Kohli was responsible for the family's mishap. To her, Dr. Kohli was one of the agents or perpetrators of violence, who belonged to the other side. Therefore, the ending is very pathetic and alarming because the sickness did not spare even the elder sister who took care of her siblings after their parents' death. Her delusions of "real bearded mussalman men out there, hundreds of them, carrying swords, shouting"

(123) were akin to those of her mother, Chitra and Om. She also feared that her family would be exterminated by the Mussalman men. To her, Dr. Prakash turned ultimately to be a psycho and a killer, an 'other' from the rival community. Not only that, she even accused Dr. Kohli of sexual assault. The story ends with the bitter tears of Dr. Kohli due to his long term engagement with this family. Professional detachment is indeed a must for a psychiatrist. But here, in this case, he could not maintain detachment. Dr Prakash Kohli was just wondering how the transgenerational trauma and its resultant shared delusional disorder arising out of post-partition migration affected the entire family. The concluding remarks of Dr Kohli are worth noting:

For a long time, I sat dazed. Then simply put my head down on the table and cried. The last time I had cried was when my father had gone out and got himself killed by a stray bullet. It was a similar blazing afternoon (123-124).

Thus, the transgenerational transmission of trauma and its associated delusional disorder gripped the entire family.

### V

The psychological effects of partition-induced trauma upon the forced/involuntary migrants can be seen in the story. The text rightly captures how buried/repressed memory resurfaces in various pathological behaviours of the victims, and those symptoms can recur in their offspring. It has its own clue/explanation in the scientific discipline of 'Epigenetics'. Epigenetics actually talks about how trauma generally is transmitted via genes inter/transgenerationally. Renowned psychologist, N. Kellerman, who had worked extensively with the children of Holocaust Trauma survivors notes that trauma can be transmitted by the "parent's child-rearing behaviour.<sup>21</sup> Here, Kellerman wanted to suggest that through the interaction between a child (trauma receptor) and the parents (trauma inducer), the trauma and its resultant psychosis may be transferred epigenetically.<sup>22</sup> The traumatic disorders of an

<sup>&</sup>lt;sup>21</sup> Interested readers can look at the article by N. Kellerman, 2013. Epigenetic Transmission of Holocaust Trauma. *The Israel Journal of Psychiatry and Related Sciences*, 50(1), pp 33-39.

<sup>&</sup>lt;sup>22</sup> Shannon Sullivan has done groundbreaking research in this field published in an essay called "Inheriting Racist Disparities in Health: Epigenetics and the Transgenerational Effects of White Racism." The article is published in *Critical Philosophy of Race*, vol. 1, no. 2, 2013, pp. 190–218.

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individual usually disrupt cellular function. According to Kellerman, it is the traumatic environment of the inducer to which the offspring is/are exposed, and it is in this process the germ cell of the source agent could be transmitted to the epigenomes of the offspring.

A handful of other geneticists like Supratim Choudhuri, Miguel Almeida, António Miguel de Jesus, Antonio Rene and others have very recently discovered one such non-coding  $RNA^{23}$ , which they think, functions in the transmission of transgenerational trauma via epigenetic mechanisms. Again, a few other researchers like Rachel Yehuda and Amy Lehrner conjecture only in 2018 that the offspring's early exposure to the traumatic environment especially, at the post-natal period, actually changes the methylation patterns, particularly the glucocorticoid receptor ( $NR_3C_1$ ) gene.<sup>24</sup>

Another way of transmitting the genes of trauma and its related delusional disorder to its later generation/s is to transfer the genes at the gestational stage of a mother's pregnancy through the uterine environment. Disturbing or chaotic stimuli enter through the uterine environment during pregnancy, and it could affect the offspring psychosomatically.<sup>25</sup> A similar mechanism can be traced in the offspring of partition victims whose

<sup>&</sup>lt;sup>23</sup> Supratim Choudhuri, in his article "Small Noncoding RNAs: Biogenesis, Function, and Emerging Significance in Toxicology" talked about this noncoding RNAs which functions in that way of transgenerational transmission of trauma. He has published his finding in *Journal of Biochemical and Molecular Toxicology*, Vol. 24, No. 3: 195–216. (May–June 2010). DOI:10.1002/jbt.20325. PMID 20143452

<sup>&</sup>lt;sup>24</sup> Rachel Yehuda and Amy Lehrner worked extensively on the survivors' traumatic traits to their offspring in the post-natal stage. See their article "Intergenerational Transmission of Trauma Effects: Putative Role of Epigenetic Mechanisms". *World Psychiatry*, 17(3). September 7, 2018.

<sup>&</sup>lt;sup>25</sup> See Michael T Kinsella and Catherine Monk. (September 2009). "Impact of Maternal Stress, Depression and Anxiety on Fetal Neurobehavioral Development". *Clinical Obstetrics and Gynecology*. 2009; 52 (3): 425–440.

parents were exposed to traumatic stimuli in the past. In this story also, the same mechanism works in both cases – Chitra and Om. The entire family shared a similar sort of delusion, of the "Muslim men baying for blood and honour" and it "had been passed down through the family like a cursed heirloom" (121).

It would be unfair to take this story of the particular family in isolation or generalise this transgenerational transmission of trauma connected with every migrant family. Anirudh Kala's story primarily talks about the shared delusional disorder, one of the many pathological, post-traumatic disorders that some migrant families had suffered from. The source of the historical trauma is the partition, but the manifestations of the traumatic experiences of the migrants vary both at the individual and the collective levels. In conclusion, it can be said that under the umbrella of Partition Fiction. Anirudh Kala's story secures a distinctive place because, it rightly captures the transgenerational transmission of the trauma of the partition migrants, which is unique in the context of the Partition-induced migration. It deals with the "Folie à Deux" syndrome, an emerging area of research in Psychoanalysis and Trauma Studies. Kala's expertise in psychiatry and his real-life experiences of treating hundreds of partition migrants are powerfully reflected in the stories of The Unsafe Asylum. This story, "Folie à Deux" along with some other narratives like"No Forgiveness Necessary", "Belly Button", and "Sita's Bus", "Partitioning Madness", "Love during Armistice" open up a new horizon in the realm of Trauma Fiction.

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# Practical Feasibility of Arago-Biot and Lorentz-Lorenz Theory Through Variation of Refractive Index of Typical Binary Liquid Mixtures Employing Low-Cost Experimental Setup

Pabitra Tripathy <sup>1,2</sup>, Prakash K. Mandal <sup>3,4</sup>, Abhijit De <sup>5</sup>, Kriti Ranjan Sahu <sup>2,6,\*</sup>

- <sup>1</sup> Dept. of Physics, P K College, Contai 721401, Purba Medinipur, W. B., India; pabitraphysics001@gmail.com (P.T.);
- <sup>2</sup> Dept. of Physics, Egra SSB College, Egra 721429, Purba Medinipur, W. B., India; kriti.sahu91@gmail.com(K.R.S.);
- <sup>3</sup> Dept. of Chemistry, Egra SSB College, Egra, 721429, Purba Medinipur, W. B., India; prakash12chem@gmail.com (P.K.M.);
- <sup>4</sup> Dept. of Chemistry, University of Calcutta, 92, A. P. C. Road, Kolkata 700009, W. B., India
- <sup>5</sup> Dept. of Physics, Taki Govt. College, Taki 743429, North 24-Paraganas., W. B., India; abhijit@tgc.ac.in (A.D.);
- <sup>6</sup> Dept. of Physics, Bhatter College, Dantan 721426, Paschim Medinipur, W. B., India
- \* Correspondence: kriti.basis2020@gmail.com (K.R.S.);

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Abstract: Optical properties of the solutions comprising of two or more miscible liquids have been of immense interest both in the area of chemical and physical sciences. To date, there are reports on studies regarding different combinations of binary liquid mixtures. However, the experiments involved are either high-ended or using sophisticated instrumentation. Our prime objective is to set up a simple laboratory arrangement to estimate the refractive index of typical binary-liquid mixtures obtained by proportionate variations in combinations selecting from benzene, ethyl acetate, tetrahydrofuran, and water; without involving high-standard instrumentation or expensive laboratory setups. In the present study, we adopted a basic method to determine the refractive index of pure liquids of low polarity, like, benzene ( $C_6H_6$ ) and tetrahydrofuran or THF ( $C_4H_8O$ ) and of high polarities, such as ethyl acetate or EtOAc or EA ( $C_4H_8O_2$ ), and water ( $H_2O$ ) and also their binary homogeneous mixture with high accuracy. Our experimental data involving variation of refractive index with molar volume fraction matched very well with theoretical interpretations by Arago-Biot and Lorentz-Lorenz equation. In our results, density corrections have been neglected as we have chosen non-volatile solvents.

# **Keywords:** refractive index; binary-liquid mixtures; Arago-Biot equation; Lorentz-Lorenz equation; benzene ( $C_6H_6$ ); tetrahydrofuran ( $C_4H_8O$ ); ethyl acetate ( $C_4H_8O_2$ ); low cost experimental setup.

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### 1. Introduction

Optical, translational, molecular, structural, and other important physical properties of liquid solutions, such as vapor pressure, surface tension, viscosity, ultrasonic velocity, volumetric and acoustic properties alongside refractive index, have been seeking attention or attracted the attention of physicists, physical chemists, and experimental theoreologists primarily of both academic and practical interest[1-30]. In most cases, the physical properties of pure liquid or mixture of liquids, such as dielectric constant, polarizability, density, mole fraction (for mixtures), etc., have been explored through measurement of refractive index at a different variation of concentration and temperature. On the one hand, polarization in optically active solution involving solute-solvent combinations led us to determine the concentration and

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# **Influence of PEDOT:PSS Doping on the Performance of Organic Solar Cells**

### Kriti Ranjan Sahu <sup>1,2,3,\*</sup> (D, Abhijit De <sup>4</sup> (D)

- 1 Dept. of Physics, Bhatter College, Dantan, 721429, 721426, Paschim Medinipur, W. Bengal, India; kriti.basis2020@gmail.com (K.R.S.);
- Dept. of Chemistry, Organic Device Laboratory, IIT, Guwahati 781 039, Assam, India;
- 3 Dept. of Physics, Egra SSB College, Egra 721429, Purba Medinipur, W.Bengal, India; kriti.sahu91@gmail.com (K.R.S.);
- 4 Dept. of Physics, Barasat Government College, Barasat, District - North 24-Paragnas, W. Bengal, Pin-700124, India; ABHIJIT.DE@bgc.ac.in (A.D.);
- Correspondence: kriti.basis2020@gmail.com (K.R.S.);

Scopus Author ID 26025165000

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Abstract: Fabrication of Organic Solar Cells (OSC) using PEDOT:PSS, has been focussed on the formation of the four-layered configuration of : ITO / PEDOT:PSS / P3TH:PC60 BM / LiF with Al metal layers its electrode. The active layer comprised P3TH:PC60 BM, where P3HT formed the donor and PC60 BM the acceptor components. Interestingly, it has been observed that the OSCs fabricated from ethylene glycol doped PEDOT:PSS depicted Power Conversion Efficiency (PCE) of about 2 times more than that of OSCs made from pure PEDOT:PSS. After optimizing process parameters(~ 16% of DMF, ~10% of DMSO, and ~ 12% EG in PEDOT:PSS) and continued loading of doped components, the conductivity reflected a decreasing trend. Such a phenomenon was attributed to an increasing distance between the successive conductive grain/domain, which has been explained based on Atomic Force Microscopy (AFM). Moreover, stress has been made on the inter-junction behavior of carrier transport, particularly the hole conduction mechanism. Further, the perovskite-based solar cell has been compared and discussed to understand material behavior and device performance better.

#### Keywords: organic solar cells; perovskite; AFM; conductivity; EG.

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### 1. Introduction

Recently, there have been sincere efforts to venture into the development of Organic Solar Cells (OSC) to make their entry in the device arena dominated by the conceptual and fundamental silicon and its alloy materials by a remarkable and revolutionary route. The amount of research and effort has been marvelous and of tremendous magnitude to open up fundamental aspects and technological importance [1]. The prime concern and criteria for solar cells along with other optoelectronic devices (LED, Photocell, Photo - Sensors, etc.), have been cost factors, large-area fabrication, reliability, and stability. To date, there are a host of references concerning both Organic Solar Cells (OSC) and PEDOT: PSS-based OSCs [2-39]. Thus, there are vast features to be attended a demanding lot of attention, study, and research to solve the lingering problems to meet the energy crisis of the present and future world. One of the main points of concern that still remains life is the multi-junction device characteristics that work wonders but bring about many device complexities and pose difficulties for integrated device application. The prime fundamental concept arose from the photo-generated carriers in the active-intrinsic layer and the conduction of both electrons and holes through the inactive https://biointerfaceresearch.com/





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Beyond Born-Oppenheimer based diabatic surfaces of 1,3,5-C<sub>6</sub>H<sub>3</sub>F<sub>3</sub><sup>+</sup> to generate the photoelectron spectra using time-dependent discrete variable representation approach<sup>+</sup>

Soumya Mukherjee, 1ª Satyam Ravi, 1ab Joy Dutta, 4 Subhankar Sardar 4 and Satrajit Adhikari 🔞 \*\*

Author affiliations

#### Abstract

In this article, Beyond Born–Oppenheimer (BBO) treatment is implemented to construct diabatic potential energy surfaces (PESs) of 1,3,5-C<sub>6</sub>H<sub>3</sub>F<sub>3</sub><sup>-</sup> over a series [eighteen (18)] of two-dimensional (2D) nuclear planes constituted with eleven normal modes ( $Q_2$ ,  $Q_{9,v}$ ,  $Q_{13,v}$ ,  $Q_{13,v}$ ,  $Q_{18,v}$ ,  $Q_{10,v}$ ,  $Q_{10,v}$ ,  $Q_{12,v}$  and  $Q_{12,v}$ ) to include all possible nonadiabatic interactions among six coupled electronic states ( $\tilde{X}^2 E''$ ,  $\tilde{A}^2 A_2'$ ,  $\tilde{B}^2 E'$  and  $\tilde{C}^2 A_2'$ ). We had formulated explicit expressions of adiabatic to diabatic transformation (ADT) equations [S. Mukherjee, J. Dutta, B. Mukherjee, S. Sardar and S. Adhikari, *J. Chem. Phys.*, 2019, **150**, 064308] for the same system forming six state sub-Hilbert space and at present, these ADT equations are solved by incorporating MRCI level *ab initio* adiabatic PESs and CP-MCSCF calculated nonadiabatic coupling terms (NACTs) to derive diabatic PESs and couplings. Such single-valued, smooth, symmetric and continuous diabatic surface matrices are utilized to carry out multi-state multi-mode nuclear dynamics with the help of time-dependent discrete variable representation (TDDVR) methodology to compute the photoelectron (PE) spectra of 1,3,5-C<sub>6</sub>H<sub>3</sub>F<sub>3</sub>. Our theoretically calculated spectra for  $\tilde{X}^2 E''$ ,  $\tilde{A}^2 A_2'$  and  $\tilde{B}^2 E' - \tilde{C}^2 A_2'$  states using BBO treatment and TDDVR dynamics show peak by peak correspondence with the experimental results as well as better than the findings of the multi-configuration time-dependent Hartree (MCTDH) method.

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Another Wave of Forest and Adivasi Land Alienation? 75 Revenue versus Forest Pattavam and Adivasi Land **Question in Kerala** Abhilash Thadathil and Amitha Bachan K.H.

# Unlawful Activities: Microeconomic Analysis of Illegal Firms

# Swastick Sen Chowdhury, Santanu Ghosh and Panchanan Das

Research on corrupt and criminal activity has been of particular interest among social scientists for over three decades. This paper examines in terms of a simple micro-theoretic exercise an illegal firm's decision-making behaviour. Simple models of a profit maximizing illegal industrial firm are set up and conditions under which illegalisation of work and production occur are derived. Moreover, we explore the cases of detection of the firm at different phases of its production process and also assess the impact of deterrence, if any, on the scale of illegal activity.

# I Context of the Study

In a developing and low-income country like India, where capitalist development is yet to reach its maturity, production and employment in the illegal sector of the economy occupy an important position. With the growth and spread of capitalism, the division between the legal and the illegal sectors gradually emerged. Unlike overground business, underground business runs on oral contracts and mutual trusts. Since the business is illegal in nature, and therefore risky, written contracts are not feasible. Because of the oral nature of the contracts, the underground firms are able to save a lot of transaction costs, which often become quite high in today's corporate world. An illegal economy is a secret market that is characterised by non-compliance of institutional set of rules. Examples include illegal currency transactions, drug trade, human trafficking, prostitution (where prohibited), income tax evasion, etc. The preferred medium of exchange in illegal transactions is cash, since it does not leave a footprint.

People tend to work in the underground economy for a variety of reasons. Most of these lack the skills to obtain jobs in the mainstream economy. Some choose these types of work because these pay more than mainstream jobs. A third category of workers prefer this because of the personal freedom they enjoy

Swastick Sen Chowdhury, Assistant Professor, Department of Economics, Bhatter College, Dantan 721426, West Bengal, Email: swastick.88@gmail.com

Santanu Ghosh, WBSES, Professor, Department of Economics, Maulana Azad College, Kolkata 700013, West Bengal, Email: manali.jheelum@gmail.com

Panchanan Das, Professor, Department of Economics, University of Calcutta, Kolkata 700050, West Bengal, Email: p.das.wbes@gmail.com

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# Measuring Citation Diffusion of Selective Indian Physics and Astronomy Journals by Citation Swing Factor (CSF)

Amit Kumar Das<sup>1</sup>, Bidyarthi Dutta<sup>2,\*</sup>

\*Central Library, Bhatter College Dantan, Paschim Medinipur, West Bengal, INDIA.
\*Vidyasagar University, Midnapore, West Bengal, INDIA.

#### ABSTRACT

The *h*-index, Introduced by Hirsch, is based on the mutual variation between the number of cited and source items. The continuous citation accumulation process over time results in diffusion of cited items from the h-core zone to the adjacent citation-asymmetric h-excess and/or h-tail zones. The indicator Citation Swing Factor (CSF) has recently been developed to measure this diffusion process quantitatively on the basis of h-core citations, excess citations and total citations. CSF is defined as the ratio of change in FET to change in FET, where FHE (Fractional H-core to Excess citation) indicates the ratio of h-core citations to excess citations and FET (Fractional Excess to Total citation) indicates the ratio of excess citations to total citations. The observed or experimental value of CSF as followed from the basic definition, i.e. the ratio of change in FHE to change in FET over consecutive years, results (-R<sup>2</sup>/he<sup>2</sup>) that was obtained on the basis of a theoretical calculation, where R<sup>2</sup>, h<sup>2</sup> and e<sup>2</sup> indicate total citations, h-core citations and excess citations respectively. The later expression indicates the expected or theoretical value of CSF. This paper found observed values of CSF for filteen esteemed Indian physics journals over the last decade (2010-2019) and compared it with the respective theoretical values. The average error over all journals for ten years is found 2.94% indicating close proximity between theoretically expected and practically observed values. Only one journal, viz. *Builetin of the Astronomical Society of India* shows large discrepancy between expected and observed values with an average error of 14.3%.

Keywords: h Index, Excess Citation, e-Index, R Index, Total Citation, Citation Diffusion, Citation Swing Factor, Indian Physics Journal.

#### INTRODUCTION

The citation analysis is a tool for quantitative studies of science research output, Pinski and Narin<sup>[1,2]</sup> were first who applied citation analysis in a systematic way to assess institutions using a standard methodology. Eugene Garfield<sup>[1,2]</sup> illustrated in several articles the potentialities of citation analysis in the evaluation of research faculty. According to Price.<sup>[6]</sup> citation

social web and its fast uptake by scholars,<sup>[12]</sup> The accretion of citation by papers, though varies widely across disciplines, yet the diffusion of citation shows the S-curve for cumulative citations in all major science disciplines that is reckoned as a general citation diffusion model introduced by Price.<sup>[6]</sup>

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Citation Swing Factor: An Indicator to Measure Citation Diffusion

#### Correspondence Bidyarthi Dutta

Department of Library and Information Science Vidyasagar University Midnapore-721 102, West Bengal, INDIA. Email id: bidyarthi.bhaswati@gmail.com

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### WIStPR encomester factor

# Scrutinising uncitedness and few h-type indicators of selected Indian physics and astronomy journals

Amit Kumar Das<sup>a</sup> and Bidyarthi Dutta<sup>b</sup> \*Central Library, Bhatter College, Dantan, Paschim Medinipur - 721 426, West Bengal; Email: amitkumardas19@yahoo.co.in

<sup>b</sup>Department of Library and Information Science, Vidyasagar University, Midnapore 721 102, West Bengal; Email: bidyarthi.bhaswati@gmail.com

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The uncitedness of twelve Indian physics and astronomy journals over twelve years (2009-2020) time span is analysed here. Besides Uncitedness Factor (UF), three other indicators are discussed, viz, Time-normalized Citation per paper (CY), H-core Density (HD) and Time-normalized H-index (TH). The journal-wise variational patterns of these four indicators, i.e., UF, CY, HD and TH and the relationships of UF with the other three indicators are inalysed. The calculated numerical values of these indicators are observed to formulate seven hypotheses, which are tested by the F-Test method. The average annual rate of change of uncited paper is found to be 67% of the total number of papers. The indicator CY is found the meanly constant. The indicator TH is found to be nearly constant for all the journals. The UF inversely varies with CY and TH for the journals and directly varies with TH over the years. Except for a few Indian journals in this field is higher by 12% as compared to foreign journals in this field, which indicates a possible poor circulation of the journals.

Keywords: Uncitedness; Uncited Paper; Citation Analysis; h-Index; h-type Indicator; Indian Physics Journal; Indian Astronomy Journal; Scientometrics: India; Bibliometrics: India; Scientometrics of Physics; India

#### Introduction

Scientometrics or bibliometrics studies generally focus on highly cited items. Poorly and uncited works are not generally studied. The literal meaning of the word 'uncited' is 'not quoted' or 'not cited', which is just opposite to 'cited'. The story of uncitedness has its roots actual cause behind the very centripetal nature of citation accumulation, which is the basis for the wellknown Preferential Attachment Model or Mathew Effect. This reason emphasises the fact that citation always has a tendency to follow some precursors resulting in the common feature of citation attracting



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# Enhancement of optical properties and dielectric nature of Sm<sup>3+</sup>doped Na<sub>2</sub>O–ZnO–TeO<sub>2</sub>Glass materials



Jyotindra Nath Mirdda<sup>a</sup>, Subhadipta Mukhopadhyay<sup>a</sup>, Kriti Ranjan Sahu<sup>b,\*</sup>, Makhanlal Nanda Goswami<sup>c</sup>

<sup>a</sup> Dept. of Physics, Jadavpur University, Kolkata, West Bengal, 700032, India

<sup>b</sup> Dept. of Physics, Bhatter College, Dantan, Paschim Midnapore, West Bengal, 721426, India

<sup>c</sup> Dept. of Physics, Midnapore College, Paschim Midnapore, West Bengal, 721101, India

ARTICLE INFO	A B S T R A C T
Keywords:	Samarium doped Na <sub>2</sub> O–ZnO–TeO <sub>2</sub> (NZT) glasses were prepared by the melt quenching method. The glass-
Thermal analysis	forming ability and glass stability of prepared glass was estimated by Hruby parameter using Differential
FTIR	Thermal Analysis (DTA) and Thermo-gravimetric Analysis (TGA). The study of FTIR spectra and X-ray diffraction
UV–Vis absorption Fluorescence	described the ionic nature and the amorphous pattern of glass respectively. The absorption peaks were observed

described the ionic nature and the amorphous pattern of glass respectively. The absorption peaks were observed for the transitions  ${}^{6}H_{5/2}$ - ${}^{4}P_{3/2}$  at 402 nm,  ${}^{6}H_{5/2}$ - ${}^{4}M_{19/2}$  at 418 nm,  ${}^{6}H_{5/2}$ - ${}^{4}I_{15/2}$  at 462 nm and  ${}^{6}H_{5/2}$ - ${}^{4}I_{11/2}$  at 478 nm in the absorption spectra. The optical band gap energy (Eg) was calculated and observed to be decreased from 2.95 eV to 1.58 eV with doping concentration. The visible emission band was observed in the Sm<sup>3+</sup> doped glass samples. The variation of dielectric constant with frequency was found to be independent for the frequency range 3 kHz - 2 MHz. The measurement of temperature-dependent dc conductivity showed Arrhenius type mechanism of conduction.

#### 1. Introduction

Dielectric constant

Tellurium di-oxide (TeO<sub>2</sub>) is a promising glass network maker in the existence of alkali, alkaline earth and transition metal oxides (TMO) as modifiers, but it does not form glass itself. So, TeO2 is familiar as a conditional glass producer, as it requires a modifier to produce the glassy state of the materials. Tellurite glass materials have some interesting properties like transparency at room temperature, hardness of satisfactory strength and attractive corrosion resistance [1–3]. Tellurite glasses are very interesting materials for linearand non-linear applications in optics, due to their significant characteristics such as low melting point, small phonon energy and large refractive index. It has also important for high dielectric constant, good chemical durability, high thermal stability, non-hygroscopic, with a large transmission window and the possibility to integrate a large quantity of rare-earth ions. It can be also applied as micro-lenses in photocopiers and mobile-phone cameras, IC photo masking in photolithography, photosensitive glass, hard disks, substrates for solar cells, artificial bones for mankind and dental transplants, etc. Besides these applications, the tellurite glass has been used for the protection of X-ray radiations,

gamma radiations and other ionizing radiations from radioactive materials. Radiation exposure from different nuclear sources such as nuclear power plants, radioactive mining, conservation of radioactive sources etc. Can have a serious negative effect on the human body. Earlier, lead (Pb) has been used to protect these radiations. But several disadvantages have been found to use lead as a shielding material of nuclear radiation. Recently, material scientists have suggested that the tellurite/borate glass can be used as an efficient shielding material of nuclear radiations without any environment pollution [4–11]. Glass materials are practically used for optical appliances due to their various compositions, physical isotropy and deficiency of grain boundaries. Tellurite glasses are useful to study by industrial researchers not only because of their methodological applications, but also owing to a fundamental significance in thoughtful their microscopic mechanisms [12,13].

The luminescence properties of optical materials have been broadly observed not only for applications in phosphors, scintillators and laser crystals but also for scientific importance during the last two decays [14–20]. In presence of rare-earth ions, the glass materials are excellent luminescence intensity because of their emission power due to 4f-4f and

\* Corresponding author. E-mail address: kriti.basis2020@gmail.com (K.R. Sahu).

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### The Pathology of Partition: Analyzing the Trauma of Partition and its Psychological Disorders in the Select Short Fiction of Bhisham Sahni

Mir Ahammad Ali Assistant Professor of English Bhatter College Dantan, Paschim Medinipur (West Bengal), India Email: mirahammadali1990@gmail.com

#### Abstract

The psychological after-effects of the 1947 Partition of India, primarily in the form of traumatic neuroses, constitute one of the emerging areas of critical engagement in the broad domain of Partition Studies. Unlike the physical violence, the psychological wounds of Partition could not be convalesced immediately. The deep-rooted traumas of partition lead to further psychological disorders. Looking at its fictional representations, primarily the short partition fiction of Bhisham Sahni, we may find that most of the characters in Sahni's short stories suffer from the 'belated experience' of Partition trauma that continues to haunt their lives later on and affects their behavioural patterns. Sahni's short narratives on Partition like "The Train Has Reached Amritsar," "Take Me Home," "Pali" and "Veero" have depicted the traumatic disorders of the victims more than the partition violence. This paper would focus on the select short Partition fiction of Sahni from a psychoanalytic point of view and try to explore the psychological trauma of Partition and its associated pathogenic effects as reflected in these stories.

Keywords: Partition and Psychological Trauma, Pathology of Partition, Psychological Disorders in Bhisham Sahni's Fiction

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In an interview with Alok Bhalla on the theme of Partition, the Sahitya Academy Award winner of modern Hindi Literature, Bhisham Sahni has rightly pointed out the main crux of the Partition induced violence and its associated guilt or trauma in the following words:

I think barbarism is not a permanent feature of human conduct. It depends on a combination of circumstances which somehow incite man's baser instincts. Under certain circumstances men lose all sense of decency and proportion, and indulge in butchery. After some time, the barbaric impulses slowly subside and give way to reason. Men begin to repent their actions. (Bhalla 132)

Sahni has suggested here that Partition violence in its varied forms stemmed out from a particular situation or "a combination of circumstances" that consequently engulfed almost the entire social fabric. Widespread 'barbarism' in the form of communal frenzy and the innate desires of the masses to annihilate the 'other' predominated in the social sphere in such a way that men were seen, as Sahni puts it, to be devoid of their basic human traits as if they had lost "all sense of decency and proportion" and solely indulged in "butchery." The horrific cataclysm of Partition, in fact, turned millions of common civilians to bloodthirsty, communal, barbaric beasts, and 'bestiality' (Chakraborti 101) emerged as one of the foremost guiding metaphors in the majority of the Partition fiction of Punjab province. This sudden change of the mass civilized beings to violent beasts in the wake of a particular historical juncture could be analyzed with the help of a number of other inter-disciplines like Psychoanalysis, Trauma Studies, and Violence Studies and many others.

In fact, the psychological after-effects of 1947 Partition of India, primarily in the form of traumatic neuroses, constitute one of the emerging areas of critical engagement in the broad domain of Partition Studies. A number of responses are coming, very recently, in the late 2010s and the early 2020s, from the mainstream Psychiatry and Trauma Studies Departments, that have mostly been silent about the horrendous traumatic aftermaths of Partition violence. The unprecedented physical violence that occurred during and after the Partition of India, in the forms of multiple sectarian attacks, mass carnage, riots, arson, brutal rapes, and body humiliations had been subjected to gradual convalescence with the passage of time. The psychological wounds along with the deep-rooted traumas, however, could not be surmounted overnight. On the contrary, they have led to multiple forms of pathological neurosis in thousands of its victims like Anxiety Disorder, madness, panic attacks, Post Traumatic Stress Disorder (PTSD), Acute Stress Disorder, Repetitive Compulsive Disorder, Emotionally unstable personality disorder (EUPD), Rape Trauma Syndrome (RTS) paranoia, and so on. This interdisciplinary dialogue between Partition Studies and Mental Health Studies (Trauma Studies and Psychoanalysis) is altogether a new domain of research that needs critical attention.

If we look at the body of Partition Literature of Punjab province, we could see that a good number of writers of Partition fiction like Intizar Hussain, Mohan Rakesh, Krishan Chander, Khuswant Singh, Chaman Nahal, Rajinder Singh Bedi, Saadat Hasan Manto, and Ismat Chughtai among others have been keenly interested in representing both the physical as well as the psychological aspect of Partition violence, although the psychological aspect has not been much discussed. There has been another leading writer who, in his short fictional pieces, is able to capture the traumatic aspect of Partition violence and its attendant pathological disorders. He is none other than Bhisham Sahni (1915-2003). His fictional masterpiece *Tamas* (1974) has vividly recorded the gloomy atmosphere of communal tension in the form of interethnic violence. But his short narratives of Partition like "Amritsar Aaa Gaya" (The Train Has Reached Amritsar), "Mujhe Mere Ghar Le Chalo" (Take Me Home), "Pali" and "Veero", have focused more on the traumatic disorders of the victims than on representing partition violence.

This paper would be analysing Partition from a psychoanalytical point of view, especially, how Partition has led to a kind of collective Psychological Trauma and its associated pathogenic effects, as reflected in the select short stories of Bhisham Sahni. I shall focus on the two short stories of Sahni: "The Train Has Reached Amritsar" and "Take Me Home" taking help from the theoretical models of trauma and psychopathology, given by Cathy Caruth, Sigmund Freud and a few other trauma theorists.

### Π

Cathy Caruth, the doyen of Trauma Theory, suggests that psychological trauma arises out of certain unpleasant or distressing events that consequently fragment the identity of an individual and the trauma continues to bedevil the victims later on in their lives.

(Caruth, *Unclaimed Experience* 4) Looking at the body of Partition Literature of Punjab province, especially the short partition fiction of Bhisham Sahni from a psychoanalytical gaze, one may find that a number of characters of Sahni (much like those of Manto and Chughtai) behave in a chaotic way due to the psychological trauma they have imbibed during Partition. Sahni's protagonists suffer from different sorts of psychic disorders that sometimes last for a few hours to a few days, and sometimes they linger throughout their lives. For example, Nathu's guilt consciousness in Sahni's *Tamas* is very much prolonged; whereas the traumatic disorders of the protagonists in his short partition stories are quite ephemeral or short-lived. The first story that I am going to analyze captures the psychological/ traumatic disorder of a man that lasts for a brief period of time. In the story "Amritsar Aaa Gaya" (The Train Has Reached Amritsar),<sup>1</sup> we observe a sudden change in the mood/behaviour of a timid, frail-looking Babu, who suddenly got so furious due to certain external stimuli like humiliations, jeering remarks, mockeries about his sexual potency, his preference of food habits etc. by a group of men that he satisfied his *ego* only through avenging the life of an innocent old man from the rival community.

Narrated mostly in the first person, the story recounts a train journey during the high tide of Partition from the newly created Pakistan to the other side of the border. Among the passengers were a Sardarji, three Pathans and a "frail looking" Babu, an old woman, and a few other passengers along with the narrator in the same compartment. Most of them were engaged in casual talks, occasional debates, funny gossips, jeering, teasing etc. The passengers were absolutely confused about the newly created border, the abrupt decision of the creation of Pakistan, and its terrible consequences. But the topic that fascinated them most was the bloody riots that were happening all around. Each one of them was very much tensed about an imminent attack on the train that may occur at any moment during the course of their journey. However, a group of Pathans was absolutely indifferent to the apprehension of the other passengers. Contrarily, they were busy cutting jokes at the frail-looking Babu by offering him the boiled meat and a piece of *naan* in a very jovial manner knowing full well that he won't accept the meal. One of the Pathans told him

Here, Babu, eat. You will become strong like us. Your wife will be pleased. Eat it, dalkhor. You are weak because you only eat dal. (2)

The Pathans continued to make fun of him and a few other passengers joined the process soon. Time and again the Pathans tittered at his masculinity, his sexual potency, and gendered identity etc, the issues that the Babu wanted to avoid inwardly but could not help it. The harmless jeering of the Pathans turned out to be an acute source of trauma for the Babu as he felt constantly humiliated. According to Sigmund Freud, disturbing or chaotic situations like this may lead to a kind of "traumatic neurosis" in the victim (Caruth, *Unclaimed Experience* 16) which may split off the *self* of the affected one. (Freud 8) This is quite evident in the story.

As the train reached Wazirabad station and the news of the communal riots was approaching the passengers, the Babu got very much frightened and continued to babble absentmindedly that something was wrong (3). The tense situation deteriorated quickly and an "eerie silence" pervaded all over the compartment. As soon as a couple tried to climb up the over-crowded compartment with a huge bundle of luggage, one of the Pathans kicked them off. The Babu witnessed this incident but preferred to remain silent. Contrarily, the Babu became so much hyper-vigilant about an uncertain dread that he became panicked and "looked deathly pale." (5) When the news of a riot reached the passengers and everyone within the compartment was pulling their windows down and a loud rattling sound approached, the Babu leaped off from his seat and reclined on the floor of the compartment out of utter panic. To humiliate him, the Pathans resumed their mocking remarks:

Oh, coward, are you a man or a woman? Don't lie there on the floor. You are a disgrace to all men. (6)

However, the Babu did not pay any attention to them as he was trembling with fear and the sense of panic disrupted his normal physical movement: "The Babu's lips were dry. He stammered something and then fell silent." (6) This traumatic happening may be termed as Acute Stress Disorder (ASD), which generally arises in a victim out of certain threats of death or some serious injuries from certain outside forces. The pathological disorders were very much conspicuous in his behaviour. Out of panic, he became speechless and his thoughts were disrupted. He seemed to suffer from a certain trepidation that "people outside were either throwing stones or firing at the train. (6)

However, his behavioural pattern changed drastically as he learned that the train was finally approaching Amritsar after crossing Harbanspura. The frail-looking, timid Babu suddenly screamed in excitement and shouted repeatedly that "We have arrived in Amritsar!" (9) There was a sudden change in his personality, and unexpectedly, he began to retort to the Pathans: "Come down, you bastard! You son of a bitch!... May your mother...." (9) This sudden change in his mood/behaviour can be analyzed with the help of Psychoanalysis. To consolidate his fractured *self*, the Babu was certainly looking for a denominator in his subconscious mind that would allow him to preserve his 'imagined' species formation. As the event of the kicking off of the couple by the Pathans flashed upon his mind, he began identifying himself along with the communal/ religious identity. The falsifying of the *ego* would give him a kind of permissive logic to perpetrate violence upon the 'other' to regain his lost/fractured identity.

As the train slowly arrived at the Amritsar station and the overcrowded platform "was buzzing with talk about the riots" (10), the Babu mysteriously disappeared and came later on with a lethal weapon in his hand only to see that the Pathans had left the compartment. (10) He roared: "The sons of bitches…they have all escaped…." (10) The frail-looking Babu suddenly became so fierce that nobody really dared to talk to him in a casual tone anymore. He was very much gripped with communalism and fanaticism and became so agitated that he could not sleep anymore. Almost all the potential symptoms of ASD like sleeplessness, uncontrollable rage, restlessness, irritability could be seen in him.

Towards the end of the story, the Babu was finally able to satisfy his *ego* by avenging the life of an innocent Muslim old man, who was merely pleading to open the door of the compartment. The Babu initially, remained indifferent to his repeated pleas "Open the door! In the name of Allah, open the door! (11), but opened the door abruptly and hit him on his head with the same iron rod surprisingly. The dying man's face was looking for an answer to this act. His female companion too couldn't grasp the logic and fell on the platform at once. There was no apparent reason why the Babu had hit him suddenly. The possible explanation one could offer was the widespread communal frenzy that allowed him to regain his lost identity and to fulfill his aggressive, annihilatory desire only by inflicting pain upon the 'communal body' (Misri 36) of the rival community. What would happen to him next after that impulsive murder? Would he remorse or become re-traumatized? The

story remains absolutely open-ended to such possibilities. The only clue we get is that the Babu threw his weapon outside the door after his reverie broke down and he looked vacant as if he had overcome from his trance. Communal antagonism was so pervasive during the Partition that it turned countless innocent victims into brutal murderers.

#### III

In the early 2020s, a host of Indian psychiatrists like Alok Sarin, Sarah Ghani and Sanjeev Jain have tried to explore the psychological roots of the Partition induced trauma. In an essay called "Bad Times and Sad Moods," they claim that: "abrupt and sudden dislocations, loss of social rootedness and exposure to social unrest have all been identified as causes of trauma." (Butalia 249) In the story, "Mujhe Mere Ghar Le Chalo" (Take Me Home),<sup>2</sup> we find a protagonist, who, like the millions of other dislocated refugees suffers from the Partition induced psychological trauma. Much like Bhisan Singh in Manto's "Toba Tek Singh", the pathological neurosis comes in the victim due to the "abrupt and sudden dislocation" from his homeland and the resultant loss of his "social rootedness."

The story describes a similar kind of train journey with a train full of refugees waiting at the overcrowded station of Wazirabad. As there was scorching heat, the passengers became very much thirsty but nobody really risked getting down at the station to fetch some drinking water due to the dread of an imminent riot that may occur at any time targeting any particular community. However, an old man who was dying of thirst, boarded down at the station to drink some water. As the train suddenly began to move, the old man, not knowing what to do, made "a wild rush" (2) to catch the train. Luckily, he was able to reach the compartment and climb up into the running train but got somehow physically wounded. His knees were bruised and "drops of blood oozed from where his chin had grazed the floor of the compartment." (2) His fellow passengers then felt pity for him and offered him a little bit of water to drink. Some of them tore off a rag from his turban to wipe "the blood off his chin."(2) But the old fellow remained absolutely indifferent to all the physical injuries as if he was possessed by something else. It took no time for the passengers to understand that he was undergoing a certain sort of psychological pain, which was so heavy on him that he hardly cared about his physical damages. He took no notice of his bruised knees or bleeding chin. His relatives might have already departed by the previous train. One is not sure about the whereabouts of his family or in which condition were they. Certain chaotic thoughts hurdled together in his mind and he remained absolutely silent. The only repetitive babble that he could utter was to take him to his home. (3) The passengers in the compartment could not make out his confusing, continuous jabber. They started questioning him:

But where is your home? What are you talking about, sir? No one has a home any more. Where shall we take you? (3)

The old man absolutely paid no attention to their queries and continued to babble the same thing again and again. The other passengers suspected that possibly, he was out of his head. (3) After a few moments, shaking his head repeatedly, the old fellow suddenly shouted "In Miyani. Miyani, district Shahpur" (3) to which the other passengers got infuriated and started shouting at him. One of the passengers yelled:

So we should take you to Miyani now, should we? ...Are you in your right mind? Here we are, homeless and knocking about from place to place and here you are, missing your blessed Miyani. Want to go there and sit in your mother's lap, do you? (3)

The old man didn't mind their retorts at all. On the contrary, he shook his head frantically and sobbed "like a little child" (3) repeating the same cry "Take me home." (3) One could understand the intensity of the psychological pain that he was undergoing due to the forced relocation. Like millions of the other migrants, this old fellow too had become so traumatized due to the division and the undesired post-partition migration that he couldn't make any sensible activity. It took no time for the other passengers to understand that "he was really out of his mind" (4) since he was repeating the same words repeatedly.

However, an old woman, who was sitting nearby and witnessing everything, suddenly approached the old man and spoke something in Multani dialect, which was, of course, unintelligible to most of the passengers. Listening to these words, the old frantic fellow "suddenly became quiet. He opened his eyes. His head shaking, for a long time he gazed at the face of the old woman" (4) and suddenly mumbled:

*Miyani vasjaso? Main tuhanoo lai vajna*? ('You want to go to Miyani? Shall I take you there?') (4)

This turned a bit therapeutic for the old man, who suddenly woke up from his deep-rooted malady of the mind. The passengers understood that both of them were speaking in the same dialect. (4) The old man, who was behaving hysterically so far, suddenly broke down to tears looking at the old woman and replied to her in the same dialect:

*O Rabba dadiya!? Mainu kitthe liya suttiya ee* ('O Lord! Where have you gone and flung me?') (4)

His loud sobbing can be taken as a way out for releasing the repressed trauma that he was carrying all the way. It is through the linguistic associations of the Multani dialect, he could ease out the trauma and agony buried within. This event may be taken as the Freudian 'return of the repressed' which suggests that it is through revisiting the past, repressed memory of a certain traumatic events, one may get cured or at least released from the subdued trauma. Towards the end of the story, the fellow passengers understood that he was not really "gone out of his mind", rather disturbed by the unexpected and chaotic events of Partition and its resultant forced dislocation.

#### IV

Partition-induced violence and its traumatic aftermath led to different kinds of psychological disorders in the individuals as well as in the collective masses. The pathological symptoms found in the victims of Sahni's stories were predominantly caused by the territorial anxiety created out of the filthy game of Partition. Traumatized subjects like the Babu or the old man inescapably bore the burden of a blotted history that they really never deserved. Their traumatic/ psychological disorders like those of millions of others were not simply the maladies of the mind or the unconscious selves, rather symptomatic of a turbulent history. Victims like the Babu or the old man became the "symptoms of history" itself. (Caruth, *Trauma 5*) Whereas the old fellow in "Take Me Home" carried the psychological trauma of being uprooted from his homeland, the Babu in "The Train Has

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Reached Amritsar", on the other hand, suffered from the victim-turned-perpetrator syndrome, which was quite common in the wake of Partition violence. Both of their maladies can be classified under the DSM - 5 (The Diagnostic and Statistical Manual of Mental Disorders) taxonomical tool. Whereas the abrupt hyperarousal disarray and its associated disorders like hypervigilance, panic, sleeplessness, avoidance complex, etc. can be categorized as the Sub-threshold Trauma or more prominently, Acute Stress Disorder (ASD); the belated experiences of the traumatized, dislocated old man can be seen as part of the Post Traumatic Stress Disorder (PTSD) with its related disorders like the Repetitive Compulsive Disorder (RCD) or the Emotionally Unstable Personality Disorder (EUPD). In conclusion, it can be said that the short partition fiction of Bhisham Sahni (along with certain other stories of partition) offer us a new territory of 'Partition Trauma Fiction' within the existing domain of Partition Literature or Partition Studies.

### Notes

The text of "Amritsar Aaa Gaya" (The Train Has Reached Amritsar) is translated by Alok Bhalla and taken from the anthology called Crossing Over: Partition Literature from India, Pakistan, and Bangladesh. eds. Frank Stewart and Sukrita Paul Kumar, Honolulu: University of Hawaii Press, 2007. 2The text of "Mujhe Mere Ghar Le Chalo" (Take Me Home) is translated by Harish Trivedi, appeared in the anthology Bruised Memories: Communal Violence and the Writer. Ed. Tarun K. Saint. Calcutta: Seagull Books, 2000.

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Sree Sankaracharya University of Sanskrit, Kalady dr.g.narayanan@gmail.com

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#### अनन्तग्रन्थप्रणेता कृष्णभक्तोऽनन्तदेवः- एका समीक्षा सनातन-दासः

#### प्रबन्धसारः

धर्मनिबन्धरचनाकाले बहुभिः स्मार्तपण्डितैर्न केवलं धर्मशास्तव्याख्याः कृताः, अपि च धर्मविषयकनिबन्धाः व्याकरण-दर्शन-काव्य-नाटकादिमौलिकग्रन्थाः रचिताः। एतेषु विविधग्रन्थप्रणेतृषु निबन्धकारेषु अन्यतमः खलु आपदेवसूनुः अनन्तदेवः। चन्द्रवंशीयराज्ञो बाजबाहदुरचन्द्रस्याश्रितोऽयं पण्डितोऽनन्तदेवो महाराष्ट्रदेशे जन्म लेभे। परन्तु जीवनस्य दीर्घसमयः काश्यामतिक्रान्तः। प्रबन्धेऽस्मिन् देवकुलोत्पन्नद्रयोरनन्तदे वयोर्मध्ये अस्मद्वर्णितद्वितीयानन्तदेवस्य देशो युक्त्या निरूपितः। प्रसिद्धो मराठीकविः एकनाथः तस्य वृद्धप्रपितामहः आसीत्। एकनाथपुत्रपौलप्रपौलादयः सर्वेऽनन्तदेववंशीयाः कृष्णभक्ताः आसन् इतिस्मृतिकौस्तुभप्रारम्भेकथितम्। अनन्तदेवस्य रचनासु सर्ववासकृत् श्रीकृष्णस्तुतिः परिलक्ष्यते। मथुरासेतुः, भगवद्भक्तिनिर्णयः श्रीकृष्णभक्तिचन्द्रिका चेति ग्रन्थास्तेन गोविन्दमुद्दिश्य विरचिताः। एवमनन्तदेवस्य वंशपरिचयः सम्प्रदायश्चाल चितितम्। अनन्तरं विभिन्नग्रन्थशोधपत्नमातृकादिपरिशीलनेन प्रत्यक्ष-परोक्षप्रमाणाभ्यां चतुर्विधयुक्तिभिः स्त्रीष्टीयसप्तदशशतकस्य मध्यभाग एव कवेर्कालः इति निरूपितम्। प्रायः पञ्चाशदधिकग्रन्थानां रचयितायमनन्तदेवः। इदानीन्तु नोपलभ्यन्ते बह्वो ग्रन्था इति परमक्लेशकरम्। ग्रन्थान्तरेषु NCC-आदिग्रन्थेषु मातृकादिषु च चिरमवेक्ष्य लभ्यन्ते केषाञ्चित् ग्रन्थानामभिधानानि। तान्यत्न निरूपयिष्यन्ते।

कुञ्चीशब्दाः- अनन्तदेवः, एकनाथः, श्रीकृष्णः, स्मृतिः, मीमांसा, भक्तिः, धर्मः, निबन्धः।

वेदोऽखिलधर्ममूलम्- इति मनुवचनानुसारेण निखिलस्य जगतः प्रथमः खलु धर्मग्रन्थो वेदः । किञ्च समेषां धर्मशास्त्राणां मूलभूतोऽयमागमः । संहिताब्राह्मणारण्यकोपनिषत्सु सुसन्नद्भा धर्मविषयाः । षड्वेदाङ्गेषु कल्पसूत्रस्यैको विभागो वर्तते धर्मः इति । धर्मसूत्रेषु धर्मविषयाः विशेषेणालोचिताः । अत्न वेदविहितानि कर्माण्येव धर्मपदेन व्यपदिश्यन्ते । धर्मसूत्राणि स्मृतिग्रन्थाश्च धर्मशास्त्रमिति नाम्नाभिधीयन्ते । धर्मसूत्राणामनन्तरं संहिताः स्मृतयो वाभिर्भूताः । संहिताग्रन्थेषु मन्वत्निवृहस्पतियाज्ञवल्क्यादयः प्रमुखाः । संहिताग्रन्थानन्तरं व्याख्याकारा धर्मसूत्राणां तथा स्मृतिग्रन्थानां व्याख्याः चक्रुः । एभिः खलु कर्तृभिः धर्मविषया निबन्धा अपि विरचिताः । यथा- विश्वरूपरघुनन्दनसतानन्दाः प्रभृतयः ।

**Sanatan Das** is Assistant Professor & Head, Department of Sanskrit. Bhatter College, Dantan. Paschim Medinipur, West Bengal. सम्पूर्णं धर्मशास्त्रसाहित्यं तिविधेषु पर्यायेषु रचितम् । तत्न प्रथमे पर्याये धर्मसूताणि तथा मनुस्मृतिः इति ग्रन्था विरचिताः । द्वितीये याज्ञवल्क्यादयोऽपरे स्मृतिग्रन्था रचिताः । तृतीये पर्याये व्याख्याग्रन्था निबन्धग्रन्थाश्च संकलिताः । बहूनां व्याख्याग्रन्थानां निबन्धानां च रचना प्रायः एकादशशतकादेव प्रारब्धा । व्याख्याकारेषु विज्ञानेश्वरः कुल्लुकभट्टः विश्वरूपः मेधातिथिः अपरार्कश्चेत्येते अन्यतमाः । निबन्धकारेषु देवस्वामी शङ्खधरः भावदेवभट्टः हिमाद्रि-माधवौ श्रीदत्तः चण्डेश्वरः शुलपाणिः कमलाकरः अनन्तदेवश्च प्रमुखाः ।

धर्मशास्त्ररचनापर्यायेषु व्याख्याकालस्तथा निबन्धकालः प्रसिद्धः । कालेऽस्मिन् बहवः स्मार्तपण्डिताः धर्मसूत्राणां संहिताग्रन्थानां च व्याख्याः रचितवन्तः । एभिर्न केवलं धर्मशास्त्राणां व्याख्याः कृताः अपि चापरशास्त्राणां व्याख्याः धर्मविषयकनिबन्धा व्याकरण-दर्शन-काव्य-नाटकादिमौलिकग्रन्था रचिताः । एतेषु श्रुतिस्मृतिन्यायादिशास्त्र निष्णातेषु विविधग्रन्थप्रणेतृषु निबन्धकारेषु अन्यतमः खलु आपदेवसूनुः अनन्तदेवः । वैदिकशास्त्रविज्ञाता, श्रौतग्रन्थव्याख्याता, स्मृतिनिबन्धप्रणेता, मीमांसादिशास्त्रटीकाकर्ता, काव्यरचयिता, अनन्तशास्त्रवेत्ता ननु अयमनन्तदेवः ।

#### देशः

अनन्तदेवो दक्षिणदेशीयो आसीत् । चन्द्रवंशीयस्य राज्ञो बाजबाहृदुरचन्द्रस्याश्रितोऽयं पण्डितोऽनन्तदेवोमहाराष्ट्रदेशेजन्मलेभे।गोदावरीनदीतटेअनन्तदेवस्य पूर्वजाःन्यवसन्निति स्मृतिकौस्तुभे वर्णितम् । तत्कृतिषु बहुल मराठीभाषायाः प्रयोगः परिलक्ष्यते । यथा-राजधर्मकौस्तुभे कविना संस्कृतशब्दस्य मराठीपर्यायशब्दः व्यवहृतः "भित्तिशिखरसन्धौ च भाषया सज्जा इति प्रसिद्धा मञ्जरी कार्य्या।"(राजधर्मकौस्तुभः, प्रासादादिलक्षणम्, पृष्ठं-२३) इति । अल मञ्जरी(Balcony) इत्यर्थे सज्जा इति शब्दः आधुनिकमराठीभाषायां वर्तते एव । पुनरस्मिन्नेव ग्रन्थे अन्यत्नोक्तम्- "बालिकेति कर्णोपरिभागस्थ-वालीति महाराष्ट्रभाषया प्रसिद्धं भूषणम्।"(राजधर्मकौस्तुभः, प्रतिमालक्षणम्, पृष्ठं-३८) अल स्पष्टरूपेण स्वमातृभाषायाः नाम उच्चारितम् । अतोऽनन्तदेवो महाराष्ट्रदेशीयो विद्वानासीत् । पुनः तत्कृतिषु बहुल काशीनगरी वाराणसी वा उल्लिखिता।<sup>1</sup> राजधर्मकौस्तुभस्य प्रतिज्ञाप्रकरणे कात्यायनमतव्याख्यानकाले देशः इत्यस्य मध्यदेशादि इति व्याख्या कृता।<sup>2</sup> भारतवर्षस्य मध्यप्रदेशादनतिदूरे एव काशी। अतः इदं वक्तुं शक्यते यदनन्तदेवस्य जन्म महाराष्ट्रे अभवत्, परन्तु तस्य जीवनस्य दीर्घसमयः काश्यामतिक्रान्तः । राज्ञो बाजबाहदुरस्य सभायामालमोरायामपि किञ्चित्कालोऽतिक्रान्तस्तेन ।

#### कुलं सम्प्रदायश्च

महाराष्ट्रप्रदेशे विप्रकुले जातोऽस्माकं कविः अनन्तदेवः। सन्तः एकनाथः तस्य वृद्धप्रपितामहः आसीत्। अयमेकनाथः मराठीभाषायाः प्रख्यातकविः साधुः चासीत्। भागवतम्, रुक्मिणीस्वयंवरम्, भावार्थरामायणम्, हस्तामलकम्, शुकाष्टकम्, स्वात्मसुखम्, आनन्दलहरी, अभङ्गानि(हिन्दीभाषया मराठीभाषया च) च प्रभृतयो नैके ग्रन्था विरचिताः सन्तेनैकनाथेन। देहलीस्थसाहित्यएकादेमीति संस्थया प्रकाशिते 'Makers of Indian

काशीस्थविद्वदादिभ्यो धनराशीनदात्सदा ।, काश्यां श्रीविश्वनाथं... ।, ...काशीपुरसुरसरितोर्वासमायान्तु सर्वे ।

<sup>2 &#</sup>x27;देशो मध्यदेशादि' (राजधर्मकौस्तुभः, प्रतिज्ञास्वरूपम्, पृष्ठं-३८७)

Literature- Eknath' इति ग्रन्थे एकनाथस्य कृतयः वर्णिताः। स्मृतिकौस्तुभस्य प्रारम्भे अनन्तदेवेन स्वपरिचयः प्रदत्तः। तस्य पूर्वपुरुषः एकनाथः श्रीकृष्णस्य एकनिष्ठो भक्तः आसीत्। स्मृतिकौस्तुभे उच्यते-

"आसीद्गोदावरीतीरे वेदवेदीसमन्वितः । श्रीकृष्णभक्तिमानेक एकनाथाभिधो द्विजः ॥"

(स्मृतिकौस्तुभः, तिथिदीधितिः १५)

अनन्तदेवस्य पितुर्नाम आपदेवः । अयं खलु द्वितीयः आपदेवः । यैन मीमांसान्यायप्रकाशः इति ग्रन्थो रचितः । धर्मशास्त्रविशयस्थलेषु अनन्तदेवेन पूर्वमीमांसापद्धतिमनुसृत्य सिद्धान्तो गृहीतः । विशेषतः तस्य संस्कारकौस्तुभस्य प्रतिचरणमियं रीतिः अनुसृता । मीमांसान्यायप्रकाशकारस्य द्वितीयापदेवस्य पितुर्नाम अनन्तः । अर्थात् अनन्तदेवस्य (द्वितीयस्य) पितामहोऽपि अनन्तदेवः (प्रथमः) इति नाम्ना परिचीतः आसीत् । श्रीकृष्णस्य सेवासु नित्योद्यतः अयं प्रथमः अनन्तदेवः प्रथमापदेवस्य पुत्नः आसीत् । अनेन सिद्धान्ततत्त्त्वादिग्रन्थाः ग्रथिताः । कथितञ्च द्वितीयानन्तदेवेन स्मृतिकौस्तुभप्रारम्भे-

"मीमांसानयकोविदो मधुरिपोः सेवासु नित्योद्यतो विद्यादानविभावितोत्तमयशा आसीत्तदीयात्मजः । यस्यानन्तगुणैरनन्त इति सन्नामार्थवत्तां गतं येनावादि च वादिनां श्रुतिशिरःसिद्धान्ततत्त्वं मुदे॥"

(स्मृतिकौस्तुभः, तिथिदीधितिः १७)

प्रथमापदेवस्य च पिता सन्तः एकनाथः । अर्थात् धर्मनिबन्धकारस्य द्वितीयानन्तदेवस्य पिता द्वितीयः आपदेवः, पितामहः प्रथमः अनन्तदेवः, प्रपितामहः प्रथमः आपदेवः, बृद्धप्रपितामहश्च एकनाथः । द्वितीयानन्तदेवस्य जीवदेवाभिधेयः एकः कनिष्ठो भ्राता आसीत् । गोत्नप्रबरनिर्णयः इत्याख्यः कश्चन प्रबन्धः जीवदेवेन प्रणीतः । द्वितीयानन्तदेवप्रणीतसंस्कार कौस्तुभे सापिण्ड्यनिर्णयप्रकरणानन्तरमुक्तम्- 'अथ गोत्नप्रबरनिर्णयो मदनुजजीवदेवकृत एवास्मिन्नवसरे प्रदर्श्यते ।' (संस्कारकौस्तुभः, पृष्ठं-१७९) प्रबन्धस्यास्यान्तिमे जीवदेवेन आपदेवपुत्तरूपेण स्वपरिचयोऽपि प्रदत्तः ।<sup>3</sup> पुनः आशौचनिर्णयो नाम ग्रन्थोऽपि जीवदेवप्रणीतः ।<sup>4</sup> अतो द्वितीयानन्तदेवस्य वंशवृक्षः प्राप्ततथ्यानुसारेण एवं स्यात्-

एकनाथः	
आपदेवः(प्रथमः)	
अनन्तदेवः(प्रथमः)	
आपदेवः(द्वितीयः)	
अनन्तदेवः(द्वितीयः)	जीवदेवः

<u>पुनः वावादेवरचि</u>तौ अधिकरणादर्शः अर्पणमीमांसा चेति द्वौ ग्रन्थौ प्राप्येते। तल 3 कृत्स्रक्ष्मातलवर्त्तिपण्डितजनालंकारचूडामणिर्गोदातीरजनिर्गुणोच्चयखनिनाम्नापदेवोग्रणीः। तत्सूनोरिह जीवदेवकृतिनः सद्धर्मशास्त्रे कृतौ गोलाणां प्रबरैः सहे्यमभवन्निर्णीतिरीशार्पणा। (संस्कारकौस्तुभः, पृष्ठं-१९५)

<sup>4</sup> श्रीकृष्णं ढुण्ढिराजं च प्रणम्याशौचनिर्णयः। क्रियते जीवदेवेन यथामति समासतः॥(स्मृतिकौस्तुभः, आशौचदीधितिः- १)

अधिकरणादर्शे प्रथमानन्तदेवस्यात्मजबालदेवपुलः वावादेवः इत्युक्तम् । अर्पणमीमांसायां च पितामहप्रथमानन्तदेवकृतमनोऽनुरञ्जननाटकात् श्लोकद्वयं समुद्धृतम् । एतत्सर्वं संनिरीक्ष्य सिद्धान्ततत्त्वशोधकर्ल्या डॉ रत्ना-पुरोहितमहोदयया प्रथमानन्तदेवस्य आपदेवः (द्वितीयानन्तदेवजीवदेवतातः) बालदेवः (वावादेवतातः) चेति द्वौ पुलावास्तामिति स्वशोधग्रन्थे प्रदर्शितम् ।

अनन्तदेववंशीयाः सर्वे कृष्णभक्ताः आसन्। द्वितीयानन्तदेवोऽपि श्रीकृष्णभक्तः आसीत्। तस्य रचनासु प्रायः कृष्णस्तुतिः परिलक्ष्यते। तद्वचितस्मृतिकौस्तुभस्य मङ्गलाचरणे मुरलीधरः एव स्तुतः।<sup>5</sup> राजधर्मकौस्तुभस्य<sup>6</sup> संस्कारकौस्तुभस्य<sup>7</sup> चापि मङ्गलश्लोके श्रीकृष्णमुद्दिश्य वन्दना विहिता। मथुरासेतुः चिन्तामण्यष्टकं चेति ग्रन्थाभिधानादेव ज्ञायते यदत्न कृष्णस्तुतिः कृष्णभक्तिर्वा प्रधानो विषयः इति। पुनः का कथा भगवद्भक्तिनिर्णयस्य, श्रीकृष्णभक्तिर्चान्द्रेकायाश्च। कविनात समग्रं काव्यमेव गोविन्दाय समर्पितम्। कृष्णभक्तोऽयं कविः शैवाद्यपरसम्प्रदायाणां मतान्यतिक्रम्य कृष्णमहिमाश्रवणं कृष्णगुणकीर्त्तनं कृष्णस्मरणं च सिद्धान्तरूपेण प्रतिस्थापितवान्। अतः विप्रकुलजातोऽयं कविः आजन्मनः श्रीकृष्णभक्तो वैष्णवो वासीत्।

#### कालः

१. द्वितीयानन्तदेवस्य पृष्ठपोषकः आसीत् राजा नीलचन्द्रपुतः बाजबाहदुरचन्द्रः । स्मृतिकौस्तुभस्य तिथिदीधितिप्रकरणस्य प्रारम्भे मङ्गलाचरणे अनन्तदेवेन बाजबाहदुरचन्द्रवंशः सम्यक् निरूपितः ।<sup>8</sup> अमुष्य नृपतेराज्ञया द्वितीयानन्तदेवेन स्मृतिकौस्तुभादिनिबन्धः विरचितः । उच्यते च स्मृतिकौस्तुभस्य मङ्गलश्लोके कविना-

"तदात्मजं वैदिकशास्त्रविज्ञं सन्तोऽसकृत्प्राहुरनन्तंदेवम्।

बाजाह्नराज्ञो वचसा विधेयं निबन्धसारोद्धरणं त्वयेति॥"

(स्मृतिकौस्तुभः, तिथिदीधितिः १९)

बाजबाहदुरचन्द्रस्य पूर्वजाः इलाहवादं निकषा झुसी इति स्थाने निवसन्ति स्म। ततः दशमशतके ते हिमालयप्रदेशमागताः। तत्न आलमोरा इति स्थाने १५६३ख्रीष्टाब्दे राज्ञा कल्याणचन्द्रेण राजधानी प्रतिस्थापिता। तस्य पुतः रुद्रचन्द्रः १५८७ ख्रीष्टाब्दे लाहोरप्रदेशे आकवरस्य वश्योऽभूत्। स्मृतिकौस्तुभस्य वचनानुसारेण रुद्रचन्द्र-बाजबाहदुरचन्द्रयोः मध्ये लक्ष्मणचन्द्रः, तिमल्लचन्द्रः नीलचन्द्रश्चेति तयः नरपतयः प्रजाः अशासुः। १५८७ख्रीष्टाब्दादनन्तरं प्रत्येकं शासकस्य शासनकालः पञ्चविंशति-वर्षाणि इति स्वीक्रियते चेत् बाजबाहदुरचन्द्रस्य कालो भवति १६६२ख्रीष्टाब्दः। स्मृतिकौस्तुभसम्पादकेन वासुदेवशर्मणा तु तत्प्रस्तावे १६४४-६४ख्रीष्ठाब्दे बाजबाहदुरः राजसिंहासने आसीदिति पण्डितवचनं स्वीकृत्य तदाश्रितस्य द्वितीयानन्तदेवस्यापि स एव काल इति सिद्धान्तरूपेण गृहीतम्। आधुनिकैः इतिहासकारैः राजाबाजबाहदुरचन्द्रस्य कालः १६३८-७८ख्रीष्टाब्दः <u>इति निर्णीतः। १६७</u>२रख्रीष्टाब्दे बाजबाहदुरचन्द्रेण मतदानकरः(Poll tax) प्रणीतः।<sup>9</sup>

<sup>5.</sup> दृष्ट्वा श्रीमुरलीधरः स्मितयुतभ्रूयुग्मभङ्गया यया...॥

<sup>6.</sup> धनञ्जयजयप्रदं जयति सूतवेशं महः ॥

<sup>7.</sup> शिरसि निहितं पालकं पाण्डवानाम् ॥ नत्वा हरि... ।

<sup>8.</sup> ज्ञानचन्द्रः कल्याणचन्द्रः रुद्रचन्द्रः लक्ष्मणचन्द्रः तिमल्लचन्द्रः नीलचन्द्रः बाजबाहदुरचन्द्रः।

<sup>9.</sup> The Imperial Gazetteer of India 1908, Vol-18, Page-324-325

अस्मिन्नेव समये अर्थात् सप्तदशशतकस्य मध्यभागे (१६३५-७५) द्वितीयानन्तदेवो राज्ञो बाजबाहदुरचन्द्रस्य पृष्ठपोषकतायामवर्त्तत।

२. पुनः पूर्वजस्य एकनाथस्य कालः १५३३-१५९९ख्रीष्टाब्दः इति स्वीक्रियते। १५७३ख्रीष्टाब्दस्य नवम्बरमासस्य नवमदिनाङ्के सन्तेन एकनाथेन मराठीभाषया भागवतं समापितम्। एकनाथ-द्वितीयानन्तदेवयोर्मध्ये प्रथमापदेवः, प्रथमानन्तदेवः द्वितीयापदेवश्चेति तयः पुरुषाः आसन्। १५७३ख्रीष्टाब्दे निश्चयेन प्रथमापदेवस्य जन्म अभूत्। ततः प्रतिपुरुषं पञ्चविंशवर्षाणि स्वीकृते सति द्वितीयानन्तदेवस्य कालः १६४८ ख्रीष्टाब्दादारभ्यते। अतः सप्तदशशतकस्य मध्यभागे द्वितीयः अनन्तदेवो व्यराजत।

३. भाट्टमतप्रदीपिकाकर्तुः कौण्डदेवस्य गुरुरासीदनन्तदेवः द्वितीयः। भाट्टमतप्रदीपिकायाः मङ्गलश्लोके कौण्डदेवेनोच्यते-

"गणेशकृष्णादिसुरान् प्रणम्य गुरुनपि श्रीमदनन्तदेवान्।

श्रीकौण्डदेवः प्रकरोति विद्वान्सतां मुदे भाट्टमतप्रदीपिकाम्॥"

(भाट्टमतप्रदीपिका १)

अतः द्वितीयानन्तदेवो निश्चयेन कौण्डदेवस्य पूर्ववर्तिनि काले विराजितः आसीत्। कौण्डदेवेन भाट्टमतप्रदीपिकायां खण्डदेवप्रणीतभाट्टरहस्यमिति ग्रन्थस्य नामोल्लिखितम्। १६६५ईशवीयाब्दे खण्डदेवस्य प्राणवियोगोऽभवदिति शिष्येण शम्भुभट्टेन कथितम्। अतस् तत्परवर्तिग्रन्थकृत्कौण्डदेवः सप्तदशशतकान्तिमे तथाष्टादशशतकप्रारम्भे काले व्यराजत इति निश्चितमेव। तस्य गुरुः द्वितीयानन्तदेवस्तु किञ्चित्पूर्ववर्ती इत्यत न संशयः। अतः खीष्टीयसप्तदशशतकस्य मध्यभाग एव द्वितीयानन्तदेवस्य कालः।

४.पुनः द्वितीयानन्तदेवस्यानुजजीवदेवप्रणीते आशौचनिर्णयग्रन्थे निर्णयसिन्धुमतमुद्धृतमस्ति।<sup>10</sup> निर्णयसिन्धोः रचनाकालविषये तत्कर्ता कमलाकरभट्टः स्वयमुल्लिखति यत् १६११ख्रीष्टाब्दे रचना समाप्ता।<sup>11</sup> जीवदेवाग्रजस्य द्वितीयानन्तदेवस्य कालः निर्णयसिन्धोः रचनाकालादनन्तरमेव इति समनुमीयते। पुनरपि १६६७खीष्टाब्दे (१७२४संवत्) लिखिता द्वितीयानन्तदेवस्य श्रीकृष्णभक्तिचन्द्रिकायारेका प्राचीना मातृका सौराष्ट्रप्रदेशस्थचुनीलालगाँधीविद्याभवने प्राप्यते। एतस्याः मातृकायाः लेखनकालात् पूर्वमेव द्वितीयानन्तदेवस्य रचनाकालः इति निश्चीयते। अतः एतेभ्यः प्रमाणेभ्यः १६३५-७५ (1635-1675)खीष्टाब्दः अर्थात् सप्तदशशतकस्य मध्यभागः एव अनन्तदेवस्य (द्वितीयस्य) सारस्वतसाधनासमयः इति स्थिरीकर्तुं शक्यते। आस्तां तावदनेन पल्लवितेन। कृतिः

पूण्यभूमेः भारतवर्षस्यायं विख्यातः कविः स्वकृतियशेनाद्यापि भारतीयसाहित्यसंस्कृतिषु दिवाकर इव देदीप्यते। "प्रायेणोत्तमवस्तूनां नामान्यर्थानुसारतः" (श्रीकृष्णभक्तिचन्द्रिका ६) इति स्ववचनं सार्थकीकृत्य अनन्तदेवः अनन्तग्रन्थरत्नानि रचयामास। मीमांसकधुरन्धरस्य मीमांसान्यायप्रकाशकारस्य सार्थनामायमात्मजः अनन्तदेवः श्रुतिस्मृतिपरम्परामनुसृत्य बहुन् स्मार्तग्रन्थान् प्रबन्धान् वा प्रणीतवान्। श्रुतिस्मृतिन्यायप्र स्थानत्रयवत् अमूनापि कविना श्रौतस्मार्तलौकिकग्रन्थाः इति ग्रन्थकोटित्नयः विरचिताः।

<sup>10. &#</sup>x27;देशान्तरे स्नानं सोदकानामिति युक्तमिति निर्णयसिन्धौ' (स्मृतिकौस्तुभः, आशौचदीधितिः, पृष्ठं-५८७)

<sup>11. &#</sup>x27;वसुऋतुऋतुभु१६६८मिते गतेऽब्दे नरपतिविक्रमतोऽथ याति रौद्रे' इति।

तल श्रौतशास्त्राणां व्याख्याः, स्मार्तकर्मविषये निबन्धाः लौकिककाव्यानि चेति नैकानि ग्रन्थरत्नानि तेन विरचितानि। प्रायः पञ्चाशदधिकग्रन्थानां रचयितायमनन्तदेवः। इदानीन्तु बहवो ग्रन्थाः नोपलभ्यन्ते इति परमक्लेशकरम्। न च प्राप्यन्ते बहूनां ग्रन्थानां नामान्यपि। तथापि ग्रन्थान्तरेषु NCC-आदिग्रन्थेषु मातृकादिषु च चिरमवेक्ष्य लभ्यन्ते केषाञ्चित् ग्रन्थानामभिधानानि। तदधः उल्लिख्यन्ते-

१.<u>श्रौतशास्ताणां व्याख्याग्रन्थाः</u>- आपस्तम्बश्रौतसूतव्याख्या, कात्यायनप्रातिशाख्यप्रति ज्ञासूतव्याख्या, अग्निहोत्नप्रयोगः, श्रौताधानप्रयोगः, दर्शपूर्णमासप्रयोगः, चातुर्मास्यप्रयोगः, नक्षत्नसत्नप्रयोगः, पुत्नेष्टिप्रयोगः, आधानप्रयोगः, सोमप्रयोगः, पवित्नेष्टिः, पूर्णराधानेष्टिः, आग्रायणेष्टिः/प्रयोगः, आहिताग्र्यन्तेष्टिप्रयोगः, आश्वलायनीयप्रायश्चित्तप्रयोगः, अग्निहोत्नहोमः, दर्शपूर्णमासहोमः, ऋत्विग्वरणनिर्णयः च।

२.स्मतिनिबन्धग्रन्थाः- स्मृतिकौस्तुभः (प्रसिद्धः स्मृतिनिबन्धग्रन्थोऽयं संस्कार-आचार-राजधर्म-दान-उत्सर्ग-प्रतिष्ठा-तिथि-संवत्सरादिभेदेन द्वादशधा विभक्तः। एतेष संस्कार-राजधर्माभिधौ द्वौ विभागौ संस्कारकौस्तुभः राजधर्मकौस्तुभश्चेत्यभिधयाभि हितौ।), प्रायश्चित्तप्रदीपिका, प्रायश्चित्तमौक्तिः, प्रायश्चित्तरतावली, प्रायश्चित्तकारिका, श्राद्धपद्धतिकारिका, फलसांकर्यखण्डनः, दत्तकपुलविधानः, पर्वनिर्णयः, भोजनविधिः, चलार्चापद्धतिः, त्निकण्डिकाभोजनविधिः, अन्त्येष्टिपद्धतिः, विष्णुयागपद्धतिः, राज्याभिषेकपद्धतिः, सर्वकर्मपद्धतिः, विधानपारिजातः, गोप्रसवशान्तिः, ज्येष्ठशान्तिः, दर्शजननशान्तिः. प्रसववैकृतिशान्तिः, आश्लेषाशान्तिः, दिनक्षयादिशान्तिः, विषनाडीजननशान्तिः, त्निकप्रसवशान्तिः, यमलजननशान्तिः, मुलाशान्तिः, व्यतिपातवैधृतसंक्रमणशान्तिः, एकनक्षत्नजननशान्तिः, तिथ्यादिगण्डान्तशान्तिः, कृष्णचतुर्दशीयजननशान्तिः, नारायणबलिनागबलिः, वगलाक्रमकल्पवल्ली, दासब्रह्मप्रायश्चित्तविधिः, चलार्चप्रतिष्ठास्थापनविधिः, गायतीपुरश्चरणविधिः, राजदीधितिः, व्रतप्रकाशः च।

३.<u>लौकिकग्रन्था</u>ः- भगवद्भक्तिनिर्णयः, वाक्यभेदवादः, मथुरासेतुः, चिन्तामण्यष्टकम्, मीमांसान्यायप्रकाशस्य भाट्टालंकारटीका, देवताविचारः (मीमांसा), सैनिकशास्त्रम्, त्रिवीर्णकधर्मः, भगवन्नामकौमुदीप्रकाशटीका, गणेशमहोत्सवः, आख्यातवादविवरणटीका, श्रीकृष्णभक्तिचन्द्रिकानाटकं च।

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अनन्तदेवः । श्रीकृष्णभक्तिचन्द्रिका । (अप्रकाशितमातृका)

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সম্পাদক ডা. মদনমোহন বেরা

কে.কে. প্রকাশন

<sup>6</sup>এবং যহয়।"–নির্বানরায্যন্তুরী আরার্ন (UGC-CANUE Ibert 2021) অনুর্যাহিত তানিকার অর্ত্র্যুক্ত। ২০২৪মারে প্রকাশিত ১৬পৃ, তানিকার (৫৪৪চির যার্ব্য) ও পৃ, ৬০বং উর্জেণিত।



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দম্পাদক **ডা. সদলমোহল বেরা** 

কে হেল একাশন মোরজুয়াচক, মেদিনীপুর, প.বস।

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কে.কে. প্রকাশন

ড. মদনমোহন বেরা, সম্পাদক। গোলকঁয়াচক, পোষ্ট-মেদিনীপুর,৭২১১০১,জেলা-প.মেদিনীপুর, প.বঙ্গ। মো -৯১৫৩১৭৭৬৫৩

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### সম্পাদ কীয়

বাংলা ভাষা ও বাংলা সাহিত্য বর্তমানে বিশাল বৃক্ষের ন্যায় পল্লবিত বহুল শাখা-প্রশাখা সমৃদ্ধ ও বিকশিত। সারা বিশ্বে সমাদৃত। শাখাগুলির মধ্যে প্রবন্ধ,গল্প-উপন্যাস,কাব্য,নাটক, ভ্রমণ কাহিনী, লোক সাহিত্য, পত্র সাহিত্য প্রভৃতি উল্লেখযোগ্য। বাংলা সাহিত্যের অন্যতম গুরুত্বপূর্ণ অংশ প্রবন্ধ সাহিত্য। যে সাহিত্যে মূলত নানান আঙ্গিকের প্রবন্ধ বা মননশীল রচনা যেমন লিপিবদ্ধ থাকে,প্রকাশিত হয় তেমনই গবেষণামূলক বিষয়, অনুসন্ধানমূলক বিষয়, আলোচনা-সমালোচনা এবং সমকালীন বহু ঐতিহাসিক তথ্য, দেশ-কালের অর্থনৈতিক, সামাজিক, রাজনৈতিক বিষয়ও প্রবন্ধের মাধ্যমে প্রকাশিত হয়।

প্রাসঙ্গিকভাবে এসে যায় পত্র-পত্রিকার কথা। উক্ত প্রবন্ধসাহিত্য সংরক্ষণ, প্রকাশ ও প্রচার বস্তুত সব রকম পত্র-পত্রিকার দ্বারাই সম্পন্ন হয়।

'এবং মহুয়া' মাসিক সাহিত্য পত্রিকা এমনই নানান আঙ্গিকের মননশীল বহু অনুসন্ধানমূলক, গবেষণামূলক প্রবন্ধ প্রকাশ ও পরিবেশন কর্মে অনন্য ভূমিকা পালন করে।

মেদিনীপুর নভেম্বর ২০২১

ড. মদনমোহন বেরা সম্পাদক

(জ্ঞাতার্থে-পত্রিকায় প্রকাশিত সমূহ বিষয় স্রষ্টার নিজস্ব চিন্তা-ভাবনা প্রসৃত। এর কোন অংশের জন্য প্রকাশনা সংশ্লিষ্ট কেউই দায়বদ্ধ নয়। লেখা প্রকাশের নিয়মাবলী অনুসৃত হয়। কেবলমাত্র স্ব-মননজাত, প্রথম প্রকাশযোগ্য মৌলিক রচনাই আহ্বান করা হয়। মুদ্রণ প্রমাদ মার্জনীয়।)

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Debasish Mondal Sukla Mondal Saha Pinki Bera

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#### Detection and Deterrence: A Microtheoretic Approach

Swastick Sen Chowdhury Assistant Professor, Department of Economics, Bhatter College, Dantan

Santanu Ghosh Professor, Department of Economics, Maulana Azad College, Kolkata

Panchanan Das Professor, Department of Economics, University of Calcutta, Kolkata

#### Abstract

For over three decades, research on crime and corruption has been of special interest among social scientists. The present paper seeks to examine the decision-making behaviour of an illegal firm in terms of a simple micro theoretic exercise. We set up simple models of a profit maximizing illegal industrial firm and derive conditions under which illegalisation of work and production occurs, taking into consideration the fact that the probability of being detected of unlawful activity is a variable and being dependent on the scale of activity, measured in terms of output or employment. Here, we try to explore the cases where the firm is detected at different phases of its production process and also examine the impact of deterrence, if any, on the scale of illegal activity.

Key Words: Illegal Sector, Fine, Profit Maximization, Detection, Output, Labour.

JEL Classification Codes: D21, E26, K42.

#### I

Crime and corruption are in existence from the very beginning of humanity. It can be defined as dishonest or fraudulent conduct by the people in power or those who have a prominent position in the society. It typically involves bribery, nepotism, extortion, patronage, cronyism, etc. It is like a disease to the economy of the country. Not only does it hold the economy from reaching new heights but also prevents the country's development. It is one of the biggest challenges faced by many countries all over the world. It has spread its roots so deep in the society that it has become difficult to get rid of it. It is becoming bigger day by day because of people's increasing wants in life.

Crime is any action that violates the law of country or rules of the state. It is that illegal action which is harmful to oneself or the society and is punishable by law. A crime can range from a minor level of robbery to the extent of homicide or suicide. Thus, any individual who commits a crime is known as a criminal. In the present day, we are most vulnerable to various criminals of the society. They can be kidnappers, rapists, murderers, or even terrorists. There are criminals who are indulged in crime under the influence of politicians and businessmen.

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#### Introduction

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রবীন্দ্রসঙ্গীত যথার্থরূপে মূল্যায়ন করা অত্যন্ত কঠিন। সময়ের সাথে সাথে সমাজ ও সংস্কৃতির পরিবর্তন হয়ে চলেছে তবুও রবীন্দ্রসঙ্গীত একইভাবে তার মৌলিকতা বজায় রেখেছে। বিভিন্ন প্রতিক্রিয়ায় বিভিন্ন অবস্থাতেই এ গানের কথা ও সুরের সামঞ্জস্য মানব হৃদয়কে স্বতঃস্ফূর্তভাবেই অনুরণিত করে। সেই আকুলতার রহস্যের একটা প্রধান দিক হল রবীন্দ্রগানে মান্য ও চলিত শব্দের অবাধ প্রয়োগ। এই মান্য ও চলিত ভাষার উচ্চারণভঙ্গির জন্যই ভাবার্থের বিপুল পরিবর্তন ঘটে যায়। রবীন্দ্রসঙ্গীত গাইতে ও বুঝতে গেলে মান্য ও চলিত ভাষার উচ্চারণে যথেষ্ট গুরুত্ব দেওয়া প্রয়োজন। ভাষার উচ্চারণ সঠিক না হলে রবীন্দ্রসঙ্গীতের ভাবসম্পদ অক্ষুন্ন রাখা মুশকিল হবে। কথ্যভাষা ও মুথের ভাষা আজও বেশ গতিশীল। দেশ ও কালের প্রয়োজনে প্রতিনিয়তই মুথের ভাষায় নতুন শব্দ যুক্ত হয়ে চলেছে। অতএব বিশ্বকবি রবীন্দ্রনাথ ঠাকুর মুথের ভাষা দিয়ে গান তৈরি করেও রবীন্দ্রসঙ্গীতের অর্থ খর্ব না করে মানবচিন্তে ভাবব্যঞ্জকপূর্ণ রসাবেদনের জাগরণ ঘটিয়েছেন।

সূচক শব্দ: মর্মস্পর্শী, অন্তর্দীপ্তি, ভাবব্যঞ্জক, স্তানিকতা, অন্তর্নির্হিত, সুদূরপ্রসারী, সামঞ্জস্যপূর্ণ, হৃদয়গ্রাহী, অন্তরীণ, অনায়াসসাধ্য, যৌথবদ্ধতা, সৌকর্য।

### প্রতিপাদ্য বিষয় :

এই মান্য-চলিত মিশ্রিত ভাষা সম্বন্ধে বিশিষ্ট শিক্ষাবিদ, সাহিত্যিক, ভাষাবিদ মাননীয় শ্রী পবিত্র সরকার মহাশয় তাঁর গানের ঝরণাতলায় বইটিতে এই সম্বন্ধে কিছু গুরুত্বপূর্ণ বক্তব্য রেখেছেন। সেটি অত্যন্ত প্রাসঙ্গিক মনে করেই এখানে উল্লেখ করতে চাইছি। তিনি বলেছেন --

"প্রত্যেক ভাষারই উচ্চারণের কিছু নীতিনিয়ম তৈরি হয়ে যায়। একথা যাকে আমরা উপভাষা বলি---ঢাকাই বা সিলেটি বা বাঁকড়ি উপভাষা যেমন--- তার সম্বন্ধে যেমন সত্য তেমনই সত্য সেই উপভাষা সম্বন্ধে, যাকে আমরা বলি মান্য বা আদর্শ উপভাষা। বাংলাভাষার ক্ষেত্রে এই আদর্শ উপভাষার নাম মান্য চলিত বাংলা (মা-চ-

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## An Essential Factor for Singing Rabindrasangeet

Sutripta Mandal

#### Abstract

Rabindrasangeet is an unique art-form of literature and culture. The identity of it lies in the lyric,tune and rhythm as well as in the usage of language itself. The inner significance of the song is expressed by singing only. Pronunciation plays a pivotal role in singing Tagore Song.

Keywords: Lyric, Melody, Rhythm, Pronunciation, Dexterity, Nectar, Dialect, Grasped, Endeavour, Elegant, Colloquial, Revealed, Impulse, Posture, Syntax, Flourish, Preserve, Sophisticated, Desire, Achieve.

Rabindrasangeet is based on literature. We cannot express this literary subject just by reading. Especially where music is not just a matter of lesson, it is a matter of singing. Therefore, appropriate pronunciation is an essential approach for singing Tagore Songs.

Since nineteenth century various evolutionary changes concerning pronunciation have been noticed in the context of singing Rabindrasangeet. If we want to feel Rabindrasangeet properly, we have to know the literature and also the mystery behind the combination of lyric and melody. The lyrical form of Rabindrasangeet helps us to picturize the proper image of the song. Therefore it is a very salient feature that we have to understand the importance of Bengali language and the linguistic pronunciation. Difference in bengali pronunciation is noticed most of the cases among the inhabitants of different geographical areas. The form of Rabindrasangeet will be changed completely if slightest modification in pronunciation has been done, which is not desirable. The correct mood of the song is diminished by inappropriate pronunciation.

Let us start with Tagore's thought of music -

"আমাদের মনোভাব গাঢ়তম তীব্রতম রূপে প্রকাশ করিবার উপায় স্বরূপে সঙ্গীতের স্বাভাবিক উৎপত্তি। যে উপায়ে ভাব সর্বোৎকৃষ্টরূপে প্রকাশ করি, সেই উপায়েই আমরা ভাব সর্বোৎকৃষ্টরূপে অন্যের মনে নিবিষ্ট করিয়া দিতে পারি।" (1)

Now it is understood that the music is the optimum means to express the position of mind. Singers create a medium to make others feel the song which is possible when singer himself is able to realize the song properly and reveal it by singing. Rabindranath imposed a great importance to these two issues. The process of feeling may be transmitted into the reader or listener's mind

Research Scholar, Department of Music, Raja N. L. Khan Women's College, Paschim Medinipur
with such a dexterity that they also feel it in the way Rabindranath portrayed. From this point of view, proper pronunciation is the technique to make the reader understand the right way of singing.

The question arises in the mind of the theorist that the song may be properly understood by adopting so many methods. That is a new idea of the written form of the song which may come to mind as soon as the song is recited. The essence of the song is hidden in the lyrical form. Just reading of the lyric gives emotional momentum to the mind but when the lyric is sung in tune the deep appeal of the lyric comes to the mind with clear and transparent idea. We are aware that the lyrics are the nectar of Rabindrasangeet. Perception of mind is being awakened through the correct pronunciation of the lyric. Simple, clear language binds people's mind with deep connotations and sensibilities unknowingly. Everyone's mind is being liberated due to balanced composition of language and melody by Tagore.

Now I would like to site an example of Rabindrasangeet-

"আমার মুক্তি আলোয় আলোয় এই আকাশে আমার মুক্তি ধুলায় ধুলায় ঘাসে ঘাসে। দেহ মনের সুদূর পারে হারিয়ে ফেলি আপনারে, গানের সুরে আমার মুক্তি উধ্বের্ব ভাসে।। আমার মুক্তি সর্বজনের মনের মাঝে, দুঃখ-বিপদ তুচ্ছ করা কঠিন কাজে। বিশ্বধাতার যজ্ঞশালা আত্মহোমের বহ্নিজ্বালা-জীবন যেন দিই আহুতি মুক্তি-আশে।" (2)

All kind of human emotions like laughter, cry, happiness ,sorrow ,joy, triumph, calamity are the part of life. Human life is not fulfilled without them. Rabindranath denoted this world as "বিশ্ববাতার যজ্ঞশালা"। If we want to keep ourself alive in this earth, we have to pass through sorrow and to accept the natural system with courage. The door of the mind will be opened one day through sorrow. Sadness helps to know the truth. Purification of mind will be acquired only by overcoming danger. People will feel their own strength.

We have to unravel the underlying meaning of the song, with the correct pronunciation. The dimensional notation must be followed accurately – viz. 'Meer'(মীড়),'sparsho swar'(স্পর্শস্বর),'aa-karanto' (আ-কারান্ড), 'o- karanto'(ও-কারান্ড), 'otikomol'(অতিকোমাল), 'onukomol'(অনুকোমল), ' hasanto' (হসন্ত), etc. These signs help to understand the pronunciation of song.

II [ •141 •	ला -1	भा-।	। বা -1	া সা	শশা -1	া মপা	गणा। ) भा	-1 I
	मा द	म् स्	ডি •	আ	লো• মু	ম্পা-	•• दम	N,
I (পা-গা	শা	ধনা -1	ৰণা	-1)} I	সা সা	ानी   बा	-1   রা	-1 I
এ ই	শা	ক্বা• •	েশ-	*.	আ য	ाद्युष्	ক্তি	
र वा ना	-111	मा -1	গা –মা	াুমা	পা -ধা	া <b>য় পা -</b>	া   মগা	-41 I
दूना	V.	इ. •	লা হ	খা	দে -	মা-	• সে •	•
I মাশা এ ই	া গা। শা	থনা -1 কা• •	। बना त्य•	-1 II •				

Let us explain it with the help of the notation —

## RABINDRANATH TAGORE, SWARABITAN-5, BISWABHARATI GRANTHANBIBHAG, PRAKASH JOISHTHYO- 1349 (BENGALI YEAR), PAGE -126

The meaning of the words are easily grasped by the help of the notation. The poet has explained the difficult mantras of life in simple language of the song. The correct pronunciation is essential to perceive these mantras.

His extraordinary artistic talent has obscured the art endeavour in such a way that it is impossible to comprehend how it was created. We need to be aware of the literary aspect and historical context of his creation, to know the nature of this work of art. His music was not created in a day. Actually,lyric is the reflection of transformation of poem into song. How he wrote the song, creation of lyric with the combination of sound words and the presence of elegant language and colloquial language. How he wrote the song, why he wrote it and in what occasion it was written, everything has been revealed in his poems, essays and literature. Rabindranath was the first person who transformed the verse of earliest "Pali" and "Prakrit" to keep the essence intact. He enriched his music with the unimaginable application of classical rhythm and light rhythm depending on the melody of literature and the poetry.

As there are various mysteries of lyrics, if the song is not sung in conjugation with the melody, the novelty of the combination of lyric and melody remains elusive. So one thing is clear that the meaning and application of the word may not arouse deep impulse in the mind without the correct pronunciation. It turns out that singing or reading and saying anything is a normal human process. So, naturally there is a phonetic feature for pronouncing Bengali letters - in case of song and in case of literature. These two forms are very important in music.

We may quote another opinion of Rabindranath in pursuance of the thought of Herbert Spencer-"কণ্ঠনিঃসৃত বিভিনত্মেন স্বর বিভিন্ন মনোবৃত্তির শারীরগত বিকাশ।" (3)

It is clear from these words that the way we speak has a special relationship with the emotion. In this context Rabindranath has mentioned some remarkable words -"signs of ideas" (4) and "signs of feeling."(5) .All kinds of word have esoteric meaning. That is, some special words may express the happiness of the heart along with the melody of sorrow. Most of the times, the way we speak becomes more important. Because attitude has a relationship with music. If we read verse and prose of Rabindranath, it is possible to understand the difference between dictionary meaning and inner meaning. In this case, it is important to keep in mind the process of recovering the emotional meaning. At the same time, it is important to know the phonetic meaning. For example, the word "আমার" contextully pronounced as "আমার" (hasanta) or the word "আমারো" (o – karanto). A word with different syllable demands something more. It is not limited to just narration. Actually, idea is revealed through pronunciation. Tagore witnessed so many diversion along with pronunciation in his songs in his lifetime. That's why he wrote— "আমার গানের বিকার প্রতিদিন আমি এত শুনেছি যে আমারও ভয় হয়েছে যে, আমার গানকে তার স্বকীয় রসে প্রতিষ্ঠিত রাখা হয় তো সন্তব হবে না।" (6)

We have to come out of the dialect in order to maintain the uniqueness of the song. The feeling of the song may be felt better, if we know the correct pronunciation of the language. We have to sing Rabindrasangeet with proper pronunciation to keep it alive and to express the meaning of the song as desired. We must be alart regarding correct pronunciation along with variation, grammatical pronunciation, pronunciation posture and the rules of syntax positively.

The true meaning of the lyric of Tagore Song is flourished and the emotional meaning is achieved by singing the song with sophisticated pronunciation only. It is the key to preserve the unique feature of Rabindrasangeet and the aesthetic beauty of the song.

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# **Optical and Electrical Properties of Nd<sup>3+</sup>doped Na<sub>2</sub>O-ZnO-TeO<sub>2</sub> Material**

# Jyotindra Nath Mirdda <sup>1</sup>, Subhadipta Mukhopadhyay <sup>1</sup>, Kriti Ranjan Sahu <sup>2,\*</sup>, Makhanlal Nanda Goswami <sup>3,\*</sup>

- <sup>1</sup> Dept. of Physics, Jadavpur University, Kolkata 700032, Kolkata, W.B., India; jyotinessbcollege@gmail.com (J.N.M.); phy.smukherjee@gmail.com (S.M.);
- <sup>2</sup> Dept. of Physics, Bhatter College, Dantan 721426, Paschim Medinipur, W. B., India India; kriti.basis2020@gmail.com (KRS);
- <sup>3</sup> Dept. of Physics, Midnapore College, Midnapore 721101, Paschim Midnapore, W.B., India; makhanlal@gmail.com (MNG);
- \* Correspondence: kriti.basis2020@gmail.com (K.R.S.); makhanlal@gmail.com (M.N.G.);

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**Abstract:** Neodymium-doped Na<sub>2</sub>O-ZnO-TeO<sub>2</sub> (NZT) glasses were prepared by the conventional melt quenching technique. DTA and TG were used to confirm glass preparation through the glass transition temperature at 447°C for the glass system. The analysis of FTIR spectra and X-ray diffraction described the samples' nature as ionic and amorphous, respectively. The optical band gap energy was estimated using absorption spectra and found to be decreased from 2.63eV to 1.32 eV due to the increase of doping concentration. The intensity of the emission spectra was enhanced for the higher concentration of Nd<sup>3+</sup> ions. The dielectric constant of the glass samples was found to be constant for the large range of frequency (3 kHz to 1 MHz). The variation of conductivity with the temperature of the samples had shown the Arrhenius mechanism of conduction.

#### Keywords: thermal analysis; FTIR; XRD; UV-Vis absorption; fluorescence; dielectric constant.

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#### 1. Introduction

Tellurite glasses are extremely attractive materials for linear and non-linear application in optics due to their important aspects such as their low melting temperature, low phonon energy, and high refractive index, high dielectric constant, good chemical durability, high thermal stability, non-hygroscopic, with a large transmission window and the possibility to integrate a large amount of rare-earth ions [1-8]. It can be used as micro-lenses, IC photo masking glass, hard disks, press modeling of spherical lenses, glass substrates for solar cells, artificial bones, dental implants, and crowns. The optical property of rare-earth ions in tellurite glasses depends on the chemical composition, which determines the structure and the nature of the bonds of the glass matrix nature of the glass matrix bonds. Besides, understanding their microscopic mechanism of structural and optical behavior gave much thrust and basic interest for both academia and the industries. Tellurite glasses doped with rare-earth ions have attracted researchers for their broad spectrum of applications in optoelectronic and photo-electronic devices viz solid-state lasers optical switches, broad-band amplification, non-linear optical devices, infra-red (NIR) laser windows, optical fibers[9,10]. The doping of rare-earth ions in tellurite glasses has shown interesting properties like an amplification of optical signal in the

## A Novel Method for Measurement of the Refractive Indices of Transparent Solid Media Using Laser Interferometry

*Arnab Pal and Pradipta Panchadhyayee,* Department of Physics (UG & PG), P.K. College, Contai, Purba Medinipu, West Bengal, India *Kriti R. Sahu,* Department of Physics, Bhatter College, Dantan, Paschim Medinipur, West Bengal, India *Debapriyo Syam,* CAPSS, Bose Institute, Salt Lake City, Kolkata 700091, West Bengal, India

efractive index is a number that governs how light changes its direction of propagation as it enters one material medium from another. This phenomenon is known as refraction and the angles of incidence and refraction of light, referred to the normal to the interface of the two media at the point of incidence, are related by Snell's law. Refractive index (RI) depends on the color (or wavelength  $\lambda$ ) of light.<sup>1-3</sup> Tables of values of refractive indices for various media and wavelengths of light, with respect to vacuum, are readily available.<sup>4,5</sup> Refractive index of a material can be measured by many methods, for example, by using a spectrometer in conjunction with a prism made of the experimental substance. An important class of methods of measuring RI involves the formation of interference patterns. Interferometric measurements are concerned with the study of separation between bright fringes (or dark fringes) resulting from the superposition of light waves, originating from a single source and propagating along paths of different optical lengths (refractive index multiplied by geometric path length). Researchers have exploited the scope of availing nearly monochromatic light from the laser sources to enhance precision in measuring refractive index by applying the interferometric techniques.

In this article we present two simple laser-based experimental arrangements to determine the values of RIs of transparent materials. Both experiments can be set up easily and one of the experimental methods leads to distinctly visible circular fringes.

#### **Theoretical background**

Researchers have focused on the use of laser<sup>6,7</sup> for the measurement of RI, instead of conventional light sources, due to the exceptionally high coherence properties of laser. The interference patterns exhibit remarkable sharpness, leading to much better experimental accuracy. In the present work, as mentioned above, we present two simple experimental arrangements to determine the values of RIs of transparent materials. In the first method we deposit a very thin layer of chalk powder (~100 particles/cm<sup>2</sup>) over the free surface (top of glass or plastic covering slab) of a mirror. A laser beam is allowed to strike some powder particles located on the free (top) surface of the transparent slab. The rays get scattered in all directions. On hitting the top surface of the slab, one of the scattered rays (that is, a ray resulting from the scattering of an incident ray) splits into a reflected ray and a refracted ray. The reflected ray leaves the top surface at an angle  $\alpha$  (see Fig. 1) to the normal. The refracted ray enters the slab at an angle  $\beta$  to the normal and, after reflection at the back surface and subsequent refraction at the front surface, produces an emergent ray that makes the same angle  $\alpha$  with the normal to the front surface. The first reflected ray and the emergent ray interfere with each other at a large distance (very large in comparison with the diameter of the laser beam) from the mirror and, together with other similar pairs of rays, form a sharp interference pattern. We can

of the pattern by a



pattern. We canFig. 1. Schematic diagram to determineeasily take snapshotsthe RI of mirror materials (first method).

high-resolution camera and analyze the intensity distribution using ImageJ software.<sup>8</sup> Subsequently the RI of the transparent material can be found using the relevant formula, which is derived below.

In the first method, we note that the pattern is the natural consequence of interference of the first scattered ray (or wave) and the refracted ray (or wave). In Fig. 1, the phase difference between the two rays is (a)  $2\mu d \cos \beta \times 2\pi/\lambda$  or (b)  $2\mu d \cos \beta \times 2\pi/\lambda - \pi$ , depending on how phase changes on reflection, where  $\mu$  is the refractive index of the slab (see Ref. 1, p. 402). Other scattered rays that enter the transparent slab at angles different from  $\beta$  interfere with the first scattered ray close to the mirror; they are not responsible for the interference pattern produced at a large distance.

Here, for case (a), if  $2\mu d \cos \beta = n\lambda$ , then constructive interference takes place and a bright ring is produced.<sup>6</sup> On the other hand, if  $2\mu d \cos \beta = (2n + 1) \lambda/2$ , then a dark ring results. (Note that for  $\beta \approx 0^{\circ}$ ,  $n \sim 10^{4}$ , assuming  $d \sim 2$  mm.) If  $\delta\beta$  is the change of  $\beta$  between the *n*th and the (n + 1)th dark rings, we can write the relation:

$$2\mu d \times \delta(\cos\beta) = 2\mu d \times \sin\beta \,\delta\beta = \lambda. \tag{1}$$

Also,

$$\sin \alpha = \mu \sin \beta, \tag{2}$$

as, in practical situations,  $\beta$  is a very small angle,  $\delta\beta = \delta\alpha / \mu$ . Therefore

$$\mu = 2d (\sin \alpha \, \delta \alpha \, / \lambda).$$

Modification of Optical Bandgap and Formation of Carbonaceous Clusters Due to 1.75 MeV N<sup>5+</sup> Ion Irradiation in PET Polymers and Search for Chemical Reaction Mechanisms

## Shiv Govind Prasad <sup>1,2,\*</sup>, Chhagan Lal <sup>1</sup>, Kriti Ranjan Sahu <sup>3</sup>, Udayan De <sup>4</sup>

- <sup>1</sup> Department of Chemistry, School of Basic and Applied Sciences, Harcourt Butler Technical University, Kanpur-208002 UP India; c.lal9940@gmail.com (C.L.);
- <sup>2</sup> Department of Chemistry, Uttar Pradesh Textile Technology Institute, 11/208, Souterganj, Kanpur-208001 UP India; sgp\_sinp@yahoo.com (S.G.P.);
- <sup>3</sup> Department of Physics, Bhatter College, Dantan, Paschim Medinipur- 721426 WB, India; kriti.basis2020@gmail.com (K.R.S.);
- <sup>4</sup> Department of Physics, Egra SSB College, Egra 721429, Purba-Medinipur, W.B. India; udekol61@gmail.com(U.D);
- \* Correspondence: sgp\_sinp@yahoo.com (S.G.P.);

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**Abstract:** The effects of 1.75 MeV N<sup>5+</sup> ion beams of varying fluences, ranging from  $1 \times 10^{11}$  to  $5 \times 10^{14}$  ions/cm<sup>2</sup> on structural, optical, and chemical properties of polyethylene terephthalate (PET) polymer, have been investigated by x-ray diffraction (XRD), UV–Visible spectroscopy, and Fourier transform infrared (FTIR) spectroscopy. The XRD patterns of PET samples show that the crystallinity increases with ion irradiation of fluences  $4 \times 10^{11}$  and  $5 \times 10^{12}$  ions/cm<sup>2</sup>. Optical bandgap energy decreases more at the ion fluences of  $5 \times 10^{14}$  ions/cm<sup>2</sup>. Absorption maxima shifted towards a higher wavelength value due to the formation of extended conjugation. Acetylenic (-C=C-) group formation and free CO<sub>2</sub> group are confirmed by FTIR spectroscopy. The reaction mechanism of the degradation product formation chemistry is discussed.

## Keywords: FTIR; UV-Vis spectroscopy; PET; XRD; polymer; ion beam; reaction mechanism; radiation chemistry.

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## 1. Introduction

Polyethylene terephthalate (PET) is an essential polymer with a high melting point, good mechanical properties, and resistance to moisture and heat. Its crystallinity can vary from amorphous to moderately high. Application of PET in optoelectronics, thin-film processing, polymer membranes, cable insulation, textile, space technology, and nuclear engineering attracted more global attention [1–14]. This polymer is suitable for medical applications [15–21] due to its high biocompatibility, low toxicity, and a range of beneficial mechanical properties[22, 23]. Polymer membranes or thin polymer films with discrete pores, formed by a bombardment of heavy ions and chemical etching [24, 25], have applications in creating different microfluid diodes and biosensors [26, 27].

A significant modification in the few properties of a polymer material by using a chosen ion beam irradiation in a controlled way is an egregious tool. Irradiation can create a chemical



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যাথ্যাসিক সাহিত্য পত্র ৪৭ বছর, ১ ম-২য় সংখ্যা (শারদ সংকলন) ১৪২৮ / ২০২১ RNI NO. 65083/96 ISSN NO. 2349-1981 UGC Journal No. 40804

সম্পাদক সূর্য নন্দী সহযোগী সম্পাদক বরুণ মাইতি সম্পাদক মণ্ডলী বিশ্বজিৎ ঘোষ তরুণ সিংহ মহাপাত্র চিন্ময় দাশ ড. বিশ্বজিৎ পাণ্ডা ভাস্করত্রত পতি রামকৃষ্ণ মণ্ডল পূর্ণেন্দু বেরা কার্তিক মাইতি পার্থ মৈত্র প্রকাশনা সহায়ক দেবাশিস দাস পার্থপ্রতীম মিশ্র মিলন বারিক সিদ্ধার্থ বেরা বরুণ নন্দী

> প্রচ্ছদ বিষ্ণু সামন্ত নামাঙ্কন প্রণবেশ মাইতি

বর্ণবিন্যাস সৌভিক কামিল্যা ও বিশ্বজিৎ পানি, দাঁতন, মো ৯৭৩৩৭২২৬৫০ মুদ্রণ ও বাঁধাই শান্তি মুদ্রণ এবং গৌরাঙ্গ বাইন্ডার্স, ৩৮ -এ সীতারাম ঘোষ স্ট্রীট, কলকাতা সহযোগিতায় মেসার্স এইচ.এল. নন্দী অফসেট প্রিন্টার্স, মেদিনীপুর, মো ৯৪৩৪২১৭৬৫৫

> সম্পাদকীয় দপ্তর দাঁতন, পশ্চিম মেদিনীপুর ডাকসূচক ৭২১৪২৬, দূরভাষ ৯৪৩৪৪১০৮৪৮ ই-মেল surja1955@gmail.com ebomsayak123@gmail.com

> > প্রকাশকাল অক্টোবর ২০২১ মূল্য ১২৫ টাকা

ভগীরথ মিশ্র 🗆 চিল ৩৭-৪৪ নলিনী বেরা 🗆 রাণীসাগর ৪৫-৪৮ গৌর বৈরাগী 🗆 ভালো লোক ৪৯ বরুণ মাইতি 🗆 অ্যালার্ম ৫০-৫২ বিনোদ মণ্ডল 🗆 বোতলবন্দী ১৩৭-১৩৯ অসিত বরণ বেরা 🗆 চরুরে ১৪০ দীপক কুমার মাইতি 🗆 বিশ্বাসভঙ্গ ১৪১-১৪২ পল্লব পত্রকার 🗆 দূরত্ব ১৪৩-১৪৬ সন্দীপ দত্ত 🗆 পায়ের তলার মাটি ১৪৭-১৪৮ মোনালিসা পাহাড়ী 🗆 যুদ্ধ জয় ১৪৯ গৌতম মহান্তি 🗖 বিলাপ ১৫০-১৫২

৬. সুরত মুথোপাথ্যায় 🗋 নব বাক্ষায় সুবনরোথক ভূখণ্ডের প্রত্ন ও লোক সম্পদের তত্ত্ব তালাশ ৮২-৮৪ বিশ্বজিৎ ঘোষ 🗆 সুবর্ণরেখা নদী অববাহিকায় গড়দুর্গ এেকটি সমীক্ষা ৮৫-৯১ পার্থ মৈত্র 💷 লকডাউনের ডায়েরি ক্রিছু মানবিক ও অমানবিক দৃশ্যপট ৯২-৯৪ শান্তিপদ নন্দ 💷 আন্দামানে দ্বীপান্তরিত বিপ্লবীগণের জীবন যন্ত্রণার কাহিনি ১১১-১১৪ ড. বিমল কুমার শীট 🗖 গান্ধীযুগে বিপ্লবী হেমচন্দ্র কানুন গো ১১৫-১১৬ শ্যামল বেরা 💷 শতাব্দী প্রাচীন 'নীহার' সংবাদপত্রে দাঁতন কেন্দ্রিক খবর ১১৭-১২১ পূর্বাশা মাইতি 🗖 একটি মুণ্ডা লোক কথা ট্রতিহাসিক বস্তুবাদের আলোকে ১২৩-১২৬ অরিজিৎ মান্না 💷 শতবর্ষে লিপিশিল্পী সত্যজিৎ রায় ১২৭-১৩০ মধুসুদন আচার্য 🗖 প্রসঙ্গ ব্রুড়া প্রবাদে রাঁধুনি ১৩১-১৩২ প্রিয়েঞ্জন পাত্র 🗌 জঙ্গল মহলের নিম্নবর্গীয় সম্প্রদায় ভুক্ত মানুযদের আর্থ-সামাজিক ও সাংস্কৃতিক পরিবেশ বিবর্তনের রূপরেখা ১৩৩-১৩৬

প্রবন্ধগুচ্ছ সুনীল মাজি 🗆 আজহার উদ্দিন সাহিত্যের এক মুসাফির ২৩-২৭ ভাস্করত্রত পতি 🗆 ড. সুব্রত মুখোপাধ্যায় জঙ্গল মহলের মঙ্গল পুরুষ ২৮-৩১ তরুণ সিংহ মহাপাত্র 🗆 মনোজ দাস ্বএক অনন্য সাহিত্য প্রতিভা ৩২-৩৬ মনোতোষ আচার্য 🗆 মনোজ দাস ব্বেক অনন্য সাহিত্য প্রতিভা ৩২-৩৬ ড. সুব্রত মুখোপাধ্যায় 🗆 নব বীক্ষায় সুবর্ণরৈখিক ভূখণ্ডের প্রত্ন ও লোক সম্পদের তত্ত্ব তালাশ ৮২-৮৪ বিশ্বজিৎ ঘোষ 🗆 সুবর্ণরেখা নদী অববাহিকায় গড়দুর্গ বিকটি সমীক্ষা ৮৫-৯১ পার্থ মৈত্র 💷 লকডাউনের ডায়েরি কিছু মানবিক ও অমানবিক দৃশ্যপট ৯২-৯৪

সম্পাদকীয় ৪-৫

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