ISSN : 0973 - 6212

AJHMC

Academic Journal of

Hooghly Mohsin College

Volume : 13 || No.: 1 & 2 || February 2026

Peer-Reviewed • Multidisciplinary • Multilingual Journal

AJHMC

Academic Journal of Hooghly Mohsin College
Chinsurah, Hooghly, West Bengal, Pin 712101

Editorial Board

About the Journal

The *Academic Journal of Hooghly Mohsin College (AJHMC)* is a peer-reviewed, multidisciplinary, and multilingual journal with an ISSN. It aims to promote quality academic research and intellectual discussion across diverse disciplines.

AJHMC invites original research papers in Literature, Science, Economics, Commerce, Management, Humanities, and related fields, with special emphasis on contemporary issues. Selected volumes may also focus on specific thematic areas.

All submissions undergo a rigorous peer-review process. The responsibility for the authenticity of data, accuracy of information, and opinions expressed in the articles rests solely with the authors. The Editorial Board is not responsible for the views expressed therein.

Published by: Principal, Hooghly Mohsin College
E-mail: journalhmc25@gmail.com

Printed at : Dutta Offset, Khadinamore, Chinsurah

AJHMC

Academic Journal of Hooghly Mohsin College

ISSN: 0973-6212

Volume: 13, Issue: 1 & 2
Date of Publication: 28th February 2026

Editor- in-Chief: Dr. Purushottam Pramanik, Principal

Editor: Dr. Atanu Saha, Assistant Professor

Hooghly Mohsin College
Estd. 1836
Chinsurah, Hooghly, West Bengal, Pin: 712101

Note from the Editor-in-Chief

It is my privilege to present the 13th Edition of the *Academic Journal of Hooghly Mohsin College* (AJHMC), releasing on 28th February 2026. By commemorating National Science Day, we celebrate the spirit of inquiry that transcends institutional boundaries and unites the global research community.

This edition marks a significant evolution for AJHMC. We have transitioned from an internal repository to an open, inclusive platform designed to host the high-quality research of scholars, academics, and experts from both our own institution and the wider academic fraternity. By inviting submissions beyond our college walls, we aim to foster a broader intellectual dialogue and elevate the standard of discourse within our pages.

The contributions featured in this volume represent a rigorous standard of academic excellence. Each manuscript has undergone a meticulous peer-review process, ensuring that the research presented is both methodologically robust and significant to its field. We have curated these works to reflect a high level of scholarly maturity, prioritizing professional research contributions that push the boundaries of their respective disciplines.

I extend my sincere appreciation to our distinguished external reviewers and our editorial board for their commitment to maintaining the integrity of this journal. To our contributors—both within Hooghly Mohsin College and from the broader scholarly community—thank you for trusting us with your research.

It is our hope that this edition serves as a vital resource for the academic community and reaffirms our commitment to the advancement of knowledge.

Dr. Purushottam Pramanik

Principal & Editor-in-Chief

Note from the Editor

It is with great pleasure and a deep sense of pride that we present the **13th Edition** of the *Academic Journal of Hooghly Mohsin College (AJHMC)*, scheduled for publication on **28th February 2026**, on the auspicious occasion of **National Science Day**. The release of this volume on a day dedicated to celebrating scientific temper and research excellence adds special significance to this milestone in our academic journey.

Following a considerable interval, the revival of the journal reflects our renewed commitment to scholarly excellence and the continuation of our rich intellectual tradition. This edition upholds the highest standards of academic inquiry and critical engagement.

The articles included in this volume represent the diverse and rigorous research contributions of our faculty members, research scholars, and students. Each manuscript has undergone a meticulous and high-standard peer review process to ensure academic integrity, originality, and scholarly quality. The thoughtful evaluation and constructive insights of our esteemed reviewers have substantially enhanced the academic merit of this publication.

We extend our sincere appreciation to all contributors, reviewers, members of the editorial board, and faculty colleagues whose dedication, professionalism, and tireless efforts have made the publication of this volume possible.

May this 13th edition, released on National Science Day, serve as a meaningful contribution to the enduring academic legacy of Hooghly Mohsin College and continue to inspire excellence in research and scholarship.

Dr. Atanu Saha

Editor

Acknowledgement

The Editorial Board sincerely acknowledges the valuable contribution and generous support of the following faculty members in the journal publication process. Their academic insight, constructive suggestions, and constant cooperation have greatly enriched the quality and integrity of the publication.

·Prof (Dr.) Ashis Kumar Das, Professor
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The Editorial Board places on record its deep appreciation for their dedication, professionalism, and commitment to maintaining high academic standards. Their collective effort has been instrumental in the successful publication of the journal.

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Exploring Floristic Diversity Through Quadrat Study of A River Bank Ecosystem: A Case Study of Hooghly Mohsin College Campus

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Date of Receipt: 04.01.2026 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

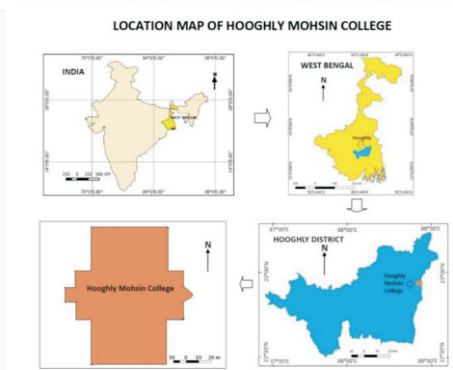
Abstract

This study presents the findings of a comprehensive native floristic survey conducted in a tropical river bank ecosystem located at Hooghly Mohsin College campus (22.883003^0 N,88.400389^{0}E), situated at the bank of river 'Ganga'. The investigation aimed to document the plant diversity, composition, and distribution of species within the study area. A multivariate least count Quadrat analysis of randomly selected 10 spots within the Campus area provide a clear findings in which a total of 45 plant species belonging to 22 families were recorded. The dominant families were Asteraceae and Malvaceae, which accounted for 24.38 % and 10.38 % respectively of the total species recorded. The study area exhibited a high Shannon-Wiener diversity index (H' = 2.660) and a moderate evenness index (J = 0.752). The findings of this study provide a valuable information into the natural floristic diversity of the region and highlight the importance of conservation strategies to protect this river bank ecosystem. The data generated from this study can serve as a baseline for future ecological research of river bank floral diversity and conservation planning in the region.

Keywords: Floristic study, plant diversity, tropical ecosystem, species composition, conservation

Introduction

The floristic study of a region provides a valuable insights into its ecological characteristics, biodiversity, and conservation status. Quadrat study, a widely used method in plant ecology, involves the systematic sampling of vegetation within a defined area to assess species composition, abundance, and distribution (Chapman and Reiss, 2000). This approach enables researchers to quantify and analyze the complex interactions between plant species and their environment (Greig-Smith, 1984). The Hooghly Mohsin College Campus, Chinsurah, Hooghly, West Bengal is a unique ecosystem characterized by its geographical location i.e., at the river bank of 'Ganga'. Despite its ecological significance, the floristic diversity of this region remains understudied.



[22.883003^0 N, 88.400389^0 E]; Image Credit toP. Parai

Address: Hooghly Mohsin College, College Road, Chinsurah, Hooghly, West Bengal, India, 712101

Geographical Locationof Hooghly Mohsin College(22.883003^0 N, 88.400389^0 E)
Source: Google Maps, Google LLC, 2026)

The objectives of the present study aims to bridge this knowledge gap and therefore are focused on the documentation of the floristic diversity as well as analyze the species composition, abundance and distribution patterns through quadrat study within the study area. The findings of this study will contribute to our understanding of the region's ecological dynamics and provide a scientific basis for conservation and management efforts. Furthermore, the data generated will serve as a valuable resource for future research and environmental planning initiatives for sustainable management and preservation of biodiversity in the region.

Methodology

This study will employ a quadrat-based sampling approach, where 10 spots with the quadrat of 5 m x 5 m will be randomly laid out across the College Campus. A quadrat is used in the campus to mark out a specific area of the plant communities to be sampled. Sampling unit of area was taken in the area of definite size. The herbaceous flora was identified by Bengal Plants (Prain, 2010), names of species and number of individual species in each unit are recorded and percentage frequency, density and abundance are calculated by the standard formula (Mahajan and Fatima, 2017). Plant species within each quadrat will be identified, counted and recorded. The data collected will be analyzed using standard ecological indices, such as species richness, Shannon-Wiener diversity index, and similarity indices (Graham and Duda, 2011). Soil samples are collected at a 15 cm depth from each of the 10 quadrats and analyzed for the nitrogen, phosphorus and potassium content at the Chinsurah Rice Research Centre**, Government of West Bengal,** using standard procedure (AOAC Official Method, 2020). Experimental data are analyzed with standard statistical procedure (Gomez and Gomez, 1984)PAST 4.03 (Hammer *et al.,* 2001) was used to calculate commonly used diversity indices of the taxa under investigation. The species diversity was determined using **Shannon-Wiener** Index (1963). The Simpson Index (1949) determined dominance concentration, while Pielou's Index (1966) aids in quantifying species evenness.

Shannon-Wiener index (H'): The Shannon-Wiener index (1963), sometimes referred to as Shannon's diversity index or simply Shannon-index incorporates both parameters and is one of the most widely used indices for measuring ecosystem species diversity. The lower the dominance, the higher the diversity.

$$H' = -\sum [(ni/N)\ln(ni/N)]$$

Where ***H'*** is the index value; **'ln'** denotes natural log, 'ni' is the number of individuals of a species, and 'N' is the total number of species in the habitat area.The diversity of species in a given community increases with increasing ***H'*** value and decreases

with decreasing ***H'*** value. A community with ***H'*** value of 0 is represented by a single species.***Simpson's index*(1-D*)*:** The Simpson index, established in 1949, determines how dominant certain species are in a specific environment.

$(D) = \sum (ni/N)^2$

Where ***D*** is the index value; n**i:** number of individuals of a species; **N:** sum total of all the individual species.This index prioritizes the most dominant species and can range in value from 0 to 1. The higher the value, the greater the chance of encountering a particular species in a given sample.

***Evenness index*(J):** Pielou's evenness is an index that measures evenness, taking into account both the number of different species and the abundance of each species in a given area (Pielou, 1966). Evenness can be calculated by dividing the Shannon index (*H'*) by the natural log of the richness (S).

Evenness index $J = H'/\ln S$

Where ***J***is the index value; ***H'*:** Shannon index; **S:** number of individuals. The value ranges from 0 (no evenness) to 1 (full evenness).

Result and Discussion

Natural floristic vegetation forms a very significant and essential constituent in a specific ecological unit since floral species are the primary producers of the ecosystem and produce food in the form of reserved carbohydrates through photosynthesis process. Therefore, the energy flow from one tropic level to another level starts with the primary producers. The different floral species which have been found during the present study in the spring season at different quadratic spots are presented in the table 1. A multivariate least count quadrat analysis of randomly selected 10 spots within the Campus area provide a clear findings in which a total of 45 plant species belonging to 22 families were recorded. The dominant families were Asteraceae and Malvaceae, which accounted for 24.38 % and 10.38 % respectively of the total species recorded.

Analysis of the soil profile status of the 10 different spots around the College Campus reveals that spot 3 and spot 7 have a high status of nitrogen, phosphorus and potassium content as compared with other spots (*Figure 1*). Diversity indices are valuable tools for assessing biodiversity (Sarkar & Margules,2002). The data indicates a significant variation in plant community structure across the campus (table 2). The **Shannon-Wiener Index** values range from 1.727 to 2.660, with a mean of approximately 2.26. In ecological terms, values between 1.5 and 3.5 typically represent moderate to high diversity. The **Simpson Index** values are consistently high (mean 0.86), suggesting that the campus generally supports a healthy variety of plant species where the probability of any two randomly picked individuals belonging to different species is over 80%. (*Figure 2*).

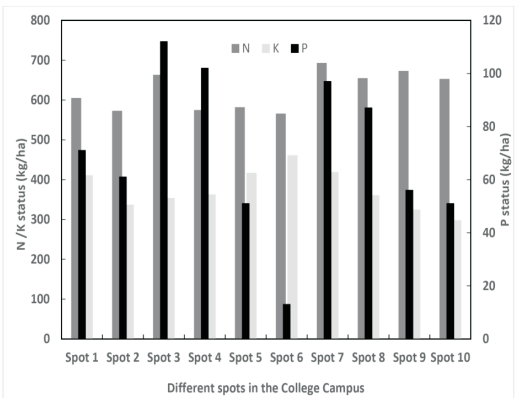


Figure 1: Major nutrient profile analyses of the soil sample from the different spots of the College Campus

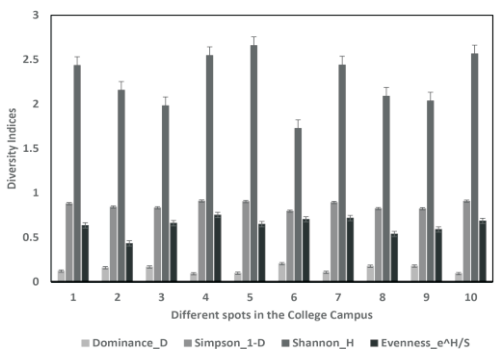


Figure 2: Different diversity indices analyses of the floristic composition from the different spots of the College Campus

Analysis of High-Diversity Spots

Spot 5 stands out as the most diverse area in terms of species richness and abundance, recording the

highest **Shannon Index** of **2.660**. This indicates a complex plant community likely benefiting from favourable environmental conditions or minimal disturbance.

Spot 4 exhibits the highest **Simpson Index (0.9085)** and the highest **Species Evenness (0.7521)**. High evenness suggests that the individuals are distributed relatively equally among the species present, rather than being dominated by a single species. This is further supported by Spot 4 having the lowest **Dominance (0.09147)**.

Analysis of Low-Diversity Spots

Spot 6 appears to be the most ecologically "stressed" or simplified area among the ten sites. It recorded the lowest **Shannon Index (1.727)** and the lowest **Simpson Index (0.796)**.

Correspondingly, Spot 6 has the highest **Dominance Index (0.204)**. This high dominance suggests that one or a few plant species are particularly successful in this area, potentially crowding out others. This could be due to specific soil conditions, localized pollution, or intense human activity (like trampling or frequent clearing).

Species Evenness and Distribution

While **Spot 2** has a respectable Shannon Index (2.157), it shows the lowest **Evenness (0.4324)**. This discrepancy suggests that while there are a fair number of species present in Spot 2, their population distribution is highly unequal—some species are likely very common while many others are rare. In contrast, spots like **Spot 7** and **Spot 4** show high evenness (>0.7), indicating more stable and balanced plant communities.

Conclusion

The native Floristic Diversity analysis at Hooghly Mohsin College campus shows a healthy ecological gradient. The high diversity and evenness in **Spots 4, 5, and 10** suggest these areas might serve as important micro-habitats or 'green pockets' within the campus. On the other hand, the high dominance and lower diversity in **Spot 6** might require some strategic management intervention if the goal is to enhance overall campus biodiversity. The variations observed likely reflect differences in micro-climatic conditions, soil quality, and the level of anthropogenic interference across different parts of the college grounds.

Acknowledgement

The authors sincerely thank the Under-graduate Botany (General) Semester VI students (2022–2025) of Hooghly Mohsin College for their active participation in the field experiments conducted as part of their academic curriculum. The authors also acknowledge the contribution of Mr. Pintu Sur, Assistant Agricultural Chemist, Soil Testing Laboratory, Hooghly Krishi Bhavan (R.R.S. Campus, Chinsurah, Hooghly--712102, West Bengal).

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Table 1: Observations on the Floristic Diversity in the Hooghly Mohsin College Campus (Families arranged according to Bentham & Hooker's Natural System of Plant Classification)

Sl No	Name of the plant species	Family	Number of individuals in each spot										Total no of plants in each species	Relative abundance	Density
			1	2	3	4	5	6	7	8	9	10			
1	*Tinospora cordifolia* (Willd.) Miers	Menispermaceae	7	3			25						35	0.570404	11.66
2	*Sida rhombifolia* L.	Malvaceae	53	176	65	121	18	10	39	5		148	635	10.34876	70.55
3	*Oxalis corniculata* L.	Oxalidaceae	55			79	46		31	94		53	358	5.83442	59.66
4	*Cayratia trifolia* (L.) Domin	Vitaceae			5	54	30		16	24			129	2.102347	25.8
5	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	9		27	6	39		3		6	7	97	1.580834	13.85
6	*Oldenlandia corymbosa* L.	Rubiaceae				53			104	17			174	2.835724	58
7	*Blumea lacera* (Burm.fil.) DC.	Asteraceae	50	9	12	112	52	14	25	121		93	488	7.953064	27.55
8	*Eleutheranthera ruderalis* (Sw.) Sch. Bip.	Asteraceae				33	185		42	9			269	4.383963	67.25
9	*Parthenium hysterophorus* L.	Asteraceae	5	24		67	69		13	6		77	261	4.253585	37.28
10	*Mikania micrantha* Kunth.	Asteraceae	8	4	39	23	14	132	2			4	226	3.683181	28.25
11	*Tridax procumbens* L.	Asteraceae	26	32	76	16	10			26	32	76	160	2.607562	20
12	*Ageratum conyzoides* L.	Asteraceae		78									78	1.271186	78
13	*Veronica persica* Poir.	Asteraceae		15									15	0.244459	15
14	*Lactuca serriola* L.	Asteraceae			3								3	0.048892	3
15	*Calotropis gigantea* (L.) W.T.Aiton	Apocynaceae	27	12		5			121	14			179	2.91721	35.8
16	*Rauvolfia tetraphylla* L.	Apocynaceae	7									10	17	0.277053	8.5
17	*Solanum nigrum* L.	Solanaceae		2									2	0.032595	2
18	*Ruellia prostrata* Poir.	Acanthaceae	7	32	79		18	42			3	57	238	3.824596	34
19	*Andrographis paniculata* (Burm.fil.) Nees	Acanthaceae									17		17	0.273214	17
20	*Lantana camara* L.	Verbenaceae		12									12	0.195567	12
21	*Anisomeles indica* (L.) Kuntz	Lamiaceae	21	155									176	2.868318	88

22	*Mentha piperita* L.	Lamiaceae										36	36	0.586701	36
23	*Clerodendrum viscosum* Vent.	Lamiaceae					10						10	0.162973	10
24	*Clerodendrum infortunatum* L.	Lamiaceae									3		3	0.048892	3
25	*Boerhavia diffusa* L.	Nyctaginaceae					43	7				2	52	0.847458	17.33
26	*Achyranthes aspera* L.	Amaranthaceae	5	2			205						212	3.455987	70.66
27	*Aerva lanata* (L.) Juss. ex Schult.	Amaranthaceae	21	4	17	54	78		10	8		8	200	3.253245	25
28	*Alternanthera sessilis* (L.) R.Br. ex DC.	Amaranthaceae				54			33	5			92	1.499348	30.66
29	*Antigonon leptopus* Hook. & Arn.	Polygonaceae	33	4		147		145	58	7			394	6.421121	65.66
30	*Acalypha indica* L.	Euphorbiaceae		3		20	86		60	4	8	67	248	4.041721	35.42
31	*Tragia involucrate* L.	Euphorbiaceae			5								5	0.081486	5
32	*Croton bonplandianus* Baill.	Euphorbiaceae					5						5	0.081486	5
33	*Euphorbia heterophylla* L.	Euphorbiaceae	4										4	0.065189	4
34	*Phyllanthus niruri* L.	Phyllanthaceae	11	2		78	27	74	30	59		17	298	4.856584	37.25
35	*Phyllanthus reticulatus* Poir.	Phyllanthaceae			10		8				5	15	38	0.619296	9.5
36	*Pouzolzia zeylanica* (L.) Benn. & R.Br.	Urticaeae	119	159			12					129	419	6.828553	104.75
37	*Curcuma aromatica* Salisb.	Zingiberaceae									2		2	0.032595	2
38	*Asparagus racemosus* Willd.	Liliaceae									4		4	0.065189	4
39	*Tradescantia spathacea* Sw.	Commelinaceae									26		26	0.423729	26
40	*Commelina benghalensis* L.	Commelinaceae		25									25	0.407432	25
41	*Colocasia esculenta* (L.) Schott	Araceae				11	50		27	7	37	15	147	2.395698	24.5
42	*Typhonium trilobatum* (L.) Schott	Araceae									28		28	0.456323	28
43	*Imperata cylindrica* (L.) Raeusch.	Poaceae					35	101					136	2.216428	68
44	*Oplismenus compositus* (L.) P. Beauv.	Poaceae									86	47	133	2.167536	66.5
45	*Eleusine indica* (L.) Gaertn.	Poaceae										50	50	0.814863	50

Table 2: Different diversity indices of the floral vegetation of different spots of the College Campus

Diversity Indices	**Spot 1**	**Spot 2**	**Spot 3**	**Spot 4**	**Spot 5**	**Spot 6**	**Spot 7**	**Spot 8**	**Spot 9**	**Spot 10**
Dominance_ *D'*	0.120	0.159	0.167	0.091	0.096	0.204	0.107	0.176	0.177	0.092
Simpson_1-D	0.879	0.840	0.833	0.908	0.903	0.796	0.892	0.823	0.822	0.907
Shannon_ *H'*	2.436	2.157	1.983	2.548	2.66	1.727	2.441	2.09	2.037	2.567
Evenness_ *J*	0.634	0.432	0.660	0.752	0.649	0.703	0.717	0.538	0.589	0.685

Annexure of Table 1: English Name and Bengali Name of the Plant species studied

Sl. No	Name of the plant species	Family	English Name	Bengali Name
1	*Tinospora cordifolia* (Willd.) Miers	Menispermaceae	Giloy/ Heart-leaved Moonseed	গুলঞ্চ (Gulancha)
2	*Sida rhombifolia* L.	Malvaceae	Arrow-leaf Sida	লাল বেড়েলা (Lal Berela)
3	*Oxalis corniculata* L.	Oxalidaceae	Creeping Wood Sorrel	আমরুল শাক (Amrul Shak)
4	*Cayratia trifolia* (L.) Domin	Vitaceae	Bush Grape	অমল লতা / গোয়াল লতা (Amal / Goal Lata)
5	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Ivy Gourd	তেলাকুচা (Telakuncha)
6	*Oldenlandia corymbosa* L.	Rubiaceae	Diamond Flower	ক্ষেতপাপড়া (Khetpapra)
7	*Blumea lacera* (Burm.fil.) DC.	Asteraceae	Blumea	কুকুরমুতা (Kukurmuta)
8	*Eleutheranthera ruderalis* (Sw.) Sch. Bip.	Asteraceae	Trailing Daisy/Aster	ওগিয়েরা (Ogiera)
9	*Parthenium hysterophorus* L.	Asteraceae	Congress Grass	গাজর ঘাস (Gajar Ghash)
10	*Mikania micrantha* Kunth.	Asteraceae	Mile-a-Minute Weed	জার্মান লতা (Jarman Lata)
11	*Tridax procumbens* L.	Asteraceae	Coat Buttons	ত্রিধারা/ ত্রিদক্ষা (Tridaksha)
12	*Ageratum conyzoides* L.	Asteraceae	Billy Goat Weed	উচুন্টি (Uchunti)
13	*Veronica persica* Poir.	Asteraceae	Persian Speedwell	নীল ঘাস (Neel Ghash)
14	*Lactuca serriola* L.	Asteraceae	Prickly Lettuce	বন লেটুস (Bon Letuce)
15	*Calotropis gigantea* (L.) W.T.Aiton	Apocynaceae	Crown Flower	আকন্দ (Aakonda)
16	*Rauvolfia tetraphylla* L.	Apocynaceae	Devil Pepper	বড় চন্দ্রিকা (Barchandrika)
17	*Solanum nigrum* L.	Solanaceae	Black Nightshade	কাকমাছি(Kakmachhi) /তিতবেগুন (Titbegun)
18	*Ruellia prostrata* Poir.	Acanthaceae	Prostrate Ruellia	ক্ষুদে পটপটি (Kshude Patpati)
19	*Andrographis paniculata* (Burm.fil.) Nees	Acanthaceae	King of Bitters	কালমেঘ (Kalmegh)
20	*Lantana camara* L.	Verbenaceae	Lantana	চোতরা (Chotra)/ বনমরিচ (Banmarich)
21	*Anisomeles indica* (L.) Kuntz.	Lamiaceae	Indian Catmint	গোলাপি গোবুরা (Golapi Gobura)
22	*Mentha piperita* L.	Lamiaceae	Peppermint	পুদিনা (Pudina)

23	*Clerodendrum viscosum* Vent.	Lamiaceae	Glory Bower	ভাঁট (Bhant)/ ঘেঁটু (Ghentu)
24	*Clerodendrum infortunatum* L.	Lamiaceae	Hill Glory Bower	ভাঁট ফুল (Bhant Phul)
25	*Boerhavia diffusa* L.	Nyctaginaceae	Punarnava	পুনর্নবা (Punarnaba)
26	*Achyranthes aspera* L.	Amaranthaceae	Prickly Chaff Flower	আপাং (Apang)
27	*Aerva lanata* (L.) Juss. ex Schult.	Amaranthaceae	Mountain Knotgrass	চায়া ঘাস (Chaya Ghash)
28	*Alternanthera sessilis* (L.) R.Br. ex DC.	Amaranthaceae	Sessile Joyweed	হেলেঞ্চা (Helencha)
29	*Antigonon leptopus* Hook. & Arn.	Polygonaceae	Coral Vine	অনন্তলতা (Ananta Lata)/প্রেমলতা (Prem Lata)
30	*Acalypha indica* L.	Euphorbiaceae	Indian Copperleaf	মুক্তাঝুরি (Muktajhuri)
31	*Tragia involucrate* L.	Euphorbiaceae	Stinging Nettle	লতা বিছুটি (Lata Bichuti)
32	*Croton bonplandianus* Baill.	Euphorbiaceae	Croton Weed	বন তুলসী (Ban Tulsi)
33	*Euphorbia heterophylla* L.	Euphorbiaceae	Wild Poinsettia	আগ্নিপত্র (Agnipatra)
34	*Phyllanthus niruri* L.	Phyllanthaceae	Stonebreaker	ভুঁই আমলা (Bhui Amla)
35	*Phyllanthus reticulatus* Poir.	Phyllanthaceae	Netted Leaf flower	পানঝুরি (Panjhuri), পানজুলি (Panjuli)
36	*Pouzolzia zeylanica* (L.) Benn. & R.Br.	Urticaeae	Graceful Pouzolz's Bush	দুধগাছি (Dudhgachhi)
37	*Curcuma aromatica* Salisb.	Zingiberaceae	Wild Turmeric	বন হলুদ (Bon Holud).
38	*Asparagus racemosus* Willd.	Liliaceae	Shatavari	শতমূলী (Satamuli)
39	*Tradescantia spathacea* Sw.	Commelinaceae	Oyster Plant	ঝিনুক গাছ (Jhinuk gach)
40	*Commelina benghalensis* L.	Commelinaceae	Bengal Dayflower	কানশিরা(Kanshira), কানাইবাঁশি (Kanaibashi)
41	*Colocasia esculenta* (L.) Schott	Araceae	Taro	বুনোকচু (Bunokochu)
42	*Typhonium trilobatum* (L.) Schott	Araceae	Bengal Arum	ঘাটকোল (Ghatkol)
43	*Imperata cylindrica* (L.) Raeusch.	Poaceae	Cogon Grass, Thatch Grass	উলু ঘাস (Ulu Ghash)
44	*Oplismenus compositus* (L.) P. Beauv.	Poaceae	Basket Grass	ঘাস (Ghas)
45	*Eleusine indica* (L.) Gaertn.	Poaceae	Goosegrass, Crowfoot Grass	চাপড়া ঘাস (Chapra ghas)

AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

প্রসঙ্গ উনিশ শতকের নব্য নাগরিকতা : ঔপনিবেশিক মেধাজীবীর মননের সংকট

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Date of Receipt: 27.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

সারসংক্ষেপ : উনিশ শতক বঙ্গদেশে এক পালাবদলের কাল। পাশ্চাত্য শিক্ষা সংস্কৃতির হাত ধরে নবজাগৃতির আলোকবৃত্তে প্রবেশ। অখ্যাত পল্লিসমষ্টির অভাবনীয় মহানাগরিক বিস্তার। বাঙালি জীবনে নতুন নাগরিকতার সংজ্ঞা নির্ধারণে সেই কলকাতা নগরীর গুরুত্বপূর্ণ ভূমিকায় অবতীর্ণ হওয়া। জ্ঞান আর ক্ষমতার নতুন সমীকরণ। নবযুগের নব্য নাগরিকের আবির্ভাব। উপনিবেশের আলো-আঁধারি প্রহরে বাঙালি ভদ্রলোকের জীবন ও মননে প্রতিফলিত স্ববিরোধিতায় ভরা আত্মরূপায়নের এক কর্মসূচী। একই সঙ্গে বাঙালি ভদ্রলোকদের স্বপ্নের সৃজন এবং স্বপ্নভঙ্গের ইতিবৃত্ত। নতুন আলোর দিশা সন্ধান অথচ শিকড়বিচ্ছিন্ন হওয়ার অভিশাপ। নতুন আকাঙ্ক্ষা এবং তারই পাশাপাশি তাকে ঘিরে এক অজানা আশঙ্কার যে আবর্ত সেই পর্বকে অস্থির করেছিল, সেই অস্থিরতার ছাপ সেকালের জীবনধর্মের গভীরে সূক্ষ্মভাবে নিহিত আছে।

সূচক শব্দ : উনিশ শতক, উপনিবেশ, কলকাতা, নাগরিকতা, শিক্ষিত ভদ্রলোক, ক্ষমতা, আধিপত্য, আনুগত্য।

মূল প্রবন্ধ :

‘একদিন কলিকাতা ছিল অখ্যাত অসংস্কৃত পল্লী; সেখানে বসল বিদেশী বাণিজ্যের হাট, গ্রামের শ্যামল আবেষ্টন সরিয়ে দিয়ে শহরের উদ্ধত রূপ প্রকাশ পেতে লাগল। সেই শহর আধুনিক কালকে দিল আসন পেতে; বাণিজ্য এবং রাষ্ট্রের পথে দিগন্তের পর দিগন্তে সেই আসন বিস্তৃত হয়ে চলল।’[১]

ব্রিটিশ সাম্রাজ্যবাদী শক্তি এই ভূখণ্ডে প্রথম পদার্পণ করেছিল বণিকবেশে। বাণিজ্য আর মুনাফা এই ছিল তখন তাদের সাধ্যবস্তু। বাণিজ্যের সুবিধা আদায় করার জন্য তাদের কূটনীতির আশ্রয় নিতে হয়েছিল। খোশামোদ করে, কৌশল করে, উৎকোচ দিয়ে, প্রয়োজনে শক্তি প্রয়োগ করে তারা তৎকালীন শাসকের কাছ থেকে যতদূর সম্ভব সুযোগ সুবিধা আদায়ের চেষ্টা করেছিল। সম্ভাব্য প্রতিদ্বন্দ্বীদের সরিয়ে নিজেদের মুনাফালাভের পথ প্রশস্ত করেছিল। দেশের বিভিন্ন প্রান্তে চলেছিল তাদের এই বাণিজ্যিক পরিকল্পনা বাস্তবায়নের নানাবিধ নিরীক্ষা। তারপর সময় এবং পরিস্থিতির সুযোগ নিয়ে আত্মপ্রকাশ করেছিল তাদের সাম্রাজ্যবাদী সর্বভুক মূর্তিতে। বণিক হিসেবে সমগ্র এশিয়া থেকে ইংরেজরা যে পরিমাণ পণ্য আমদানি করত, তার প্রায় ষাট শতাংশই ছিল বাংলার পণ্য। কাজেই বোম্বাই, সুরাট ও মালাবার তথা পশ্চিম উপকূলের বাণিজ্যের চাইতে কোম্পানির বাংলাদেশে বাণিজ্যিক স্বার্থ অনেক বেশি গুরুত্বপূর্ণ হয়ে ওঠে। আর এই বাণিজ্যিক স্বার্থরক্ষার জন্য এখানে উপযুক্ত বাণিজ্যকেন্দ্র স্থাপন করা খুবই প্রয়োজন ছিল। বিভিন্ন স্থান নিয়ে পরীক্ষা-নিরীক্ষার পর ঘটনাচক্রে কলকাতাই হয়ে উঠল প্রাচ্যে বাণিজ্যের সেই প্রধান কেন্দ্রবিন্দু। গ্রামের পাঁজর ফাটিয়ে জেগে উঠতে লাগল ভবিষ্যতের মহানগর। জীবন-জীবিকার তাগিদে আর ভাগ্যান্বেষণে গ্রাম থেকে শহরবাসী হল অজস্র মানুষ। ইতিমধ্যে নবীন মহানগরের দরজায় কড়া নাড়ল উনিশ শতক। এই দিগন্তবিস্তারী মহানাগরিকতার পটে উনিশ শতকে রচিত হল তথাকথিত ভদ্রলোকের নতুন সংজ্ঞা। এতকালের সামাজিক কাঠামোয় এল নানা রূপান্তরের ছোঁয়া। হঠাৎ আলোর ঝলকানির মতো এক ভিন্নস্বাদী নাগরিক স্বাধীনতা নিয়ে এল নতুন নগর। অর্থ, বিত্তের পাশাপাশি নব্য শিক্ষার মানদণ্ডে নতুন করে নির্ণীত হতে লাগল শিষ্ট এবং অশিষ্ট নাগরিকের চরিত্রলক্ষণ। আধুনিক শিক্ষানীতির সোনার কাঠির স্পর্শে সূক্ষ্মভাবে বৈষম্যের জাল ছড়িয়ে দেওয়া হল। নতুন সভ্যতার স্পর্শে আলোকিত হল যারা, বদলাতে থাকল তাদের রুচি। এই রুচির পার্থক্য ক্রমশ

বৃদ্ধি করতে লাগল উভয় শ্রেণির ব্যবধান। গ্রাম থেকে নতুন নগরে চলে আসা প্রথম প্রজন্মের শহরবাসীদের মধ্যে সভ্যতা-সংস্কৃতির দিক থেকে জল-অচল ব্যবধান ছিল না। কিন্তু ক্রমশ রচিত হতে থাকল অপরিমেয় দূরত্বের রূপরেখা।

নতুন শিক্ষা, নতুন রুচি, নব্য জীবনচেতনা উনিশের মানুষের মননে এনেছিল এক সুদূরপ্রসারী বিবর্তন। পাশ্চাত্য সভ্যতা-সংস্কৃতির স্পর্শে উনিশ শতকে ঘটেছিল বাংলায় নবজাগরণ। যে জাগরণের ফলে পাশ্চাত্য থেকে আগত নতুন চেতনার স্রোত ভাসিয়ে নিয়ে গিয়েছিল এদেশে সঞ্চিত বহুবিধ জীর্ণতা আর বদ্ধতাকে। সবচেয়ে বড় কথা, তা এক নতুন শ্রেণির বিকাশের সহায়ক হয়েছিল। তাঁরা হলেন শিক্ষিত মধ্যবিত্ত। মুক্ত চিন্তার সূত্র ধরে নতুন আলোর পথযাত্রীরা একই পথের পথিক হয়ে উঠছিলেন। সমালোচক এ প্রসঙ্গে উল্লেখ করেছেন :

'what connected them all was that they shared in the creation and formation, in one way or another, of a mentality which straddled two cultures, Western and Indian. This cross-cultural mentality, let us call it the Indo-Western mind, was the ultimate and supreme product of the Bengal Renaissance.'[২]

কী করে মানুষের জীবনে দূর সভ্যতার বীজ এসে পড়ে, কেমনভাবে তাদের চেতনায় মুদ্রিত হয় সেই সভ্যতার চিত্র, এই যুগ তার প্রত্যক্ষ উদাহরণ। ঔপনিবেশিক পর্বে যখন পশ্চিমের খোলা জানালা দিয়ে এক অভাবনীয় আলো বাঙালির জীবনে বিচ্ছুরিত হল তখন তা সাহিত্য-সংস্কৃতি এবং চিন্তাজগতকে সম্যকভাবে প্রভাবিত করেছিল। তারই সাপেক্ষে কেমনভাবে নব্য বাঙালি বুদ্ধিজীবীরা পাশ্চাত্য সংস্কৃতির টানে সাড়া দিচ্ছিলেন, নতুনকে চয়ন করার নিজস্ব শর্তগুলো কেমনভাবে বাঙালির বুদ্ধিচর্চা ও জীবনচর্চায় অন্তর-বাহিরে সমবায়, সন্ধি বা সংঘর্ষের আকার নিচ্ছিল, এই ভাবধারা কেমনভাবে কখনো উচ্চকিত, কখনো অন্তঃশীল হয়ে বইছিল সেকালের বাঙালির মননে, এই যুগ তার সাক্ষ্যবাহী।

তবে বাংলার নবজাগরণের যে উজ্জ্বল মুহূর্তের বিবরণ পাওয়া যায়, তার মধ্যেও যে কিছু কিছু ব্যাধির জীবাণু ছিল, ছিল কিছু নেতিবাচকতা, সেকথা অস্বীকার করার উপায় নেই। ঐতিহাসিক সুশোভন সরকার (১৯০০-১৯৮২ খ্রিস্টাব্দ) এ বিষয় সম্পর্কে আলোকপাত করতে গিয়ে লিখেছেন :

'Yet the Bengal Renaissance has certainly its own specific relative value. Historians are now acutely conscious of the serious limitations of the renaissance in Europe itself; the old halo has largely faded. Our 'pre-renaissance' society, again was undoubtly depressing; a recovery from the stupor has its own merit.

The guide-line for a proper assessment of what happened in the cultural life of 19th century Bengal must then steer between uncritical adulation and scornful rejection. A historical appreciation of the 'new life' in Bengal is possible, even after recognising its obvious weakness: it did move on the axis of the upper stratum alone of society, the 'bhadroloks'; it could not draw in the Muslim community and the masses of the backward Hindus; it failed to strike a consistent anti-imperialist note, in sharp contrast to the role of the intellectuals in the Russia of the same period.'[৩]

মূলত শিক্ষিত মধ্যবিত্ত হিন্দু সমাজে সৃষ্টির একটা জোয়ার এসেছিল। চিন্তা-চেতনার জগতেও কমবেশি একটা পরিবর্তন এসেছিল। সেই সৃজনশীলতা এবং মনোজগতের পরিবর্তন আপামর জনতাকে কতটা স্পর্শ করতে পেরেছিল তা নিয়ে অবশ্য কিছু প্রশ্নের অবকাশ আছে। এমনকি সামগ্রিকভাবে মুসলিম সমাজের মধ্যেও তা বিশেষ আলোড়ন তুলতে পারেনি। তবে এইসব ত্রুটি-বিচ্যুতি সত্ত্বেও বাঙালির জীবনে এই সময়পর্বের গুরুত্বকে অস্বীকার করা যায় না। উনিশ শতকের প্রথমার্ধের বাংলা নানা ঘটনার ঘাত-প্রতিঘাতে চঞ্চল, সেকালের বাঙালি যেন এই পর্বে জীবনকে পুনর্গঠন করতে প্রয়াসী। এ পর্ব

নব্য বাঙালির আত্মআবিষ্কারের পর্ব। বাঙালি তার মধ্যযুগীয় মনের কাঠামো থেকে এইসময় ক্রমশ বেরিয়ে আসতে থাকে। গতানুগতিক নির্বিকারত্ব অতিক্রম করে নানা বিষয়ে প্রশ্নমুখর হয়ে উঠতে থাকে। ফলে একথা অস্বীকার করলে চলবে না যে, শিক্ষিত মধ্যবিত্ত বুদ্ধিজীবী শ্রেণির উদ্ভব আর বিকাশের অনুকূল পরিবেশ সৃজিত হয়েছিল সে পর্বেই। তারাই হয়ে উঠছিল আগামী দিনের সভ্যতা-সংস্কৃতির ধারাপথের নির্ণায়ক শক্তি। তাদের ছিল নতুন শিক্ষার তেজ, নতুন সামাজিক মর্যাদালাভের গৌরব। সেকালের শিক্ষিত যুবকেরা ইংরেজি শিক্ষা এবং সাহিত্যের হাত ধরে পাচ্ছিল এক ভিন্নমাত্রিক জগতের স্বাদ। তখনও 'য়ুরোপের চিত্তদূত' হিসেবেই ইংরেজদের গণ্য করা হত। রবীন্দ্রনাথ যথার্থই বলেছিলেন:

'য়ুরোপের চরিত্রের প্রতি আস্থা নিয়েই আমাদের নবযুগের আরম্ভ হয়েছিল; দেখেছিলুম জ্ঞানের ক্ষেত্রে য়ুরোপ মানুষের মোহমুক্ত বুদ্ধিকে শ্রদ্ধা করেছে এবং ব্যবহারের ক্ষেত্রে স্বীকার করেছে তার ন্যায়সংগত অধিকারকে। এতে করেই সকলপ্রকার অভাবত্রুটি সত্ত্বেও আমাদের আত্মসম্মানের পথ খুলে গিয়েছে।'[৪]

ইংরেজি সাহিত্য যোগাচ্ছিল মনের খোরাক, আর ভাষা ছিল তার চাবিকাঠি। নতুন জগতের খবর পাওয়ার বাসনায় ইংরেজি ভাষা আর সাহিত্যের প্রতি আকর্ষণ যেমন বৃদ্ধি পেয়েছিল, তেমনই এটাও মনে হয়েছিল যে এই ভাষায় দক্ষতা এনে দেবে কর্মক্ষেত্রে নিরাপত্তা, পদমর্যাদা বৃদ্ধির সুযোগ, আর্থিক সমৃদ্ধি। সমালোচক বলছেন :

'সাগরপারের নাম না জানা বিভিন্ন কবি-সাহিত্যিক এদেশের তরুণদের সামনে নিয়ে এলেন এক অজানা জগতের খবর।...অনেক শিক্ষিত বাঙালি যুবক ইংরেজিকেই প্রাণের ভাষা হিসাবে গ্রহণ করে, তাতে শুধু লিখতে, বলতে, পড়তেই আরম্ভ করলেন না, তাঁরা স্বপ্নও দেখতে আরম্ভ করলেন ইংরেজিতে! এর পেছনে অন্যান্য কারণের সঙ্গে ইংরেজি শিক্ষিতের উজ্জ্বল সামাজিক ও আর্থিক ভবিষ্যতের প্রলোভনও কাজ করেছিল।'[৫]

এদিকে ইংরেজ বণিকের নির্মোক ছেড়ে উপনিবেশের প্রভু হয়ে ওঠার পর বিদেশি শাসকদের প্রয়োজন হয়েছিল নিজেদের শিক্ষা এবং রুচির অনুরূপ এক সম্প্রদায় গঠন। যারা তাদের প্রতি অনুগত থেকে এই উপনিবেশের সাম্রাজ্যরক্ষায় সুরক্ষা বলয়ের কাজ করবে। পরিণামে পাবে উপশাসকের পুরস্কার। প্রয়োজনীয় ইংরেজি শিক্ষা এই শ্রেণির উত্থানে সহায়ক হবে। এভাবেই তৈরি হচ্ছিল ভারতীয় ইংরেজিনবিশ এক সম্প্রদায়। নীরদচন্দ্র চৌধুরী (১৮৯৭-১৯৯৯ খ্রিস্টাব্দ) পরবর্তীকালে তাঁর 'কন্টিনেন্ট অব সার্সি'তে (১৯৬৫ খ্রিস্টাব্দ) 'ডমিন্যান্ট মাইনরিটি' বলে যে শ্রেণির কথা উল্লেখ করেছেন, তারা এদের উত্তরপুরুষ বললে ভুল হয় না। তারা দেশের বিপুল জনসংখ্যার তুলনায় মুষ্টিমেয়, কিন্তু দেশের শাসনক্ষমতাকে, বিভিন্ন নীতিকে প্রভাবিত করার অধিকার তাদের সবচেয়ে বেশি। এই নতুন নাগরিকেরা আলোর ফাঁদে বন্দী। তাদের নাগরিক দায়িত্ববোধ এমনভাবে নির্মিত যে তারা নিজেরই কারাগারের রক্ষী হয়ে উঠেছিল বিনা বাক্যব্যয়ে। উপনিবেশের অধিবাসীদের ওপর চলছিল নিরন্তর খবরদারি, সেই খবরদারির চাপ তারা যত আত্মস্থ করছিল, তার প্রভাব ততই গভীরে অনুপ্রবিষ্ট হচ্ছিল, ক্ষমতার অভিব্যক্তি হচ্ছিল তত অবাধ। কারণ মানুষের মর্মমূলে যত পাকা হয় ক্ষমতার ভিত, ততই অসাড় হয়ে আসে ক্ষমতার ক্রিয়া-বিক্রিয়ার বোধ। এই বিষয়ে তৃণা বন্দ্যোপাধ্যায় বলছেন :

'শুধু বাহ্যিক রাজনৈতিক, আইনি অথবা সরকারী শাসন নয়, বরং মানুষের 'ব্যক্তিসত্তা'র বোধকে নিয়ন্ত্রণ করতে শুরু করে এক আপাত আভ্যন্তরীণ শাসন ব্যবস্থা যাকে আধুনিক রাষ্ট্রের নাগরিক 'বিবেক', 'সভ্যতা', 'শালীনতা', 'জাতীয় কর্তব্যবোধ' ইত্যাদির আখ্যা দিয়ে থাকে।'[৬]

আর তা পালন করার জন্য সে হয়ে ওঠে দায়বদ্ধ। নিজের উদ্দেশ্যসিদ্ধির জন্য 'নাগরিকদের ক্রমশ স্বতশ্চল নিয়ন্ত্রণে অভ্যস্ত করে তোলাই প্রতাপের লক্ষ্য, যাতে স্বশৃঙ্খলা সমাজে অবিসংবাদী নীতি হিসেবে প্রতিষ্ঠিত হয়ে যায়।'[৭]

যতদিন এ দেশের সঙ্গে ইংরেজদের সম্পর্কটা বাণিজ্যের মাধ্যমেই সম্পর্কিত ছিল ততদিন এদেশবাসীর কোনো বিষয়েই তাদের মাথা ঘামাবার বিশেষ প্রয়োজন হয়নি। কিন্তু যখনই এই সম্পর্কের মাত্রা বদলে যায়, জেতা-বিজেতা, রাজা-প্রজার ধারণা অনুপ্রবিষ্ট হয়, তখনই আধিপত্য আর আনুগত্যের সমীকরণ নতুন করে সাজিয়ে

নেওয়ার প্রয়োজন পড়ে। এদেশের বিপুল কাঁচামাল এবং বৃহৎ বাজার ঔপনিবেশিক প্রভুশক্তিকে উল্লসিত করে তোলে। এদেশে উপনিবেশের মেয়াদ দীর্ঘস্থায়ী করার জন্য, সুবিশাল বাজারকে সুরক্ষিত রাখার জন্য, নিরাপদে শাসন চালাবার জন্য করতে হয় বিভিন্ন আয়োজন। মূল থেকে বিনষ্ট করে দিতে হয় যে কোনো অন্তর্ঘাতের সম্ভাবনাকে। বিচ্ছিন্ন করে দিতে হয় দেশের শিকড়ের সঙ্গে দেশের বুদ্ধিজীবীদের আত্মিক সংযোগকে। প্রতিনিয়ত মেধাজীবীর মস্তিষ্কের দখল নেওয়ার জন্য পরিকল্পনা করতে হয়। পৃথিবীর সমস্ত উপনিবেশের ক্ষেত্রেই যেহেতু এমনটা সত্যি তাই এখানেও তার ব্যতিক্রম হয়নি। বিনয় ঘোষ যথার্থই বলেছেন ব্রিটিশের প্রধান লক্ষ্য ছিল নিরাপদ নিশ্চিন্ত শাসনের উদ্দেশ্যে দেশের আইনশৃঙ্খলা ও সামাজিক স্থিতি যে কোনো উপায়ে বজায় রাখা। তাঁরা এমনভাবে সমাজের শ্রেণিবিন্যাসটিকে ঢেলে সাজিয়েছিলেন যাতে তার অতীতের সামন্ততান্ত্রিক বনেদটি মূলত বজায় থাকে। গ্রাম্য সমাজে নতুন জমিদারশ্রেণি, বৃহৎ একটি জমিদারি নির্ভর মধ্যস্বত্বভোগী ও গ্রাম্য মধ্যশ্রেণি, নাগরিক সমাজে নতুন অর্বাচীন অভিজাত-ধনিকশ্রেণি, খুদে ব্যবসায়ী দোকানদার চাকুরীজীবী প্রভৃতিদের নিয়ে বড় একটি নাগরিক মধ্যশ্রেণি এবং তার মধ্যে সোনার চাঁদের মতো একদল ইংরেজি শিক্ষিত এলিট। সাম্রাজ্যবাদীর অধীন দেশে, যেমন আমাদের বাংলাদেশে এই শিক্ষিত এলিট গোষ্ঠী সম্পর্কে জ্যাঁ পল সার্ত্র যে উক্তি করেছিলেন তা নির্মম হলেও সত্য:

'The European elite undertook to manufacture a native elite. They picked out promising adolescents: they branded them, as with a red-hot iron, with the principles of western culture; they stuffed their mouths full with high sounding phrases, grand glutinous words that stuck to the teeth...These walking lies had nothing left to say to the their brothers;they only echoed' (Preface, Fanon : The Wretched of the Earth).'[৮]

আসলে ইউরোপীয়ান এলিটের আদর্শপুষ্ট হয়ে এদেশের শিক্ষিত এলিট গড়ে উঠেছিল। সেই আদর্শের বীজ থেকে অঙ্কুর এবং অঙ্কুর থেকে গাছ ফুল ফল হবার মতো দেশের মানুষের মনের মাটি তৈরি হয়নি। যাবতীয় উন্নতি ও প্রগতি মূলত বর্ধিষ্ণু বুর্জোয়াশ্রেণি আর নতুন মধ্যবিত্তের জন্য নির্ধারিত ছিল। ইংরেজ শাসন এবং জাতীয় জীবনে নবজাগরণ সম্পর্কে একদিকে বিশ্বাস-মুগ্ধতা আর অন্যদিকে সাধারণ মানুষের দুরবস্থা এবং জনজীবন থেকে শিক্ষিত নাগরিক সমাজের বিচ্ছিন্নতার বোধ উনিশ শতকে বাঙালির মধ্যে একই সঙ্গে লক্ষিত হয়। তথাকথিত শিষ্ট ভদ্রলোক এবং তার অভিজ্ঞতার বাইরে থেকে যাওয়া অগণন জনতা, যারা অপর হিসেবে চিহ্নিত হবে, উভয় শ্রেণির মধ্যে রচে দেওয়া হয় সাত সমুদ্রের ব্যবধান। আর সবকিছুর মতই সাহিত্য-সংস্কৃতিও এখানে হয়ে ওঠে তার একটি মাধ্যম। এই কারণেই সাহিত্য-সংস্কৃতির মানচিত্রে নতুন করে বিভাজনের কলঙ্করেখা পড়ে। নতুন শিক্ষা এবং সভ্যতার স্পর্শে নতুন করে জেগে উঠতে থাকে সমাজের মান্য বা শিষ্টবর্গের আস্বাদিত নতুন নতুন সাহিত্য-শাখা। বিভিন্ন তার রূপভেদ, তার আঙ্গিক, তার শৈলী, তার বিস্তার। তা আলোকপ্রাপ্ত শিষ্ট সম্প্রদায়ের মননচর্চার ফসল। এই সাহিত্য পাশ্চাত্যের দ্বারা বহুলাংশে প্রভাবিত। এর ফলে আমাদের গতানুগতিকভাবে বহমান সাহিত্যধারায় একটা বিপুল পরিবর্তনের সূচনা হয়েছিল, সাহিত্যক্ষেত্র উর্বর হয়ে উঠেছিল, তাতেও সন্দেহ নেই। কিন্তু দেশের আপামর জনতার সঙ্গে তার সংযোগ তুলনায় ক্ষীণ। সমালোচক তপোধীর ভট্টাচার্য (১৯৪৯ খ্রিস্টাব্দ) জানাচ্ছেন:

'উনিশ শতকে সামন্ততন্ত্রের সঙ্গে আপোষ করে এদেশে ঔপনিবেশিক শাসকের চাতুর্যে এবং মুৎসুদ্দি বুর্জোয়ার সহযোগিতায় আধুনিকতার যে বিশেষ আদলটি গড়ে উঠেছিল, স্থিতাবস্থার পোষকতা করাই তার প্রধান বৈশিষ্ট্য। মেনে নেওয়া আর মানিয়ে নেওয়ার দর্শনকে ভিত্তি করে সাহিত্য ও সংস্কৃতির নন্দনকে তা জন্মসূত্রে পঙ্গু করে দিয়েছে। যত দিন গেছে, প্রতীচ্যের সংস্পর্শে স্তরে-স্তরে পলিমাটি অনেক জমে উঠেছে; ফসলও গোলায় উঠেছে অনেক। কিন্তু প্রকৃত বাস্তবতার সঙ্গে তার সম্পর্ক

রয়েছে নামমাত্র। বরং নিজস্ব শেকড় থেকে বিচ্ছিন্ন হয়ে আর ঐ বিচ্ছিন্নতার মনস্তাত্ত্বিক ক্ষতিপূরণ করার চেষ্টায় মুখোশের ওপরে চেপে বসেছে আরো অনেক রঙিন মুখোশ।'[৯]

আর জনরুচি যাতে তৃপ্ত, সেই সাহিত্য, সেই সংস্কৃতি প্রাপ্ত হয়েছে অপরত্বের অভিধা। সাংস্কৃতিক রাজনীতির চরম কৌশলে মান্য সাহিত্য হিসেবে যা স্বীকৃত হয়েছে তা আসলে পাশ্চাত্য রুচির মাপকাঠিতে মার্জিত এবং পরিশীলিত। এই পরিশীলনের কোপ এসে পড়েছে বাংলা ভাষার ওপরেও। অতীতাশ্রয়ী সংস্কৃত ঘেঁষা 'ইতরজনের দুরধিগম্য' ভাষায় সাহিত্যচর্চার প্রবণতা দেখা গেছে নিজেদের উন্নততর প্রমাণের লক্ষ্যে। হুতোম বলেছিলেন বাংলা ভাষাটা 'বেওয়ারিশ লুচির ময়দা', তাকে নিয়ে যে যা ইচ্ছে করছে। ভাষা ও সংস্কৃতির পবিত্রতা রক্ষার নাম করে বাংলা ভাষাকে তার স্বাভাবিক ভূমি থেকে উচ্ছেদ করার পরিকল্পনা এবং প্রক্রিয়া শুরু হয়েছে। প্রতি সমাজেই তার ক্ষমতাশালী শ্রেণির ব্যবহৃত ভাষাই সেই সমাজের আদর্শ বা standard হিসেবে প্রতিপন্ন হয়। এক্ষেত্রেও তার ব্যতিক্রম হয়নি। সংস্কৃতের ভারে বাংলা তার স্বচ্ছন্দ গতি হারিয়ে ফেলতে শুরু করেছে। লৌকিক বাংলার সাবলীলতা তার মধ্যে মেলেনি। আসলে আর্য সভ্যতার সঙ্গে ঘনিষ্ঠ হবার তাগিদে একসময় ব্রাহ্মণ্য-নিয়ন্ত্রিত অভিজাত সমাজ সংস্কৃতের দিকে ঝুঁকে পড়েছিল। তথাকথিত সাধারণ জনজীবনের প্রাত্যহিক ব্যবহারের ভাষার সঙ্গে সাহিত্যের ভাষার কোনো যোগই স্থাপিত হয়নি। বরং তাদের ভাষা থেকে দূরত্ব বজায় রাখার একটা সচেতন প্রয়াস লক্ষিত হয়েছিল। আর ইংরেজরা এদেশে রাজত্ব কায়েম করার পর থেকে এই সংস্কৃতঘেঁষা সাধু বাংলাই বাংলা গদ্যরীতির আদর্শ হিসেবে বিবেচিত হতে থাকে। এক্ষেত্রে ইংরেজ শাসক এবং মিশনারিদের যথেষ্ট অবদান ছিল তা অস্বীকার করা চলে না। সজনীকান্ত দাস লিখেছেন :

'১৭৭৮ খ্রিস্টাব্দে হালহেড এবং পরবর্তীকালে হেনরি পিটস্ ফরস্টার ও উইলিয়ম কেরি বাংলাভাষাকে সংস্কৃত জননীর সন্তান ধরিয়া আরবি-ফারসির অনধিকার প্রবেশের বিরুদ্ধে রীতিমত ওকালতি করিয়াছেন এবং প্রকৃতপক্ষে এই তিন ইংলন্ডীয় পণ্ডিতের যত্ন ও চেষ্টায় অতি অল্পদিনের মধ্যে বাংলা সংস্কৃত হইয়া উঠিয়াছে।'[১০]

এদেশে সাম্রাজ্যবিস্তারের সুবর্ণসুযোগ হস্তগত হওয়ায় ইংরেজ শাসক তাদের শাসনের সুবিধার্থে এই দেশের শিক্ষিত বুদ্ধিজীবীর মগজ ধোলাই করতে চেয়েছে নিজেদের শেখানো মন্ত্রে। তাদের সেই মন্ত্রবলেই যা কিছু তাদের অনাকাঙ্ক্ষিত, তাকেই ব্রাত্য করে দেওয়া হয়েছে। আর এই কাজটা করেছে তাদের দ্বারা সম্পূর্ণভাবে গ্রস্ত মোহমুগ্ধ এদেশের শিক্ষিত সম্প্রদায়। পাশ্চাত্যের শিক্ষা, পাশ্চাত্যের সভ্যতা-সংস্কৃতির আলোকিত মণ্ডলের বাইরে যে জগতে সারবস্তু কিছু থাকতে পারে, তাই তাঁদের কাছে অজানা। বিদ্যায়, শিক্ষায়, সহবতে, প্রতিভায় প্রভুশক্তির তুল্য কিছুই নেই। সমালোচক এই শ্রেণির সম্পর্কে চমৎকার বলেছেন:

'ইহাঁদের বিশ্বাস এই, সেকালে লক্ষ্মণ-প্রদত্ত গণ্ডী উল্লঙ্ঘন করিয়া জনক-নন্দিনী সীতা যেমন পঞ্চবটীর পত্র-কুটীরাভ্যন্তর হইতে বাহিরে আসিতে নিষিদ্ধ হইয়াছিলেন,---একালে প্রতিভা-সতীও তেমনি সভ্যতালোক-বিভাসিত পাশ্চাত্য দেশের গণ্ডী উল্লঙ্ঘন করিয়া, আমাদের এই তৃণ-শ্যামল সিকতা-ধূসর বঙ্গভূমে পদার্পণ করিতে নিষিদ্ধ হইয়াছেন।'[১১]

তাঁরা বিশ্বাসমুগ্ধ, অতএব প্রশ্নহীন। আর তাঁদের মধ্যে কখনো প্রশ্ন উত্থাপিত হলে তাকে ভুলিয়ে দেওয়ার চেষ্টা হয় নানাভাবে। সফল হলে ভালো, না হলে তার কণ্ঠরোধ করতে বিন্দুমাত্র ভাবিত হয় না ক্ষমতার সাম্রাজ্যের শীর্ষে থাকা মহারথীরা।

একথা সত্য যে, এই আধিপত্যবাদের রাজনীতি শুধুই আধুনিক সময়ের দান নয়। পুরাকাল থেকেই পৃথিবীর ইতিহাসে সুরক্ষিত হয়েছে ক্ষমতাবানের আধিপত্যের সাম্রাজ্য। যার হাতে ক্ষমতা, পরিণামে তারই জয় হয়েছে। ভারতবর্ষের পুরাণ আর ইতিহাসের ধারা অনুসরণ করলেও এর প্রমাণ মিলবে। এই প্রাচীন সভ্যতার ভিত্তিভূমিতে আর্য-অনার্যের, উচ্চ-নিম্নের অজস্র যুগসঞ্জাত বিরোধ আবহমানকাল ধরে জমি প্রস্তুত করেই রেখেছে। ব্রিটিশ সাম্রাজ্যবাদ সেই বহু বিভাজিত সমাজের অন্তর্গত দুর্বলতার সুযোগ নিয়ে ফায়দা লুটতে দ্বিধা করেনি। সঙ্গত কারণেই নতুন আলোকের ফাঁদ নতুন নাম

নিয়ে আরেকবার উনিশ শতকে এই বিচ্ছিন্নতার রাজনীতিতে আগ্রহী হয়ে পদানতের ঐতিহ্যকে আঘাত করেছে, তাকে সুকৌশলে বিনষ্ট করে দিতে চেয়েছে।

ঔপনিবেশিক শক্তির হাত ধরে সমাজের তথাকথিত প্রগতিশীল অংশ প্রবেশ করে এক নতুন মায়াবিশ্বে। কিন্তু ক্রমশ সেই মায়ামোহ বিলীন হতে শুরু করলে তারা আবিষ্কার করে সব দিক থেকেই তারা পর-অধিকৃত হয়ে পড়েছে। সেই আত্মঅবমাননা থেকে সহজে মুক্তি মেলবার নয়। পরঅধিকৃত দেশকে হয়তো বাহুবলে মুক্ত করা সম্ভব, কিন্তু পরকবলিত চৈতন্যের উদ্ধার বড় সহজ কাজ নয়। আর তা যদি না হয়, তাহলে সেই মুক্তিও অসম্পূর্ণ। কিন্তু প্রাথমিক পর্বের এই ভ্রান্তিবিলাসের জন্য সেকালের শিক্ষিত সম্প্রদায়কে পুরোপুরি দোষারোপ করা অনুচিত। ঔপনিবেশিক শাসনের মঙ্গলময়তার মুখোশ প্রতারিত করেছিল ভদ্রলোক বুদ্ধিজীবীদের। আসলে উনিশ শতকের ভদ্রসমাজ নানা টানাপোড়েনে অস্থির, নানা অসঙ্গতিতে বিভ্রান্ত। এতকাল সীমিত গণ্ডির মধ্যে সীমাবদ্ধ থাকার ফলে তারা স্বাভাবিকভাবেই, স্বতঃস্ফূর্তভাবেই নতুন চেতনার আলোকে আলোকিত হতে চেয়েছিল। আর যাদের হাত ধরে এই নতুন আলোকরেখা তমসা ভেদ করে দেখা দিয়েছিল তাদের প্রতি কৃতজ্ঞতার বোধ থাকাটাই স্বাভাবিক। ফলে উচ্চবিত্ত এবং মধ্যবিত্তের ইংরেজের প্রতি বিশ্বাসের যুগ উনিশ শতকের প্রথমার্ধ। এই বিশ্বাসের জায়গা থেকেই তাদের প্রশস্তিমালার অন্ত ছিল না। সেকালের সংবাদ বা সাময়িক পত্রগুলির পৃষ্ঠায় এর অজস্র উদাহরণ মিলবে। বিখ্যাত, অখ্যাত বা স্বল্পখ্যাত যে কোনো পত্রিকাই এমন মহৎ আর উদার রাজশক্তির গুণকীর্তনে খামতি রাখেনি। যেমন 'দুর্জনদমন মহানবমী' নামক এক পত্রিকাতে উল্লিখিত হয়েছিল : 'এরূপ রাজ্যশাসক ভূপতি অতি দুর্লভ পূর্ব্বে এমত রাজা প্রায় ছিল না, সর্ব্বলোকানুকম্পী, জনহিতার্থে সর্ব্বদাই যত্নবান, কেহ কাহার অনিষ্ট করণে সক্ষম নহেন...প্রবল পরাক্রমী ও সাম দান দণ্ড ভেদাদি নীতিজ্ঞ, দয়ালু, পরোপকারী, এমন ভৈরব শাসন ভূপতি কি আর আছে!'[১২]

ব্রিটিশের সভ্যতা-গরিমার ধারণা ইংরেজি-শিক্ষিত ভদ্রলোকদের রীতিমতো আচ্ছন্ন করেছিল। সেই সভ্যতার মূলস্রোতে সামিল হবার জন্য তাঁরা উদগ্রীবও হয়েছিলেন। কিন্তু বিশ্বাসমুগ্ধতার মধুচন্দ্রিমাপর্ব অতিক্রান্ত হলে পরিণামে বাঙালী সমাজকে মুখোমুখি হতে হয়েছিল যে ধরনের আত্মমর্যাদাহীন অপমান ও লাঞ্ছনার তা রীতিমত মর্মভেদী। তবে সেই বেদনা এবং বিক্ষোভ তখনই দানা বেঁধে উঠতে না পারার জন্য সেকালের শিক্ষিত বাঙালিকে নিন্দাবাদে জর্জরিত করা অনুচিত। বাঙালি বুদ্ধিজীবী সমাজ সে সময়ে ছিল সচেতনরূপে অচেতন, প্রকৃত সত্যসন্ধানে অনিচ্ছুক অথবা সত্যের অগ্নিপরীক্ষার মুখোমুখি হতে দ্বিধাগ্রস্ত, এসব বহিরঙ্গের তথ্যে যতখানি সত্য, অন্তর্গত সমাজ-দ্বন্দ্বের গূঢ়তর তত্ত্বের প্রয়োগে তা অনেকাংশে ভিন্নমাত্রিক। তাই তাদের আচরণকে নিষ্ক্রিয়তার অভিযোগে কাঠগড়ায় না তুলে পরিস্থিতির সাপেক্ষে তার বিচার করা উচিত।

আসলে ঔপনিবেশিক শক্তির দখলদারি মানসিকতার সূত্রে উপনিবেশের মানুষ অনেককিছু হারিয়েছে। তাদের রীতি-নীতি, আচার-বিচার, ভাষা-ধর্ম-সংস্কৃতি সমস্ত কিছুই প্রশ্নচিহ্নের মুখে পড়েছে। উড়ে-এসে জুড়ে বসে ঔপনিবেশিক প্রভুরা উচ্ছেদ করে দিয়েছে উপনিবিষ্টের এতকালের জীবনযাপনের সমস্ত শর্তগুলিকে। মুখে প্রচার করেছে তাদের সাধু-সংকল্পের কথা। অনুন্নতদের সভ্য এবং উন্নত করে তোলার মহান ব্রতের কথা। এদিকে বিনিময়ে দখল করেছে তথাকথিত অনুন্নতদের সমস্ত সম্পদ। চেয়েছে তাদের প্রশ্নহীন আনুগত্য। উপনিবিষ্টের মনে খোদাই করে দিতে চেয়েছে এই বীজমন্ত্র যে, শাসকের ছত্রছায়ায় পালিত হলে তবেই মিলবে উন্নততর জগতে প্রবেশের চাবিকাঠি। শাসকশক্তির মতে চেতনার দিক থেকে তারা শিশু মাত্র। সুতরাং তাদের সাবালক হয়ে উঠতে গেলে উপযুক্ত শাসকের অধীনে থাকাই শ্রেয়। The Intimate Enemy গ্রন্থে আশিস নন্দী উল্লেখ করেছেন :

'The new concept of childhood bore a direct relationship to the doctrine of progress now regnant in the West. Childhood now no longer seemed only a happy, blissful prototype of beatific angels...It increasingly looked like a blank slate on which adults

must write their moral codes-an inferior version of maturity, less productive and ethical, and badly contaminated by the playful, irresponsible and spontaneous aspects of human nature'.[১৩]

শৈশব থেকে সাবালকত্বে উত্তীর্ণ হতে গেলে অবধারিত ভাবে হতে হবে শাসকের ছায়ার মত অনুগত এবং বিশ্বস্ত। নিজেদের সত্তা, স্বাতন্ত্র্য বিসর্জন দিয়ে হয়ে উঠতে হবে কলের পুতুল। উনিশ শতকীয় একজন ঔপনিবেশিক ভারতীয়ের সামনে মার্গ তখন এটাই। মেনে নেওয়া, মেনে না নেওয়ার দ্বন্দ্বে সে অস্থির। তখনও তীব্র আন্দোলন-প্রতিরোধ জানে না সে। বশংবদ হওয়াই তখন তার নিয়তি। সমালোচক যথার্থই বলেছেন :

'....'মানুষ' হতে হবে, আর 'মানুষ' হওয়া মানে শোষকদের ছায়া হতে হবে—ক্রমে এই হয় তখন তাদের ধ্যানজ্ঞান। সে-দুর্বিপাকে শাসিতের চৈতন্য পরিলিপ্ত হয় শাসকের আদর্শে; তাদের হৃদয়, মনন, অস্তিত্ব জুড়ে বিরাজ করে শোষকেরই মূর্তি। এতে শাসক-সত্তা থেকে নিজেদের বিশ্লিষ্ট স্বতন্ত্র করে, দেখবার ক্ষমতাও তারা যেমন অনেকখানি হারিয়ে বসে, তেমনি নিজেদেরও জরিপ করতে শুরু করে শাস্তার চোখে।'[১৪]

আসলে নাম আর পরিচয় ভুলিয়ে দেওয়াই ঔপনিবেশিক শক্তির সবচেয়ে বড় অস্ত্র, সবচেয়ে কার্যকর অস্ত্রও বটে। জ্ঞানও তাদের কাছে নিপীড়ন করার অস্ত্র। ক্ষমতাশালীর স্বার্থের পোষকতা করার জন্যই জ্ঞান ব্যবহৃত হয় সেখানে।

আসলে উনিশ শতকের মূল সংকট ঔপনিবেশিক মেধাজীবীর মননের সংকট। তাঁদের সংস্কৃতির এক দীর্ঘ পরম্পরা আছে, ঐতিহ্য আছে, একথা তাঁদের একেবারে অজানা এমন নয়। স্বাভাবিকভাবেই তা শাসকশক্তির সাহিত্যিক-সাংস্কৃতিক ঐতিহ্যের থেকে পৃথক। কিন্তু শুধু শাসকের রুচির কাছে মান্যতা পাবে না ভেবে অদ্ভুত হীনমন্যতায় তার প্রতি অবহেলা করেন। তাঁরা প্রত্যেকে একটি ব্যাধিতে আক্রান্ত। যার নাম কলোনিয়াল সিনড্রোম। সেকারণে প্রতিনিয়ত তাঁরা তীব্র দ্বিচারিতায় ভোগেন। নিজেদের সমস্ত কিছু তুচ্ছ আর ম্লান মনে হয়, পশ্চাৎপদ মনে হয়, বিপরীতে সগৌরবে নিজের বিজয়পতাকা তুলে ধরা পাশ্চাত্য সভ্যতা আর সংস্কৃতিকেই মনে হয় সভ্যতার শ্রেষ্ঠ পরাকাষ্ঠা। সমালোচক ব্যাখ্যা করেছেন :

'ঔপনিবেশিক হওয়ার পর ধীরে-ধীরে উপনিবেশের মানুষের একধরনের সমবেত স্মৃতিক্ষরণ ঘটে। কে-কারা দায়ী একটি স্বায়ত্তশাসনাধীন দেশের ঔপনিবেশিক হয়ে ওঠার জন্য, ধূসর হয়ে যায় দোষারোপের পরিসরও।'[১৫]

এই ধূসরতার পরিসরেই ক্রমশ অনুভূত হতে থাকে যে হারিয়ে যাচ্ছে নিজেদের সমস্ত সম্পদ, আত্মিক এবং মানসিক দিক থেকেও চেতনাকে গ্রাস করছে নিঃসীম শূন্যতা। প্রকট হতে থাকে স্বাধীনতা হারানোর বেদনা। প্রকৃত অর্থে উনিশ শতকের শেষপর্বে পৌঁছে তীব্রভাবে অনুভূত হয়েছিল পরাধীনতার গ্লানি। তার আগে অবধি ইস্ট ইন্ডিয়া কোম্পানির দীর্ঘ শাসনের অবসানে মহারানীর হাতে রাজদণ্ড চলে যাওয়াকে শিক্ষিত সমাজ আনন্দ-সংবাদ হিসেবেই বিবেচনা করেছিল। মহারানীর আশ্বাসবাক্যে প্রজা হিসেবে সর্বক্ষেত্রে ন্যায়বিচার পাওয়ার আকাঙ্ক্ষায় বুক বেঁধেছিল তারা। তাদের ধারণা ছিল রাজানুগ্রহ (এক্ষেত্রে রানি ভিক্টোরিয়ার অনুগ্রহ) পেলে আর কোথাও কোনো অসাম্য থাকবে না। সম্রাজ্ঞী ভার নিলে যে ভারতের দুঃখ ঘুচবে সে বিষয়ে অনেকেই সহমত ছিলেন। ঈশ্বরচন্দ্র গুপ্তের (১৮১২-১৮৫৯ খ্রিস্টাব্দ) 'নীলকর' কবিতাতেও এমন কথা উল্লিখিত হয়েছে। এমনকি ইংরেজদের অত্যাচার যে দিনে দিনে মাত্রা ছাড়িয়ে যাওয়ার উপক্রম হচ্ছে সে বিষয়েও এই বুদ্ধিজীবীদের মধ্যে একটা ধারণা বাসা বেঁধেছিল। তা হল 'ভাল ইংরেজ' আর 'খারাপ ইংরেজ' এর তত্ত্ব। খারাপ ইংরেজরাই অব্রিটিশোচিত আচরণ করে থাকে, কিন্তু ভালো ইংরেজরা মহানুভব। তাদের সহায়তা পেলে এসব অত্যাচার বা পীড়ন বন্ধ হতে সময় লাগবে না। কিরণচন্দ্র বন্দ্যোপাধ্যায়ের 'ভারতমাতা' (১৮৭৩ খ্রিস্টাব্দ) জাতীয় নাটকগুলির কথা এখানে বলা যেতে পারে। যেখানে একদিকে 'ইংরাজ জাতির কলঙ্ক' খারাপ সাহেব আর অন্যদিকে 'ভাল সাহেব'কে তুলে ধরা হয়েছিল এবং অকুণ্ঠভাবে ব্রিটানিকার প্রতি কৃতজ্ঞতা জ্ঞাপন করা হয়েছিল। ব্রিটিশ সম্রাজ্ঞী ভিক্টোরিয়া এই দেশের শাসনভার নিলেও মৌলিক পরিবর্তন যে তেমন কিছুই

ঘটবে না, নাম বদলাবে—শাসনের স্বরূপ বদলাবে না, এটা বুঝতে দেরি হয়েছিল অনেক। এর ফলে স্বর্গসুখ লাভ হয়নি তাদের। বরং বিভিন্ন ক্ষেত্রে দমন-পীড়নের মাত্রা বৃদ্ধি হয়েছিল। শাসনব্যবস্থার চূড়ান্ত ক্ষমতা শ্বেতাঙ্গদের হাতে কেন্দ্রীভূত ছিল, দেশের অর্থনীতি নিয়ন্ত্রিত হত তাদের সুবিধা অনুযায়ী, প্রশাসনের সমস্ত উচ্চপদগুলি ছিল তাদের জন্যই সংরক্ষিত, দেশের আইন-কানুন পর্যন্ত তাদের স্বার্থরক্ষায় তৎপর ছিল। ভার্নাকুলার প্রেস অ্যাক্ট (১৮৭৮ খ্রিস্টাব্দ), আর্মস অ্যাক্ট (১৮৭৮ খ্রিস্টাব্দ) ইলবার্ট বিলের (১৮৮৩ খ্রিস্টাব্দ) মত ঘটনা তো দেশীয় মানুষের বিরুদ্ধে শ্বেতাঙ্গ সমাজের স্বার্থজনিত সংহতিকে চোখে আঙুল দিয়ে দেখিয়ে দিয়েছিল। নানা প্রকারের পক্ষপাতমূলক আচরণ ছিল প্রতিদিনের ঘটনা। অগণিত ভারতবাসী যে মূলত বিদেশি শাসকের গোলামে পরিণত হয়েছে, তাদের স্বপক্ষে কথা বলার স্বাধীনতাটুকু নেই একথা স্বীকার করে 'কুমারী' নামক একটি পত্রিকায় প্রকাশিত হয়েছিল এই আক্ষেপবার্তা :

'When we were strong and independent none durst say a high word to us, but now that we have lost our independence, we are being trampled upon and tyrannised over by foreigners and have not the liberty of speaking even just a word in our defence. With independence are gone prosperity and happiness. What is then left to us?We have become accustomed to oppreaaion, ill treatment and injustice. What is there to comfort us? We have lost everything. Why is then life left to us? O God you have ruined India!'[১৬]

স্বপ্নাতুর চোখে যে পাশ্চাত্য সভ্যতাকে মনে হয়েছিল নতুন ঊষার স্বর্ণদ্বার, চিত্তবিকাশের সহায়ক শক্তি, জ্ঞানমার্গের আলোকবর্তিকা, তা অচিরেই নিজের স্বরূপ প্রকাশ করল। রবীন্দ্রনাথ ঠাকুরের (১৮৬১-১৯৪১ খ্রিস্টাব্দ) বক্তব্য অনুসারে বললে : 'ক্রমে ক্রমে দেখা গেল য়ুরোপের বাইরে অনাত্মীয়মণ্ডলে য়ুরোপীয় সভ্যতার মশালটি আলো দেখাবার জন্যে নয়, আগুন লাগাবার জন্যে।'[১৭] সে আগুনে জ্বলে পুড়ে খাক হয়ে যায় সবকিছু। মানুষকে শোষণ এবং পেষণ করাই তার এক এবং অদ্বিতীয় লক্ষ্য। উপনিবেশবাদের মনভোলানো অনুদানকে যাচাই করে নেবার সময় এলে দেখা গেল সভ্যতার নামে আগ্রাসনের কুৎসিত বিস্তারের স্বরূপ। সে নিজের লোলুপ থাবায় শাণ দিয়ে কেবল সমস্ত অধিকার করতে চায়, দখল করতে চায়, ভোগ করতে চায়। তার এই সর্বগ্রাসী চাহিদা ঘনিয়ে তোলে সংকটের কালো মেঘ। সিভিলাইজেশনের এই কুশ্রী চেহারা দেখে পীড়িত রবীন্দ্রনাথ নিজের কলমে তুলে ধরেছিলেন ব্যথিত অনুভূতির অক্ষরমালা :

'সভ্যতা কারে বলে ভেবেছিনু জানি তা-
আজ দেখি কী অশুচি, কী যে অপমানিতা
কলবল সম্বল সিভিলাইজেশনের,
তার সবচেয়ে বড় কাজ মানুষকে পেষণের।'[১৮]

ঔপনিবেশিক শাসনব্যবস্থার আদিতেই বিরাজ করে সাম্রাজ্যবাদের বীজ। সাম্রাজ্যবাদ পৃথিবীব্যাপী সম্প্রসারণ চায়। সাম্রাজ্যলোভী শাসকের একমাত্র লক্ষ্যই শাসনবিস্তার এবং যেনতেনপ্রকারেণ তাকে অক্ষত রাখা। এখানেও তার অন্যথা হয়নি। ভূখণ্ড এবং মন বিভাজনের নীতিতে দক্ষতার পরিচয় দিয়ে তারা নিজেদের সুবিশাল সাম্রাজ্য সুরক্ষিত রাখতে চেয়েছে। শুধু অস্ত্রবলে হয়তো ক্ষমতা দখল করা যায়, কিন্তু দীর্ঘমেয়াদে অধিকার কায়েম করতে গেলে, রাজ করতে গেলে শাসিতের চৈতন্যের ওপর প্রভুত্ব স্থাপন সবচেয়ে জরুরি। সেটাই তার সবচেয়ে জোরের জায়গা হয়ে দাঁড়ায়। শাসিত যদি স্বেচ্ছায় স্বীকার করে নেয় শাসকের উৎকর্ষকে, তাহলে কাজ হয়ে যায় অনেক বেশি সহজ। বাঙালি বুদ্ধিজীবীর চোখে ব্রিটিশ শাসন প্রসঙ্গে উল্লিখিত অধ্যাপিকা অনুরাধা রায়ের কথাটা যথার্থ মনে হয় যে আসলে ঔপনিবেশিকতা হল একটা মানসিক প্রক্রিয়া, যেখানে শাসক ও শাসিত উভয়েই অংশগ্রহণ করে। এখানেও উন্নততর সভ্যতা এবং সংস্কৃতির দাবি প্রতিষ্ঠা করে, মানসিকভাবে উপনিবিষ্টকে অবশ করে দিয়েই তারা রাজত্ব বজায় রেখেছে। আর আখের গোছানোর এই সুপরিকল্পিত চক্রান্তে আস্তে আস্তে খসে পড়েছে সুসভ্যতার মুখোশ। তাই একসময় যে সভ্যতাকে মনে হয়েছিল মুক্তির সোপান, বেদনার সমুদ্র মন্থন করে জানা গেছে তারই কৃপণতা আর দীনতায়

উপনিবেশের প্রজাদের মুক্তির পথ রুদ্ধ হয়ে গেছে। এ প্রসঙ্গে আরো একবার রবীন্দ্রনাথ ঠাকুরের (১৮৬১-১৯৪১ খ্রিস্টাব্দ) বক্তব্য উল্লেখ করা যেতে পারে :

'এই বিদেশীয় সভ্যতা, যদি একে সভ্যতা বলো, আমাদের কী অপহরণ করেছে তা জানি; সে তার পরিবর্তে দণ্ড হাতে স্থাপন করেছে যাকে নাম দিয়েছে Law and Order, বিধি এবং ব্যবস্থা, যা সম্পূর্ণ বাইরের জিনিস, যা দারোয়ানি মাত্র। পাশ্চাত্য জাতির সভ্যতা-অভিমানের প্রতি শ্রদ্ধা রাখা অসাধ্য হয়েছে। সে তার শক্তিরূপ আমাদের দেখিয়েছে, মুক্তিরূপ দেখাতে পারে নি। অর্থাৎ, মানুষে মানুষে যে সম্বন্ধ সবচেয়ে মূল্যবান এবং যাকে যথার্থ সভ্যতা বলা যেতে পারে, তার কৃপণতা এই ভারতীয়দের উন্নতির পথ সম্পূর্ণ অবরুদ্ধ করে দিয়েছে।'[১৯]

মনে রাখতে হবে, উপনিবেশীকৃত অসহায় মন কখনও আধিপত্যবাদকে, তার নির্মিত বাচনকে প্রশ্ন করতে পারে না। জ্ঞান আর প্রতাপের রাজনীতি টিকে থাকে পরাজিত উপনিবিষ্টের এই বিকল্পহীনতার ওপর ভর করে। একথা ঠিক যে উনিশ শতকের রূপান্তরশীল পরিবেশে অবগাহন করে কোনো সংবেদনশীল মানুষের পক্ষেই ইউরোপীয় জীবনাদর্শ ও সংস্কৃতি দ্বারা প্রভাবিত না হওয়া অসম্ভব ছিল। তাই প্রাথমিক উদ্দীপনার কালে ব্রিটিশ শাসনকে মেধাজীবীরা বিধাতার আশীর্বাদ রূপে বরণ করেছিলেন। কিন্তু সেই সমাজের পরিধি খুব প্রসারিত ছিল না। আসলে পাশ্চাত্য ভাবনায় কৃতবিদ্য ব্যক্তিরা স্বদেশের জনসমষ্টিকে তাঁদের অনুভবের জগতে টেনে আনতে পারেন নি। অরবিন্দ পোদ্দার জানাচ্ছেন: 'যাঁরা শস্যের ভিতরে রৌদ্র আবিষ্কার করে নতুন জীবনবোধে দেশের আকাশ আলোকিত করবেন বলে প্রত্যাশা ছিল, তাঁরা, ইংরেজদের সঙ্গে একান্ত সান্নিধ্যে ব্যক্তিগত সমৃদ্ধির বাসনায়, জনসমষ্টি থেকে হলেন বিচ্ছিন্ন, অনন্বিত।'[২০]

কলোনির নকলনবিশি শিক্ষার নিরর্থকতা, খর্বিত আত্মমর্যাদার গ্লানিবোধের স্বরূপ চিহ্নিত করে শতাব্দীর শেষলগ্নে বিপিনচন্দ্র পাল আত্মধিক্কারের সঙ্গে ইংরেজি শিক্ষাগর্বীদের অবস্থানটি ব্যক্ত করেছিলেন এই বলে যে:

'আমাদের ব্যক্তিত্ব গঠিত হয়েছে টবে; ঠিক টবেও না, অর্কিডের মধ্যে। আমাদের পৌরুষ বারান্দায় ঝুলিয়ে রাখা ব্যক্তিত্ব, আমাদের জাতি ও জীবনের কর্মপ্রবাহে, আমাদের পিতৃপুরুষদের সনাতন ঐতিহ্যে এর কোনই শিকড় নেই।...আর সর্বাপেক্ষা মর্মান্তিক ব্যাপার এই যে তা (ইংরেজি শিক্ষা) আমাদের মন, আমাদের হৃদয়, আমাদের আত্মা, আমাদের ব্যক্তিত্ব এবং আমাদের পৌরুষকে আমাদের জাতীয় জীবন থেকে রেখেছে বিচ্ছিন্ন করে।'[২১]

আসলে সমাজ, অর্থনীতি, রাজনীতি, সংস্কৃতির পারস্পরিক অন্তর্লীন সংযোগকে কখনোই অস্বীকার করা যায়না। উনিশের কলকাতার বুকে বিভাজিত মানচিত্রে ভদ্রলোক এবং অপরের যে সামাজিক অবস্থানটি নির্মিত হয় তার পশ্চাতে একই সঙ্গে ক্রিয়াশীল ছিল নানা জটিল অঙ্ক। এর আগে গোটা অষ্টাদশ শতক জুড়ে কলকাতার বুকে রাজ করা ধনাঢ্য পরিবারগুলির সঙ্গে নিম্নবিত্ত পরিবারের বিত্তগত বৈষম্য থাকলেও তাদের শিকড় ছিল একই মাটিতে। তখন উভয়ের মধ্যে আর কোনো বড় ব্যবধান ছিল না। কিন্তু উনিশে যখন নতুন শিক্ষার জয়যাত্রা শুরু হল তখন ক্রমে ইংরেজি জানা এবং না জানার ভিত্তিতে মানুষের মধ্যে বিভাজন দেখা দিল। এই বিভাজনের শিকড় পৌঁছে গেল এত গভীরে যে নব্যশিক্ষার আলোকবৃত্তের বাইরে থেকে যাওয়া মানুষগুলো হারিয়ে যেতে লাগল অপরিচয়ের আড়ালে। মেকলের চুঁইয়ে পড়াশিক্ষানীতি তেমন কোনো সুফল ফলাতে পারল না আগামীতে। একথা ভুল নয় যে ইংরেজি শিক্ষার সংস্পর্শে এসে ভারতবাসী পাশ্চাত্য সভ্যতা, জ্ঞান-বিজ্ঞান, মানবতাবাদ, গণতন্ত্র, স্বাধীনতা প্রভৃতি আদর্শের সঙ্গে পরিচিত হয়েছিল এবং নিজ সমাজ, ধর্ম, দেশ ও জাতির দুর্বলতাগুলি অনুভব করতে পেরেছিল। ইংরেজি শিক্ষা শিক্ষিত ভারতবাসীকে এক সূত্রে আবদ্ধ করেছিল। এর ফলেই শুরু হয়েছিল নানা যুক্তিবাদী সামাজিক, ধর্মীয় ও রাজনৈতিক আন্দোলনের জোয়ার। কিন্তু এই শিক্ষার সবচেয়ে বড় ত্রুটি যে তা দেশের মুষ্টিমেয় মানুষের মধ্যেই সীমাবদ্ধ ছিল, সর্বসাধারণের মধ্যে বিস্তৃত হয়ে কখনই তা গণশিক্ষায় পর্যবসিত হয়নি। আপামর জনগণের সঙ্গে শিক্ষিতের এই ব্যবধান উনিশ শতকের তথাকথিত ভদ্র ও অপরের দূরত্ব রচনার একটা প্রধান কারণ তাতে সন্দেহ নেই। এই দূরত্ব থেকেই বিচ্ছিন্নতা, হতাশা, গ্লানিবোধ আর সংকটের চোরা ঘূর্ণিপাকে নিমজ্জন। প্রভুশক্তির অঙ্গুলিহেলনে নির্মিত নতুন নাগরিকের লগ্নতাহীন হয়ে

আলোর ফাঁদে পড়ে আলেয়ার পিছে ছুটে যাওয়ার বিফল
বৃত্তান্ত।

উল্লেখপঞ্জি

১. ঠাকুর, রবীন্দ্রনাথ, বাংলা সাহিত্যের ক্রমবিকাশ, রবীন্দ্র রচনাবলী, দ্বাদশ খণ্ড, ১২৫তম রবীন্দ্রজন্মজয়ন্তী উপলক্ষ্যে প্রকাশিত সুলভ সংস্করণ, বিশ্বভারতী, কলকাতা, জ্যৈষ্ঠ ১৪২২, পৃ ৫২৮

২. Dasgupta, Subrata, Awakening : The Story of the Bengal Renaissance, Random House India in 2011, Prologue

৩. Sarkar, Susobhan, On the Bengal Renaissance, Papyrus, Calcutta 1979, p 71

৪. ঠাকুর, রবীন্দ্রনাথ, কালান্তর, বিশ্বভারতী গ্রন্থন বিভাগ, কলকাতা, ভাদ্র ১৪১৭, পৃ ১৯

৫. বসু, স্বপন, বাংলায় নবচেতনার ইতিহাস, পুস্তক বিপণি, কলকাতা, ষষ্ঠ সংস্করণ অগাস্ট ২০১৬, পৃ ২০৭

৬. বন্দ্যোপাধ্যায় তৃণা, আমি অতি সাধারণ পুরুষ-পশ্চিমবঙ্গের সমকালীন রাজনৈতিক ভাষা ও পৌরুষের পরিবর্তনশীল রূপ, আলোচনা চক্র, ৩১ বর্ষ ১ম সংখ্যা সংকলন ৪২, পৃ ৪৬-৪৭

৭. ভট্টাচার্য তপোধীর, মিশেল ফুকো, তাঁর তত্ত্ববিশ্ব, দে'জ পাবলিশিং, কলকাতা, সেপ্টেম্বর ২০১৩, পৃ ৯২

৮. ঘোষ, বিনয়, বাংলার নবজাগরণ সমীক্ষা ও সমালোচনা, বাংলার নবজাগৃতি, ওরিয়েন্ট লংম্যান, কলকাতা, ১৩৮৬, পৃ ১৫২

৯. ভট্টাচার্য, তপোধীর, উপনিবেশোত্তর চেতনাবাদ, প্রতীচ্যের সাহিত্যতত্ত্ব, অমৃতলোক সাহিত্য পরিষদ, তৃতীয় সংস্করণ ফেব্রুয়ারি ২০০৬, পৃ ১৩০

১০. দাস, সজনীকান্ত, বাংলা গদ্য সাহিত্যের ইতিহাস, কলকাতা, ১৯৭৫, পৃ ৩২

১১. মুখোপাধ্যায়, হরিমোহন (সম্পাদিত), দাশরথি রায়ের পাঁচালী, কলিকাতা, ভবানীচরণ দত্তের ষ্ট্রীট, বঙ্গবাসী-ষ্টীম মেসিন প্রেস হইতে শ্রীঅরুণোদয় রায় দ্বারা মুদ্রিত ও প্রকাশিত, সন ১৩০৯, পৃ ২

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Impact of Occupational Stress on Cognitive and Physical Health of Traffic Police Personnel in West Bengal

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Date of Receipt: 23.05.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract:
Traffic Police Personnel ensure public safety and smooth traffic flow by paying close attention and concentration. They deal with difficult events such as accidents and emergencies, which require constant attention and psychological exhaustion. They must move rapidly in dynamic situations, keeping others and themselves safe. Police Personnel frequently multitask by monitoring road conditions, managing traffic, engaging with automobiles and pedestrians, and enforcing traffic laws. The study sought to determine the impact of occupational stress on the psychological health and cognitive performance of traffic officers. Traffic Police Personnel were selected at random and requested to participate individually.The primary inclusion criteria were that the workers had at least two years of traffic experience, were at least 20 years old, and had no previous history of clinically confirmed infectious infections. 113 participants agreed to participate in this phase of the study. The DASS 21 questionnaire was used to determine their degree of stress, anxiety, and depression. The cognitive performance evaluation tests, ruler drop tests, and polar heart rate monitors were utilized to evaluate alertness, attentiveness, and reflex quality. Blood pressure and heart rate were measured with a sphygmomanometer.It is important to note that most of the Police Personnel on duty are overweight and mostly obese in category. The rise in anxiety and sadness is frightening. While heart rate and blood pressure may fluctuate during strenuous exercise, such as biking or traffic control. Reducing cognitive and psychological stress is crucial for their well-being and job performance. Strategies include stress management training, healthy lifestyles, psychological support, work-life balance, de-escalation techniques, improved communication, leadership, and frequent activity evaluations.

***Keywords*:** Traffic Police Personnel, Occupational Stress, anxiety, cognition

1.Introduction:

The Policing administration faces many challenges in managing mobility inside as well as outside the city, including dealing with traffic congestion and health risks resulting from environmental pollution [1].Traffic Police Personnel maintain public safety and smooth traffic flow through constant attention and concentration as front line workers maintaining social safety and security. They handle stressful situations like accidents and emergencies, requiring constant focus and psychological drain. They must act quickly in dynamic situations, considering others' and their own and public safety. Police Personnel often multitask, involving monitoring road conditions, directing traffic, interacting with vehicles and pedestrians, and enforcing traffic regulations. One of the main causes of police fatalities and injuries experienced while on duty is motor vehicle crashes. The primary causes of these collisions include multitasking while driving and the usage of in-car technological devices [2]. Police Personnel are required to 'maintain high levels of consistent attention and concentration in order to perform effectively and safely'. Traffic police officers are unsung heroes, ensuring the smooth

flow of traffic movement and maintaining public safety on roads. However, this job comes with a heavy burden of both physical and mental workload [3]. Police departments are open around-the-clock. They must contend with unstable situations, unpleasant situations, challenging situations, extended duty hours, and a lot of effort. In such a situation, traditional family-friendly policies may not be feasible. But due to occupational stress factors of their job; personal lives are neglected [4].

The physical workloads of traffic police personnel in West Bengal, as in any region, can vary depending on their specific demand in duties and the conditions in which they operate. However, traffic police personnel often spend their shifts standing at intersections or on street corners, directing traffic or monitoring flight as well as pedestrian. This requires physical endurance, particularly in the legs and feet. Directing traffic involves using hand signals or a whistle to control the flow of vehicles, and it requires repetitive arm movements and body coordination. Weather conditions in West Bengal can be extreme, ranging from hot and humid to rainy and windy. This can make the job more physically demanding, particularly when standing under the Sun for long periods or getting wet in the rain. Traffic enforcement can involve walking or running to chase after drivers who violate traffic laws, which requires both physical stamina and speed [5].

Because of the nature of their work, traffic officers frequently deal with stressful events, like handling accidents or controlling traffic in an emergency. Apart from this, their biggest problem is stress. "Cognition" refers to the mental processes required to obtain and understand information. Thinking, remembering, problem-solving, reasoning, and knowing are some of the many different cognitive processes. Cognitive processes are influenced by a wide range of factors, including experiences and genetics. There are things one may do to maintain and improve cognitive ability, even when age and heredity cannot be changed. Due to the psychological stress of their jobs, police officers may experience a range of problems in their social and professional life [6], [7].

Police officers must also deal with another sort of psychological stress: family members may receive insufficient family time from officers, which can lead to a range of domestic issues. Psychological stress may also have an effect on family bonding and relationships [8]. This part of research intends to dive into the complexities of the physical and mental strains that traffic police officers endure in West Bengal.

2. Objectives of the Study:

Hence the study has to be undertaken with following aims and objectives–

1. To evaluate the working environment and occupation related physiological parameters of traffic police personnel
2. To evaluate the psychological stressors and its consequences on traffic police personnel.

3. Methodology:

Methods of the study include the data collection by questionnaire and assessment of relevant parameters.

I. Study Population:

Selection of subjects for the study was performed via Cochran's formula for sample size estimation, adjusted for finite people correction [9].Traffic Police Personnel were taken by stratified random sampling collecting information from the traffic guards and being asked for their solitary participation. The study was carried out on both 'exposed' and 'control' group of traffic police personnel. Those who handle traffic on-site and are engaged in outdoor activities and predominantly exposed to road environment are referred to as the "exposed" group; those who work predominantly indoor and are not exposed to outdoor road environment throughout their shift are referred to as the "control" group. Primary inclusion criteria were set whether the workers had a minimum two-year experience in traffic, having aged 20 years and above and having no previous history of clinically diagnosed infectious diseases. After exclusion, 113 subjects consented and were selected for this phase of study. DASS 21 questionnaire, cognitive performance evaluation tests, ruler drop tests, and polar heart rate monitors were used to assess

alertness, attention, and reflex quality. Blood pressure and heart rate was recorded using sphygmomanometer.

II. Measurement of Physical Parameters:

Physical parameters such as height, weight heart rate, and blood pressure were measured. Anthropometer was used to measure height and weighing machine to measure weight. Blood pressure and heart rate was recorded using sphygmomanometer (Omron HEM 7124).

III. Assessment of Psychological parameter:

Evaluation of Stress Parameter will be performed via stress questionnaire DASS-21 [10] to evaluate perceived stress by the traffic police personnel. Obtained data from responses will be used to find out the severity of stress, depression and anxiety.

IV. Cognitive Performance Evaluation Test:

1.Letter Cancellation Test (LCT) – Traffic police personnel were asked to strike out particular letter from a random letter passage of fixed length. The time taken to complete it was recorded. The number of errors, number of letters missed were also recorded. The test measures the cognitive ability and attention of the police personnel. [11].

2. Ruler drop test- The ruler drop test is performed to evaluate the reaction time of the traffic police personnel[12]. A properly graduated uniform stick was dropped, and the subject was instructed to catch it. The response time was calculated in milliseconds. The stick drop test was carried out two times in a shift.

The reaction time was computed in milliseconds (ms) using the formula -

A falling object covers distance $d = \frac{1}{2} gt^2$; where "d" is height, "g" is the acceleration caused by gravity, and "t" is time.

V. Statistical Analysis:

The descriptive statistics were conducted in all parameters. To test differences of LCT values between the exposed and control group, different statistical tests were used for parametric and categorical data with the significance level chosen predetermined at (=0.05).

4. Results:

Traffic Police Personnel often work in a stressful condition, not only physically but also psychologically. Demographic data collected from the exposed group revealed that 56% of Police Personnel work more than 8 hours each day, 37% smoke, and 46% are graduates. In the control group, 23% of Police Personnel worked more than 8 hours, 28% were determined to be smokers, and 45% were graduates.

The physical parameters of the study participants are displayed in this table. Independent-samples t-tests using Welch's correction showed that the exposed and control groups did not differ significantly in age, height, weight, body mass index, body surface area, or work experience (all $p > 0.05$). This indicates that both groups were broadly similar with respect to their baseline demographic and anthropometric characteristics, reducing the likelihood that these factors influenced subsequent comparisons.It is important to note that most of them are overweight in category. No significant differences were found in between two groups of Police Personnel.

Table 1: **Physical data for the subjects included in the study (exposed and control)**

Parameters	Exposed (n =62)		Control (n=51)		t value	p value
	Mean	SD	Mean	SD		
Age (yr)	32.15	5.41	33.01	5.67	−0.82	0.415
Height (cm)	168.21	8.96	167.35	99.61	0.49	0.627
Weight (kg)	76.25	10.91	75.29	8.17	0.53	0.594
BMI (kg/m^2)	27.22	4.87	27.12	5.34	0.10	0.918
BSA(m^2)	1.89	0.24	1.91	0.19	−0.49	0.622
Work Experience(yr)	8.06	3.41	7.94	4.28	0.16	0.871
Data is represented as Mean±SD, level of significance p<0.05						

Table 2 presents heart rate and blood pressure measurements recorded during different occupational activities among police personnel. The control group was primarily engaged in sedentary duties,including office-based documentation, challan processing, data entry, and CCTV monitoring, whereas the exposed group performed physically demanding tasks such as traffic regulation and motorcycle patrolling. Given the differing nature of these activities, heart rate and blood pressure are expected to vary more substantially during physically intensive tasks, such as traffic control and bike patrolling, compared with desk-based work, where physiological fluctuations are generally less pronounced.

Table 2: Physiological variables of Traffic Police Personnel involved different occupational activities (exposed and control)

Parameters	During Rest	During Official Documentation	During Traffic Controlling	During Patrolling
Heart Rate (beats/min)	77.62±4.69	81.06±5.57	100.31±9.63	123.22±7.35
Systolic Blood Pressure (mm/Hg)	128.15±9.4	135.27±7.84	142.05±6.98	144.7±10.04
Diastolic Blood Pressure(mm/Hg)	81.16±5.52	82.05±7.11	88.74±3.40	91.45±5.41
Data is represented as Mean±SD				

This table shows the observational variance of single letter cancellation test among the exposed and control group. Two sample t tests with unequal variances is done for both exposed and control group to check if there is significant differences between performance oflatter cancellation test (LCT). The p-value equals 0.005208, (p(x= T) = 0.9974). The observed effect size d is medium, 0.54. This indicates that the magnitude of the difference between the average and average is medium.

Table 3: Physiological profile result of letter cancellation test of referent group of subjects

Parameters	Exposed (n=61)	Control (n=52)	Mann-Whitney U (z score)	p Value
	Median (IQR)	Median (IQR)		
LCT Completion Time (s)	104(19)	98.5(6.2)	546(	<0.0001

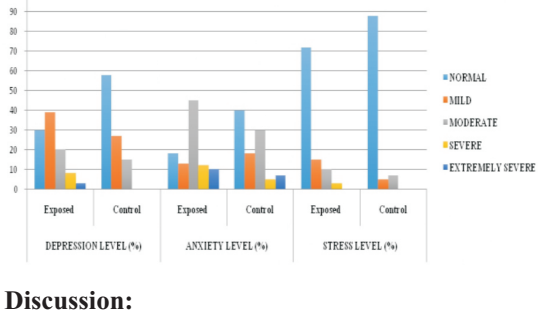
This table 4 displays the RDT values. It is a quick and easy way to gauge someone's response time; the speed at which they can react to a stimulus, which is to use the ruler drop test. It is frequently utilized in neurological and cognitive evaluations.Mann-Whitney U analysis revealed a significant difference in ruler drop test distance between exposed and control personnel in the 5–10 years' experience category ($p < 0.0001$), with exposed workers demonstrating shorter drop distances. No significant differences were observed in the <5 years or 10–15 years categories ($p > 0.05$)

Table 4: Physiological profile result of Ruler Drop Test of referent group of subjects

Parameters	Control (n=52)		Exposed (n=61)		Mann-Whitney U (z score)	p Value
	Frequency	Distance Median (IQR)	Frequency	Distance Median (IQR)		
<5 years	19	21.25(3.20)	16	20.94(2.67)	95.5(1.8544)	0.06432
5-10 years	31	23.47(2.94)	28	21.57(3.76)	63.5(5.61638)	<0.0001
10-15 years	11	25.01(4.31)	8	24.21(0.40)	20.5(1.89916)	0.05744

In figure 1, the results of the DASS 21 surveys are recorded. Percentages are used to express values. It is evident that exposed groups of participants experienced higher levels of stress, anxiety, and depression than control groups.

Fig 1: Representation of the various DASS 21 scores of the Traffic Police Personnel



. Discussion:

The subjects were subdivided into two groups two compare the parameters. Basic physiological parameters were collected, but no observable difference found. By evaluating distinct but related facets of mental functioning, the DASS Questionnaire, Ruler Drop Test, and Letter Cancellation Test all contribute significantly to cognitive evaluation. Because excessive levels of stress, anxiety, or depression can impair cognitive functions including memory, attention, and decision-making, it is important to assess an individual's emotional and psychological condition using the DASS (Depression, Anxiety, and Stress Scales) questionnaire [11].

A straightforward yet useful method for assessing response speed is the Ruler Drop Test, which measures how rapidly an individual can take in and react to a visual stimulus. It sheds light on motor coordination, processing speed, and alertness—all of which are essential for activities requiring rapid thought and physical reaction [13]. RT is linked to higher cognitive function assessments, is correlated with age, and may be a sign of a person's neurological condition. RT starts to slow down at age 30, and around age 60, this reduction becomes more noticeable [14]. Findings of this study suggests that occupational exposure is associated with slower cognitive processing speed and/or reduced attention, as reflected by increased LCT completion time among exposed personnel. The use of a non-parametric test supports the robustness of this result given the non-normal distribution of the data.When activities are more complicated and demand more cognitive/motor processing, RT is much more slowed [15]. Reaction time differed between exposed and control police personnel across experience categories. A significant improvement in reaction time was observed in the exposed group with 5–10 years of experience, while differences in the <5 years and 10–15 years groups were not statistically significant. Overall, active field duties appear to be associated with better psychomotor performance during mid-career.Reduced stride length, slower walking, poorer mobility, decreased lateral stability, difficulty negotiating stairs, and balance issues have all been linked to increased RT [16, 17].

6.Conclusion:

Police Personnel are stressed during their work schedule. Better cardiovascular health enables police officers to react to crises faster, keep composure in physically taxing circumstances, and give their best effort in high-stress scenarios. Both public safety and the general efficacy of police operations are improved by this. The variance in work load they encounter is indicated by data from their blood pressure and heart rate. RDT and LCT assessed the visual reflexibilities and reacting abilities of the exposed group, and found that these abilities declined with increasing work experience. This is concerning and needs to be addressed. Reducing cognitive and psychological stress among Traffic Police Personnel is crucial for their well-being and performance on the job.

7. Acknowledgements

This work is supported by West Bengal Department of Science and Technology and Biotechnology. Special thanks the Kolkata and West Bengal Traffic Department for allowing to perform the study.

8. Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee of Sister Nibedita General Degree College for Girls. Written informed consent was obtained from all participants.

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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

Confronting Global Health Challenges: Innovation, Equity, and the Role of Multisector Collaboration - A Review

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Date of Receipt: 20.05.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract

The 21st century has brought urgent global health challenges affecting populations worldwide, with low- and middle-income countries (LMICs) bearing the heaviest burden. These issues include infectious diseases like HIV/AIDS and malaria, rising non-communicable diseases (NCDs) such as diabetes and heart conditions, mental health concerns, malnutrition, and environmental threats like pollution and climate change. These problems are worsened by poverty, inequality, weak healthcare systems, antimicrobial resistance (AMR), and recurring global pandemics. Addressing these complex challenges demands innovative, collaborative, and multisector strategies. Technological advancements—such as telemedicine, mobile health apps, AI-powered logistics, and decentralized vaccine production—are expanding access and improving healthcare delivery in under-resourced areas. Promoting clean energy and building climate-resilient health systems also contribute to long-term health security. Moreover, mRNA vaccine platforms and low-cost diagnostic tools are helping reduce disparities in healthcare access and outcomes. The joint efforts of community organizations working alongside government and private entities have demonstrated success in creating stronger, more inclusive health systems. These efforts empower local populations, enhance healthcare governance, and ensure more inclusive, responsive service delivery. This research underscores the urgent need for sustained global cooperation, continued innovation, and greater investment in public health infrastructure. International cooperation is crucial for establishing sustainable healthcare frameworks that can handle existing and potential health emergencies.

Keywords: Pandemics, NCDs, Telemedicine, Vaccines

Introduction

Today's global health landscape is increasingly multifaceted, marked by persistent disparities and emerging transnational challenges that call for immediate, unified responses [8],[13]. The stark differences in health outcomes across different regions highlight the urgent need for solutions that are adaptable, equitable, and sustainable [17],[9]. Health is shaped by an intricate interplay of biological, environmental, and socio-economic elements, all of which influence disease trends and the overall effectiveness of healthcare systems [38],[41]. To effectively address these issues, an integrated, evidence-based, and interdisciplinary approach is essential—one that merges scientific innovation, inclusive policymaking, and grassroots-level engagement [7],[12]. Advancements in areas like digital health, artificial intelligence, and international collaboration are creating new pathways for progress [1],[37],[40]. In this context of increasing global interconnectivity, the development of flexible and robust public health systems is vital to achieving long-term, equitable

health outcomes 15],[16]. This paper explores strategic frameworks to improve global health equity and strengthen the resilience and preparedness of health systems.

2. Key Global Health Challenges

2.1 Infectious Diseases

Although medical science has advanced significantly, infectious diseases still remain a serious challenge, especially in low- and middle-income countries. Conditions such as HIV/AIDS, tuberculosis, and malaria account for a significant share of global illness and death [31]. About 1.6 million people lost their lives to TB infections during 2021 [38]. The COVID-19 pandemic, driven by the SARS-CoV-2 virus, reignited awareness about the continual danger of emerging pathogens and highlighted the need for comprehensive global preparedness strategies to confront future outbreaks [18],[31].

2.2 Non-Communicable Diseases (NCDs)

Research indicates that deaths worldwide are predominantly (74%) caused by diseases that are not transmissible, particularly those affecting the heart, cellular growth, blood sugar regulation, and respiratory function [40]. Contributing factors include poor dietary habits, tobacco use, excessive alcohol consumption, sedentary lifestyles, and exposure to polluted air [10]. Urbanization and an aging population are accelerating the NCD burden, especially in LMICs where healthcare systems may lack the capacity to manage these long-term conditions effectively [3].

2.3 Antimicrobial Resistance (AMR)

Antimicrobial resistance poses a mounting threat to modern healthcare by rendering commonly usedtreatments less effective. The global impact of antimicrobial resistance in 2019 was substantial, with data showing 4.95 million related deaths, including 1.27 million directly caused by resistant infections [20]. If left unaddressed, AMR could result in up to 10 million deaths annually by 2050 and inflict a staggering $100 trillion in global economic losses [21]. Key contributors to this crisis include the misuse of antibiotics in both human and veterinary medicine, inadequate infection control practices, and sluggish development of new antimicrobial therapies [33].

2.4 Health Disparities and Access Gaps

Substantial health inequities persist across the world, driven by social, economic, and environmental imbalances. Individuals living in marginalized communities or conflict zones often face significant barriers to accessing healthcare, including life-saving vaccines and essential

Medicines [7],[17]. These disparities are further amplified by systemic issues like poverty, gender-based discrimination, and structural racism [2]. Achieving universal health coverage (UHC), a central objective of the UN's Sustainable Development Goal 3.8, is a crucial step toward bridging these gaps and ensuring equitable healthcare access for all.

3. Breakthroughs and Interventions in Global Health

3.1 Digital Healthcare and Telemedicine

The healthcare landscape is being transformed by digital advancements, especially benefiting areas with limited access to medical services. Accessibility to healthcare has been greatly enhanced through various technological solutions, including smartphone health apps, digitized medical records, systems for remote patient monitoring, and platforms enabling virtual medical consultations [40].The COVID-19 crisis led to a swift expansion of telehealth services, enabling ongoing patient care while reducing the risk of viral spread [27]. Evidence shows telemedicine can improve chronic disease management and broaden access to mental health services [1],[29].

3.2 Advancements in Vaccine Technology

The swift development and rollout of COVID-19 vaccines highlighted the promise of advanced platforms, particularly those based on mRNA technology.Rapid advancement from DNA

sequencing to mass production was made possible after gaining regulatory clearance [24],[26]. Additionally, other emerging vaccine technologies—such as viral vectors, protein subunits, and nanoparticle formulations—are being adapted to combat diseases like HIV, influenza, and certain cancers, marking a transformative era in preventive medicine [39],[26].

3.3 Artificial Intelligence in Healthcare

AI is revolutionizing medical practice through enhanced diagnostics, personalized treatments, drug discovery, and outbreak forecasting. Algorithms now match or even exceed human expertise in detecting conditions like melanoma, diabetic eye disease, and pulmonary abnormalities [12],[30]. AI has also been used to model COVID-19 spread, optimize the allocation of hospital resources, and process large-scale genomic and epidemiological datasets to inform public health strategies [22].

3.4 Locally Driven Health Interventions

Community-centered approaches, particularly through community health workers (CHWs), have proven vital in expanding access to essential services in low-resource settings. These workers provide maternal and child healthcare, improve immunization rates, and support chronic disease management by leveraging local trust and cultural familiarity [23],[26]. These inclusive approaches help guarantee that health interventions are both impactful and aligned with local cultures, making them more sustainable in the long term.

3.5 Collaborative Global Health Efforts

International partnerships like The Global Fund and Gavi, the Vaccine Alliance, have significantly improved health outcomes in LMICs by coordinating large-scale funding, procurement, and program execution. These collaborations ensure the provision of vaccines, diagnostics, and treatments to those who need them most [1],[4]. Public-private alliances and institutions like the WHO and CEPI are also pivotal in enhancing global preparedness and ensuring fair access to innovations, especially during pandemics.

Table 1: Health Outcomes Improved by Key Innovations

Disease Area	Key Innovation	% Reduction in Morbidity Rate	Reference(s)
HIV/AIDS	Antiretroviral Therapy (ART)	~62% ↓	[1]
Tuberculosis	DOTS strategy	~13% ↓	[38]
Malaria	ITNs and ACTs	~27% ↓	[37]
COVID-19	mRNA Vaccines	~90% ↓ (in severe cases)	[4], [24]
Cardiovascular Disease	Screening & statins	~24% ↓ in DALYs	[40]
Diabetes	Digital monitoring & lifestyle	~15–20% ↓ (in complications)	[11]
Antimicrobial Resistance (AMR)	Stewardship & diagnostics	~10–15% ↓ (in pilot areas)	[20], [21]
Mental Health	Teletherapy & mobile apps	~20–30% ↑ in access	[29], [39]

4. Illustrative Case Studies

4.1 Rwanda's Health System Overhaul

Rwanda serves as a leading example of successful health reform in a low-income setting. Through strategic investment in digital infrastructure, universal health coverage (UHC), and CHWs, the country has significantly lowered maternal and child mortality rates [3]. These achievementsemphasize the value of healthcare approaches that prioritize community leadership and equity.

4.2 India's Digital Health Ecosystem

India's Ayushman Bharat Digital Mission (ABDM) aims to build an integrated digital health system by providing every citizen with a unique health identification number. This initiative facilitates seamless data integration and personalized care across the country and represents one of the largest efforts globally to digitize health records at scale [18].

4.3 Equitable Vaccine Access through COVAX

COVAX, led by the WHO, Gavi, and CEPI, was established to promote equitable access to COVID-19 vaccines across all countries. Despite facing logistical and supply hurdles, it managed to deliver vaccines to over 100 nations [4]. The initiative demonstrates the power—and the limitations—of international cooperation in managing global health emergencies.

5. Barriers to Implementation

While technological innovation holds great promise, several barriers hinder widespread adoption. These include insufficient funding, political instability, infrastructure deficits, and resistance to policy reform. Addressing these barriers requires systemic transformation, long-term investment, workforce development, and inclusive leadership models that prioritize community voices and local ownership [8].

6. Pathways Forward

Future strategies in global health must integrate emerging technologies with community engagement and climate resilience. The “One Health” framework—which links human, animal, and environmental health—offers a comprehensive strategy to manage new and evolving health threats [6]. Emphasis should also be placed on strengthening supply chains, promoting equity, and supporting adaptive governance to address cross-border health challenges effectively.

7. Conclusion

Global health continues to evolve amidst an intricate web of longstanding and emerging threats. Addressing these challenges demands bold, coordinated actions that embrace innovation, equity, and sustainability. Prioritizing inclusive health systems, expanding digital tools, and fostering international collaboration are essential steps toward achieving universal health coverage and protecting the well-being of current and future generations.

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AJHMC
ISSN : 0973-6212

Volume : 13 No. 1 & 2
February. 2026

A Model Based Study on How to Reduce Misuse of Various Government Schemes

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Date of Receipt: 29.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract:
A simple mathematical model has been proposed here to discuss the misuse of various government schemes with the assistance of an epidemiological approach. The equilibrium points of the considered model have been found, and their stability has been determined. Some sensitive parameters of the model have been found to help reach the desired outcome of the proposed model. Also, some threshold values (Basic reproduction number) have been found to help analyse the model epidemiologically. Some numerical techniques have been used here to establish the existence of analytical results.

Keywords: Threshold value, Stability, Awareness, Sensitivity.

1. Introduction

All of us know that the government always tries to launch various schemes for the benefit of the people. The people who fulfil the eligibility criteria of the scheme can apply to avail the benefits of the scheme. Sometimes it happens that some truly eligible people do not get the benefit of the scheme. It is a real fact that a hundred per cent of eligible people do not get the benefits of the schemes (as per various media report). On the other hand, some people get the benefit of the scheme, but they do not fulfil the eligibility criteria of the scheme. Look into the matters very carefully, so many reasons can come out. For this reason, the success rate of the schemes does not reach a satisfactory level. In this situation, it is essential to find a positive way to control it. Nowadays, mathematical biology is an important research area of researchers. So many crucial problems like HIV/AIDS, dengue, cholera, cancer, COVID-19, etc. [1-2], have been discussed by constructed mathematical models. A mathematical model has been constructed here to analyse the proposed model with the assistance of an epidemiological approach. The idea has been taken here from the Kermack and McKendrick initial SIR model and some published work [3-8]. Here the considered problem is that non-eligible people are taking benefit of various government schemes that have been compared with a disease because one non-eligible person gets the benefit him or her tries to motivate another one to achieve it. The main perspective of the work is to decrease the rate of non-eligible people who have availed of the benefits of the schemes. This work's main motivation is to find an efficient way to prevent disease transmission. Here, it tries to impose awareness and fear effect such that the application rate of the non-eligible people decreases slowly, who are not eligible to avail the benefits of theschemes, and the genuinely eligible people get the benefit of the scheme.

2. The mathematical model

First, a simple mathematical model to discuss the misuse of various government schemes. The total peoples considered here into three subclasses such that;S(t) the susceptible people who are willing or not to avail the benefits of the scheme at time t,Considered the total number of people is constant, i.e. $N(t)=S+S_{nb}+S_{fnb}$. Under this consideration, the model takes the following form.

$$\frac{dS}{dt} = \Pi_{rs} - \beta_c S S_{nb} - (\mu + \sigma_a)S,$$
$$\frac{dS_{nb}}{dt} = \beta_c S S_{nb} - (\mu + \gamma_f + \delta_{rc})S_{nb}, \quad (1)$$
$$\frac{dS_{fnb}}{dt} = \sigma_a S + \gamma_f S_{nb} - \mu S_{fnb}$$

Where, the susceptible people recruited by the rateΠ_{rs}, $\beta_c$is the contact rate between S and S_{nb} people, σ_a is the awareness rate of the susceptible people, γ_f is the fear effect, δ_{rc} is

the rejection rate due to wrong credentials and μ is the usual death rate of all the classes.

3. Initial Discussion of the system (1)

3.1 Positiveness

for all t>0 in R_+^3 with the initial conditions S(t)≥0, S_{nb}(t) ≥0 and S_{fnb}(t) ≥0.

Proof: From **Theorem 3.1.1 The solutions S, S_{nb} and S_{fnb} of the considered model (1) are positive** model (1), $(\frac{dS}{dt})_{at\ S=0} = \Pi_{rs}$, $(\frac{dS_{nb}}{dt})_{at\ S_{nb}=0}$ =0 and $(\frac{dS_{fnb}}{dt})_{at\ S_{fnb}=0}$ =$\sigma_a S + \gamma_f S_{nb}$. From the above results, it is ensured that all possible solutions of the system are positive for all time (t>0) with the consideration of initial conditions.

3.2 Boundedness

Theorem 3.2.1 All positive solutions of the proposed model (1) are bounded and contained in

$$\Gamma_b = \{(S, S_{nb}, S_{fnb}) \in R_+^3 : 0 \le S + S_{nb} + S_{fnb} \le \frac{\Pi_{rs}}{\mu}\}.$$

Proof: Here, N=S+S_{nb}+S_{fnb}. Therefore,

$$\frac{dN}{dt} = \frac{dS}{dt} + \frac{dS_{nb}}{dt} + \frac{dS_{fnb}}{dt}$$
$$= \Pi_{rs} - \mu(S + S_{nb} + S_{fnb}) - \delta_{rc} S_{nb}$$
$$\le \Pi_{rs} - \mu(S + S_{nb} + S_{fnb})$$
$$\le \Pi_{rs} - \mu N.$$

Hence $\lim_{t\to\infty} sup(S + S_{nb} + S_{fnb}) \le \frac{\Pi_{rs}}{\mu}$, which proves the theorem.

4. Basic Reproduction number R_0

In epidemiology, the infection either spreads or does not, depending on the basic reproductive number. It is necessary to find out the value of the basic reproduction number of the system (1) because here the problem has been compared with a disease. Therefore, the value of the basic reproduction numbers has been found here with the assistance of the next-generation matrix technique [9]. The nonnegative matrix m_i, has been prepared only by the infection terms. Also, the positive matrixm_{ni}, which has been prepared only by the non-infection terms. Therefore,

$m_i = \begin{pmatrix} \beta_c S S_{nb} \\ 0 \end{pmatrix}$ and

$m_{ni} = \begin{pmatrix} (\mu + \gamma_f + \delta_{rc}) S_{nb} \\ -\sigma_a S - \gamma_f S_{nb} + \mu S_{fnb} \end{pmatrix}$

Now, M_i = The Jacobian matrix of 'm_i' at the disease-free equilibrium point=$\begin{pmatrix} \frac{\beta_c \Pi_{rs}}{\mu+\sigma_a} & 0 \\ 0 & 0 \end{pmatrix}$ *and*

$\mathbf{M_{ni}}$= The Jacobian matrix of '$\mathbf{m_{ni}}$' at the disease-free equilibrium point=$\begin{pmatrix} (\boldsymbol{\mu + \gamma_f + \delta_{rc}}) & \mathbf{0} \\ -\boldsymbol{\gamma_f} & \boldsymbol{\mu} \end{pmatrix}$

Therefore,

$R_0 = \rho M_i M_{ni}^{-1}$ = Spectral radius

$$= \frac{\beta_c \Pi_{rs}}{(\mu + \sigma_a)(\mu + \gamma_f + \delta_{rc})}$$

5 Equilibria and its presence

The model (1) has two types of equilibrium points namely,

(i) The equilibrium point which does not include any disease $E_{de}\left(\frac{\Pi_{rs}}{\mu+\sigma_a}, 0, \frac{\sigma_a \Pi_{rs}}{\mu(\mu+\sigma_a)}\right)$

(ii) The equilibrium which includes disease $E_{ee}(S^*, S_{nb}^*, S_{fnb}^*)$

Where, $S^* = \frac{\mu+\gamma_f+\delta_{rc}}{\beta_c}$,$S_{nb}^* = \frac{(R_0-1)(\mu+\sigma_a)}{\beta_c}$ and $S_{fnb}^* = \frac{\gamma_f(R_0-1)(\mu+\gamma_f+\delta_{rc})(\mu+\sigma_a)}{\beta_c}$

From the above expression, the disease certainly persists when the value of R_0 is greater than one. On the other hand, the disease does not persist when the value of $R_0$is less than one.

6 Stability analysis of E_{de} and E_{ee}

Theorem 6.0.1. The disease-free equilibrium point E_{de} of the system (1), which does not include any disease, is asymptotically stable locally if R_0<1 and unstable while $R_0 > 1$.

Proof: The Jacobian matrix around the equilibrium point E_{de} which does not include any disease of the system (1)

$$J_{de}^0|E_{de} = \begin{pmatrix} -(\mu + \sigma_a) & -a_{12} & 0 \\ 0 & a_{12} - a_{22} & 0 \\ \sigma_a & \gamma_f & -\mu \end{pmatrix}$$

$$a_{12} = \frac{\beta_c \Pi_{rs}}{\mu + \sigma_a}, a_{22} = (\mu + \gamma_f + \delta_{rc})$$

The three eigenvalues of the characteristics equation $|J_{de}^0|E_{de}$-$\lambda^{de} I_d'|$=0 are (I_d' denotes the identity matrix)

$\lambda_1^{de} = -\mu < 0$, $\lambda_2^{de} = -(\mu + \sigma_a) < 0$and $\lambda_3^{de} = a_{12} - a_{22} = \frac{\beta_c \Pi_{rs}}{\mu+\sigma_a} - (\mu + \gamma_f + \delta_{rc}) = (R_0 - 1)(\mu + \gamma_f + \delta_{rc})$

From the above result, it is clear that the three eigenvalues are negative while R_0<1. Therefore, the equilibrium pointE_{de}, which does not include

any disease of the system (1), is asymptotically stable locally. On the other hand, while R_0>1, there exist two negative and one positive eigenvalue. Hence, the equilibrium point is unstable.

Theorem 6.0.2. The equilibrium point E_{ee} which includes disease of the model (1) is stable locally asymptotically if R_0 its value is greater than one.

Proof: The Jacobian matrix around the equilibrium point E_{ee} which includes disease of the system (1)

$$J^*|E_{de} = \begin{pmatrix} -\beta_c S^*_{nb} - a_{11} & -a^*_{12} & 0 \\ \beta_c S^*_{nb} & a^*_{12} - a_{22} & 0 \\ \sigma_a & \gamma_f & -\mu \end{pmatrix}$$

$$a_{11} = (\mu + \sigma_a), a^*_{12} = \beta_c S^* \text{and}$$

$$a_{22} = (\mu + \gamma_f + \delta_{rc})$$

The one eigenvalue of the characteristics equation $|J^*|E_{de}$-$\lambda^{ee} I'_d|$=0 is $\lambda_1^{ee} = -\mu$<0 and another two eigenvalues of the following second degree equation

$$f(\lambda^{ee}) = (\lambda^{ee})^2 + a_0\lambda^{ee} + a_1 = 0$$

Where,$a_0 = R_0(\mu + \sigma_a)$ and $a_1 = (R_0 - 1)(\mu + \sigma_a)(\mu + \gamma_f + \delta_{rc})$. As per the above result, it is clear that a_0 and a_1 values are positive while R_0>1. Therefore, the quadratic equation has two eigenvalues with negative real parts. Hence the equilibrium point E_{ee}, which includes disease of the model (1), is asymptotically stable locally while R_0 >1.

7 Sensitivity Analysis

For the prevention of disease transmission, try to find some more sensible parameters. Table 1 represents the sensitivity analysis values of parameters on R_0. In the epidemiology sense, any disease that is either spread or not depends onR_0. So it is essential to detect some sensible parameters. With the help of the following formula [10-12], calculated the elasticity and the sensitivity values of all the sensitive parameters.

$$S^{\rho_i}_{R_0} = \frac{\partial R_0}{\partial \rho_i}, \quad E^{\rho_i}_{R_0} = \frac{\partial R_0}{\partial \rho_i} \times \frac{\rho_i}{R_0}$$

The value of the basic reproduction number R_0 is either increased or decreased, which depends on the elasticity value. The positive value of $E^{\rho_i}_{R_0}$indicates that the value of R_0 will increase if the corresponding values of the parameter will increase. On the other hand, the negative value of $E^{\rho_i}_{R_0}$ indicates that the value of R_0will decrease if the corresponding values of the parameter increase. Table: 1 indicates thatΠ_{rs} and β_c have positive elasticity values on R_0. The values of R_0will increase (decrease) while the values of Π_{rs} and β_c will increase (decrease). Again σ_a, μ, γ_f *and* δ_{rc} have negative elasticity value onR_0. While increasing (decreasing) any one parameter's value ofσ_a, μ, γ_f *and* δ_{rc} then R_0 it value will decrease (increase). While the value of σ_a*and* γ_f will increase by 20 percent, the value of R_0will decrease by 15 and 14 per cent. From the detailed elasticity analysis, it is clear that the system (1) has two more sensitive parameters, that is σ_a*and* γ_f. If given more attention to these two parameter values, then disease transmission is kept under control.

Table 1: Sensitivity indicates of R_0 with respect to the parameters

Parameter (ρ_i)	Π_{rs}	β_c	σ_a
Value	0.4	0.001	0.004
$E^{\rho_i}_{R_0}$	1	1	-0.80
Paramater (ρ_i)	μ	γ_f	δ_{rc}
Value	0.001	0.02	0.01
$E^{\rho_i}_{R_0}$	-0.23	-0.64	-0.32

8 Numerical Analysis

This portion tries to validate the analytical result of the proposed model (1) with the assistance of some numerical techniques. Figure (1-7) shows the analytical outcomes. For all the parameter values taken from Table 2, Figure 1 shows that the equilibrium point E_{de}(30, 0, 120) is LAS (locally asymptotically stable) while R_0=0.9677<1 and the eigenvalues are -0.001, -0.005 and -0.001. While takingΠ_{rs}=0.4 and other parameter values from Table 2. Figure 2 shows that the equilibrium point E_{ee}(31, 7.9032, 282.0645) is locally asymptotically stable (LAS), R_0=2.5806>1 and eigenvalues are -0.001, -0.0065+0.0143i and -0.0065-0.0143i. Figure 3 indicates the sensitivity and elasticity analysis on R_0 of all the concerned parameters. Figures 4show that the values of R_0 will decreases from 1.1730 to 0.9926 while the values of $\sigma_a$increases from 0.01 to 0.012. Figure 5 indicate that the values of R_0 will decreases from 1.1594 to 0.9926 while the values of γ_f increases from 0.058 to 0.0696. Figure 6(a) says that the values of $\sigma_a$increases from 0.004 to 0.012, then R_0 its value will decrease from 2.5806 to

0.9926 and S_{nb} class goes to extinction. Figure 6(b) shows the while the values of γ_f increases from 0.02 to 0.0696, then the values of R_0 will decreases from 2.5806 to 0.9926 and S_{nb} class goes to extinction. Figure 7 shows that the values of R_0 will increase (decrease) while the values of $\Pi_{rs}$and $\beta_c$increase (decrease).

Table 2: Explanation and presumption of parameter

Symbol	Explanation	Value
Π_{rs}	Influx rate of the susceptible peoples	$0.15month^{-1}$
β_c	Contact rate between S and S_{nb} peoples	$0.001month^{-1}$
σ_a	Awareness rate of the susceptible peoples	$0.004month^{-1}$
μ	Usual death rate	$0.001month^{-1}$
γ_f	The fear effect	$0.02month^{-1}$
δ_{rc}	The rejection rate due to wrong credentials	$0.01month^{-1}$

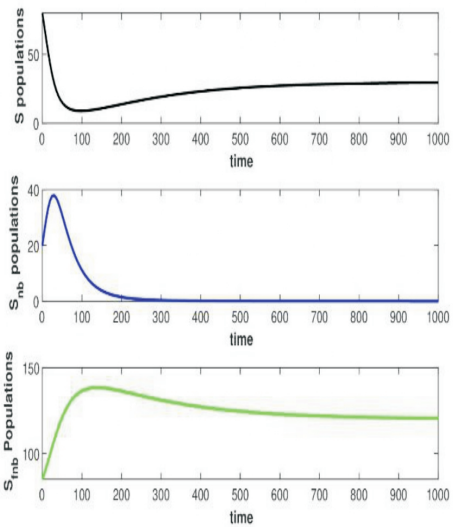

Figure 1: The disease free equilibrium point E_{de} is locally asymptotically stable while R_0=0.9677.

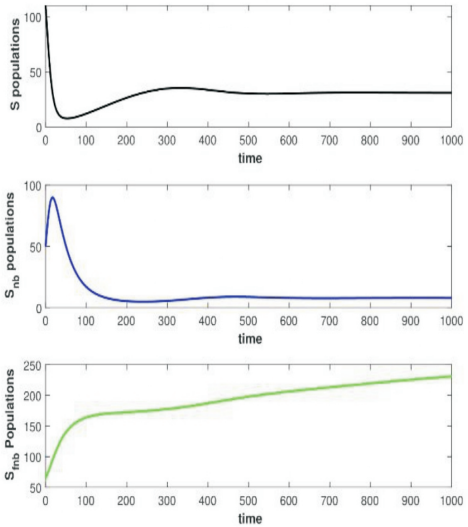

Figure 2: The endemic equilibrium point E_{ee} is locally asymptotically stable while R_0=2.5806.

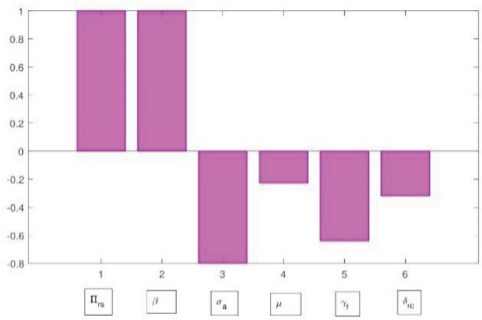

Figure 3: Elasticity values on R_0 of all the concern parameters

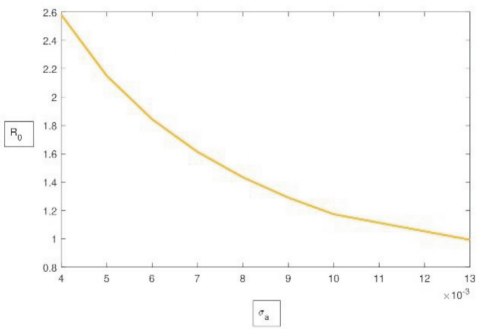

Figure 4: Relation among R_0 and σ_a.

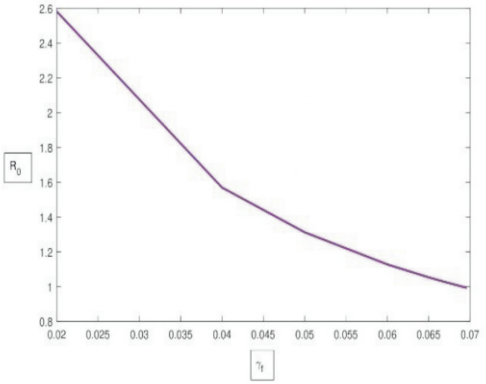

Figure 5: Relation among R_0 and γ_f .

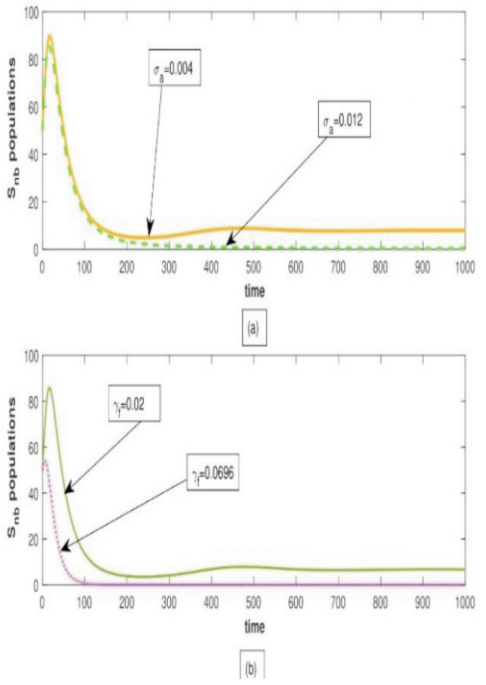

Figure 6(a)& 6(b): Impact of σ_a *and* γ_f and R_0 and S_{nb} population classes.

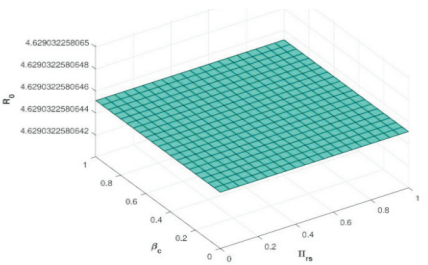

Figure 7: The relation among R_0, Π_{rs} and β_c.

9 Conclusion

The government always tries to launch a scheme for needy people. Sometimes it happens that a hundred percent of needy people do not benefit from the scheme. Why does this happen? keep it in mind and try to sort it out somehow. This problem compares with a disease and proposes a three-dimensional deterministic model to discuss the various government schemes. First, calculate the value of the basic reproductive number R_0 with the support of the next-generation matrix technique. In disease dynamics, any type of disease that is either spread or not depends on R_0. From the computed values, it is ensured that the disease persists while $R_0>1$ and fades out while $R_0<1$. The proposed model conveys two positive equilibria: endemic and disease-free. The analytical result shows that both the equilibrium points are locally asymptotically stable and proves that the analytical result is numerical. Also, find out which parameters are more sensible on R_0. The calculated elasticity value says that more reliable sensitive parameters are σ_a and γ_f.If the value of σ_a increase (from 0.004 to 0.012), then the value of R_0 decrease (2.5806 to 0.9926). Also, if the value of γ_f increase (from 0.02 to 0.0696), then the value of R_0decrease (2.5806 to 0.9926). However, the sensitive analysis shows that the more sensible parameters are Π_{rs} and β_c, which indicates that if we increase (decrease) the value of any one of them, then the value of R_0 also increases (decreases). In reality, it is easier to increase the value of σ_a *and* γ_f rather than decrease the value of Π_{rs}andβ_c. Therefore, the study concludes that if the value of awareness (σ_a from 0.004 to 0.012) and the fear effect (γ_f from 0.02 to 0.0696), then the values of R_0decrease and go below 1, which ensures that the disease fades out and the class of people who are not eligible to avail the benefit of the scheme goes to extinction. Finally concludes that if it is possible to increase the awareness rate and fair effect rate, then such types of disease transmission can be kept under control.

Acknowledgments

The authors express his gratitude to the reviewers whose comments and suggestions have helped the improvements of this paper.

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AJHMC
ISSN : 0973-6212

Volume : 13 No. 1 & 2
February. 2026

Visceral Leishmaniasis: Advances in Research and Their Public Health Impact: A Review

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Date of Receipt: 20.05.2025 **Date of Acceptance: 24.02.2026** **Date of Publication:28.02.2026**

Abstract:

Leishmania donovani is the causative agent of the deadly neglected tropical disease known as kala-azar, or visceral leishmaniasis, which is spread by the bite of an infected sandfly. The disease, which is endemic to regions of South Asia, East Africa, and Latin America, is a major public health concern, especially in areas with low resources. As a result of the intensive study, over the last few decades significant progress has been made in understanding the pathogenesis, diagnosis, therapy, and control of the condition. Rapid diagnostic testing, potent medications like liposomal amphotericin B and miltefosine, and creative vector control techniques have all greatly enhanced case discovery, treatment, and prevention. Significant drops in disease incidence and death have been achieved as a result of these research-driven initiatives, particularly in South Asia, which have influenced regional elimination programs. Post-kala-azar dermal leishmaniasis (PKDL), growing treatment resistance, and restricted access to healthcare in endemic areas are some of the obstacles that still exist in spite of these advancements. Ongoing investments in research and public health infrastructure are very crucial to maintain progress and meet the worldwide kala-azar elimination targets.

KeyWords: *Leishmania donovani,* Epidemiology, Kala-azar, Publichealth.

1.Introduction:

Visceral leishmaniasis (VL), also referred to as kala-azar, is a potentially fatal parasitic disease that is spread by the bite of female *Phlebotomus argentipes* sandflies carrying the *Leishmania donovani* infection [1]. Malnutrition, substandard housing, and restricted access to healthcare are some of the factors that worsen the disease's effects among South Asian and East African underprivileged areas [2]. Historically, the bulk of VL infections worldwide have occurred in the Indian subcontinent, which includesNepal, Bangladesh,and India. The endemic foci of this disease are primarily in rural and underdeveloped areas [3]. Urbanization has increased the spread of VL outside rural areas, creating special obstacles for management measures [4], [5]. Brazil is the most affected country, where domestic dogs act as reservoirs for the zoonotic disease[6]. The WHO estimates that between 50,000 and 90,000 new cases of VL are reported each year worldwide, with over 90% of cases concentrated in a small number of countries [7]. One of the major epidemiological concerns is post-kala-azar dermal leishmaniasis (PKDL), which serves as a chronic parasite reservoir and contributes to the continuous spread of *Leishmania donovani,* especially in endemic regions where anthroponotic transmission occurs, like India [8], [9]. The majority of PKDL cases are recorded from 54 districts, including 11 in West Bengal,33 in Bihar, 6 in Uttar Pradesh and 4 in Jharkhand in India [10]. The socioeconomic effect

on vulnerable people, high morbidity and mortality, and intricate transmission mechanisms involving human and animal reservoirs make VL a serious public health concern. Even with improvements in diagnosis and treatment, VL still puts a burden on health systems, particularly in endemic areas with limited resources [11]. This review aims to synthesize current research on kala-azar, emphasizing its impact on public health, the effectiveness of intervention strategies, and the challenges that remain in the path towards global elimination.

2. Advances in Diagnosis and *Visceral leishmaniasis*:

An accurate diagnosis is essential, for successful disease management. Although splenic aspiration for parasitological confirmation is still the gold standard, it is intrusive and dangerous. Field diagnostics has been revolutionized by serological assays like the rK39 dipstick test, which offer great sensitivity and specificity in endemic areas [12]. Molecular techniques, such as PCR and LAMP tests, have recently shown promise as early and precise detection tools; nevertheless, their application is restricted in low-resource environments [13].Under parasitological diagnosis in conventional diagnostic methods the gold standard for demonstrating *Leishmania* parasites is still microscopy in spleen, bone marrow, or lymph node aspirates. However, it is intrusive, has a potential for difficulties, and calls for trained staff [14]. The Direct Agglutination Test (DAT) and the enzyme-linked immunosorbent assay (ELISA) are two serological diagnostics that have good sensitivity. Cross-reactivity with other pathogens or previous infections, however, could result in false positives [12].The recombinant K39 antigen of *Leishmaniadonovani* is the main target of antibodies in Rapid Diagnostic Tests. Because of the genetic diversity of parasites, sensitivity and specificity are higher on the Indian subcontinent than in East Africa, although they are lower there [15], [16]. Polymerase chain reaction (PCR) and its variations have emerged as effective tools because of its high sensitivity and specificity, for VL diagnosis in molecular diagnostic techniques. It provides less invasive alternatives to splenic aspiration by detecting parasite DNA in blood or tissue aspirates [17]. In order to differentiate active VL from asymptomatic infection and forecast treatment results, research is being conducted on host immunological biomarkers, including as cytokine profiles (e.g., IFN-γ, IL-10) [18]. New markers for early diagnosis and prognosis are being found using proteomic and metabolomic techniques [19].

3. Therapeutic developments and Kala-azar Research:

Chemotherapy is still the primary therapeutic method. Amphotericin B has demonstrated outstanding effectiveness with decreased toxicity, particularly in its liposomal formulation (AmBisome) [20]. The first oral treatment for VL, miltefosine, showed promise at first but has since encountered difficulties because of patient noncompliance and new resistance [21]. Sodium stibogluconate and other pentavalent antimonials (SbV) were the cornerstone of conventional therapies for many years, but they are currently limited because of their toxicity and pervasive resistance, particularly in the Indian subcontinent [20]. The first oral medication that effectively treated VL was miltefosine, which was first made available in the early 2000s. Despite requiring a 28-day treatment and exhibiting acceptable efficacy and safety, there are worries about teratogenicity and growing resistance [22]. Although paromomycin is safe, effective, and reasonably priced, its effectiveness as a monotherapy varies, hence it is frequently used in combination regimens [23]. An oral nitroimidazole called fexinidazole is already approved to treat African trypanosomiasis and shows potential in treating VL [24]. Drug delivery methods based on nanotechnology seek to decrease toxicity and increase drug bioavailability now a days [25].

4. Vector Control and Surveillance and *Visceral Leishmaniasis*:

Historically, indoor residual spraying (IRS) of insecticides like pyrethroids and DDT has been the mainstay of vector control. Control efforts have

been strengthened by integrated vector management, which includes the use of long-lasting insecticidal nets (LLINs) and environmental cleanliness[26]. However, insecticide-resistant sandflies are a new concern that necessitates constant observation and modification of management measures[27]. Techniques for Vector Control Vector habitats are reduced when sandfly breeding and resting areas are altered (i.e. by removing vegetation, caulking wall crevices, or upgrading dwellings).The durability of vector control initiatives is improved by community involvement in environmental management[28]. Entomopathogenic fungiandPheromone traps provide ecologically favorable alternatives for biological control[29].Entomological monitoring, human case detection, and geographical mapping are all integrated into effective surveillance.Vector control measures are guided by routine monitoring of sandfly numbers,vector behavior and pesticide susceptibility[30].Migration, urbanization, and climatic change all affect the distribution of vectors and the epidemiology of VL[31].The Indian subcontinent's VL incidence has significantly decreased as a result of persistent vector control measures, advancing the objective of elimination[32]. The data from surveillance has been essential for identifying outbreaks and stopping the spread of disease.

5. Public Health Impact and Kala-azar:

The disease burden has been greatly decreased by large control initiatives like the Kala-azar Elimination Programme (KAEP) in South Asia, mostly because to early case discovery, efficient treatment, and vector management[33]. Due to coordinated efforts under KAEP, India recorded a >90% decrease in VL infections between 2005 and 2020[34]. Post-kala-azar dermal leishmaniasis (PKDL) is still a source of transmission, nevertheless, which makes eradication efforts more difficult[35]. The socioeconomic effect on vulnerable people, high morbidity and mortality, and intricate transmission mechanisms involving human and animal reservoirs make VL a serious public health concern. Health systems are still under stress from VL despite improvements in diagnosis and treatment, particularly in endemic areas with limited resources.Poor, rural areas are disproportionately affected by VL, which results in lower production, higher healthcare expenses, and worsening poverty cycles[36].The combination of VL with HIV/AIDS, starvation, and other illnesses increases the severity of the illness and makes treatment more difficult[11].The WHO Roadmap on Neglected Tropical Diseases calls for integrated approaches that include early diagnosis, efficient treatment, vector control, surveillance, and community involvement in order to eradicate VL as a public health issue in East Africa and the Indian subcontinent by 2030[7].

6. Conclusion:

Over a century of Kala-azar (*visceral leishmaniasis*) research has transformed a neglected tropical scourge into a largely controllable—yet still formidable—public-health challenge. Advances in parasite genomics, vector ecology, and immunopathology have clarified transmission dynamics and illuminated new therapeutic and vaccine targets. Field studies integrating molecular diagnostics with geo-spatial surveillance now enable earlier case detection, while single-dose liposomal amphotericin B and miltefosine–paromomycin combinations have shortened treatment courses and improved cure rates. Importantly, implementation science has shown that these biomedical gains translate into real-world impact only when embedded in strengthened primary-health systems, sustained vector control, and robust social-behavioral interventions that address poverty, malnutrition, and gender inequities. The regional elimination initiatives in South Asia demonstrate that political commitment, cross-border collaboration, and community engagement can drive incidence to historic lows; yet persistent foci in East Africa and emerging HIV–Leishmania coinfections warn against complacency. Future progress hinges on affordable oral therapies, pan-Leishmania vaccines, point-of-care tests for latent infection, and climate-informed surveillance networks capable of anticipating vector range shifts. By aligning scientific innovation with equitable health-system

delivery, the global health community can move from episodic control toward sustainable elimination—advancing not only the fight against Kala-azar but also the broader agenda of poverty-related and neglected diseases.

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Volume : 13 No. 1 & 2
February. 2026

Optimizing Occupational Performance in Police Personnel: Exploring the Interplay between Sleep, Dietary Patterns, and Cognitive Function in Police Personnel

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Date of Receipt: 30.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract: Police personnel work in challenging environment, such as irregular shift work, long duty hours, high stressful conditions and uncertain demands at any time, which hamper physiological and psychological balance. These state notably hamper sleeping habits, eating patterns and cognitive tasks, which are important for their job performance and health Well-being. This review paper seeks to interconnection between sleep, diet and cognitive function and increase their role in enhancing performance and well-being. Studies shows that officers frequently have sleep disorders, faulty sleep hygiene, often experience fatigue and circadian misalignment. Simultaneously, the unpredictable nature of police work leads to poor dietary habits like high intake of processed food and improper nutrient consumption may elevate sleep deprivation, which controls cognitive function like attention, rapid decision making, and emotional control for fruitful policing. This review highlights the importance of sleep hygiene, shift planning and healthy nutrient intake practice to elevate cognitive power and working competence of police personnel. Managing these associated factors can play a pivotal role in aiding safety, work efficiency within police personnel.

Keywords:Police personnel, Shift work, Sleep deprivation,Dietary patterns, Cognitive performance, circadian disruption.

Introduction

Police professions are very difficult, it need consistent attention, information analysis of decision-making in an erratic work schedule, long shifts and high mental stress. Law enforcement work needs long night shifts, rotating schedules, prolonged on call times and exposure to unpredictable important occurrences which can affect their regular sleep-wake cycle and behavioral routines as compare to many civilian professions [1]. Based on scientific research, a majority of police officers report minimal sleep or sleep disturbance due to their operational demands and shift work schedules, which shows a high rate of poor sleep quality and abnormal circadian rhythms among them [2]. Officers who work inconsistently tend to eat at irregular times and rely more on convenience food, leading to inaccurate dietary patterns and an elevated risk of gaining weight and cardio metabolic disease [3,4]. This prolonged sleep disorders also affects psychological replenishment, along with eating behaviors and metabolic regulation. Nutrition and sleep are closely linked. Appetite management, food timing and nutrient metabolism can be influenced by energy level, glucose tolerance and circadian disruption [2, 5]. Altogether, these lifestyle factors influence the

cognitive function, especially in concentration on memory, executive control and neuromotor function, which are critical for effective regulation[5]. Studies indicates the both sleep deprivation and poor diet hurt cognitive functions, inattention and slow reaction time, this puts operational safety and decision making at risk for long time[6].

Physiological Mechanisms

↓Cortisol
↓
↓Leptin, ↑Ghrelin
↓
Insulin resistance
↓
Systemic inflammation (IL-6, CRP)
↓
Oxidative stress

Given the crucial role that cognition resilience plays in the effectiveness of law enforcement officers and the well-being of them, research finding related to sleep, dietary habits and neurocognitive outcomes need to be integrated to further investigate how these factor collectively influence performance [7]. This review shows recent research on the relation between diet sleep patterns and cognitive function in police personnel and focuses on how sleep and nutritional disruption caused by the nature of their work can have a negative impact on health and cognitive ability [8, 9]. This Research paper synthesizes data from sleeping patterns, nutrition research and cognitive performance analysis to emphasis the need for comprehensive evidence-based strategies that target sleep habits, work schedule and dietary patterns to improve the efficiency and long-term well-being of police personnel [9, 10].

Neurocognitive Impact

Prefrontal cortex dysfunction
↓
Hippocampal impairment
↓
↓ Attention & vigilance
↓
↓ Executive function
↓
Impaired decision-making & emotional control

Methodology

This narrative review synthesized peer-reviewed literature identified through searches of PubMed, Scopus, Web of Science, and Google Scholar using keywords related to police personnel, shift work, sleep, diet, circadian disruption, and cognitive function. English-language studies published up to 2025 examining sleep, dietary patterns, cognitive outcomes, or their interactions in police or comparable shift-working populations were included. Relevant articles were qualitatively analyzed to integrate mechanistic and functional evidence.

Sleeping patterns of police personnel

Sleep is an essential biological function and crucial for sustaining physical health, mental performance, and emotional stability [1]. The modern lifestyle, marked by long working hours, high stress levels resulted in widespread sleep deprivation [2, 11]. Optimum and good quality sleep is very much needed for the human body to function properly [1]. While we sleep, our body regulates metabolic processes, bolsters the immune system, and aid in tissue healing[12]. The secretion of growth hormone is high during deep sleep, aiding in muscle recovery and cell regeneration. A lack of sufficient sleep can interfere with glucose metabolism and reduce insulin sensitivity and alter hormones that control appetite, thereby increasing the risk of obesity, cardiovascular diseases, and so on [13, 14]. Other than this, chronic sleep deprivation is linked to elevate blood pressure and systemic inflammation, both of which can lead to serious long-term health issues [15]. It is increasingly seen as a major public health-related complication [15].

Occupational Stressors

- Shift work
↓
- Night duty
↓
- Long working hours
↓
- Psychological stress

Policing is a high-risk profession where mistakes in judgment or delayed responses can lead to significant consequences [1].The lifestyle of police personnel is largely influenced by occupational demands such as shift rotations, night duties,urgent emergency responses, traumatic events, irregular workload intensity, and high occupational stress [1, 8]. These demands frequently disturb the body's natural circadian rhythm, causing sustained sleep disruption and chronic sleep deprivation [2].A study examining the sleep habits of police officers found that many of them sleep less than 7 hours each night, with a significant number getting less than 6 hours. This pattern is associated with fatigue [16].

Insufficient and inadequate sleep, along with poor sleeping quality, may impair the brain's capacity to replenish neuronal energy stores. Other than this, prolonged sleep deprivation affects glucose metabolism in the prefrontal cortex, which reduces insulin sensitivity and elevates inflammatory markers and oxidative stress [8]. These long-term physiological alterations lead to declines in attention, short-term memory, decision-making capacity and emotional stability of them and increase the risk of hypertension, obesity, cardiovascular disease, diabetes and reduced physical fitness [13, 14].

Biological Disruption

- Circadian misalignment

↓

- Reduced sleep duration & quality

As time goes on, these health problems can negatively affect work performance and lead to increased absenteeism and early retirement among them. Sleep disturbances among them represent not only an individual health issue but also have significant implications for public safety [17]. Officers experiencing fatigue are more prone to judgmental inaccuracy, delayed reaction times, and increased risk during high-stakes tasks such as driving or responding to critical incidents [18]. Other than this, poor sleep quality has been linked to poor eating choices and bad dietary habits and associated with high intake of fats, processed carbohydrates [8].

Dietary patterns of police personnel

Diet is the integral part of human life for growth, development and prevention of disease. A healthy diet can meet all nutrient requirements for an individual which can provide energy and support the physiological functions [19, 20]. Therefore, a healthy dietary habit is important to allow people to do their job efficiently. Other than this, healthy dietary practice can exclude long-term diseases like heart-related disease, diabetes, stroke, several type of cancer, which can lead to death [8, 15, 21]. Policing is the highly demanding and stressful work, including shift work, improper work schedule, patrolling in night, and emergency action at any time [2]. So this type of working patterns may impair their proper consumption of meal at a particular timing and having improper eating practices, including skipping meals, late night eating, dependence on fast food and consumption of high amount of sugary beverages which results, their diet is insufficient in nutrients and rich high amount of energy, saturated fats and sodium which can affect their health [22].

Studies show that police personnel frequently ingest an inadequate amount of fruits, vegetables and eat high amount of sugar-containing beverages, especially at night. The consumption of fat, mainly saturated fat, is high among traffic policeman and they ingestless amount of calcium, β-carotene, and protein-rich food in their diet [23, 24].According to research, police officers who have greater levels of job-related stress have a tendency to select poor food choices, along with eating excess amounts of alcohol and caffeine-rich drinks, which often serve as coping strategies for combating psychological strain and fatigue [16, 24, 25]. These dietary patterns may increase metabolic syndrome including obesity, diabetes, hyperlipidemias, and elevates their blood pressure. The police personnel have higher levels of C-reactive protein, systolic blood pressure, body mass index, and waist circumference than other people [8, 26].

According to recent research, eating poorly may increase the adverse implications of insomnia and long-term stress at work, increasing stress on the

body and impairing the regulation of emotions, alertness, and cognitive function [27]. Other than this, police officers who consume a proper diet full of complex carbohydrates, proteins, good fats, and antioxidants have an improved metabolic state and less chance of cardiovascular and metabolic diseases [24, 27]. It is very much necessary to police personnel to maintain all dietary guidelines and nutritioneducation, which helps them to do their job efficiently [24].

Dietary Dysregulation

- Irregular meal timing
- ↓
- High intake of processed foods
- ↓
- Low micronutrient & antioxidant intake

Cognitive function of police personnel

Cognitive function in humans entails the proficient operation of mental processes that enable individuals to effectively perceive, process, store, and utilize information in daily life. It includes critical functions such as attention, long-term memory, learning, cognitive function and decision-making [28]. These all are important for adaptive behaviours and problem-solving. When cognitive function is high, individuals may retain their mental focus, act properly to environmental challenges, regulate mental state, and make proper judgement during their stressful conditions [28, 29]. It depends on the consistent activity of brain's cortical and subcortical areas, specifically the prefrontal cortex, hippocampus and neural networks. These parts need sufficient cerebral blood circulation, optimum neurotransmitter function, and effective energy utilization [30]. Lifestyle choices such as acquiring sufficient sleep, consuming a healthy diet, doing in regular physical activity, and staying mentally active are important for supporting these processes. So, effective cognitive ability is essential not only for personal performance and learning ability but also for overall mental well-being, productivity, and quality of life [31].

According to Research, insufficient sleep impaired the functions of the prefrontal cortex, which resulting in reduced inhibitory control, slowing the process of information, and impaired judgment. It can increase their mistakes and create negative impact during duty time [32]. Moreover, several work-related stresseselevate neuroendocrine pathways, along with cortisol release, which can have a negative effect on hippocampal and prefrontal neural circuits. This is responsible for memory and executive functions [33].Some factors, like insulin sensitivity, inflammation, are closed linked with improper dietary habit, which can aggravate cognitive impairment by changing brain's glucose utilization and may raise the oxidative state [8]. These alterations hurt their duty, performance and may alter the security of public, cognitive health and their effectiveness of decisions [34].

Association between sleep, diet and cognitive function

Diet and sleep are that factors which are depending on each other and impact on cognitive function [35]. Lack of sleep may change the appetite regulatory hormones and elevate the addiction to calorie-dense food, which weakens the sleep quality [8]. The secretion of cortisol, Leptin, ghrelin is changes due to lack of sleep[36]. Excess secretion of cortisol may lead to chronic sleep loss and decrease the hippocampal memory, and divert attention [30]. Excess secretion of ghrelin and decrease secretion of leptin may raise the addiction for calorie-containing food, which is not good for health [37]. Beside these, lack of sleep can reduce the secretion of dopamine and serotonin. These two hormones are important for attention, mood, and controlling anxiety. Lack of these two hormones may effect on cognitive function [38]. Other than this, increasedcortisol levels may increase insulin sensitivity and elevate physiological fatigue [39]. Moreover, improper dietary habits and sleep can trigger the inflammation and elevate the levels of pro-inflammatory cytokines like interleukin-6, which can decrease attention and reduce emotional control during stressful conditions [40].

Less consumption of antioxidants, polyphenols, micronutrients and Omega 3 fatty acids in diet,

along with sleep deprivation, can increase oxidative stress in police personnel, which impairs their cognitive function and memory conservation and increases irritation in them. A diet high in dietary fibre, fermented food can increase gut microbiota, which is essential for decreasing inflammation and stress, which can elevate the addiction to unhealthy foods and elevate dysbiosis. This unhealthy dietary pattern can increase insomnia, which can reduce the cognitive function [8, 24].

Discussion

This review is aimed to improving operation and effectiveness, safety, long-term health, and it also focuses on the crucial and interdependent relationship between sleep, food habits and cognitive function in police officers [1]. Needs like optimal attention, executive control, judgement, and quick decision making are critical in the cognitively demanding field of policing ; but regular sleep and circadian alignment are some of the commonly disrupted issues caused by occupational structure of law enforcement, which is characterized by shift work, long duty hours and probabilities of high psychological stress [2]. Some consequences of prolonged sleep deprivation and poor sleep quality are prolonged weariness, slowed psychological recovery, and increase susceptibility to cognitive deterioration [28].

Besides, bad eating habits such as variable meal timing and increased consumption of foods that are high in energy but low in nutrients are frequently encouraged by the erratic and inconvenient schedules of police officers, along with operational pressures [8]. There's growing evidence that inadequate nutrition and sleep disturbance work together to exacerbate metabolic deregulation, neuroinflammation, and insufficient mental energy usage [4]. These psychological changes adversely affect major cognitive domains like sustained attention, working memory, executive functioning and decision-making abilities, which are essential to save an efficient policing [41].Such mental disorders raise the possibility of mistakes, injuries and on favourable public safety outcomes in addition to having an impact on an officer's performance [42].

This analysis highlights the necessity of adopting integrated, evidence-based solutions that concurrently address sleep hygiene, shift schedules and proper dietary quality rather than just relying on standalone interventions. The psychological resilience and operational effectiveness of police officers can be significantly increased by organizational policies that encourage circadian-friendly shift designs and offer nutrition and sleeping structure with increased availability to healthy food options during duty hours [2]. Priority should be given to longitudinal and intervention-based studies in future research to elucidate the causative mechanism and assess the efficacy of comprehensive strategies adapted to law enforcement settings. Law enforcement organisations should promote greater performance, increased safety, and better long-term health outcomes for police personnel by addressing the interrelated effects of sleep, nutrition and cognition [43].

Conclusion

Police work places continuous demands on both physical endurance and mental sharpness. This review shows that irregular duty hours and high job stress often disturb normal sleep and eating routines among police personnel. Poor sleep and unhealthy dietary habits tend to occur together, gradually affecting metabolic balance, increasing inflammation, and weakening cognitive abilities such as attention, memory, emotional control, and decision-making. These changes can reduce work efficiency and increase long-term health risks. Improving performance and well-being in policing therefore requires practical, combined approaches that support better sleep habits, more stable work schedules, and healthier food choices. Addressing these factors together can help police personnel maintain cognitive resilience, work safely, and sustain their health over time.

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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

A Comparative Analysis of BRICS Economies in terms of Its Health and Education

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Date of Receipt: 25.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract:
The BRICS group—comprising Brazil, Russia, India, China, and South Africa—emerged as a coalition of major emerging economies with the potential to reshape global economic and political landscapes.These BRICS countries collectively represent more than 40% of the world's population and a significant share of global GDP. However, per capita income is a better measure of the well-being of the population of a country compared to GDP or GNP. As populations vary, therefore same GDP of two countries will not reflect the same level of well-being of their people. In contrast, the Human Development Index (HDI) offers a broader view by incorporating quality-of-life indicators.This paper tries to examine the trends in Human Development Index (HDI) values in BRICS countries over a specified period of time in terms of individual components of HDI—health and education indices across the BRICS nations.

Key Words: Health, Education, Human Development Index (HDI), BRICS

INTRODUCTION

The BRICS group—comprising Brazil, Russia, India, China, and South Africa —emerged as a coalition of major emerging economies with the potential to reshape global economic and political landscapes. Originally coined as "BRIC" in 2001 by economist Jim O'Neill, the term highlighted the growing influence of these four economies Brazil, Russia, India, and China. The group formally began cooperation in 2006, and in 2010, South Africa joined, expanding it to BRICS. Since then, the BRICS nations have worked together on various multilateral platforms to promote development, trade, and global reform. Recently Iran, Egypt, Ethiopia, UAE, and Indonesia join BRICS in 2024-25, now it is known as BRICS +.

These BRICS countries collectively represent more than 40% of the world's population and a significant share of global GDP. However, per capita income is a better measure of the well-being of the population of a country compared to GDP or GNP. As populations vary, therefore same GDP of two countries will not reflect the same level of well-being of their people. In contrast, the Human Development Index (HDI) offers a broader view by incorporating quality-of-life indicators. The Human Development Index (HDI), developed by the United Nations Development Programme (UNDP) in 1990, is a composite measure designed to assess a country's average achievements in three key dimensions of human development: a long and healthy life, access to knowledge, and a decent standard of living. Inspired by the work of Mahbub ul Haq and Amartya Sen, the HDI shifts the focus of development from purely economic growth to human capabilities. Prior to 2010, the HDI was calculated using an arithmetic mean of three-dimension indices: Life Expectancy Index (LEI), Education Index (EI), and the Income Index (II). In 2010, the methodology was revised to improve accuracy and comparability. The education dimension was updated to include Mean Years of Schooling (MYS) and Expected Years of Schooling (EYS), normalized as

RATIONALE:

While traditional economic indicators like GDP have long been used to evaluate national progress, they often fail to capture the social and human aspects of development. The Human Development

Index (HDI), developed by the United Nations Development Programme (UNDP), addresses this gap by incorporating indicators related to health, education, and income. Given the rapid economic changes within the BRICS nations over the past two decades, it is essential to investigate whether these shifts have translated into genuine improvements in human developmentThis studybestowsa comparative analysis of HDI growth across the BRICS economies—Brazil, Russia, India, China, and South Africa—between 2006 and 2023. These nations, despite their shared classification as emerging economies, display varying patterns in human development due to their distinct economic structures, policy priorities, and demographic trends. By leveraging data analytics techniques, the study explores how life expectancy, education levels, and income indices have evolved in these countries over time, while also assessing the influence of government expenditure in health and education on these outcomes. We added South Africa in analysis because it is a long-term prominent member from 2010 and it also fulfil the term BRICSUnderstanding these dynamics is essential for policymakers and researchers seeking to identify effective strategies for inclusive and sustainable development. This paper not only highlights the progress achieved by each BRICS nation but also offering insights into the drivers and barriers to human development within these economies.By examining the internal components of HDI—life expectancy, education, and income—along with related government spending on health and education, the project seeks to uncover patterns, correlations, and disparities. The rationale lies in understanding how economic policies and resource allocation contribute to human development and where gaps still remain.

LITERATURE REVIEW

Nixon and Ulmann (2006) conducted a panel data analysis across several developed nations, including the United States (Lichtenberg, 2000), Canada (Crémieux et al., 2005), and OECD member countries (Hitiris&Posnett, 1992; Shaw et al., 2005), to examine the impact of healthcare spending on population health outcomes. Their findings state that increased health expenditure is significantly associated with improved life expectancy and reduced mortality rates.

Scholars such as Fahrika et al. (2020) and Deb (2015) have emphasized that HDI offers a more inclusive view by considering life expectancy, education, and income, thus reflecting the overall well-being of a population.

Elistia and Barlia (2018) established a correlation between HDI and economic growth for ten ASEAN countries from the time period 2010-16. They usedCausal Analysis Correlation to find out the relationship between economic growth and HDI.

Nguyen and Duong (2021) examinedthe influence of the shadow economy, corruption, and other fiscal variables on BRICS' economic growth from 1991 to 2017 using Bayesian linear regression. Their findings advocatethat *public expenditure and trade openness steadily improve economic growth*, while foreign direct investment (FDI), inflation, and tax revenue revealpositive but less specifiedeffects. surprisingly, the study challenges traditionalperceptions by observing that both the shadow economy and control of corruption had a *modestly positive association* with economic growth.

Complementing this, Simo-Kengne and Bitterhout (2023) utilizedpanel data analysis to explore corruption's nonlinear effects on BRICS nations' growth. Their study found that *corruption significantly undermines economic performance*, though the extent varies across countries. By focusing these cross-country differences, the research advocates for tailored anti-corruption strategies rather than one-size-fits-all policy recommendations. Their results strengthenthe importance of institutional quality and transparent governance as essential ingredients for sustainable development.

Sušnik and Pieter (2017) used advanced quantitative methods to examine how the Human Development Index (HDI) is influenced by economic factors and resource use. Their findings established that *personal wealth and equitable access to resources*have a close relationship with HDI than aggregate national figures, highlighting the role of distributional fairness.

Iskandar (2017) investigateddata from 23 districts in Indonesia to explore how special autonomy funds affect economic growth through HDI. The study revealed a *negative correlation*, suggesting that such funds may not effectively promote growth unless better managed and aligned with local priorities.

Building on this foundation, more recent studies have broadenedthe analysis to developing and less developed countries (e.g., Bayati et al., 2013), suggesting that the positive relationship between healthcare expenditure and public health indicators holds true across varying economic contexts, although the magnitude of impact may differ due to differences in system efficiency and baseline health conditions.

OBJECTIVES

The objectives of this study are:

1. To examine the trends in Human Development Index (HDI) values in BRICS countries over the period 2006–2023.
2. To analyse the individual components of HDI—life expectancy and educationindices—for each BRICS nation.
3. To assess the relationship between government expenditure (on health and education) and life expectancy and mean year of schooling.
4. To compare the pace and nature of human development across BRICS countries using descriptive and correlation-based data analysis.

METHODOLOGY

This study adopts a quantitative, data-driven approach to analyze the Human Development Index (HDI) and its components across BRICS nations—Brazil, Russia, India, China, and South Africa—from 2006 to 2022. The methodology integrates descriptive statistics, correlation analysis, linear regression analysis.

Data Collection

The study is completely based on secondary data. Data were extracted from credible international databases including:

- United Nations Development Programme (UNDP) for HDI values,life expectancy, education indices.
- World Bank and UNESCO Institute for Statistics for government expenditure on health and education.
- National statistical databases and budget documents of BRICS countries for supplementary socio-economic indicators.

Tools developed

Tomakethisstudyreadilycomprehensible,differentt ablesandgraphsareused

- To find out the relationship among the indicators,analysis ofcorrelation and regression have been applied accordingly. For systematic analysis, Microsoft Excel is used.

It appears from the table that over the past 17 years the HDI value of BRICS' countrieshas increased and it has been represented in Fig.-1. Brazil's HDI value increased from 0.725 to 0.786. It made the least growth amongst all the other countries. Russia is having highest HDI among the 5 countries, with value increased from 0.791 to 0.832. India, between 2006 and 2022, its HDI value increased from 0.557 to 0.685. Though it has the lowest HDI in all the Countries, it made the maximum growth in these years. China's HDI value increased from 0.666 to 0.797. South Africa's HDI value increased from 0.622 to 0.741.

From 2006 to 2022, all BRICS nations showed progress in their Human Development Index (HDI), with notable shifts in their developmentcategories, which are determined by the UNDP based on HDI value ranges: *low human development* (below 0.550), *medium* (0.550–0.699), *high* (0.700–0.799), and *very high* (0.800 and above). India, despite starting at the lowest HDI of 0.540 in 2006 and ranking 139th, made the largest leap in category—from low to medium human development by 2022 with an HDI of 0.640. South Africa and China moved from medium to high human development, reflecting substantial improvements in living standards. Brazil maintained a steady position within the high human development bracket throughout the period. Russia consistently led among the five, advancing from high to very high human development, with its HDI

rising from 0.778 to 0.821. These shifts highlight diverse development trajectories, shaped by different policy priorities and investments in health, education, and income.

DATA ANALYSIS AND FINDINGS

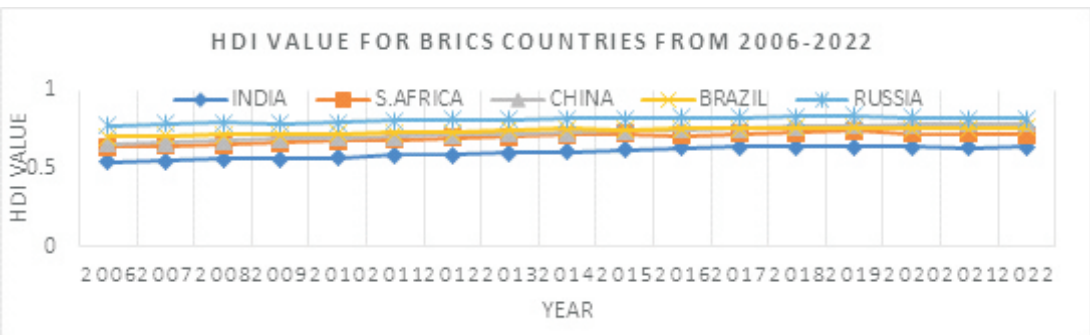
Table-1 represents the HDI values and ranks of the BRICS countries from the year 2006 -2022 in the following table:

Table 1: HDI values and its rank for BRICS countries from 2006-2022

Year	INDIA		S.AFRICA		CHINA		BRAZIL		RUSSIA	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
2006	0.54	139	0.637	121	0.656	111	0.701	92	0.778	53
2007	0.55	139	0.644	120	0.668	110	0.708	93	0.789	51
2008	0.56	140	0.653	116	0.678	109	0.714	93	0.793	54
2009	0.56	140	0.665	114	0.689	108	0.717	91	0.791	55
2010	0.57	140	0.675	112	0.698	107	0.722	93	0.797	55
2011	0.59	138	0.686	112	0.706	105	0.727	92	0.807	53
2012	0.59	139	0.696	111	0.715	104	0.732	92	0.811	52
2013	0.6	138	0.705	108	0.723	97	0.75	87	0.816	51
2014	0.61	138	0.714	107	0.732	95	0.753	88	0.818	51
2015	0.62	138	0.721	104	0.741	93	0.752	89	0.823	53
2016	0.63	136	0.711	109	0.749	93	0.753	91	0.826	52
2017	0.64	134	0.725	105	0.757	92	0.758	91	0.827	54
2018	0.64	135	0.731	104	0.766	85	0.762	91	0.836	51
2019	0.64	136	0.741	100	0.775	81	0.764	89	0.839	51
2020	0.64	134	0.722	107	0.781	76	0.758	86	0.826	53
2021	0.63	135	0.721	105	0.785	74	0.756	84	0.818	55
2022	0.64	134	0.717	110	0.788	75	0.76	89	0.821	56

Source: https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

Fig.1: HDI value for BRICS countries from 2006-2022



Relation between health care expenditure and life expectancy at birth

Russia spend highest amount per person around $ 936, and India spend lowest among BRICS country about $74 per person in 2021.Table-2 depicts health care expenditure per capita by government of the BRICS countries. It also appears from the table that there is correlation between health expenditure and life expectancy at birth across BRICS countries.

Table -2: Per capita Healthcare Expenditure (in $)

YEAR	S. AFRICA	BRAZIL	CHINA	INDIA	RUSSIA
2000	237.83	310.61	42.99	18	95
2001	204.26	268.65	44.57	20	118
2002	180.86	245.66	50.16	20	140
2003	288.38	250.31	56.79	22	164
2004	365.53	294.38	64.54	25	209
2005	404.4	383.55	73.29	27	272
2006	422.19	483.92	82.79	29	353
2007	460.02	600.64	98.88	36	462
2008	446.9	705.13	134.21	38	610
2009	492.94	719.43	165.29	38	516
2010	628.13	893.78	189.34	45	567
2011	694.1	1028.08	239.75	48	684
2012	654.25	953.7	285.31	49	759
2013	602.68	977.82	329.78	56	809
2014	547.83	1013.57	363.01	57	740
2015	499.36	782.52	393.78	58	499
2016	463.34	795.94	398.79	60	465
2017	536.78	937.34	440.59	57	580
2018	570.1	863.28	504.8	58	609
2019	551.44	850.43	539.62	61	654
2020	492.21	705	583.43	64	771
2021	583.67	761.27	670.51	74	936

Source:https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD

China (0.98) shows a very strong link—more spending leads to longer life. India (0.75) and Brazil (0.62) also show good alignment between health investment and life expectancy. South Africa (0.31) and Russia (0.30) have weak connections, suggesting spending alone isn't enough—other social or systemic issues likely interfere.

Table 3: Regression between per capita Healthcare Expenditure and Life Expectancy at birth across BRICS countries

country	Regression Equation	p value
Brazil	$y = 0.0044x + 70.642$, $R^2 = 0.3878$	0.00
China	$y = 0.0067x + 74.205$, $R^2 = 0.9654$	0.00
India	$y = 0.1085x + 62.644$, $R^2 = 0.5663$	0.00
S. Africa	$y = 0.0834x + 12.484$, $R^2 = 0.1705$	0.23
Russia	$y = 0.004x + 67.678$, $R^2 = 0.0907$	0.25

Source: Author's own calculation from secondary data

From the table,it is obvious that China shows the robust relationship between health spending and life expectancy ($R^2 = 0.97$, $p < 0.0001$), where each additional dollar in per capita healthcare spending is associated with a **0.0067-year**(about 2.4 days) increase in life expectancy. India follows with a moderately strong fit ($R^2 = 0.57$, $p < 0.001$), and a one-dollar increase corresponds to a **0.1085-year** rise—the largest marginal effect among the BRICS nations. Brazil demonstrates a moderate relationship ($R^2 = 0.39$, $p \approx 0.01$), with a dollar increase contributing **0.0044 years** to life expectancy. In contrast, South Africa and Russia show weak and statistically insignificant links ($R^2 < 0.2$, $p > 0.23$). Despite South Africa's comparatively larger coefficient (**0.0834 years** per dollar), the high p-value means we cannot confidently say this effect is real; similar caution applies to Russia's modest gain of **0.004 years** per dollar. These findings suggest that while spending has a measurable impact in China, India, and Brazil, other non-monetary factors likely influence health outcomes more heavily in South Africa and Russia.

Relation between Government Expenditure on Education and Mean year of schooling

Similarly, we try to focus on the relation between government expenditure on education and mean year of schooling. Government expenditure on education(% of GDP), of BRICS countries shown in table-4

Table 4: Government Expenditure on Education (% of GDP)

Time	India	China	Brazil	South Africa	Russia
2006	3.14	2.44	4.8	4.52	3.86
2007	..	2.70	4.7	4.	..
2008	..	3.63	5.26	4.3	4.10
2009	3.27	3.75	5.4	4.76	4.47
2010	3.37	3.55	5.6	5.13	3.84
2011	3.76	3.80	5.73	5.28	3.71
2012	4.08	4.29	5.85	5.52	3.79
2013	3.84	4.12	5.83	5.35	3.76
2014	3.8	4.10	5.94	5.48	4.01
2015	4.11	4.24	6.21	5.48	3.83
2016	4.25	4.20	6.31	5.44	3.76
2017	4.30	4.11	6.32	5.59	4.6
2018	4.37	4.02	6.08	5.64	4.6
2019	3.89	4.05	5.9	5.9	3.69
2020	4.04	4.23	5.77	6.1	4.01
2021	4.63	3.98	5.4	6.59	3.90
2022	4.12	4.02	..	6.16	4.05

Source: https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD

From the data we can see that there is no significant change in education budget across all country; also, it can be seen that S. Africa spent highest percentage in 2023 (6.16 %) and China spent lowest (4.02 %). Table also depicts that **South Africa** shows the strongest correlation (0.92), meaning e`ducation spending closely aligns with gains in schooling. **India (0.75)** and **China (0.71)** also reflect strong links between investment and educational outcomes. **Brazil (0.66)** has a moderate correlation, suggesting other factors might influence results. **Russia** stands out with almost no correlation (–0.01), indicating change in spending had little impact on schooling duration

TABLE -5: Regression of government expenditure on education, total (% of GDP) and mean year of schooling of BRICS countries.

COUNTRY	REGERSSION EQUATION	P VALUE
INDIA	Y = 1.1243X + 1.3155, R^2 = 0.5662	0.001901
CHINA	Y = 0.6166X + 5.0517, R^2 = 0.5152	0.001177
BRAZIL	Y = 0.9796X + 1.7506, R^2 = 0.4314	0.005705
S.AFRICA	Y = 1.213X + 3.6089, R^2 = 0.853	1.23E-07

Source: Author's own calculation from secondary data

From the table-5 we can find that **South Africa** shows the strongest link between government education spending and mean years of schooling, supported by a high R^2 of 0.853 and an extremely low p-value (≈ 0)indicating a very significant and reliable relationship. **India**establishes statistically significant positive correlations, with **1.1243 and 0.6166 years** of additional schooling per 1% increase in spending, respectively. Their R^2 values (0.5662 and 0.5152) and p-values (both < 0.01) suggest that higher spending is meaningfully associated with longer schooling. **Brazil** shows a similar positive trend, with nearly **0.98 years** of gain per 1% increase in spending, though the relationship is slightly weaker ($R^2 = 0.4314$, $p = 0.0057$), implying that additional factors might be at play. In contrast, **Russia** exhibits no meaningful correlation at all, with a **negative slope**, a near-zero R^2 (0.0002), and a very high p-value (0.9648), suggesting that education spending has little to no explanatory power for schooling duration there.

Conclusion

The comparative analysis of HDI growth among BRICS economies from 2006 to 2023 reveals significant progress, though at varying rates and across different dimensions. All five nations—Brazil, Russia, India, China, and South Africa—have establishedprogressin their HDI, with notable advances in health and education indicators. Among them, Russia consistently maintains the highest HDI, while India, despite starting from a lower base, has achieved the most substantial overall growth.Correlation analysis between public expenditure and human development sequelsunderscores the importance of prolonged and effective investment in health and education. The findings advocatethat while financial inputs are necessary, the effectiveness of policies and their implementation quality are crucial in transformingexpenditure into actualimprovements in human development.

In conclusion, although BRICS countries share resemblancesas emerging economies, their HDI pathsestablishthat development is multi-layeredand context-dependent. Continued efforton inclusive growth, equitable entranceto services, and directedpublic investment is crucialfor fostering long-term human development. This study focuses the value of data analytics in understanding development trends and leadingevidence-based policymaking.

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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

Cross-Talk Between Jasmonate, Salicylate and Volatile Signalling Pathways in Herbivore-Induced Angiosperm Communication

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Date of Receipt: 31.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract

Plants synthesize complex chemical signalling networks to repel herbivores and coordinate defense responses across tissues and trophic levels. Herbivore-induced plant volatiles (HIPVs) occupy a central position in this network, incorporating jasmonate-salicylate-mediated volatile signalling pathways. Herbivore attacks are identified by signals from herbivore-derived elicitors and physical damage, which initiate early cellular responses such as membrane depolarization, calcium signalling, activation of mitogen-activated protein kinases, and changes in redox states. These signals alter phytohormone dynamics, particularly the jasmonic acid and salicylic acid pathways, which influence the composition, strength, and timing of HIPV release.

This review examines the crosstalk among jasmonate, salicylate, and volatile signalling pathways in regulating plant communication triggered by herbivores. Studies suggest that HIPVs act as versatile signals in systemic signalling within plants and in interactions between plants and herbivores, carnivores, omnivores, and neighbouring plants. Jasmonate signalling plays a predominant role in HIPV induction and direct defense activation, whereas salicylate signalling modulates these responses through context-dependent, antagonistic and synergistic interactions. The ecological consequences range from enhanced resistance and indirect defense to neutral or maladaptive outcomes, depending on species identity, and community composition.

Keywords: *plant communication, jasmonic acid, salicylic acid, herbivore-induced plant volatiles,*

Introduction

In response to threats, animals use behavioural avoidance and locomotion to evade predation, while sessile plants have evolved "chemical plasticity." This adaptation enables plants to modulate their phenotype in response to environmental stresses. Research suggests that inducible defenses conserve energy by triggering expensive secondary metabolites and Volatile Organic Compounds (VOCs) only when tissue damage occurs (Hu *et al.* 2025).

Plants optimize resource allocation toward growth through a phytohormonal regulatory network mediating the inducible defense system. The "cross-talk" between phytohormones Jasmonate (JA) and Salicylate (SA) serves as a key controller in the biosynthesis of defensive compounds against herbivore attacks (Pandey*et al.* 2025).

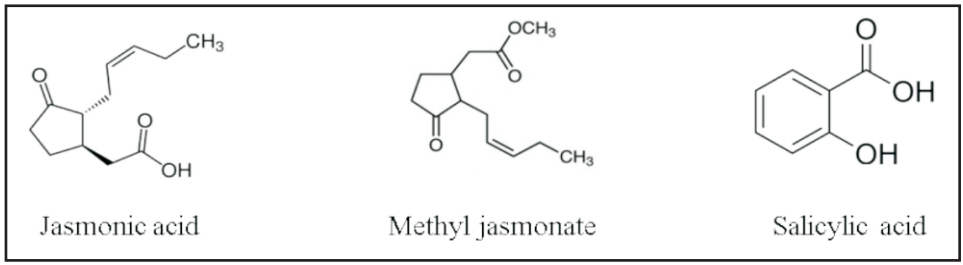
Overview of Jasmonate- Salicylate Signalling Pathways in Angiosperms

The regulation of plant defenses against both biotic and abiotic stressors is mainly controlled by the jasmonic acid and salicylic acid pathways. Among these, the defense mechanism mediated by jasmonic acid is chiefly linked to responses to abiotic stress and herbivore attacks.In contrast, salicylic acid pathways mainly target microbial pathogens (Smith *et al*., 2009; Zhang *et al*., 2025).

During stress events, such as insect attacks, jasmonic acid accumulates and initiates complex signal-transduction cascades. Early events include calcium influx, reactive oxygen species, nitric oxide, and mitogen-activated **protein kinase,** which contribute to this process (Hu *et al*., 2009; Wang *et al*., 2023). In the drought resistance pathway, JASMONATE ZIM-DOMAIN (JAZ) proteins regulate JA signalling (Gupta *et al*., 2021).

The SA signalling pathway acts antagonistically to JA signalling and triggers systemic resistance. In *Arabidopsis*, SA suppresses JA-responsive gene expression downstream of JA biosynthesis, indicating that antagonistic interactions occur during signalling rather than biosynthesis (Leon-Reyes *et al*., 2010, Zhao *et al*., 2025). SA can positively influence JA, depending on the elicitor type, timing, and concentration (Thaler*et al*., 2002; Jiao *et al*., 2022). This interplay enables plants to adapt their defenses according to the attacker, efficiently allocating resources between anti-herbivore and anti-pathogen defense (Venegas-Molina *et al*., 2020).

Both JA and SA signalling modulate defense responses and influence secondary metabolites and VOCs for plant communication and interactions (Lv*et al*., 2021). Advanced LC-MS/MS techniques enable quantification of JA, SA, and metabolites during plant stress responses, measuring multiple hormones in samples. These techniques profile hormone levels during stress, revealing temporal changes and crosstalk. Methods use isotope-labelled standards and advanced chromatography for hormone discrimination (Matsuura *et al*., 2008). The jasmonate and salicylate signalling pathways form an interconnected network that integrates signals to regulate plant defense at molecular and systemic levels (Rao*et al*., 2000; Wang *et al*., 2020).



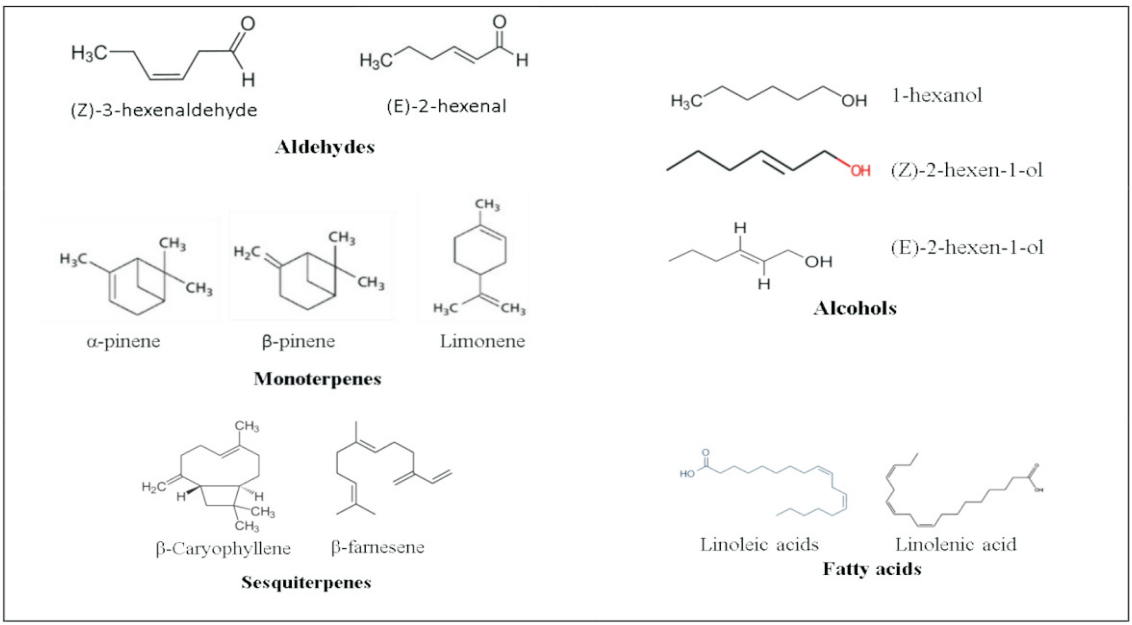


Figure 1: *Chemical structures of major signalling molecules involved in plant defense responses includes jasmonic acid, jasmonate derivative, salicylic acid, and representative herbivore-induced volatile compounds*

Table 1. Major volatile compounds emitted in response to herbivory and their regulatory pathways

Volatile compound	Chemical class	Biosynthetic / regulatory pathway	Hormonal regulation	Functional role in plant defense	Key references
(Z)-3-Hexenol	Green leaf volatile (GLV)	Fatty acid–lipoxygenase (LOX) pathway	JA, SA	Early herbivory signal; primes local and systemic defense responses	Arimura*et al*., 2009
(Z)-3-Hexenyl acetate	Green leaf volatile	Acetylation of (Z)-3-hexenol	JA	Induces defense gene expression; attracts predators and parasitoids	Arimura*et al*., 2009
(Z)-3-Hexenyl propanoate	Green leaf volatile	Esterification of (Z)-3-hexenol	JA, SA	Repels herbivores; enhances indirect defense	Riahi*et al*., 2022
Methyl salicylate	Aromatic ester	Phenylpropanoid / SA methylation pathway	SA	Mobile signal for systemic acquired resistance; plant–plant communication	Arimura*et al*., 2009
Methyl jasmonate	Jasmonate derivative	Jasmonic acid biosynthesis and methylation	JA	Airborne signal activating jasmonate-dependent defenses	Richter *et al*., 2016
Indole	Aromatic heterocycle	Shikimate–tryptophan pathway	JA, ABA	Primes systemic tissues and neighboring plants for enhanced defense	Erb*et al*., 2015
(E)-Nerolidol	Sesquiterpene	Terpene synthase pathway (TPS genes)	JA	Precursor for homoterpene production; indirect defense	Richter *et al*., 2016
DMNT ((E)-4,8-dimethyl-1,4,7-nonatriene)	Homoterpene	Oxidative cleavage of (E)-nerolidol via cytochrome P450 (CYP92C5)	JA	Attracts natural enemies; modulates multitrophic interactions	Richter *et al*., 2016
TMTT ((E,E)-4,8,12-trimethyltrideca-1,3,7,11-tetraene)	Homoterpene	Oxidation of geranyllinalool via cytochrome P450 (CYP92C6)	JA	Key signal in indirect defense and plant–plant communication	Richter *et al*., 2016

Types and roles of herbivore-induced VOCs

VOCs represent a broad category of chemicals released in response to herbivory, including green leaf volatiles, oxylipin-related compounds, and various terpenoids. Green Leaf Volatiles (GLVs) are substances that are rapidly released from green leaves when they are damaged by herbivores. These substances include six-carbon aldehydes, alcohols, and esters, and they are involved in both direct defense mechanisms and signalling processes (Figure 1).

Monoterpenes, such as β-ocimene, α-pinene, and β-myrcene, along with sesquiterpenes, such as β-caryophyllene, and homoterpenes, such as (E)-4, 8–dimethyl–1,3,7-nonatriene (DMNT), are crucial herbivore-induced volatiles that play a role in systemic defense signalling (Meents et al., 2019; Mujionoet al., 2021; Niuet al., 2024). In some plant species, sesquiterpenes are stored in glandular trichomes, where they exhibit lower volatility and adhere to plant surfaces. This characteristic aids in indirect defense by deterring herbivores or attracting their natural predators (Mofikoyaet al., 2019)(Table 1).

Methyl Salicylate is an induced compound that facilitates plant signalling, attracting predators or parasitoids of herbivores. Parasitoids lay eggs in herbivorous insects, and their larvae feed on and kill their hosts. As natural enemies, parasitoids regulate herbivore populations and suppress pest populations in crops, thereby reducing pesticide use. Their host specificity makes them valuable for integrated pest management (Singewar*et al*., 2021).

Herbivore injury activates jasmonate-dependent pathways, leading to the production of Oxylipin-Derived Volatile Compounds. In rice, herbivore-induced volatiles are unregulated through oxylipin-dependent signalling mechanisms involving jasmonates (Mujiono*et al*., 2021). These compounds contribute to plant defense via various pathways. DMNT deters sweet potato herbivores by reducing larval weight and inducing systemic defense responses (Meents*et al*., 2019). Certain VOCs, such as α-pinene and β-myrcene, attract predators (Niu*et al*., 2024) (Table 1).

Herbivore-induced VOCs influence multitrophic interactions by altering insect behaviour, mediating communication, and affecting atmospheric chemistry (Holopainen, 2011; Niu*et al*., 2024). Plants release VOCs that react with hydroxyl radicals (OH), ozone (O3), and nitrate radicals (NO3) to form secondary organic aerosols (SOA) (Edtbauer*et al*., 2021). SOA particles affect the climate through sunlight scattering and cloud formation (Virtanen *et al*., 2010). VOCs are affected by light quality, temperature and herbivore identity. Dense vegetation alters light quality and suppresses VOC emissions, affecting herbivore-enemy interactions (Kegge*et al*., 2013) (Table 1).

Molecular mechanisms underlying jasmonate-salicylate cross-talk

The molecular mechanisms governing the cross-talk between jasmonate (JA) and salicylate (SA) in plants involve antagonistic and synergistic interactions that modulate plant immunity. JA and SA are phytohormones regulating interconnected signalling pathways. SA-mediated signalling activates systemic acquired resistance (SAR) through non-expressor of pathogenesis-related protein 1 (NPR1), inducing pathogenesis-related gene expression (Spoel*et al*., 2003). SA inhibits JA signalling subsequent to the SCF (COI1)-JAZ complex, which degrades JAZ proteins to activate JA-responsive genes. While SA does not alter JAZ proteins, it inhibits JA gene expression through transcription factors such as ORA59, reducing its protein levels and diminishing the expression of JA-responsive genes such as PDF1.2 (He *et al*., 2017; Van Der Does *et al*., 2013).

Transcription factors play a key role in signal communication. In rice, OsbHLH6 modulates resistance by influencing JA and SA signalling. It moves between the nucleus and cytosol, activating JA and suppressing SA signalling in the nucleus. However, OsNPR1 sequesters OsbHLH6 in the cytosol, thereby inhibiting this effect (Meng*et al*., 2020). In *Arabidopsis*, ORA59, which facilitates JA and ethylene signalling interactions, is degraded by EIN3 in the presence of SA, linking ethylene signalling to the SA-JA balance (He *et al*., 2017).

Redox changes influence the interaction between JA and SA. When SA suppresses JA-responsive genes, such as PDF1.2, it increases glutathione levels to maintain redox balance. Inhibiting glutathione synthesis compromises SA's ability to suppress JA signalling, indicating that redox changes are crucial for hormone interactions (Koornneef*et al*., 2008). The JA-SA antagonism regulates plant volatiles, affecting herbivore host selection (Wei *et al*., 2014). Pathogen-induced SA accumulation inhibits JA signalling, a mechanism exploited by pathogens to enhance their virulence (Hou&Tsuda, 2022; Rao*et al*., 2000).

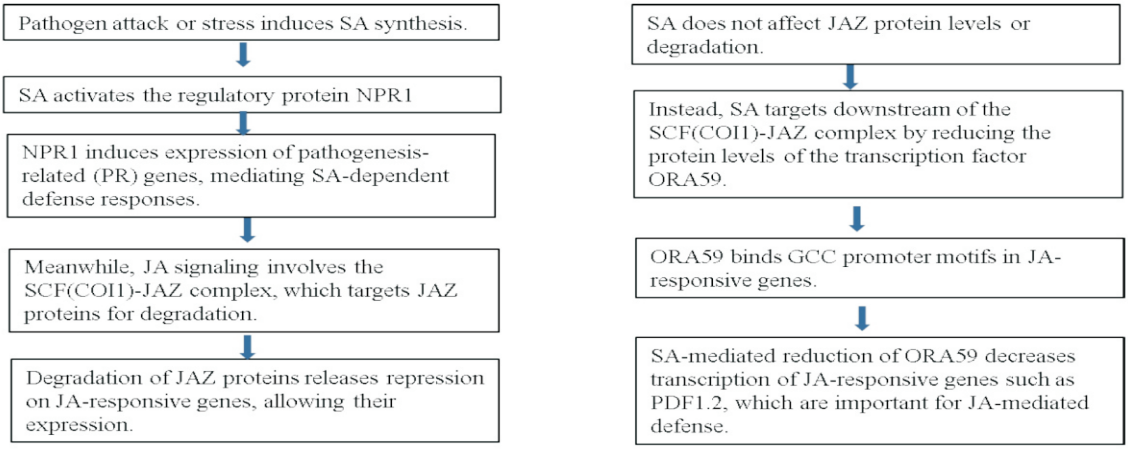


Figure 2: *The flow chart showing the process of salicylic acid (SA) inhibition of jasmonic acid (JA) ignalling through NPR1 and downstream factors*

Regulation of volatile signalling by jasmonate and salicylate pathways

The control of volatile signalling in plants is managed by the JA and SA pathways, which are crucial for plant defense and communication processes. Jasmonates trigger defense mechanisms against herbivores and pathogens by stimulating the production of defensive metabolites and VOCs, including green leaf volatiles and terpenes. These volatiles attract herbivore predators, thereby enhancing indirect plant defenses (Lou *et al*., 2005; Okada *et al*., 2014). Jasmonate signalling triggers volatile emissions after herbivore damage. In rice, jasmonic acid increases the emission of aldehydes, alcohols, monoterpenes, sesquiterpenes, and methyl salicylate, attracting parasitoids that prey on herbivores (Lou *et al.* 2005). Sorghum cultivars vary in their herbivore-induced volatile emissions, such as methyl salicylate, which influences the attraction of aphid parasitoids and predators (Russavage*et al*., 2024).

Jasmonate signalling interacts with ethylene to regulate the biosynthesis of defensive metabolites through stress-activated transcription factors (Zhou et al., 2022). Salicylic acid signalling targets pathogen defense and antagonizes the jasmonate pathways. Crosstalk between SA and JA fine-tunes the defense responses. Salicylic acid suppresses jasmonate signalling through transcriptional regulation and protein modification, activating WRKY transcription factors that repress JA-responsive genes (Caarls et al., 2015; Koornneef et al., 2008).

The interaction between these pathways is exemplified by whitefly infestation, which activates salicylic acid (SA)-dependent defenses while concurrently suppressing jasmonic acid (JA)-dependent responses. This affects both infested plants and their neighbours through volatiles that prime SA defenses and inhibit JA defenses, thereby increasing insect susceptibility (Zhang *et al*., 2019). The jasmonate and salicylate pathways regulate volatile signalling by controlling the emission of defense-related volatiles, while their antagonistic interaction ensures balanced allocation of defense resources (Caarls*et al*., 2015; Koornneef*et al*., 2008; Okada *et al*., 2014; Zhang *et al*., 2019).

Table 2. Key genes and enzymes involved in jasmonate and salicylate biosynthesis and signalling pathways

Phytohormone pathway	Gene / Enzyme	Full name	Primary function	Key references
Jasmonate	LOX	Lipoxygenase	Catalyzes oxygenation of α-linolenic acid to form hydroperoxides, initiating jasmonate biosynthesis	Rahimi*et al*., 2016
	AOS	Allene Oxide Synthase	Converts LOX-derived hydroperoxides into unstable allene oxide intermediates	Leon-Reyes *et al*., 2010
	AOC	Allene Oxide Cyclase	Cyclizes allene oxide to form 12-oxo-phytodienoic acid (OPDA)	Leon-Reyes *et al*., 2010
	OPR3	OPDA Reductase 3	Reduces OPDA to jasmonic acid (JA) in peroxisomes	Leon-Reyes *et al*., 2010
	JAR1	Jasmonate-Resistant 1	Catalyzes conjugation of JA to isoleucine (JA-Ile), the bioactive jasmonate signal	Staswick*et al*., 2002
	MYC2	bHLH transcription factor	Central regulator of jasmonate-responsive gene expression	Kim *et al*., 2013
Salicylate	ICS1	Isochorismate Synthase 1	Produces isochorismate, a major precursor for salicylic acid biosynthesis	Lu, 2009
	PAL	Phenylalanine Ammonia-Lyase	Converts phenylalanine to cinnamic acid, contributing to an alternative SA biosynthesis route	Lu, 2009
	NPR1	Nonexpresser of PR genes 1	Master regulator of SA-mediated defense signalling and systemic acquired resistance	Mur *et al*., 2013
	TGA	TGA transcription factors	Interact with NPR1 to activate SA-responsive pathogenesis-related genes	Mur *et al*., 2013

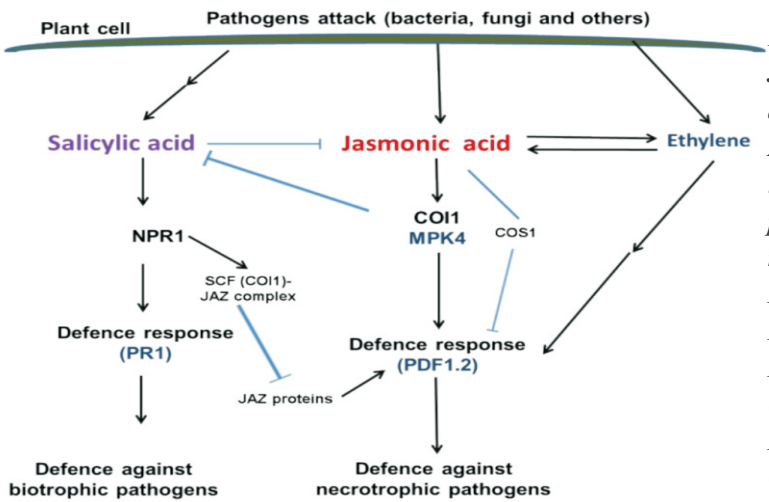


Figure 3: *An overview of the SA and JA signalling pathways in the plant defence response against pathogens. Arrows indicate positive regulatory interactions between these signalling pathways and blunt-end indicates negative interaction. Abbreviations: NPR1: Non- expressor of Pathogenesis- Related genes 1; PR1: Pathogenesis-Related 1; COI1: Coronatine-Insensitive 1; MPK4: Mitogen-Activated Protein Kinase 4; COS1: COI1 suppressor1*

Impact of cross-talk on plant defense responses to herbivory

Interactions among plant hormone signalling pathways play a crucial role in shaping plant defense strategies against herbivores by influencing the initiation and prioritization of these actions. The primary hormones involved in this interaction are jasmonic acid (JA), salicylic acid (SA), ethylene (ET), and abscisic acid (ABA), which work together to regulate defensive responses.

The antagonistic interaction between jasmonic acid (JA) and salicylic acid (SA) pathways occurs in Colorado potato beetles through bacteria present in their oral secretions. These bacteria activate SA signalling while suppressing JA defenses, redirecting plant responses toward microbial rather than herbivore defense. Antibiotic treatment of larvae eliminated JA suppression, whereas the isolated bacteria reproduced defense suppression. SA-deficient plants showed no JA defense suppression, confirming the requirement for SA signalling (Chung *et al*., 2013; Costarelli*et al*., 2019). The beetle uses microbial symbionts as a biological decoy, misleading the plant's immune system into prioritizing pathogen defense over herbivore defense mechanisms. These findings demonstrate the advantages conferred to herbivores that harbour microbes capable of manipulating plant hormone signalling. This study suggests that managing microbial communities could be a strategy for pest control. The antagonistic crosstalk between the SA and JA pathways, influenced by external microbial factors, may determine susceptibility in plant-herbivore interactions (Hou&Tsuda, 2022; Zhang *et al*., 2025).

Ethylene signalling interacts with JA, influencing defense responses to herbivory and wounding. In *Nicotiana attenuata*, JA and ET collaboratively restrict local cell expansion following herbivore attack, reallocating resources towards defense. Disruption of JA or ET signalling perturbs this equilibrium, resulting in abnormal cell expansion and modified expression of genes associated with cell wall remodelling. This JA-ET interaction precisely regulates local defense responses and growth modulation in response to herbivory (Onkokesung*et al*., 2010). Crosstalk integrates responses to multiple stresses, with JA and ABA signalling interacting synergistically to enhance insect resistance during drought, whereas ethylene signalling from flooding reduces resistance to herbivores.

These interactions vary with environmental conditions and stress combinations (Nguyen *et al*., 2016). Calcium signalling initiates defenses by intersecting with JA biosynthesis through ERF16 and calmodulin proteins. Ca^{2+} influx activates ERF16-mediated JA biosynthesis genes, enhancing defense responses (Hu *et al*., 2022). Plants adapt their defenses to herbivore attacks through cross-talk that prioritizes resistance to prevalent herbivores. This adaptation considers sequential attacks and modulates resistance through pathways specific to feeding guilds (Mertens*et al*., 2021). Receptor-like kinases participate in herbivore-specific signalling by interacting with molecules and ethylene pathways to mediate defense (Uemura*et al*., 2020). Crosstalk among hormonal networks orchestrates plant defense responses to herbivory, enabling plants to balance growth and defense for survival (Arimura*et al*., 2011; Van Poecke&Dicke, 2004).

Ecological roles of volatile-mediated plant communication

Plants use smells to talk and protect themselves. When attacked, they release VOCs to warn nearby plants. Sweet potato plants release DMNT to protect against insects without using jasmonate (Meents*et al*., 2019). In *Solidago altissima*, these smells change chemicals in nearby plants (Morrell & Kessler, 2016). VOCs attract pollinators, good microbes, and predators that eat harmful insects. Terpenoids are important for plant-insect and microbe interactions (Niu*et al*., 2024). Root smells affect soil and help bring helpful organisms (Delory*et al*., 2016). These smells let plants share stress information (Abbas *et al*., 2022; Ninkovic*et al*., 2020). Plants detect smells through pathways like KAI2 in petunias (Stirling *et al*., 2024), and *Fusarium oxysporum* smells boost plant growth through auxin (Bitas*et al*., 2015). These studies show smell-based communication's importance for plants and ecosystems (Abbas *et al*., 2022; Ninkovic*et al*., 2020; Niu*et al*., 2024).

Table 3. Comparative overview of herbivore types and associated plant signalling responses

Herbivore type / species group	Dominant plant signalling pathways	Key elicitors or cues	Characteristic defense responses	Representative references
Chewing insects (e.g., caterpillars, beetles)	Jasmonic acid (JA), JA–ethylene	Mechanical wounding, oral secretions, fatty acid–amino acid conjugates, peptides	Strong induction of jasmonate signalling, proteinase inhibitors, secondary metabolites, and HIPV emission	Wu & Baldwin, 2010
Phloem-feeding insects (e.g., aphids, whiteflies)	Salicylic acid (SA), SA–JA cross-talk	Salivary proteins, effectors, oviposition-associated signals	Activation of SA-responsive genes, suppression or modulation of JA responses, altered volatile profiles	Uemura&Arimura, 2019
Cell-content feeders (e.g., mites, thrips)	JA, JA–ethylene	Local tissue disruption, feeding damage	Induction of wound-responsive genes and volatiles; responses intermediate between chewers and piercers	Arimura*et al*., 2011
Herbivore oviposition (e.g., moth eggs)	SA, JA modulation	Egg-associated elicitors, egg surface compounds	Priming or suppression of defense signalling; altered volatile emission affecting subsequent herbivory	Peñaflor*et al*., 2011
Herbivore-associated molecular patterns (HAMPs)	JA-dominant immune signalling	Peptides, protein fragments, oral secretion components	Activation of herbivore-specific immune responses via pattern recognition receptors	Steinbrenner *et al*., 2020
Mixed herbivore communities	Integrated JA–SA–ethylene signalling	Combined damage types and elicitors	Context-dependent prioritization of defenses; altered HIPV blends	Wu & Baldwin, 2010

Experimental methods to study signalling cross-talk and volatile emissions

Experimental methodologies for investigating signalling cross-talk and volatile emissions include approaches to detect, characterize, and analyse VOCs and their biological interactions. Analyzing VOCs is essential for understanding the signalling mechanisms in plants, microorganisms, and other systems where cross-talk occurs via chemical volatiles. For volatile emissions, dynamic sampling with gas chromatography and specific detectors is the primary method, particularly in agriculture, for analyzing plant VOCs and their changes due to biotic or abiotic stressors (Jansen *et al*., 2011).

Proton-transfer-reaction mass spectrometry (PTR-MS) enables real-time and sensitive monitoring of VOCs at the ppt level. This method is employed in medical breath analysis, food research, and environmental studies to identify changes in volatile signals during biological interactions (Lindinger& Jordan, 1998).Novel experimental chambers designed for microbiological volatile interaction assays enable the assessment of VOC-mediated signalling. Volatile organic compound chambers allow controlled environments to study gaseous interactions between microorganisms, supporting both vented and nonvented conditions that influence volatile signals. This method enhances the sensitivity and reproducibility of microbial signalling studies and aids in understanding the role of VOCs in these interactions (Álvarez-García*et al*., 2021). Leaf-level models integrate environmental variables, such as temperature and light, with physiological status to understand VOC emissions, providing insights into indirect interactions vital for interpreting volatile signalling in plants (Grote *et al*., 2013). Analytical techniques, including flux measurements, air sampling, and transport coefficient calculations, help quantify the emission profiles of VOCs from biological sources, capturing the dynamics affected by environmental transport processes (Zahn *et al*., 1997).

Current advances and future perspectives in herbivore-induced signalling interactions

Recent progress in understanding how plants signal in response to herbivores has greatly improved our knowledge of the molecular and ecological processes involved in plant reactions to being eaten by herbivores. Current research elucidates the signal transduction pathways activated by herbivore-associated factors, such as elicitors, effectors, and wounding, which in turn stimulate signalling networks involving phytohormones like jasmonic acid and salicylic acid, as well as plant volatiles (Arimura*et al*., 2011).

The role of ethylene is in modulating defense responses is emphasized, particularly its influence on jasmonic acid sensitivity and defenses, including volatile emissions and proteinase inhibitor activity. Advancements are expected by examining ethylene signalling mutants and genetically modified plants (Hatcher *et al*., 2004; Von Dahl & Baldwin, 2007). The integration of molecular insights into natural field conditions is crucial. The notion of "kaleidoscopic defense" refers to the complex interactions among plants, herbivores, and pathogens, which are influenced by signalling crosstalk and environmental factors (Agrawal, 2005; Hatcher *et al*., 2004). Climate change factors impact plant-herbivore interactions by modifying consumption rates and defensive traits, potentially disrupting coevolved relationships (Hamann*et al*., 2020).

Variability in plant-herbivore interactions across scales has emerged as a critical factor. Water availability modulates plant anti-herbivore defenses, enhancing resistance in some systems while reducing tolerance in others, highlighting the research gaps concerning the effects of abiotic stressors on plant defense evolution (Lin *et al*., 2022; Wetzel *et al*., 2023). Induced defenses incur ecological costs by compromising mutualistic interactions and creating conflicts that plants resolve through mediation (Kessler &Chautá, 2020). Future research should integrate molecular genetics with ecological realism and examine community-level interactions. The interplay between climate change and herbivore signalling pathways requires field studies to predict the ecological outcomes. Environmental context at multiple scales will enrich evolutionary models and guide the sustainable management of plant-herbivore systems (Agrawal, 2005; Kariñho-Betancourt, 2018). Current advancements represent a convergence of molecular biology and ecological perspectives, advancing our understanding of herbivore-induced signalling interactions under global changes.

How do the jasmonic acid and salicylic acid signalling pathways interact in response to different types of pathogens∑

Jasmonic acid (JA) and salicylic acid (SA) are essential phytohormones mediating plant immune responses through antagonistic interactions. SA signalling defends against biotrophic pathogens,

which rely on living host tissue, whereas JA signalling defends against necrotrophic pathogens and herbivorous insects (Rahman*et al*., 2012; Zhang *et al*., 2025).

During infection by the rice blast fungus *Magnaporthe oryzae*, OsbHLH6 enhances JA signalling while suppressing SA signalling; however, the SA regulator OsNPR1 can sequester OsbHLH6 to mitigate this suppression (Meng*et al*., 2020). NPR1 suppresses JA signalling through a cytosolic function distinct from its nuclear role in SA-induced defense gene expression. NPR1 controls SA-JA crosstalk by regulating factors such as WRKY62, which negatively regulates JA-responsive genes (Mao *et al*., 2007; Spoel*et al*., 2003).

In *Arabidopsis*, SA accumulation suppresses JA production during infection, prioritizing SA-dependent defense against biotrophic pathogens (Spoel*et al*., 2003; Stotz*et al*., 2002). Some biotrophic fungal pathogens activate both JA and SA signalling during early infection stages, with pathway interactions varying by pathogen type (Guerreiro*et al*., 2016). For necrotrophs, SA signalling promotes disease by suppressing JA-dependent defenses.

In tomatoes, SA increases susceptibility to necrotrophs through NPR1 and TGA1.a by reducing JA-related defense genes (Rahman*et al*., 2012). JA provides resistance against these pathogens, whereas SA counteracts this effect (Jia*et al*., 2013). Pathogens exploit hormone crosstalk; for example, *Pseudomonas syringae* produces coronatine to activate JA signalling and suppress SA-mediated defense (Allu*et al*., 2016). Disruption of the JA pathway enhances resistance to *P. syringae* (Scalschi*et al*., 2020). In root-microbe interactions, SA-dependent defenses are repressed in mutualistic associations, whereas JA activation promotes fungal colonization (Martínez-Medina *et al*., 2017). JA increases susceptibility to root-knot nematodes, whereas SA maintains defense (Bhattarai*et al*., 2008). These hormones can act either antagonistically or synergistically during pathogen infections (Ullah*et al*., 2022). The SA-JA balance determines pathogen restriction and beneficial colonization (Gutjahr&Paszkowski, 2009; Zhang *et al*., 2025). SA mediates resistance to biotrophic pathogens by suppressing JA defenses, whereas JA defends against necrotrophs.

Necrotrophic pathogens, such as *Botrytis cinerea*, produce exopolysaccharides that activate SA pathways, antagonizing JA-dependent resistance (El Oirdi*et al*., 2011; Rahman*et al*., 2012). Necrotrophs manipulate SA signalling to suppress JA-dependent defense gene expression (Rahman*et al*., 2012). JA also protects against certain biotrophs, as shown in grapevines infected with *Plasmopara viticola*, where early infection shows increased JA and SA (Guerreiro*et al*., 2016). JA-deficient mutants show increased susceptibility to biotrophic fungi (Antico*et al*., 2012). JA defense requires the regulation of SA pathways (Spoel*et al*., 2007; Yang *et al*., 2015).

Conclusion

Antagonistic crosstalk between salicylic acid (SA) and jasmonic acid (JA) pathways is a fundamental mechanism underlying plant immunity. As discussed earlier, when plants are subjected to certain herbivore attacks, they emit HIPVs that attract the natural predators of these herbivores. Specifically, when tomato plants are attacked by leaf-mining moth larvae, they release terpenoids that attract predators, such as *Macrolophus basicornis* and *Engytatus varians* (Silva *et al*., 2017). Researchers have developed synthetic HIPVs to attract predators for pest control (Silva *et al*., 2020). Terpenoids, including α-pinene and β-caryophyllene, facilitate these interactions both above and below ground (M. Y. Ali *et al*., 2023; Niu*et al*., 2024). Below ground, roots release pregeijerene to attract nematodes that eliminate root pests (J. G. Ali *et al*., 2012). However, concurrent above-and belowground herbivore attacks can diminish the attraction of natural enemies (Rasmann&Turlings, 2007). Thus, plant volatiles enhance defense mechanisms through multiple interactions (J. G. Ali *et al*., 2012; Niu*et al*., 2024; Silva *et al*., 2017, 2020). This dynamic interplay is tightly regulated by molecular components, such as NPR1 and OsbHLH6, which modulate the balance between the pathways depending on the pathogen type and infection stage. Pathogens have evolved

strategies to exploit this hormonal antagonism, as exemplified by *Pseudomonas syringae,* which produces coronatine to activate JA signalling and suppress SA defenses, thereby enhancing virulence. Additionally, the SA-JA balance plays a crucial role in root-microbe interactions, influencing compatibility and defense in symbiotic and parasitic relationships. The ability of the Colorado potato beetle to secrete bacteria that induce the SA pathway while suppressing the JA pathway exemplifies how antagonistic hormone crosstalk shapes plant defense outcomes. The primary consequence is enhanced herbivore growth due to the reduced efficacy of JA-mediated anti-herbivore defenses, illustrating a sophisticated ecological interaction in which microbial symbionts act as modulators of host plant immune signalling for the benefit of the herbivore. The complexity and context-dependent nature of SA-JA interactions underscore the importance of understanding their regulatory networks to develop effective approaches for improving plant resistance and disease management.

Acknowledgement:The author gratefully acknowledges the editorial team of the journal for the opportunity to contribute this work and extends sincere thanks to the Principal and departmental colleagues of HMC for their institutional support and scholarly guidance. Heartfelt appreciation is also expressed to family members for their constant encouragement and support.

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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

বাংলার মুসলিম মানসে পাশ্চাত্য শিক্ষা ও ইসলামিয়া কলেজ

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Date of Receipt: 23.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

সংক্ষিপ্তসার:

ঔপনিবেশিক শাসনের সূচনালগ্নেই বাংলার মধ্যশ্রেণির হিন্দু সমাজ নতুন আর্থসামাজিক পরিস্থিতির সঙ্গে সাযুজ্য রক্ষা করে সংস্কৃত মাতা ও ফার্সি বিমাতার আঁচল ছেড়ে পাশ্চাত্য বিদ্যা শিখতে যত্নবান হয়েছিল। ফলস্বরূপপ্রভূত বিত্ত ও বিদ্যার অধিকারী হয়েছিল তারা। কিন্তু অবিভক্ত বাংলার সংখ্যাগরিষ্ঠ মুসলমান জনতা প্রথম থেকেই এই পাশ্চাত্য শিক্ষা সম্বন্ধে ছিল সন্দিহান। এর ফলে তারা পেশাগত ভাবে পিছিয়ে তো পড়েছিলই, পাশ্চাত্যের যুক্তিবাদীজ্ঞানালোক থেকেও হয়েছিল বঞ্চিত।

ইংরেজ রাজত্ব প্রতিষ্ঠার প্রায় একশো বছর পরে তাদের সেই ঘুম ভেঙেছিল, বাংলা থেকে অনেক দূরে উত্তর ভারতে সৈয়দ আহমেদের নেতৃত্বে পাশ্চাত্য পেশা ও জ্ঞানের জগতে হাঁটি হাঁটি পা পা করে অনুপ্রবেশ মুসলমান সমাজ। বাংলায় তার প্রভাব পড়েছিল বৈকি। এখানে এই নবচিন্তার অগ্রদূত হিসেবে আমরা আবদুল লতিফ, সৈয়দ আমীর আলি প্রভৃতি স্বনামধন্য ব্যক্তিবর্গের নাম উল্লেখ করতে পারি। তা সত্বেও কিন্তু বাংলার আর্থসামাজিক ও রাজনৈতিক ক্ষেত্রে হিন্দু উচ্চবর্গের প্রাধান্যই চলতে থাকে।

পাশ্চাত্য শিক্ষার দ্বারা আনুষ্ঠানিক ভাবে বাংলার মুসলিমদের সামনে খুলে গেলেও, হিন্দু প্রাধান্য যুক্ত স্কুল কলেজে তাদের প্রবেশ সহজসাধ্য ছিল না। এই অসুবিধা দূর করার মানসে বিংশ শতকের প্রথম থেকেই বাংলার অবিসংবাদিতজননেতা শের-ই-বাঙ্গাল ফজলুল হক সচেষ্ট ছিলেন। তিনি অনুধাবন করতে সক্ষম হয়েছিলেন মুসলমানের পৃথক শিক্ষা প্রতিষ্ঠান প্রতিষ্ঠা করতে না পারলে, তাদের হাতে পাশ্চাত্য শিক্ষার যাদুকাঠি চিরকাল অধরা থেকে যাবে। তাঁর ব্যক্তিগত প্রচেষ্টায় ১৯২৪ খ্রিস্টাব্দে স্থাপিত হয় ইসলামিয়া কলেজ (অধুনা মৌলনা আজাদ কলেজ)। বাংলার মুসলিম যুবকদের কাছে পাশ্চাত্য শিক্ষার দ্বার খুলে দেয় তা। এরই সালতামামী আমাদের গবেষণাপত্রেরউপজীব্য।

সংকেত শব্দ:

পাশ্চাত্য শিক্ষা - মুসলিম মানস – আধুনিকতা - ইসলামিয়া কলেজ

মূল আলোচনা : ভারতে ঔপনিবেশিক শাসন প্রতিষ্ঠা হবার পরবর্তীকালে দেশে যে প্রচলিত শিক্ষা কাঠামো ছিল তা ভেঙে পড়ে। ইংরাজ পূর্ব যুগে হিন্দু-মুসলিম নির্বিশেষে আমাদের স্ব-ভূমির শিক্ষা মূলতঃ সামন্ততান্ত্রিক জমিদারবর্গের পৃষ্ঠপোষকতাতেই পরিচালিত হত। ১৭৯৩-এর 'চিরস্থায়ী বন্দোবস্তের'ফলে এই পুরনো জমিদার শ্রেণির প্রায় অবলুপ্তি ঘটে[১]-এই কারণেই মূলতঃ পুরনো শিক্ষা কাঠামো হয়ে পড়ে অভিভাবকহীন। হিন্দুদের পাঠশালা টোল-এর মতোমুসলিমদের মাদ্রাসা মক্তব কেন্দ্রিকশিক্ষাধারারও ঘটে মহতি বিনষ্টি।[২]

হিন্দুরা অবশ্য কিছুদিনের মধ্যেই জীবন ও জীবিকার প্রয়োজনে, পাঠশালা, টোলের অতীত স্মৃতি ভুলে, পাশ্চাত্য ধাঁচের শিক্ষা গ্রহণে মন প্রাণ ঢেলে দিয়েছিল। ১৮১৭-তে হিন্দু কলেজে 'ইংরাজি শিক্ষা'চালু করার মধ্য দিয়ে ক্রমশঃ গড়ে উঠতে থাকল হিন্দুর আধুনিক উচ্চ শিক্ষার প্রাসাদ।[৩] ১৮৪৩ থেকে সরকারি চাকুরিতে ইংরাজী জ্ঞান আবশ্যিক হবার ফলে বিভিন্ন প্রশাসনিক কার্যালয় ছাড়াও আইনজীবি, চিকিৎসক, শিক্ষক সহ সমস্ত পেশায় আধিপত্য প্রতিষ্ঠা করল হিন্দুরা বিশেষত বাঙালি বর্ণ হিন্দু শ্রেণিরভদ্রবাবুরা। তাদের সাফল্যের একমাত্র আয়ুধ ছিল কাজ চালানোর মতো ইংরাজী জ্ঞান।

অন্যদিকে, ১৭৫৭-এর পলাশী যুদ্ধে এবং পরবর্তীকালেও প্রধানতঃ মুসলিম ধর্মাবলম্বী শাসকবর্গকে পরাজিত করেই রাজদণ্ড হাতে নিয়েছিল ইংরেজ। একশো বছর পরে ১৮৫৭-তে হিন্দু-মুসলিম ঐক্যের প্রতীক, শেষ মুঘল সম্রাট বাহাদুর শাহ জাফরকে নির্বাসনে পাঠানো হয়েছিল রেঙ্গুনে।

স্বাভাবিকভাবেই, সারা দেশের সঙ্গে বাংলারও আপামর মুসলিম জনতা প্রথম থেকেই ইংরাজশাসনকে বিদ্বেষ ও সন্দেহের চোখে দেখতো। ইংরেজ সৃষ্ট দার-উল-হারব পরিচালিত ভাষা-সংস্কৃতি-শিক্ষা ব্যবস্থা সবকিছু গ্রহণেই অনীহ হয়ে পড়েছিল তাঁরা।[৪] বিশেষ করে ইংরাজী শিক্ষায় অনাগ্রহের ফলস্বরূপ অনিবার্যভাবে ইংরাজ প্রশাসনে ও অন্যান্য স্বাধীন পেশায় তাঁদের যোগদানের পথ হয়ে গিয়েছিল রুদ্ধ। বিশেষ করে বাংলায় কিছু হস্তশিল্প ও প্রধানত কৃষিকাজকে কেন্দ্র করে কষ্টে ক্লিষ্টে প্রাণ বাঁচিয়ে রেখেছিল তারা।

উত্তর ভারতে সৈয়দ আহমেদ খান প্রথম অনুধাবন করেন যে মুসলিমদের সামগ্রিক আর্থ-সামাজিক উন্নয়নের পথে সবচেয়ে বড় বাধা পাশ্চাত্য শিক্ষায় তাদের অনাগ্রহ। যুগের দাবি মেনে ইংরাজী শিক্ষায় মুসলিমদের পারদর্শী হতেই হবে, না হলে তাদের হিন্দু ভাইদের তুলনায় 'বিদ্যা ও পেশার'দিক দিয়ে চিরকালই তারা পিছিয়ে থাকবে-এই সত্য বুঝতে পেরে আহমেদ খানের চেষ্টাতেই গড়ে উঠেছিল আলিগড় অ্যাংলো ওরিয়েন্টাল কলেজ, মুসলিমদের জন্য পাশ্চাত্য শিক্ষাদানের কেন্দ্র হিসাবে।[৫] সেই প্রতিষ্ঠানটিই আজ পরিণত হয়েছে দেশের গর্বের অন্যতম শিক্ষা প্রতিষ্ঠান, আলিগড় মুসলিম বিশ্ববিদ্যালয়ে।

উত্তর ভারতের উদাহরণ সামনে রেখে, বাংলার মুসলিম নেতৃবর্গওক্রমশঃ হৃদয়ঙ্গম করছিলেন, যে যদি বাঙালি মুসলমানকে রাজনৈতিক ও আর্থ-সামাজিকভাবে, 'হিন্দুদের'সমপর্যায়ে উন্নীত হতে হয়, তবে পাশ্চাত্য শিক্ষা তাদের গ্রহণ করতেই হবে। মুসলিম এই নবচেতনারবার্তাবাহক হিসাবে বাংলায় এগিয়ে এসেছিলেন আবদুল লতিফ বা সৈয়দ আমীর আলির মত বিদগ্ধ ব্যক্তিরা।[৬]

এদিকে, ১৮৭১ খ্রিস্টাব্দে স্যার উইলিয়ম হান্টারের বিখ্যাত গ্রন্থ 'The Indian Mussalmans'প্রকাশিত হলে, মুসলিম মানস নিজেদের দুরবস্থার আত্মানুসন্ধানে প্রবৃত্ত হয়। বাংলায় আবদুল লতিফের মত সুশিক্ষিত মানুষ, মহানবীহযরত মহম্মদ-এর অমরবাণী 'জ্ঞানচর্চার জন্য যদি চীন দেশেও যেতে হয়, তাহালে যেও' উদ্ধৃত করে মুসলমান সমাজের দৃষ্টি পাশ্চাত্য শিক্ষার দিকে তুলে ধরতে সচেষ্ট হন। ১৮৩৬-এ হাজী মহম্মদ মহসীনের দানের টাকায় হুগলি কলেজ গড়ে উঠলেও, অন্যান্য ধর্মের মানুষদের সঙ্গে প্রতিযোগিতা করে খুব বেশি মুসলিম উক্ত শিক্ষায় প্রবেশ করতে অবশ্য সমর্থ হয়নি।[৭] ১৮৭৩-এ প্রেসিডেন্সি কলেজের দ্বার মুসলিম ছাত্রদের জন্য খুলে দেওয়া হলেও তার সুযোগও খুব বেশি মুসলিম ছাত্র নিতে পারেনি। কিন্তু এইসব সীমিত সুযোগ তাদের মধ্যে ইংরাজী শিক্ষাগ্রহণের চাহিদা বৃদ্ধিতে সহায়ক হয়েছিল এ বিষয়ে কোনো সন্দেহ নেই।

ইতোমধ্যে ১৮৭৭-এ স্বনামধন্য মুসলিম বুদ্ধিজীবী সৈয়দ আমীর আলির নেতৃত্বে মুসলিমদের আধুনিক শিক্ষা-সংস্কৃতির সঙ্গে পরিচয় ঘটানোর লক্ষ্য নিয়ে গঠিত হয়েছিল 'সেন্ট্রাল ন্যাশনাল মহামেডান অ্যাসোসিয়েশন অব ক্যালকাটা'। উদ্দেশ্য ছিল বাঙালি মুসলমানদের পাশ্চাত্য ধাঁচের উচ্চশিক্ষায় উৎসাহিত করা।[৮] আলোচনার আলোকে দেখা যাচ্ছে যে এইভাবে বাংলার মুসলিম সমাজ সীমিতভাবে হলেও পূর্বের বিরাগ ভুলে, পাশ্চাত্য শিক্ষার সংস্পর্শে আসতে সমর্থ হয়েছিল, কিন্তু তখনো অনেক পথচলা বাকি। হুগলি, কৃষ্ণনগর বা প্রেসিডেন্সি কলেজ ক্রমশঃ মুসলিম ছাত্রদের ভর্তি হবার সুযোগ দিলেও এসব ক্ষেত্রে তাদের অগ্রসর হিন্দু সমাজের সঙ্গে প্রতিদ্বন্দ্বিতায় রত হতে হত-এই প্রতিযোগিতার পর্দা সরিয়ে বাস্তবে খুব কম মুসলমান ছাত্রই তখন পাশ্চাত্য ধাঁচের উচ্চশিক্ষার দ্বার প্রান্তে পৌঁছতে পারত।[৯]

এইভাবে বাংলাদেশে মুসলিম সমাজের শিক্ষা সমস্যা বিংশ শতকের প্রারম্ভেই একটা অন্য স্তরে প্রবেশ করেছিল। একদিন মুসলিম সমাজ পাশ্চাত্য শিক্ষা সম্বন্ধে ছিল উদাসীন-এরপর সমাজের অগ্রবর্তী মানুষদের প্রচেষ্টায় তাদের অজ্ঞতা ও আর্থ-সামাজিক দুরবস্থাদূরীকরণের মহৌষধি হিসাবে মুসলিমরা পাশ্চাত্য শিক্ষাকে চিহ্নিত করতে সমর্থ হল। কিন্তু এই শিক্ষা কাঠামো প্রতিযোগিতামূলক পরিবেশে অংশত তাদের কাছে অধরা থেকে গেলে, তারা নতুন সুযোগ সৃষ্টির দিকে নজর দিতে বাধ্য হল।[১০]

১৮৮১ খ্রিস্টাব্দেই অবশ্য ঔপনিবেশিক সরকার মুসলিম জনতার উচ্চশিক্ষা লাভের অভিলাষকে কিছুটা মান্যতা দিতে সচেষ্ট হয়। এই সময়ে কোলকাতা মাদ্রাসা ভবনের প্রাঙ্গণেই শুধুমাত্র মুসলিম ছাত্রদের জন্য ইংরাজী শিক্ষার কেন্দ্র হিসাবে একটি 'Second Grade কলেজ প্রতিষ্ঠা করা হয়-এখানে ছাত্রদের FA পড়বার

সুযোগ দেওয়া হয়েছিল। দুর্ভাগ্যক্রমে কিছুদিনের মধ্যেই উক্ত কলেজটি বন্ধ হয়ে যায়।[১১]

বিংশ শতকের প্রথমে বাংলার রাজনৈতিক রঙ্গমঞ্চে আবির্ভূত হন এক 'চাষার ব্যাটা-মুসলিম'। এতদিনকার মুসলিম অভিজাততন্ত্রের নিগড় ভেঙে, বাংলার খেটে খাওয়া সাধারণ মুসলিম জনতার আশা আকাঙ্ক্ষার কথা তিনি সরকার ও সহকর্মী মানুষদের কাছে তুলে ধরেন। স্বনামধন্য এই ব্যক্তিটিই হলেন আবুল কাশেম ফজলুল হক-বাংলার মানুষ ভালোবেসে তাঁর উপাধি দিয়েছিল শেরে বঙ্গাল।[১২] মুসলিমদেরউচ্চশিক্ষা নিয়ে ভাবিত ফজলুল হক ১৯০৬ খ্রিস্টাব্দেই ঢাকায় অনুষ্ঠিত 'মহামেডান এডুকেশন কনফারেন্সে'মুসলিম ছাত্রদের উচ্চশিক্ষার প্রয়োজনে, পৃথক শিক্ষা প্রতিষ্ঠানসমূহ প্রতিষ্ঠার ডাক দেন।

১৯১৩-তে বাংলার আইনসভায় ঢাকা ডিভিশনের প্রতিনিধি হিসাবে তাঁর প্রথম বক্তৃতাতেই বজ্র নিনাদে তিনি বলে উঠেছিলেন, 'It seemstome that officials made a very fundamental mistake with regard to the claims of Muhammadans on the Government....where it be question of state patronage, grant of political right or privilege or expenditure....for promoting Muhammadans education....is the official will not meet the demand....there is certain to be discontentment in the community.'[১৩] মুসলিমদের মধ্যে উচ্চশিক্ষা প্রসারের দাবি জানিয়ে তিনি বলেন, 'The time has come for establishment of a first grade college of Arts for the Muhammadans in Calcutta.'[১৪]। ১৯২০ খ্রিস্টাব্দে 'দ্বৈতশাসনের' সূত্রে তিনি অবিভক্ত বঙ্গের প্রথম শিক্ষামন্ত্রী নিযুক্ত হলে, তাঁর এতদিনকার'স্বপ্নের প্রতিষ্ঠান'গড়ার ইচ্ছা বাস্তবায়িত হবার মতো একটি পরিস্থিতির সৃষ্টি হল। ১৯২১-এ কোলকাতায় মুসলিমদের জন্য একটি কলেজ প্রতিষ্ঠার যৌক্তিকতা বিচার করবার জন্য স্যার সামসুলহুদারসভাপতিত্বে একটি এনকোয়ারি কমিটি গঠিত হল। এই কমিটি দীর্ঘ অনুসন্ধান ও বিচার বিবেচনা অন্তে শুধুমাত্র মুসলিম ছাত্রদের উচ্চশিক্ষার জন্য এরকম একটি উচ্চশিক্ষা প্রতিষ্ঠান গড়ে তোলার পক্ষেই মত দিলেন।[১৫] মূলতঃ হক সাহেবের অক্লান্ত চেষ্টার ফলেই কোলকাতার বুকে মুসলিম ছাত্রদের জন্য এরকম একটি শিক্ষা প্রতিষ্ঠান গঠনের কাজে শেষ পর্যন্ত ঔপনিবেশিক সরকার অগ্রসর হল।

সরকারি সিদ্ধান্ত অনুযায়ী ১৯২৪-এর ৯-ই ডিসেম্বর, বাংলার গভর্নর জেনারেল লর্ড লিটন কর্তৃক ভিত্তি প্রস্তর স্থাপিত হল এই কলেজের নিজস্ব ভবনের। নাম দেওয়া হল 'ইসলামিয়া কলেজ'।[১৬] কলেজ গভর্নিংবডির প্রথম সভাপতি হিসাবে নিযুক্ত হলেন সৈয়দ নবাব আলি চৌধুরী। মাত্র পৌনে দুই বছরের মধ্যে ওয়েলিংটন স্কোয়ার (বর্তমানে সুবোধ মল্লিক স্কোয়ার)-এর সন্নিকটে সুদৃশ্য গথিক ও স্যারাসেনিয় স্থাপত্যে নির্মাণ শেষ হল কলেজ ভবনটির। কলকাতা বিশ্ববিদ্যালয়ের তৎকালীন'কলেজ সমূহের পরিদর্শক ড. হরেন্দ্র কুমার মুখোপাধ্যায়ের (পরবর্তীকালে আমাদের রাজ্যপাল) সদর্থক রিপোর্টের উপর ভিত্তি করে, ১৯২৬-এর ২রা জুলাই থেকে নতুন শিক্ষাক্রমে ভর্তি শুরু হল ছাত্রদের। বাংলার মুসলিম সমাজের অর্ধশতবর্ষের স্বপ্ন সাকার হল এইভাবে।[১৭]

কলেজের প্রথম অধ্যক্ষ হিসাবে মনোনীত হলেন, বিখ্যাত শিক্ষাবিদ এ.এইচ্.হার্লে। মোট আঠারোজন শিক্ষক নিয়োগ করা হল বিভিন্ন বিষয়ে। প্রথম থেকেই পাশ্চাত্য শিক্ষাক্রমের সঙ্গে দেশীয় ইসলামিক শিক্ষা ধারার এক সংমিশ্রিত পাঠ্যক্রম চালু করতে কলেজ কর্তৃপক্ষ যত্নবান ছিল। দেশীয় ও পাশ্চাত্য সাহিত্য, ইতিহাস, দর্শনের পাশাপাশি সীমিতভাবে হলেও বিজ্ঞান শিক্ষার ব্যবস্থা গ্রহণের মাধ্যমে, ইসলামিয়া কলেজে ভাবগত এবং বস্তুগত উভয়ভাবেই বাংলার মুসলিম নবজাগরণে সহায়ক শক্তি হিসাবে কাজ করতে সচেষ্ট হয়েছিল।[১৮]

প্রথম থেকেই এই কলেজে ছাত্রদের পারস্পরিক বন্ধন ও ভ্রাতৃত্ববোধ দৃঢ় করবার লক্ষ্যে কতকগুলি ব্যবস্থা গ্রহণ করা হয়। সেই সময়ের কলেজগুলিতে কোনো নির্দিষ্ট ইউনিফর্ম থাকত না-আজও থাকে না। এর বিপরীতে ইসলামিয়া কলেজে শৃঙ্খলা বজায় রাখার প্রয়োজনেই ছাত্রদের জন্য নির্দিষ্ট ইউনিফর্ম-এর বন্দোবস্ত করা হয়েছিল। লাল ফেজটুপি, হাঁট ঝুল কালো শেরওয়ানী এবং সাদা পায়জামা পরে বাধ্যতামূলকভাবে ছাত্রদের কলেজে আসতে হত।[১৯] প্রথম অধ্যক্ষ মি. হার্লে এ বিষয়ে বিশেষভাবে কঠোরতা প্রদর্শন করতেন। তাঁর আমলে কোনো ছাত্র নির্দিষ্ট

পোশাক ছাড়া কোনোভাবেই কলেজে প্রবেশ করতে পারত না। ছাত্রদের মধ্যে আধ্যাত্মিক চেতনা জাগ্রত করবার প্রয়োজনে কলেজে একটি মসজিদ নির্মাণও করা হয়েছিল। 'প্রেয়ারের নির্দিষ্ট সময়ে ছাত্র শিক্ষক নির্বিশেষে সেখানে প্রার্থনায় যোগ দিতেন।'[২০]

মি. হার্লের পর শিক্ষাবিদ জেনকিন্স এই কলেজের অধ্যক্ষ নির্বাচিত হলেও, তিনি মাত্র কয়েক মাস প্রতিষ্ঠানটির দায়িত্ব সামলেছিলেন। এরপর ১৯৩৭-এ স্বনামধন্য শিক্ষাবিদ কুরুভিলা জ্যাকেরিয়া কলেজের অধ্যক্ষ পদ অলঙ্কৃত করেন। তাঁর সময়েই কলেজে ভূগোল বিভাগ খোলা হয়। সেই সময়ে জ্যাকেরিয়ার প্রস্তাব মতো ইসলামিয়া কলেজকে আরো প্রশস্ত স্থানে স্থানান্তরণের একটা চেষ্টা হয়েছিল। সরকারি সম্মতি মিললেও শেষ পর্যন্ত অবশ্য কলেজটির স্থানান্তরণ ঘটেনি।[২১] ১৯৪১ থেকে ৪৭ পর্যন্ত কলেজের অধ্যক্ষ ছিলেন পণ্ডিত প্রবর ড. ইতরাত হোসেন জুবেরী সাহেব। শের এ বঙ্গাল ফজলুল হক তখনো অবধি ব্যক্তিগতভাবে তাঁর মানস সন্তান ইসলামিয়া কলেজের ভালোমন্দ সম্বন্ধে খোঁজ রাখতেন। তাঁরই আগ্রহাতিশয্যে ড. জুবেরী কলেজের অধ্যক্ষ হিসাবে মনোনীত হন। ১৯৪৭-এ দেশভাগের আগে পর্যন্ত তিনিই ছিলেন কলেজের কর্ণধার।

এবার আসা যাক, প্রাথমিক পর্বে ইসলামিয়া কলেজের পাঠ্যক্রমের আলোচনায়। প্রথম থেকেই কলেজটিতে তর্কশাস্ত্র, ইতিহাস বা আরবী ফার্সীর মত সমাজ বিজ্ঞান বিষয় ও ভাষার পাশাপাশি পদার্থবিদ্যা, গণিত ইত্যাদির চর্চাও হত। ভাষা হচ্ছে ভাব প্রকাশের বাহন-তাই ভাষা চর্চাকে ইসলামিয়া কলেজ কর্তৃপক্ষ যথেষ্ট গুরুত্ব দিয়েছিল।[২২] ইংরাজীর পাশাপাশি ছাত্রদের আবশ্যিকভাবে বাংলা বা উর্দু শিখতে হত এখানে। এটা ঠিকই প্রথম দিকে 'প্রথম প্রজন্মের' ছাত্ররাই কলেজটির ছাত্র ছিল। বহুলাংশে এরা সাধারণত ভাষা বা কলা বিভাগের অন্যান্য বিষয় পড়তেই উৎসাহী ছিল। প্রাথমিক পর্বে বিজ্ঞান বিভাগের ছাত্র সংখ্যা ছিল খুবই কম। এক প্রজন্মের ভিতরেই অবশ্য এই পরিস্থিতির পরিবর্তন ঘটে গিয়েছিল। ছাত্ররা ক্রমশঃ বিজ্ঞান মনস্ক হবার ফলস্বরূপ কলেজের বিজ্ঞান বিভাগ জমজমাট হয়ে পড়েছিল। সেই সময় বিজ্ঞান বিভাগের উপযুক্ত গ্রন্থাগার, বিজ্ঞানাগার নির্মাণের জন্য স্থানাভাব দেখা দিয়েছিল প্রতিষ্ঠানটিতে।

আধুনিক যুগে শুধুমাত্র বিশুদ্ধ জ্ঞানচর্চা নিয়ে থাকলে চলবে না-বিদ্যাকে অন্ততঃ আংশিকভাবে, বৃত্তিমুখী হতে হবে-এই সত্য অনুভব করে কলেজের পরিচালকবর্গ ১৯৪০ খ্রিস্টাব্দ থেকে বিভিন্ন সর্বভারতীয় প্রতিযোগিতামূলক পরীক্ষার প্রস্তুতির জন্য ছাত্রদের তালিম দেওয়ার বন্দোবস্ত করে। আধুনিক জব্ ট্রেনিং সেন্টারগুলির পূর্বসূরী হিসাবে এই প্রচেষ্টাটিকে আমরা চিহ্নিত করতে পারি।[২৩]

প্রথম থেকেই ইসলামিয়া কলেজের লাইব্রেরীটি ছিল যথেষ্ট সমৃদ্ধ। আরবী, ফার্সী, উর্দু প্রভৃতি ভাষার বই-পুস্তক ছাড়াও প্রচুর পাণ্ডুলিপির অধিকারী ছিল লাইব্রেরীটি। প্রতিষ্ঠার প্রথম বছরেই সরকারি দশ হাজার টাকার অনুদানে কলেজে একসঙ্গে প্রায় আড়াই হাজার বই কেনা হয়েছিল। স্বাধীনতা পূর্ববর্তী কালেই লাইব্রেরীর পুস্তক সংখ্যা বৃদ্ধি পেয়ে ষোল হাজার হয়েছিল।[২৪] পরবর্তীকালে সরকারী অনুদানের সাহায্যে কলেজ লাইব্রেরীর পুস্তক সংখ্যা ছাড়িয়েছিল প্রায় সত্তর হাজারে। মিষ্টার হার্লের অধ্যক্ষতার সময়েই নির্দিষ্ট বৈজ্ঞানিক পদ্ধতিতে কলেজ সংগৃহীত পুস্তকাদির ক্যাটালগ প্রস্তুতের কাজ সম্পন্ন হয়েছিল। যার ফলে ছাত্ররা সহজেই নিজেদের প্রয়োজন অনুসারে কলেজ লাইব্রেরীর বইপত্র ব্যবহার করতে সক্ষম ছিল।

শুধুমাত্র বাঁধা ধরা পাঠ্যক্রম পরিচালনা করা নয়-ছাত্রদের ভবিষ্যৎ রাষ্ট্রের আদর্শ নাগরিক হিসাবে গড়ে ওঠার শিক্ষা দেবার মানসে প্রথম থেকেই ইসলামিয়া কলেজে, 'কলেজ ইউনিয়ন' গঠিত হয়েছিল, অন্য সব কলেজের মত শুধু ছাত্রদের নিয়ে এই ইউনিয়ন গঠিত হত না-বরঞ্চ ছাত্র, শিক্ষক, শিক্ষাকর্মী সবাই মিলে গঠন করতেন এই ইউনিয়ন।[২৫] কলেজের সমস্ত রকম সাংস্কৃতিক ও খেলাধুলা পরিচালনার পাশাপাশি এই ইউনিয়ন বাইরের বিভিন্ন রাজনৈতিক ইস্যু সম্বন্ধে নিজস্ব মতামত ব্যক্ত করত। কলেজের পুরনো ম্যাগাজিন ঘাঁটলে এর অনেক উদাহরণ দেখা যাবে। বিভিন্ন সময়ে কলেজ ইউনিয়নের আহ্বানে বাংলার তৎকালীন গভর্নর স্ট্যানলি জ্যাকসন, হায়দ্রাবাদের নিজাম, পটনা বিশ্ববিদ্যালয়ের উপাচার্য সুলতান আহমেদ, অধ্যাপক চন্দ্রশেখর ভেঙ্কট রমন, দীনেশচন্দ্র সেন, নীলরতন সরকার, কবিপুত্র রথীন্দ্রনাথ ঠাকুর, এমনকি মহম্মদ আলি জিন্নাহ এই কালেজে এসে বক্তৃতা দিয়ে গিয়েছেন।[২৬] এরকমই একটি বক্তৃতা

সভায় বিখ্যাত চিকিৎসা বিজ্ঞানী স্যার নীলরতন সরকার ক্রমবর্ধমান সাম্প্রদায়িক রাজনীতির বিরুদ্ধে কলেজের ছাত্রদের অগ্রণী ভূমিকা নেবার আহ্বান জানিয়ে বলেছিলেন, '....try to cultivate clear thinking. Try to see the truth without being carried away by slogans or dogmas. If slave mentality is to be abjured in anything, it is the slavery to slogans.....the unthinking acceptance of a demagogue as an oracle have been the bare of our politics in recent times.'।[২৭] স্মর্তব্য বঙ্গবন্ধু শেখ মুজিবর রহমান ইসলামিয়া কলেজের ইউনিয়নের সম্পাদক হিসাবেই তাঁর রাজনৈতিক জীবন শুরু করেছিলেন।

এছাড়া কলেজে সাহিত্য চর্চার পরিবেশ গড়ে তুলে, ছাত্রদের বিশেষ করে উর্দু ও বাংলা সাহিত্য চর্চার জন্য গড়ে তোলা হয়েছিল, ইসলামিয়া কলেজ লিটেরারি সোসাইটি। ১৯৩৩ খ্রিস্টাব্দে এই সোসাইটির এক অধিবেশনে রায়বাহাদুর দীনেশচন্দ্র সেন, তাঁর বিখ্যাত প্রবন্ধ, 'বাংলা সাহিত্যে মুসলিমদের অবদান' পাঠ করেছিলেন। প্রথম থেকেই কলেজের উদ্যোগে বাংলা-উর্দু, ইংরাজি, ত্রিভাষিক কলেজ পত্রিকা প্রকাশের রেওয়াজ ছিল।[২৮]এই পত্রিকায় পরবর্তীকালের অনেক খ্যাত লেখকের ছাত্রজীবনের লেখা প্রকাশিত হয়েছিল কতকগুলি লেখা, যেগুলি ম্যাগাজিনের বিভিন্ন সংখ্যায় প্রকাশিত হয়েছিল, সেগুলির শীর্ষনাম দেখলেই বোঝা যায় কত বিভিন্ন বিষয়ে লেখা ছাপা হত পত্রিকাটিতে। উদাহরণ স্বরূপ, 'Ghalib-An Everlasting Poet','Be Musslim','Some Aspect of Browing's Love Poetry'বা 'Rural Conflict and Indian Government'প্রভৃতি লেখা উল্লিখিত হতে পারে। সমসাময়িক বাংলার নিয়ে বিভিন্ন সময়ে পত্রিকাটিতে নানা লেখা প্রকাশিত হতো। সাংস্কৃতিক ক্ষেত্রে বিশেষভাবে উল্লেখযোগ্য নবী দিবসে অনুষ্ঠিত সারা রাত্রিব্যাপী মুশায়েরা।[২৯] বিশেষ করে আল্লামারেজা আলি ওয়াসেত যখন ইসলামিয়ার উর্দু বিভাগের প্রধান ছিলেন, তখন তার উৎসাহে অনুষ্ঠানটি আলাদা ব্যঞ্জনা লাভ করেছিল। সারা কোলকাতায় ছড়িয়ে পড়েছিলঅনুষ্ঠানটির সুখ্যাতি।[৩০]

খেলাধুলার ক্ষেত্রেও ইসলামিয়া কলেজ পিছিয়ে ছিল না। এই কলেজে ১৯২৯ থেকেই ছেলেদের শরীরচর্চা ও খেলাধুলা পরিচালনার জন্য স্থায়ী ক্রীড়া শিক্ষক নিয়োগ শুরু হয়েছিল। উক্ত বছরেই সরকারি দুই লক্ষ টাকা অনুদানে কলেজের খেলার মাঠ হিসেবে ব্যবহারের জন্য গোরাচাঁদ রোডে বারো বিঘা জমি ক্রয় করা হয়। ক্রীড়াঙ্গনটি উদ্বোধন করেন, সন্তোষের খেলাপ্রেমী মহারাজা মন্মথ নাথ রায়।[৩১]

প্রাথমিক পর্বে ইসলামিয়া কলেজের বেশির ভাগ ছাত্রই গ্রামবাংলার দরিদ্র ও স্বল্পবিত্ত মুসলিম পরিবারগুলি থেকে আসতো। স্বাভাবিকভাবেই তাদের কলেজ সন্নিহিত স্থানে বসবাসের জন্য ছাত্রাবাসের প্রয়োজন হয়ে পড়েছিল। ১৯২৭-এ এই সমস্যা দূরীকরণের জন্য কলেজ স্ট্রিটের একটি ভাড়া বাড়িতে অস্থায়ী হোস্টেল খোলা হয়।[৩২] পরবর্তীকালে অবশ্য সরকারি বেকার হোস্টেলেও কলেজের কিছু ছাত্রের থাকার বন্দোবস্ত করা সম্ভব হয়েছিল। ১৯৪৭-৪৮-এ ইসলামিয়ার ছাত্ররা এলিয়ট হোস্টেলেও থাকবার অনুমতি পায়।

এরপরে এল সেই কালবেলা-একই সঙ্গে বড় সুখের আবার বৃহৎ দুঃখের সেই সময়-১৯৪৭। দেশ স্বাধীন হল, আবার ভ্রান্ত দ্বিজাতিতত্ত্বের ভিত্তিতে হল বিভক্ত। ফলতঃ দুই বঙ্গেই সংখ্যালঘু মানুষেরা নিজেদের এতদিনকার স্বদেশ ছাড়তে বাধ্য হল। কেউ স্বেচ্ছায়-বেশিরভাগই অনিচ্ছায়। এই সময় ইসলামিয়া কলেজ থেকে ইসলাম ধর্মাবলম্বী প্রচুর ছাত্র এবং অধ্যাপকেরা 'Option'দিয়ে পূর্ববঙ্গে অভিগমন করলে, ইসলামিয়া কলেজে উভয়তঃ একটি শূন্যতার সৃষ্টি হল। অধ্যক্ষ জুবেরী সাহেবও পূর্ববঙ্গে চলে যাওয়া মনস্থ করলে এফ. জে. পেরেরা কলেজের অধ্যক্ষের দায়িত্বভার গ্রহণ করেন। নতুন পরিস্থিতিতে জাতি-ধর্ম-বর্ণ নির্বিশেষে সমস্ত ছাত্রের জন্য উন্মুক্ত করে দেওয়া হয় কলেজটিকে - নতুন নামকরণও করা হয় কলেজটির - সেন্ট্রাল ক্যালকাটা কলেজ।[৩৩] ১৯৫৮ খ্রিস্টাব্দে ভারতের প্রথম শিক্ষামন্ত্রী ও ধর্মনিরপেক্ষতার মূর্ত প্রতীক মৌলানা আবুল কালাম আজাদের এন্তেকালের পর, ১৯৬০ থেকে পশ্চিমবঙ্গ সরকার পরিচালিত এই কলেজটি মৌলানা আজাদ কলেজ নামে পরিচিত হয়-ইতোমধ্যে সহশিক্ষাও চালু হয় প্রতিষ্ঠানটিতে। ফজলুল হকের মানস সন্তান ইসলামিয়া কলেজ নতুন নাম ধারণ করে আজো কলকাতার বুকে আত্মমর্যাদার সঙ্গে দাঁড়িয়ে আছে-তার অতীত গৌরবকে সাক্ষী রেখে।

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১৬) তদেব, পৃ. ২৮
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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

*In-vitro S*tudy of Rice field Algal Diversity from Selected Alluvial Regions of West Bengal, India

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Date of Receipt: 26.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication:28.02.2026**

Abstract :
In the present study, a microalgal population was isolated from rice field soils of selected alluvial regions in the Bankura, Purba Bardhaman, Hooghly, and Nadia districts of West Bengal, India, to compile a species database. The soil samples were collected after harvesting the rice crop in the fields. The main focus of the present research is to study the diversity and occurrence of different algal species. Different physicochemical parameters of isolated soil samples were measured, while algal identification and examination were investigated through microscopy. Algal examination revealed the presence of 3 phyla (Bacillariophyta, Chlorophyta, and Cyanophyta) with 30 genera in the rice field. The present study shows that isolated algal species belong to the three broad algal groups, *viz*. Cyanobacteria, Green algae and Diatoms. Cyanobacterial genera are *Nostoc, Anabaena, Cylindrospermum, Scytonema, Calothrix, Gloeotrichia, Westiellopsis, Tolypothrix, Fischerella, Oscillatoria, Lyngbya, Phormidium, Gloeocapsa, Chlorogloeopsis, Aphanothece, Gloeothece, Microcoleus and green algae are Spirogyra, Chara, Nitella, Cladophora, Hydrodictyon, Botrydium, Rhizoclonium, Pithophora, Vaucheria, Oedogonium* and diatoms such as *Navicula, Fragilaria, Gomphonema* were isolated and characterized. BG-11(+N)/(-N) and BBM culture media were used for the isolation of soil algal flora.

Keywords: Rice field soil, Algal diversity, Cyanobacteria, Physicochemical parameter.

1. Introduction

In the present study, a diverse cyanobacterial populations and other microalgae from rice field habitats, especially from West Bengal, was established to prepare a species database along with environmental data. Luxuriant growth of microalgae from various rice field habitats from four districts was documented in the present study. These autotrophic organisms, with their unique physiological characteristics and high adaptability in variable environments, offered an important group for biotechnological prospecting.

Research on cyanobacteria of the adjoining area from Calcutta [1], [2], cyanobacteria in Bakreshwar [3], cyanobacteria in the rice field of the 24 Pargana district [4], Murshidabad district [5], Gangetic plains of West Bengal [6], [7], saline habitats [8], [9], and the cyanobacteria of Bankura district [10] were done in great detail. Literature reveals that a handful of scientists or researchers from West Bengal have worked on cyanobacteria [11], [12], [13], [14], [15], [16].

2. Materials and Methods

Sampling was done from rice field soils of 8 sites from the four districts of West Bengal, namely Hooghly, Purba Bardhaman, Bankura, and Nadia. All the soils were alluvial type. Among them, 2 sites from each district in a total of 8 sites (Bankura- S1 & S2; Purba Bardhaman- S3 & S4; Hooghly- S5 & S6; and Nadia- S7 & S8) were selected for culture establishment from rice field soil crust samples

1.1. COLLECTION AND IDENTIFICATION OF SAMPLES

Samples were collected from various types of rice field soil at selected sites in Hooghly, Bankura, Nadia, and Purba Bardhaman districts, West Bengal, during the rice cultivating and harvesting season in August-September and November-December 2023, respectively. This suggests a diverse range of habitats were sampled to capture a comprehensive view of the microbial life in the area. Fine forceps, a scalpel, sampling pouches, and clean polythene bags were used for collecting the samples. These tools would ensure aseptic and contamination-free collection of specimens. Upon collection, each sample was immediately assigned a unique number and the collection date was recorded in a field notebook. This documentation helps in keeping track of the collected samples and their associated information. The samples were identified based on their morphological features. This could involve observing characteristics like the colour of thallus (a plant body in algae), cell shape, cell size, shape of heterocysts (specialised cells in some cyanobacteria), and akinetes (dormant, thick-walled cells). The identification process seems to have been guided by established monographs, which are detailed written works providing descriptions and classifications of organisms [17],[18],[19], [20], [21], [22], [23], [24].

1.1. MORPHOTAXONOMIC STUDY

The specimen was mounted in 10% glycerin and studied under a light microscope. Photographs were taken using Olympus OIC 912118.

1.2. CULTURE OF THE SAMPLES

The culture was established from the natural sample collected during sampling time. The samples were managed by enrichment culturing in freshly prepared BG-11±N [25], [26], [27] and BBM [28] medium in a culture plate under 28±1°C temperature & 25-30 µmol photons m-2 s-1 in 12/12h light/dark cycles.

1.3. SOIL NUTRIENT ANALYSIS

For the assessment of soil nutrient status, the soil sample was randomly gathered, air-dried, and analysed for various physico-chemical characteristics using standard procedures. The soil pH was determined at a 1:2.5 soil/water ratio. Available P was determined using a spectrophotometer [29], and organic carbon by the sulphuric acid-dichromate digestion method [30].

Results

From these results, it was determined that Nostoc is the dominant genus among the identified cyanobacterial species from the studied sites. It had the highest number of occurrences (based on colony number) compared to other genera. This dominance suggests that Nostoc is well-suited to the environmental conditions of the studied sites and plays a significant role in the rice field ecosystem. The study provides valuable insights into the composition of the algal community in different sites studied. By characterising the relative abundance and diversity of different algal species, the research contributes to our understanding of oxygenic photosynthetic microbial ecology in this specific region. This type of information is crucial for assessing the health of agricultural soil ecosystems, understanding nutrient cycles and potentially predicting any ecological changes or imbalances. For the assessment of soil nutrient status, the soil

1.Table 1 The GPS location of the Sampling areas.

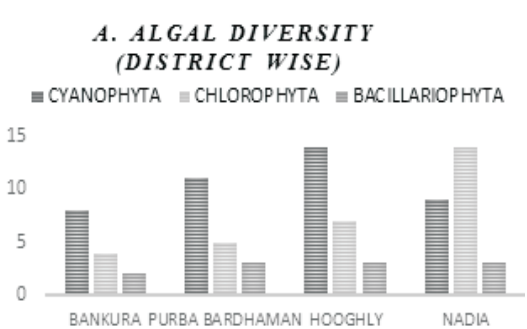
Region/place	Sample Site No.	GPS Data
Bankura	S-1	N-22°92'22.26'', E-87°61'49.58''
	S-2	N-23°18'34.38'', E-88°25'04.43''
Purba Bardhaman	S-3	N-23°11'15.84'', E- 88°02'9.84''
	S-4	N-23°8'3.18'', E- 88°09'10.62''
Hooghly	S-5	N- 23°2'32.04'', E-82°19'5.82''
	S-6	N- 23°3'6.9'', E- 88°19'2.46''
Nadia	S-7	N- 23°12'29.89'', E-88°31'44.98''
	S-8	N-23°14'39.60'', E-88°18'21.82''

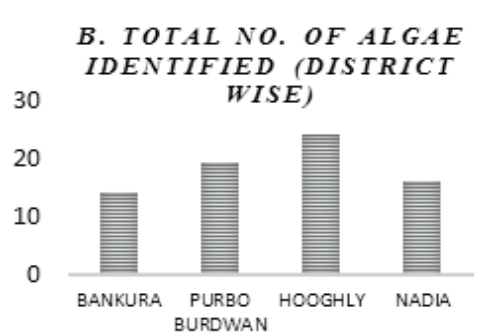
2.Table 2 Species diversity of studied sites

Location	Cyanophyta	Chlorophyta	Bacillariophyta
Bankura (S1& S2)	*Nostoc* sp., *Anabaena* sp., *Gloeotrichia sp., Cylindrospermum* sp., *Lyngbya* sp., *Phormidium* sp., *Oscillatoria* sp., *Gloeocapsa* sp.	*Cladophora* sp., *Spirogyra* sp., *Hydrodictyon* sp., *Chara* sp.	*Navicula* sp., *Fragilaria* sp.
Purba Bardhaman (S3 & S4)	*Nostoc* sp., *Anabaena* sp., *Westiellopsis* sp., *Calothrix* sp., *Scytonema* sp., *Tolypothrix* sp., *Chlorogloeopsis* sp., *Lyngbya* sp., *Phormidium* sp., *Oscillatoria* sp., *Gloeocapsa* sp.	*Cladophora* sp., *Spirogyra* sp., *Botrydium* sp., *Rhizoclonium* sp., *Oedogonium* sp.,	*Navicula* sp., *Fragilaria* sp., *Gomphonema* sp.
Nadia (S5 & S6)	*Nostoc* sp., *Anabaena* sp., *Calothrix* sp., *Scytonema* sp., *Fischerella* sp., *Lyngbya* sp., *Phormidium* sp., *Oscillatoria* sp., *Aphanothece* sp.	*Cladophora* sp., *Spirogyra* sp., *Hydrodictyon sp., Pithophora* sp.	*Navicula* sp., *Fragilaria* sp., *Gomphonema* sp.
Hooghly (S7 & S8)	*Nostoc* sp., *Anabaena* sp., *Westiellopsis* sp., *Calothrix* sp., *Scytonema* sp., *Fischerella* sp., *Chlorogloeopsis* sp., *Lyngbya* sp., *Phormidium* sp., *Oscillatoria* sp., *Aphanothece* sp., *Gloeocapsa* sp., *Gloeothece* sp., *Microcoleus* sp.	*Cladophora* sp., *Spirogyra* sp., *Vaucheria* sp., *Rhizoclonium* sp., *Chara* sp., *Nitella* sp., *Pithophora* sp.	*Navicula* sp., *Fragilaria* sp., *Gomphonema* sp.

3.Table 3 Algal (Genus) Biodiversity, District-wise

Sl. No.	Algal types	**Bankura** (S1& S2)	**Purba Bardhaman** (S3 & S4)	**Hooghly** (S5 & S6)	**Nadia** (S7 & S8)
1.	Cyanophyta	08	11	14	09
2.	Chlorophyta	04	05	07	04
3	Bacillariophyta	02	03	03	03
	Total algae genera	**14**	**19**	**24**	**16**





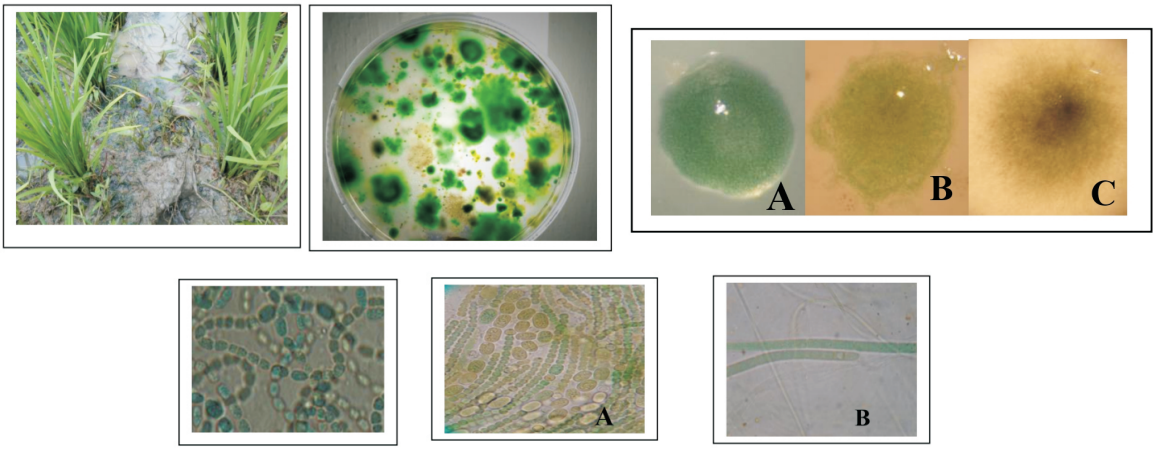


***Plate* 1 Natural algal mat in Rice field, Agar plate showing colony of Cyanobacteria, A. *Nostoc* sp., B. *Anabaena* sp., and C. *Lyngbya* sp.**

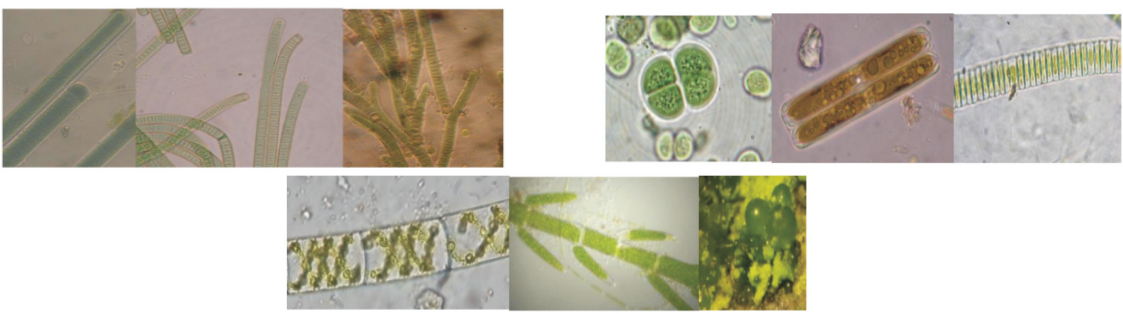


***Plate 2* Photomicrographs of some algal genera, A. *Lyngbya* sp., B. *Oscilatoria* sp., C. *Tolypothrix* sp., D. *Gloeocapsa* sp., E. *Gomphonema* sp., F. *Fragilaria* sp., G. *Spirogyra* sp., H. *Cladophora* sp., I. *Botrydium* sp.**

4.Table 4 Physico-chemical Parameters of the collected soil samples

Collection sites	pH	EC at 25° C (mS/dS)	Organic carbon (%)	Available Phosphate (mg/kg)
Bankura S-1	5.54±0.018	0.257±0.008	0.18±0.07	36.32±0.428
Bankura S-2	5.3±0.015	0.198±0.003	0.12±0.025	33.09±0.281
Purba Bardhaman S-3	6.72±0.043	0.296±0.002	0.10±0.015	23.07±0.308
Purba Bardhaman S-4	6.6±0.023	0.276±0.003	0.15±0.015	44.24±0.221
Hooghly S-5	6.86±0.049	0.276±0.002	0.17±0.010	41.19±0.234
Hooghly S-6	7.34±0.038	0.04±0.006	0.534±0.039	49.08±0.329
Nadia S-7	7.6±0.059	0.13±0.012	0.23±0.052	23.57±0.151
Nadia S-8	6.4±0.026	1.53±0.018	0.29±0.035	47.04±0.232

4.Discussion

Algae indeed have significant ecological and biotechnological importance. Algae are found in various environments worldwide, including soil, freshwater bodies like ponds, pools, rivers, gutters, drains, sewage water, as well as in marine waters. They can also be present in terrestrial habitats such as damp soil, paddy fields, decaying house walls, and even attached to calcareous rocks. Cyanobacteria are known to produce a variety of bioactive compounds. Due to their rapid growth rate, they are utilized in various biotechnological applications such as bioenergy production, natural product synthesis, medicine, agriculture, and environmental management.

Cyanobacteria have the potential to produce lipids that can be used as a biofuel source. This can contribute to addressing the increasing demand for alternative and sustainable energy sources. Algae play a crucial role in global nutrient cycling. They can fix carbon dioxide (CO_2) and nitrogen gas (N_2) from the atmosphere, using enzymes like ribulose-1,5-bisphosphate carboxylase/oxygenase (rubisco) and nitrogenase, respectively. This helps in maintaining nutrient balance in ecosystems.

Therefore, the widespread distribution of algae, especially cyanobacteria, in the four studied districts gave an idea for future researchers on raw material collection for applied aspects.

5. Conclusion

The studies conducted in 8 sites from four districts have revealed a significant diversity of green algae, and especially cyanobacteria. Some previously unexplored area has the potential to contribute to our understanding of algal diversity and its ecological significance, as well as to inform various applications and studies related to this group of microorganisms. Research conducted across different sites in four districts could yield important discoveries, insights, and collaborations that advance scientific knowledge and contribute to various fields of study.

Some key findings are:

- Among the natural population of cyanobacteria, there is maximum species diversity, followed by Green Algae and diatoms.
- Filamentous heterocystous genera (*Nostoc* > *Calothrix* >*Anabaena*) are dominant in rice field soils.
- Important genera isolated are *Nostoc, Calothrix, Cylindrospermum, Tolypothrix, Anabaena* and *Westiellopsis*.

Acknowledgements

Both the authors are thankfully acknowledging research facilities developed from Panskura Banamali College (Autonomous) Institutional funding, and hence thankful to the Principal, Prof. (Dr.) Nandan Bhattacharyya of this college.

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AJHMC
ISSN : 0973-6212

Volume : 13 No. 1 & 2
February. 2026

Audible Agency: Epistemologies of the Female Gaze in Bollywood's Musical Narratives

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Date of Receipt: 26.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract:

The "male gaze," a concept famously theorized by Laura Mulvey, has long been the default lens through which mainstream cinema, including Bollywood, has been analyzed. It describes how visual media is often structured from a masculine, heterosexual perspective, objectifying women for the pleasure of the male viewer. However, this dominant framework, while crucial, has often overshadowed a potent, parallel, and persistent counter-narrative: the expression of female subjectivity, desire, and agency through the film's musical component. This article argues that the song-and-dance sequence in Bollywood cinema has historically functioned as a unique and powerful epistemological site—a space for the articulation and validation of a "female gaze." By temporarily suspending the realist diegesis, songs create a sanctioned, oniric realm where female characters can articulate interiority, challenge patriarchal norms, and express transgressive desire, and claim narrative and spatial agency. Through a close analysis of specific songs from different eras—from the golden age of studio productions to the contemporary era of digital streaming—this article will trace the evolution, strategies, and enduring power of this "audible agency," positing the Bollywood musical number as a critical, yet often overlooked, archive of female subjectivity.

Introduction: Beyond the Visual – The Sonic as a Site of Resistance

Bollywood cinema is an industry of spectacles, and at its heart lies its most distinctive feature: the musical number. For decades, these sequences have been dismissed by some critics as mere interruptions, commercial insertions, or narrative superfluities. Yet, to dismiss them is to ignore a fundamental layer of the film's text. As scholar Sangita Gopal contends, songs are not just additions to the narrative; they are often the very engine of it, especially for the emotional and subjective arcs of characters (Gopal, 2012).

The concept of the "female gaze," while debated and multifaceted, can be understood here not simply as a reversal of the male gaze (where men are objectified), but as a mode of storytelling that privileges female experience, subjectivity, and desire. It is an epistemological standpoint—a way of knowing and representing the world that originates from a feminine position. In a traditionally patriarchal industry where male protagonists drive the plot and female characters are often relegated to symbolic roles (the mother, the lover, the victim), the realistic narrative frequently confines their expression

It is within the non-realist, expressive space of the song that this confinement is broken. The song sequence, with its inherent license for fantasy, heightened emotion, and symbolic expression, becomes a sanctioned breach. It is a diegetic loophole that allows for the articulation of what otherwise remains unsayable and unseeable. This article will explore this phenomenon through three primary epistemological functions of the song: as an expression of **interiority and desire**, as a claim to **spatial and narrative agency**, and as a tool for **subversion and commentary**.

I. The Dream Sequence and the Articulation of Interior Desire

The most classic trope for the expression of female desire is the dream sequence. In the era of the "social" film, where overt female sexuality was

heavily censored and morally policed within the narrative proper, the dream sequence became its primary vessel.

A quintessential example is **"Pyar Hua Iqrar Hua" from *Shree 420* (1955)**, sung by Lata Mangeshkar for the character Vidya (Nargis). On the narrative surface, Vidya is the idealized, modest, and educated Indian woman. Her interactions with Raj Kapoor's Raju are chaste, framed by societal propriety. However, the song reveals her deepest interior world. The rain, the shared umbrella, and the iconic imagery of the two silhouettes against the Bombay skyline are not just romantic; they are a full-throated, ecstatic expression of her romantic and sexual awakening. The lyrics—"Pyar hua, iqrar hua, hai / Phir kyuun dil hai bekaraar?" (Love has happened, confession has happened, so why is the heart still restless?)—are entirely from her subjective point of view. The music, composed by Shankar-Jaikishan and voiced by Mangeshkar's characteristically crystalline and yearning tone, sonically maps her emotional state. This sequence is not for the male protagonist's pleasure; Raju is a participant, but the vision is hers. It is her fantasy, her gaze upon their union, and it grants the audience access to her passionate inner life, which starkly contrasts her demure external reality.

This tradition of the female-centric dream sequence continues powerfully into the modern era. **"Agar Tum Saath Ho" from *Tamasha* (2015)** is a masterclass in using the song to articulate complex female interiority. While the song is a duet, its narrative weight and perspective are profoundly anchored in Tara's (Deepika Padukone) experience. The sequence intercuts the couple's trip to Corsica with Ved's (Ranbir Kapoor) subsequent psychological breakdown back in India. The song's melancholic melody (by A.R. Rahman) and the pleading, painful lyrics ("Laagi naahi chhoote / Ram jaane mere man ko kyu lage / Tumse hi pyaar hai kitna / Kahu main kaise tumse") function as Tara's internal monologue. We see Ved's chaos through *her* worried, confused, and heartbroken gaze. The song is her epistemological tool; it is how she processes the trauma of watching the man she loves disintegrate. It doesn't advance the plot in a literal sense but is indispensable for understanding the emotional and psychological plot from her perspective.

II. Claiming Space and Narrative: The Item Number and its Ambiguous Power

Perhaps the most complex and contested site of the female gaze is the "item number." Traditionally, these are songs featuring a female performer, often not central to the plot, designed as a commercial highlight. They are frequently cited as the ultimate example of the male gaze, where a woman's body is displayed for heterosexual male titillation. However, a closer reading of many iconic item numbers reveals a more nuanced power dynamic, one where the female performer often exerts a formidable agency over the narrative and cinematic space.

Consider **"Choli Ke Peeche Kya Hai" from *Khalnayak* (1993)**. On the surface, it is the epitome of scandalous, objectifying spectacle. The lyrics are explicitly sexual, and the camera lingers on Madhuri Dixit's body. However, to reduce it to mere objectification is to ignore its narrative context and performance. The character, Ganga, is an undercover police officer performing this song to entrap the villain. This immediately introduces a layer of performance and subversion. Dixit's performance is not one of passive availability but of aggressive, challenging, and controlled power. Her gaze is direct, often breaking the fourth wall to implicate the audience in their own voyeurism. She asks a provocative question—"What is behind the blouse?"—and then answers it herself: "Choli ke peeche dil hai, mera dil hai" (Behind the blouse is a heart, my heart). This can be read as a reclamation. She takes the archetype of the hypersexualized village temptress and weaponizes it, using the male gaze itself as a tool for her mission. She controls the space, the rhythm, and the narrative outcome of the sequence. The male onlookers within the diegesis are rendered passive, mesmerized, and ultimately outsmarted. As scholar Jyotika Virdi notes, the popular cinema of the 90s often saw the heroine "negotiate a complex terrain of tradition and modernity," and the item number became a key site for this negotiation, where "display is

simultaneously a performance of sexuality and a performance of performance" (Virdi, 2003).

This tradition of the agential item performer finds a modern heir in **"Dola Re Dola" from *Devdas* (2002)**. The song is a celebration of female solidarity and joyous, unapologetic sexuality performed by Paro (Aishwarya Rai) and Chandramukhi (Madhuri Dixit). While ostensibly performed for a male audience (the patrons of the kotha), the true energy of the song is the electrifying connection between the two women. Their gazes are locked on each other; they dance in sync, a united front of powerful, skilled performance. The camera, instead of fragmenting their bodies in a typical voyeuristic fashion, often pulls back to showcase the grandeur and complexity of their synchronized movements. They command the massive set and the large crowd of male performers, who function primarily as a backdrop. The song is a moment of narrative pause where the two female rivals, bound by their love for the same self-destructive man, transcend that limiting plot to claim a space of pure, unadulterated artistic and personal power. It is a spectacle, but one orchestrated by and for the women themselves.

III. Subversion, Irony, and the Contemporary Commentary

In contemporary Bollywood, as narratives have become more explicitly feminist, the song has evolved from a vessel of subconscious expression to a direct tool of subversion and ironic commentary. Here, the female gaze is not just implied; it is the text.

Nothing exemplifies this better than **"Dhoodh Bhanvra" from *Tumbbad* (2018)**. This haunting lullaby, sung by a mother to her son, is the antithesis of the romantic ideal. Its lyrics are a stark, brutal warning about the perils of greed, a curse passed down through generations. The female voice here is not one of desire but of ancient, weary knowledge. She is the keeper of a terrifying epistemological truth about the family's curse. Her gaze is not forward-looking towards romance but backward-looking, into a mythic past of trauma. The song establishes the film's dark, folkloric tone and positions female knowledge as central to the narrative's moral and horrific core.

A more mainstream and brilliantly subversive example is **"Ghoongroo" from *War* (2019)**. On one level, it is a classic item number: a spectacular dance by Vaani Kapoor in a glamorous setting. However, the context completely subverts the trope. The performer, Altaaf, is actually a deep-cover agent (Hrithik Roshan) in drag. This simple twist fundamentally dismantles the mechanics of the gaze. The diegetic audience (and by extension, the cinema audience) is led to believe they are objectifying a female body, but the revelation that it is a man performing femininity creates a profound Brechtian distanciation. It exposes the item number as a constructed performance, a costume to be worn for strategic gain. The "female" performer's gaze becomes a knowing, ironic smirk—he is aware of the spectacle he is creating and is using it to manipulate the very gaze directed at him. It is a meta-commentary on the nature of the Bollywood item number itself.

Finally, **"Dilbaro" from *Raazi* (2018)** represents a nuanced reclamation of a traditional form. The song is a *rukhsati* (farewell) song, a genre typically steeped in the patriarchal notion of the daughter as property being transferred from one man (her father) to another (her husband). It is often a moment of profound sorrow for the woman. However, in *Raazi*, the context of the daughter, Sehmat (Alia Bhatt), being a spy on a patriotic mission changes the meaning. The lyrics, sung from the perspective of the father (played by Rajit Kapur), are filled with pain and pride. But the performance is not just about his loss. Sehmat's gaze throughout is resolute, strong, and determined. She is not a passive commodity but an active agent in her own destiny. The song becomes a bittersweet tribute to her immense sacrifice, acknowledging the pain of the tradition while simultaneously subverting its power dynamics by centering her agency and courage.

Conclusion: The Unending Melody of Subjectivity

The Bollywood song, far from being a mere interruption, is a critical cinematic language. It provides an alternative epistemology—a way of knowing the female character that the rigidities of

the main narrative often suppress. From the whispered dreams of Nargis in the rain to the defiant performance of Madhuri Dixit in the court, from the shared power of "Dola Re Dola" to the subversive drag of "Ghoongroo," these sequences form a rich and continuous archive of the female gaze.

They demonstrate that agency is not only found in realistic dialogue and action but can be powerfully asserted through fantasy, performance, and music. The female gaze in Bollywood is not a modern invention but a persistent undercurrent, a melody that has always played alongside the dominant theme, sometimes harmonizing, often challenging, and always enriching the narrative. To listen to these songs with attentive ears is to hear the enduring voice of female subjectivity, claiming its space, one musical number at a time. As the industry continues to evolve, this sonic territory remains the most vital and dynamic space for exploring the complexities of women's desires, fears, and power.

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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

From Root to Genome: Plant-Mediated Uptake of Micro- and Nanoplastics (MNPs) and Significance to Human Genome Stability

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Date of Receipt: 27.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract

The exponential increase in plastic production and improper waste management have resulted in the pervasive presence of microplastics (MPs; <5 mm) and nanoplastics (NPs; <1 µm) across environmental compartments. While marine ecosystems have received substantial research attention, terrestrial ecosystems—particularly agricultural soils—are increasingly recognized as major sinks of micro- and nanoplastics (MNPs). Recent studies demonstrate that MNPs can be absorbed by plant roots and aerial tissues, translocated to edible plant parts, and thereby enter the human food chain. Concurrently, the detection of microplastics in human blood, placenta, lung tissue, and internal organs raises concerns regarding their long-term biological impacts. This review critically examines the uptake, transport, and accumulation of MNPs in plants and synthesizes current evidence linking human health exposure to genome instability. Particular emphasis is placed on mechanisms involving genotoxicity, oxidative stress, chronic inflammation, and epigenetic reprogramming. Evidence from plant studies, *in vitro* human cell models, *in vivo* animal experiments, and limited human observations indicates that MNPs can induce DNA strand breaks, chromosomal aberrations, altered DNA methylation, histone modifications, and dysregulation of non-coding RNAs. Although direct causal evidence in humans remains limited, the mechanistic plausibility, persistence of exposure, and bioaccumulative potential of MNPs highlight an urgent need for focused research on genome-level effects. Understanding plant-mediated transfer of MNPs and their genomic consequences is essential for accurate health risk assessment and the development of effective regulatory strategies.

Keywords: Microplastics,Nanoplastics, plant uptake, food chain, genome instability, genotoxicity, human health.

1. Introduction

Plastics have become indispensable materials in modern society due to their durability, versatility, and low production cost. Global plastic production has increased dramatically, exceeding 460 million tonnes annually, with projections indicating continued growth (Geyer *et al*., 2017). However, the environmental persistence of plastics has created a global pollution crisis. Through physical, chemical, and biological degradation, large plastic items fragment into microplastics (MPs) and nanoplastics (NPs), which are now ubiquitous in aquatic, atmospheric, and terrestrial environments (Kaweck*iet al*., 2019).Early microplastic research primarily focused on marine ecosystems, driven by visible accumulation in oceans and marine organisms. In contrast, terrestrial ecosystems were long considered less affected. Recent evidence, however, indicates that soils—particularly agricultural soils—may contain higher concentrations of microplastics than marine sediments (Bläsing& Amelung, 2018). Agricultural practices such as plastic mulching, greenhouse cultivation, application of sewage sludge and compost, irrigation with contaminated water, and atmospheric deposition contribute substantially to soil microplastic contamination (Rillig*et al*., 2019). Plants, as primary producers, form a crucial link between environmental contamination and human

exposure. The ability of plants to absorb, translocate, and accumulate MNPs has raised serious concerns regarding food safety and public health. Simultaneously, the detection of microplastics in human tissues—including blood, placenta, lungs, liver, and intestines—has intensified interest in understanding their biological effects (Leslie *et al*., 2022; Ragusa *et al.,* 2021).Among the potential health consequences, genome instability represents a particularly critical endpoint. Genome instability, characterized by DNA damage, chromosomal aberrations, and epigenetic dysregulation, is a hallmark of cancer and numerous chronic diseases (Hanahan & Weinberg, 2011). This review integrates plant science, environmental toxicology, and human molecular biology to critically examine the role of plant-mediated MNPs exposure in inducing genome instability in humans.

2. Sources and Environmental Distribution of Micro- and Nanoplastics in Terrestrial Ecosystems

Terrestrial ecosystems receive microplastics from multiple anthropogenic sources. Agricultural soils are directly contaminated by the use of plastic mulch films, which degrade under ultraviolet radiation, mechanical stress, and temperature fluctuations (Li *et al*., 2021). Sewage sludge applied as fertilizer represents another major pathway, as wastewater treatment plants efficiently remove microplastics from water but concentrate them in biosolids (Nizzetto*et al*., 2016).

Atmospheric deposition has emerged as a significant, yet underappreciated, source of microplastics in soils. Fibers from synthetic textiles and tire wear particles can be transported over long distances and deposited onto agricultural land (Dris *et al*., 2017). Once in soil, MNPs interact with soil particles, organic matter, microorganisms, and plant roots, influencing their mobility, bioavailability, and biological effects.Nanoplastics are of particular concern due to their high surface area-to-volume ratio and enhanced reactivity. They can adsorb heavy metals, pesticides, and persistent organic pollutants, acting as vectors for combined chemical and physical toxicity (Hüffer*et al*., 2017).

3. Uptake of Micro- and Nanoplastics by Plants

3.1 Root Uptake Mechanisms

Plant roots represent the primary interface for MNP uptake from soil. Experimental studies using fluorescently labeled polystyrene particles have demonstrated that nanoplastics can penetrate root tissues through cracks at lateral root emergence sites, root hairs, and intercellular spaces (Li *et al*., 2020). The apoplastic pathway allows movement along cell walls, while the symplastic pathway involves transport through plasmodesmata (Barberon, 2017)

Nanoplastics may also enter plant cells via endocytosis, a process typically reserved for nutrient uptake and cellular signalling (Sun *et al*., 2020). This suggests that NPs can bypass size exclusion barriers that normally restrict the movement of larger particles.The efficiency and pathway of MNP uptake are governed by particle size, surface chemistry, polymer composition, and environmental conditions within the rhizosphere (Rillig*et al*., 2019).

Comparative Table: Effects of Microplastics vs Nanoplastics on Major Crop Plants

Parameter	Microplastics (MPs)	Nanoplastics (NPs)
Typical size	1 μm–5 mm	<1 μm
Uptake efficiency	Limited (mainly surface adherence)	High (cellular penetration)
Translocation	Rare	Common via vascular tissues
Impact on germination	Moderate inhibition	Strong inhibition
Oxidative stress	Low–moderate	High ROS induction

3.1.1 Physical Entry Pathways at the Root Surface

The root epidermis, rhizodermis and its associated cuticular layer function as the primary barrier against exogenous particles, anatomical discontinuities—such as emerging lateral root primordia and lenticel-like ruptures—facilitate the translocation of micro- and nanoplastics (MNPs) into the stele. Using fluorescently labelled polystyrene nanoplastics (Li *et al*., 2020) demonstrated their accumulation at lateral root junctions followed by movement into cortical tissues.

Root hairs further enhance susceptibility to nanoplastic uptake by increasing root surface area and contact with soil particles. Their thin cell walls and high metabolic activity promote adhesion and internalization of nanoplastics through electrostatic and van der Waals interactions (de Souza Machado *et al*., 2019). In addition, intercellular spaces in the root cortex allow passive movement of nanoplastics, particularly under conditions of high soil moisture, facilitating deeper penetration into root tissue es (Sun *et al*., 2020).

3.1.2 Apoplastic Transport of Nanoplastics

Once nanoplastics cross the root surface, they may migrate via the apoplastic pathway, which consists of interconnected cell walls and intercellular spaces external to the plasma membrane. The porous architecture of plant cell walls generally restricts movement to particles smaller than 20 nm; however, studies have shown that flexible, irregularly shaped, or aggregated nanoplastics may still traverse the apoplast (Sun *et al*., 2020).

Apoplastic transport enables nanoplastics to bypass metabolic control mechanisms and move radially through cortical tissues. Although the Casparian strip in the endodermis normally blocks apoplastic flow into the vascular cylinder, nanoplastics may circumvent this barrier via passage cells or regions with incomplete lignification, particularly in young and developing roots (Li et *al*., 2021).

3.1.3 Symplastic Transport and Plasmodesmatal Movement

Symplastic transport requires nanoplastics to cross the plasma membrane and enter the cytoplasm. Once internalized, particles may move cell-to-cell through plasmodesmata, which form cytoplasmic connections between adjacent plant cells. Although plasmodesmata typically restrict movement to molecules smaller than 1–2 nm, environmental stress conditions can increase their permeability (Robards & Lucas, 1990).

Exposure to nanoplastics has been shown to induce oxidative stress due to excessive generation of reactive oxygen species (ROS) and membrane destabilization in plant cells, potentially enhancing plasmodesmatal conductivity and facilitating intercellular movement (Giorgetti *et al*., 2020). This mechanism enables radial transport toward vascular tissues, increasing the likelihood of systemic distribution.

3.1.4 Endocytosis-Mediated Cellular Uptake

Endocytosis represents a key active mechanism by which plant cells internalize nanoplastics. This energy-dependent process, primarily mediated by clathrin-coated vesicles, is typically involved in nutrient acquisition and signal transduction. Experimental inhibition of clathrin-mediated endocytosis has been shown to significantly reduce nanoplastic uptake, confirming its role in particle internalization (Sun *et al*., 2020).

After internalization via endocytosis, nanoplastics are trafficked to early endosomes and can later be compartmentalized within vacuoles or released into the cytosol. Their surface functionalization, including carboxyl or amino groups, critically regulates cellular uptake by influencing membrane receptor interactions, allowing nanoplastics to circumvent size-exclusion barriers and directly access intracellular organelles (Li *et al*., 2020).

3.1.5 Role of Rhizosphere Chemistry and Root Exudates

The rhizosphere plays a pivotal role in regulating nanoplastic bioavailability. Root exudates—including organic acids, amino acids, sugars, and polysaccharides—can modify the surface properties of nanoplastics by promoting aggregation or dispersion (Rillig*et al*., 2019). These exudates may also form bio-coronas around plastic particles, altering their affinity for root cell surfaces and influencing uptake efficiency (Hüffer*et al*., 2020).

Soil pH, ionic strength, and microbial activity further regulate nanoplastic mobility and interaction with root tissues. Acidic conditions and elevated microbial activity have been shown to enhance desorption of adsorbed contaminants from nanoplastic surfaces, potentially increasing combined phytotoxic effects (de Souza Machado *et al*., 2019).

3.1.6 Size-Dependent Uptake: Microplastics versus Nanoplastics

Particle size is a critical determinant of root uptake. Microplastics (>1 µm) are generally excluded from internal tissues and remain attached to root surfaces or confined within rhizospheric matrices (Rillig*et al*., 2019). In contrast, nanoplastics exhibit significantly higher uptake efficiency due to their small size, high surface reactivity, and ability to exploit cellular uptake mechanisms.

Although microplastics may not be readily internalized, their presence can indirectly affect root physiology by altering root architecture, nutrient uptake, and interactions with beneficial soil microorganisms (de Souza Machado *et al*., 2019).

3.1.7 Implications for Trophic Transfer and Human Exposure

Root uptake of nanoplastics represents the first critical step in the entry of plastic particles into terrestrial food chains. Once internalized, nanoplastics can be translocated to aerial tissues and edible plant organs, thereby increasing the likelihood of human exposure through plant-based foods (Li *et al*., 2021). Given the limited capacity of plants to metabolize synthetic polymers, nanoplastics may persist within tissues throughout the plant life cycle.These uptake mechanisms underscore the critical role of plants as gateways for microplastic transfer from soil ecosystems into the human food chain.

3.2 Foliar Uptake

In addition to root-mediated pathways, foliar uptake represents an important yet comparatively underexplored route for the entry of micro- and nano plastics (MNPs) into plants. Stomatal openings and cuticular cracks can facilitate entry of fine particles into leaf tissues, particularly under high humidity conditions.Atmospheric deposition arising from urban dust, agricultural plastic mulching, tire wear, and industrial emissions can result in the direct settling of plastic particles on leaf surfaces (Dris *et al*., 2016). Once deposited, the interaction between MNPs and leaf microstructures determines their potential for internalization.

Stomata constitute the primary biological gateways for foliar uptake. These microscopic pores, which regulate gas exchange and transpiration, typically range from 5 to 20 µm in diameter, making them accessible to fine microplastics and nanoplastics (Wang *et al*., 2021). Under conditions of high relative humidity, stomatal apertures remain open for extended periods, facilitating the penetration of suspended particles into the substomatal cavity (Eichert *et al*., 2008). Experimental evidence using fluorescent nanoplastics has demonstrated their localization within mesophyll tissues following foliar exposure, confirming stomatal-mediated entry (Wang *et al*., 2021).

In addition to stomata, structural imperfections in the leaf cuticle—such as cracks, trichome bases, and damaged epidermal regions—can act as secondary entry points. The cuticle, although generally hydrophobic and protective, becomes more permeable under environmental stress, UV exposure, or mechanical abrasion, increasing susceptibility to nanoplastic infiltration (Schreiber, 2005). Once inside the leaf, nanoplastics may be translocated via apoplastic or symplastic pathways, contributing to systemic distribution within the plant (Li *et al.*, 2021).Collectively, foliar uptake highlights the significance of atmospheric microplastic pollution as a direct exposure route for plants and reinforces the need to consider aerial pathways when assessing food-chain contamination risks.

4. Translocation and Accumulation of MNPs in Plant Tissues

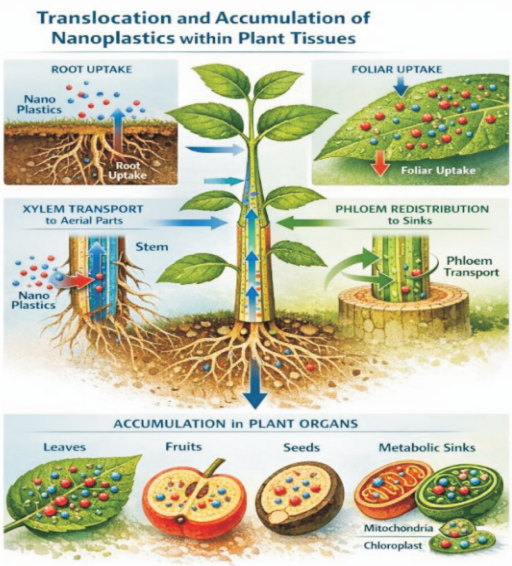
Once absorbed, MNPs can be translocated through the vascular system. Xylem transport enables upward movement from roots to stems and leaves, while phloem transport allows redistribution to metabolically active sinks such as fruits and seeds

(Zhang *et al*., 2021). Accumulation in edible plant parts is of particular concern, as it represents a direct route of human exposure (Figure1). Studies on wheat, lettuce, rice, and maize have demonstrated accumulation of nanoplastics in leaves and grains, suggesting that staple crops may contribute significantly to dietary microplastic intake (Li *et al*., 2020; Sun *et al*., 2020).

5. Transfer of MNPs from Plants to Humans

Dietary intake is widely recognized as one of the dominant routes of human exposure to micro- and nanoplastics (MNPs), with plant-based foods serving as a significant entry point into the human body. Agricultural crops grown in contaminated soils or exposed to atmospheric deposition can accumulate MNPs in edible tissues, including leaves, grains, fruits, and seeds, thereby facilitating their transfer along the food chain (Deng *et al*., 2020). Cereals, vegetables, and processed plant-derived foods are of particular concern due to their high consumption rates and minimal processing barriers to particle retention(Figure 2).

Quantitative exposure assessments estimate that humans may ingest between 39,000 and 52,000 microplastic particles per year through food and drinking water alone, with substantially higher exposure levels when inhalation is considered (Cox *et al*., 2019). The detection of microplastics in human blood provides compelling evidence of systemic exposure and internal circulation, suggesting that ingested particles can translocate across the intestinal barrier (Leslie *et al*., 2022). Moreover, the identification of microplastics in human placental tissues indicates the ability of MNPs to cross complex biological barriers, raising serious concerns regarding prenatal exposure and potential developmental and genomic consequences (Ragusa *et al*., 2021). These findings underscore the urgent need to evaluate long-term health risks associated with dietary microplastic exposur.



(Image created taking help from Google)

Figure 1. Translocation and accumulation of nanoplastics within plant tissues. Following root or foliar uptake, MNPs are transported via xylem to aerial organs and redistributed through phloem to metabolically active sinks such as leaves, fruits, and seeds.(Image created taking help from Google)

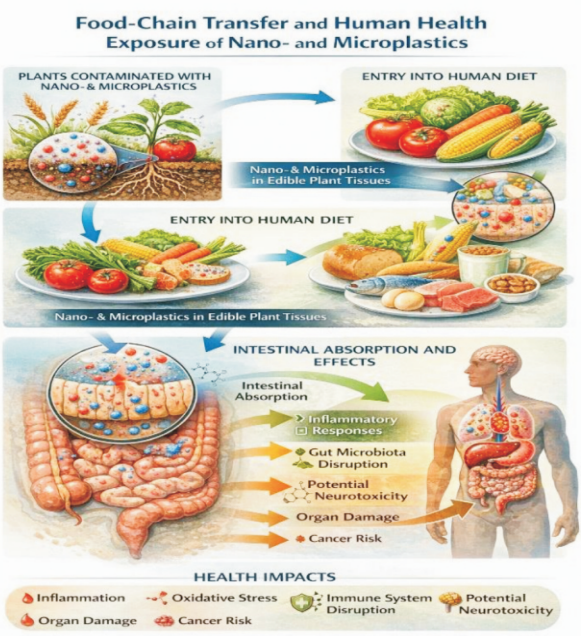


Figure 2. Food-chain transfer and human health exposure pathways. Accumulated MNPs in edible plant tissues enter the human diet, where they may cross intestinal barriers, induce inflammatory responses, disrupt gut microbiota, and act as vectors for toxic additives and co-contaminants.

6. Cellular Uptake and Distribution of MNPs in Humans

Following ingestion or inhalation, MNPs can cross epithelial barriers in the gut and lungs. Nanoplastics, due to their small size, are readily taken up by cells via endocytosis and may escape lysosomal degradation (Yong *et al*., 2020). Once internalized, they can interact with cellular organelles, including mitochondria and nuclei, potentially interfering with fundamental biological processes.

Following ingestion or inhalation, micro- and nanoplastics (MNPs) can translocate across epithelial barriers of the gastrointestinal tract and respiratory system (Figure3). In the gut, MNPs may cross the intestinal epithelium via paracellular transport, M-cell–mediated uptake in Peyer's patches, or transcytosis through enterocytes, while inhaled particles can penetrate alveolar epithelium and enter systemic circulation (Wright & Kelly, 2017; Lehner *et al*., 2019).

At the cellular level, nanoplastics,due to their small size, are predominantly internalized through energy-dependent endocytic pathways, including clathrin- and caveolin-mediated endocytosis (Yong *et al*., 2020). Once internalized, they can interact with cellular organelles, including mitochondria and nuclei, potentially interfering with fundamental biological processes.Experimental studies have shown that some nanoplastics can evade lysosomal degradation, enabling their persistence within the cytoplasm and facilitating interactions with subcellular organelles (Hu *et al*., 2021). Accumulation of nanoplastics in mitochondria has been associated with impaired membrane potential and increased reactive oxygen species production, while nuclear localization raises concerns about direct interference with DNA integrity and chromatin organization (Dong *et al.,* 2020). Collectively, these findings highlight the capacity of MNPs to disrupt cellular homeostasis and contribute to long-term genomic instability.

7. Genome Instability Induced by Micro- and Nanoplastics

7.1 DNA Damage and Chromosomal Aberrations

Multiple *in vitro* studies using human epithelial and fibroblast cell lines demonstrate that exposure to micro- and nanoplastics (MPs and NPs) can directly compromise genomic integrity in human cells.

Studies using human lung epithelial, intestinal, and dermal fibroblast cell lines have reported significant increases in DNA single- and double-strand breaks, as detected by comet and γ-H2AX assays, following nanoplastic exposure (Dong *et al*., 2020; Schirinzi*et al*., 2017). In addition, elevated frequencies of micronuclei, nucleoplasmic bridges, and chromosomal mis-segregation have been observed, indicating both clastogenic and aneugenic effects. These genotoxic outcomes are largely attributed to oxidative stress, inflammatory signaling, and direct physical interactions between nanoplastics and chromatin, all of which disrupt normal DNA repair processes and promote genome instability (Yong *et al*., 2020).

7.2 Oxidative Stress-Mediated Genotoxicity

Oxidative stress is widely recognized as a central mechanism of microplastic toxicity. Excessive production of reactive oxygen species (ROS) can damage DNA bases, and induce single- and double-strand breaks (Schirinzi*et al*., 2017). Persistent oxidative stress also impairs DNA repair pathways, allowing mutations to accumulate.

8.1 DNA Methylation Changes

DNA methylation is a fundamental epigenetic mechanism involved in gene regulation, genomic imprinting, and chromosomal stability. Emerging studies indicate that exposure to micro- and nanoplastics can induce both global hypomethylation and locus-specific hypermethylation in human and animal cell models (Jin *et al*., 2022). Such alterations are often associated with oxidative stress–mediated disruption of DNA methyltransferase activity, leading to aberrant gene expression profiles. Changes in methylation status of genes involved in cell cycle regulation, DNA repair, and inflammatory responses have been reported, suggesting a mechanistic link between microplastic exposure and increased susceptibility to genomic instability (Table 1) and disease development (Luo *et al*., 2022).

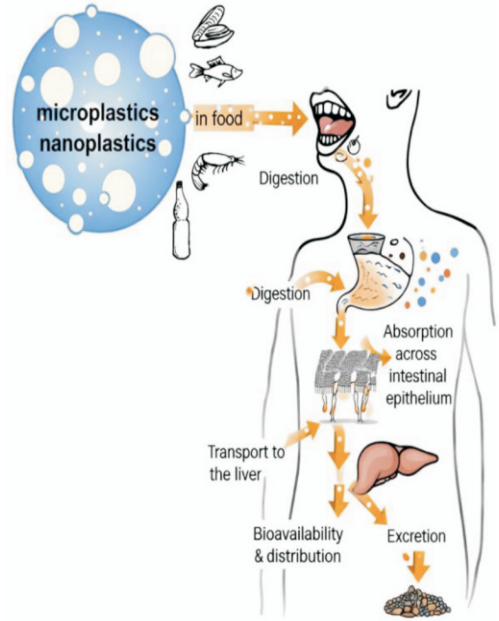


Figure 3. Micro- and Nano Plastics (MNPs) journey by consuming foods and then passing through the human body

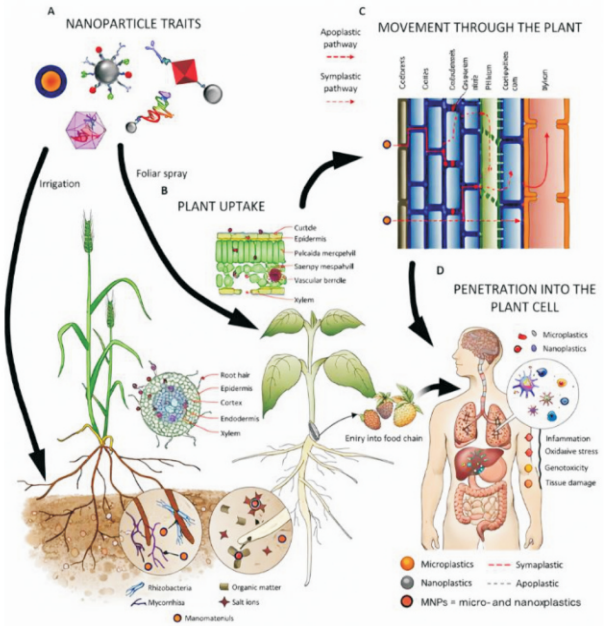


Figure 4. Pathway of micro- and nanoplastics (MNPs) from contaminated soil to plant roots, their uptake at the root–soil interface, internal transport via apoplastic and symplastic pathways, and accumulation in aerial plant tissues and finally entry into Human body.

8.2 Histone Modifications and Chromatin Remodeling

Histone modifications, including acetylation and methylation, play a critical role in regulating chromatin accessibility and transcriptional activity. Microplastic-induced oxidative stress and inflammatory signaling have been shown to interfere with histone-modifying enzymes, resulting in altered histone acetylation and methylation patterns (Chen *et al*., 2023). Disruption of histone H3 lysine acetylation and methylation marks can lead to chromatin condensation or relaxation, thereby affecting gene transcription and DNA repair efficiency. Persistent changes in chromatin structure may compromise genome organization and promote long-term transcriptional dysregulation, even after cessation of exposure (Zhang *et al*., 2022).

8.3 Non-Coding RNA Dysregulation

Non-coding RNAs, particularly microRNAs (miRNAs), are key regulators of post-transcriptional gene expression and play essential roles in apoptosis, inflammation, and DNA damage response pathways. Experimental studies have shown that microplastic exposure can significantly alter miRNA expression profiles in human cells, affecting pathways related to oxidative stress and genomic maintenance (Liu *et al*., 2021). Dysregulation of miRNAs targeting DNA repair genes and cell cycle regulators may exacerbate DNA damage accumulation and impair cellular stress responses. Such epigenetic reprogramming highlights a novel mechanism by which microplastics contribute to genome instability and long-term health risks (Wang *et al*., 2022).

9. Implications for Human Health

Genome instability is a recognized driver of carcinogenesis, reproductive toxicity, neurodevelopmental disorders, and immune dysfunction. Genome instability is a fundamental pathological process underlying a wide spectrum of human diseases, including carcinogenesis, reproductive toxicity, neurodevelopmental

Table 1. Effects of Epigenetic Alterations Induced by Micro- and Nanoplastics (MNPs)

Epigenetic Endpoint	Model System	Observed Effects	Reference
DNA methylation	Human epithelial cells	Global hypomethylation, DNMT inhibition	Jin *et al*., 2022
DNA methylation	Zebrafish embryos	Altered gene -specific methylation	Luo *et al*., 2022
Histone acetylation	Human fibroblasts	Reduced H3K9ac, chromatin condensation	Chen *et al*., 2023
Histone methylation	Mouse cells	Dysregulated H3K4me3, H3K27me3	Zhang *et al* ., 2022
miRNA expression	Human lung cells	Dysregulation of DNA repair miRNAs	Liu *et al*., 2021

Table 2. Mechanistic Links Between Microplastics and Genome Instability

Mechanism	Molecular Outcome	Genome-Level Effect	Reference
Oxidative stress	ROS overproduction	DNA strand breaks	Dong *et al*., 2020
Inflammation	NF-κB activation	Chromatin remodeling	Yong *et al*., 2020
Epigenetic disruption	DNMT/HDAC inhibition	Genome instability	Jin *et al*., 2022
miRNA dysregulation	Impaired DNA repair	Mutation accumulation	Wang *et al*., 2022

disorders, and immune dysfunction (Figure4). Chronic exposure to micro- and nanoplastics (MNPs), even at low doses, may exacerbate these risks through persistent oxidative stress, inflammation, and epigenetic dysregulation (Yong *et al*., 2020; Jin *et al*., 2022; Table 2). Epidemiological and experimental evidence indicates that genome instability arising from DNA damage, chromosomal aberrations, and impaired DNA repair contributes to tumor initiation and progression, as well as to developmental abnormalities (Hanahan & Weinberg, 2011).

Dietary intake of MNPs via plant-based foods represents a continuous exposure route, particularly concerning for vulnerable populations such as pregnant women, infants, and individuals with compromised detoxification or antioxidant defences (Cox *et al*., 2019; Ragusa *et al*., 2021). The detection of microplastics in human blood and placental tissues suggests systemic distribution and potential foetal exposure during critical developmental windows, raising concerns about long-term health consequences and intergenerational effects (Leslie *et al*., 2022).

10. Knowledge Gaps and Future Research Directions

Despite rapid progress, major gaps remain, including:

- Limited human studies linking dietary MNP exposure to genomic biomarkers
- Insufficient understanding of plant-to-human transfer efficiency
- Lack of standardized experimental exposure models
- Poorly understood transgenerational effects

Addressing these gaps requires interdisciplinary collaboration across plant sciences, toxicology, genomics, and public health.

11. Conclusion

Micro- and nanoplastics (MNPs) represent a class of pervasive, biologically active contaminants that increasingly challenge existing environmental and public health governance frameworks. Their documented capacity to interact with biological systems across trophic levels establishes a continuous exposure pathway linking environmental contamination, agricultural production, and human health. In this context, plants—particularly food crops—constitute a critical regulatory interface through which environmental MNP burdens may translate into dietary exposure, raising concerns directly relevant to food safety oversight.

Emerging evidence that chronic, low-level MNP exposure can perturb genome integrity via genotoxic, inflammatory, and epigenetic mechanisms underscores the need for precautionary action, despite remaining uncertainties regarding definitive human health outcomes. From a policy perspective, these findings highlight important gaps in current regulatory frameworks, which largely address plastics as inert materials rather than biologically active stressors. Integrating MNPs into existing food safety and environmental risk assessment paradigms—such as those coordinated by the European Food Safety Authority (EFSA), the Food and Agriculture Organization of the United Nations (FAO), and the World Health Organization (WHO)—will require standardized detection methods, harmonized exposure metrics, and the inclusion of molecular and genomic endpoints.

Collectively, advancing regulatory recognition of MNPs as emerging contaminants is essential for developing evidence-based thresholds, strengthening environmental emission controls, and safeguarding food systems. Such measures will be critical not only for protecting ecosystem integrity and public health but also for addressing potential long-term and transgenerational risks in an increasingly plastic-dependent globaleconomy.

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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

Contribution of Yoga in Modern Psychology

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Date of Receipt: 13.01.2026 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Yoga is derived from Sanskrit word 'Yuj' which means 'to unit' to join and indicates completion with the addition of the suffix ghan. This classical root yuj survives in German Joch, Latin jugun and also forms the parent root of English 'yoke' means 'to couple' to connect. Thus etymologically yoga means union of the individual soul with the universal soul. The goal of religion and of philosophy is union with the ULTIMATE. And yoga means just that union. Worldly life is an embodiment of yoga (union) .

To understand correctly 'what is yoga'? it is necessary to answer the counter question 'what yoga is not'? Yoga is typically Indian in originand has given content and orientation to psychological thinking in the East. In fact Yoga-psychology is the nucleus of Indian psychology as a whole. Yoga is often regarded as irrational, unscientific, confused or impractical and unconnected with experience. But yoga is none of these. It is so very practical that can be lived every moment in life. Yoga is neither a sect nor a religion nor merely an abstract philosophy. If philosophy is the vision of truth, then yoga is its practical side making for its realization. To many it signifies some deep breathing exercises or bodily postures. But yoga is not so much a mode of physical exercises. In fact a man without limbs can practice yoga. Yoga is not only a view of life but also a way of life.Beingayogi he has to be transformed and renewed in life and mind. Yoga is a unique synthesis in which physical culture, spiritual discipline, ethics and psychology are harmoniously integrated into one. Thus, rightly conceived and correctly interpreted, yoga is the art of healthy living- physically, mentally, ethically, and spiritually. Yogasiddhi is the gospel of perfect life.

The clue to the modern views of personality is found in the concept of 'asmitā' as expounded in 'Yogasūtras'(Y.S.II,6). According to Patañjali the transformation of puru?a and buddhi into an apparent identity is an affliction called 'asmitā or egoism. The feeling of personality arises from ahamkara or the principal of egoity which causes the exclusive feeling of 'I' and 'Mine'. This view of personality when examined in the light of yogic view is due to avidyā or ignorance. This is traceable the false identification of puru?a with prakriti and its component parts. According to Sri Aurobindo this view of personality which rests upon ego hood is superficial. The reality behind personality can be known by going deep within ourselves and "when we have seen both ourself and our nature as a whole". Indian wisdom conceives this ego-personality as an illusion and suggests that to die to this pseudo-self is to realize one's real personality. It has been suggested in the Upani?ads that one should peel off the five kosas or sheaths which represent layers of ego-personality to find the Atman which constitutes the real personality. The discipline of yoga is directed towards this consummation, that is, realization of this central core of personality.

There are three motives which impel a man to the practice of yoga:

1.Desire to escape from the burden of life.

2.Desire for psychic power.

3.Search for one's reality.

Search for reality or self-exploration is the only satisfactory motive for pursuit of yoga. Meditation has been the spiritual discipline of yogis in India since ancient times. The practice of meditation constitutes the very core of spiritual life and it is often referred to as 'dhyānayoga'. The goal of both yogic meditation and modern psychotherapy is mental health. Yoga is the practice of the Truth of which knowledge gives the vision, and its practice has for its motor-power a spirit of illumined

devotion, of calm or fervent consecration to that which knowledge sees to be the Highest.

In whatever sense yoga is used it involves first, last and always, cessation of the mental function (citta-vṛttis). And Patañjali uses the very same words to define yoga(Y.S.1-2). This is the most precise and expressive definition of yoga which contains in one sutra the quintessence of Rāja-Yoga. The term yoga is used not only for 'uniting processes' but also for 'isolating processes' which are intended to help in the right direction towards ultimate reality. All the different forms of yoga though varying in approach have in common the goal of samādhi, self-realization or kaivalya. It is the basic thesis of all yogas that they regard the attainment of calm, one-pointed mind as a pre -requisite to this goal. In Bhagavad Gita, Sri Krishna advices Arjuna to lead a contemplative life and to practice meditation,Rāja-Yoga.

Steps of Integration inRāja-Yoga

PatañjalaYogasūtras divide the process of yoga into four stages(Padas):

1. Samādhipāda- that of identification;
2. Sādhanapāda- that of practice;
3. Vibhūtipāda- that of attainment;
4. Kaivalyapāda -that of supreme realization.

However, Rāja-Yoga essentially comprises of eight main steps, which should preferably be practised in the given order in order to attain to yoga. These steps as given in Yogasūtra 29 of Sādhanapāda are called in Sanskrit: yama, niyama,āsana,prā?āyāma, pratyāhāra, dhāra?ā, dhyāna and samādhi. These steps will now be taken up in the subsequent sections in the prescribed order as given inPatañjali'sYogasūtras. However, the first two steps (i.e. yama and niyama) which primarily deal with ethical discipline have been taken together. Likewise, the next three steps(i.e.āsana,prā?āyāma, pratyāhāra) which primarily deal with the body and the senses have been taken up together. Taking collectively, these five steps constitute the external steps or limbs ofRāja-Yoga.The last three steps called the internal limbs of Rāja-Yoga, primarily deal with the training and useof the mind. As these steps have profound psychological and spiritual significance for the main problem of integration of personality, these steps have been dealt with separately in three sections. These three namely dhāra?ā, dhyāna and samādhi together constitute ayogic technique designated as' Sa? yama' (Y.S.III.4).

YAMAAND NIYAMA

In the eightfold path of Rāja-Yoga, the first two steps lay the very foundation for the path of yoga; yoga practice has often been referred as a way (mārga). According to Patañjali, the five restraints(yamas) as enumerated inYogasūtras II-30 are "ahi? sā(non-violence),truth,non stealing, brahmacarya(chastity) and non-possession", and the five observances(niyamas)asenumerated inYogasūtras II-32 are " purity, contentment, penance, study of scriptures and surrender to God".

Yama and Niyama constitute ethical discipline and are basically concerned with ethics and morality in the broadest sense of these terms. The practice of these preliminary steps not only eradicates physical and mental ailments but also strengthens nervous system. Practice of yama actually means the practice of right conduct(sadācāra), which has been emphasized in every religion. The noble eightfold path of Buddha Primarily deals with the practice of yama. In a sense, yama might be called inhibitionin psychoanalytic terminology. However, this can be called so with one very important reservation that in yoga this inhibition is a concious practice directed to a well-defined aim. Niyama means observance of limits within which tension-free life may be lived.All the five yamas and five niyamas have important psychological implications. The practice of very first yama(ahi? sā) serves the aim of clearing up built-in aggressions; and the practice of very first niyama (sauca) clears up the built- in compulsions. Thus yamas and niyamas which demand searching self- analysis have therapeutic value for mental integration.

In the ultimate analysis adequate practice of yama and niyama leads to purification of mind, which according toPatañjali is absolutely necessary for spiritual growth. Though yoga prescribes a code of mental and moral discipline yet it is not essentially a science of ethics. Dr. Radhakrishnan said, 'The spiritual is not an extension of ethical it is

a new dimension altogether." In- fact in yoga, the practice of ethics and higher psychology go together and underlie all spiritual realization. Ethical steps of yama and niyama primarily give spiritual turn to primary urges by sublimating and purifying them, resulting in greater harmony and integration. If one carries on the practice of yama and niyama for a long time and one ultimately becomes master of senses and mind is able to follow spiritual life without any conflicts. This practice contributes to what is called 'cittasuddhi'(Psychic Purity) which according to yoga is a pre-requisite for complete integration of personality.

ĀSANA-PRĀ∑ĀY∑MA- PRATYĀHĀRA

In yoga practice, the body should be placed in a favourable and conformable position before one can begin the practice of concentration and meditation. In fact it is considered desirable that the aspirant should choose the same spot, the same hour besides affixed posture for this purpose. Yama and niyama which are based on the principles of economy of nervous energy help the practice of āsana, the third limb of yoga. ? sanas are also directed to a similar purpose and help in the release of musculature towards free-functioning of bio- physical part of the personality.In point of fact,the first five limbs of Rāja-Yoga are intended to bring the body and the mind to the highest possible peak of health and efficiency.

The word "āsana" means "easy, comfortable".Patañjalihas defined it in the following way: 'To sit in a posture fixedly and comfortably for a sufficient length of time is āsana, (Y.S.II.46). when one can comfortably remain in one particular posture at least for three hours at a stretch, he is said to have attained perfection in that āsana(āsanajaya). Āsanas not only give elasticity and endurance to the body but they also give a feeling of well-being to the mind.

Prā?āyāma,the fifth limb ofRāja-yoga, has been defined by Patañjali in Yogasūtra 49 of Sādhanapāda. Like āsanas, prā?āyāma is also a bio-physical process. Both āsanas and prā?āyāma bring about integration and enhancement of prā?a-śakti, the vital force. ? sanas, prā?āyāma has a greater bearing on the control and discipline of mind. The. spiritual significance of āsanas and prā?āyāma lies in the freedom of the mind through the release of certain vital areas of the body like spiritual cord,cortex and muscles etc.

Pratyāhāra,the fifth limb of Rāja-yoga, is the one step preliminary to the practice of dhāra?ā (concentration). "When the senses have withdrawn from their objects and transmuted themselves into the modes of consciousness, this is called pratyāhāra." (Y.S.II.54). In actual practice pratyāhāra means to cultivate "unconcern" towards the so- called vital concerns of life. Preliminary steps of yama, niyama, āsana,prā?āyāma help the practice of pratyāhāra in the release of acquired emotional charge and giving a proper orientation to life organism as a whole. In this direction of setting life free from its conditionings, this process which begins with yama reaches its climax in pratyāhāra. However,pratyāhāra itself finds its fulfillment in the stage of samādhi.Pratyāhāra by serving this end, reinforces the process of integration of personality.

DHĀRA∑Ā

Now we shall deal with three internal limbs(antara?ga) of A?ā?gayoga; the triad of which is characterized as sa? yama. The first of these three, which is the sixth limb of Rāja-yoga is called 'dhāra?ā', which etymologically means to "hold fast". According to Patañjali's definition its mark is as follows: "Fixity of mind on one spot is called dhāra?ā'. (Y.S.III.1)

It is for the perfection in dhāra?ā that the first five steps of external yoga have to be practiced. Specially success in dhāra?ā is essentially dependent on pratyāhāra. Swami Akhilananda observes: "Apart from the religious and philosophical attainments of man through the practice of concentration, we also recognize its pragmatic value in the integration of human mind and personality."

DHYĀNA

Dhyāna is the next logical step after dhāra?ā; with the attainment of perfection in dhāra?ā, dhyāna startsautomatically. Patañjali's defines it in the following way:

"Flow of all the mental faculties without cessation

towards the object of meditation is called dhyāna or meditation". (Y.S.III.2)

When the mind's energies are focused upon one subject whether external or internal, concrete or abstract and if the flow of thoughts remains steady towards that object without any cessation as 'oil poured from the vessel to another', it is dhyāna or meditation. Meditation is essentially an individual matter in the sense that it is not for society but for one's spiritual advancement. The conscious mind may be very wise but the unconscious may be equally foolish and it is essentially the latter which is re-educated by meditation. At the stage of meditation (dhyāna) needs to be clearly distinguished from concentration (dhāra?ā). Concentration is the first stage of the process which develops into meditation.The practice of dhyāna gradually leads one to the spiritual freedom. Thusthe process of dhyāna helps in revealing total range of conscious i.e. the unconscious, the conscious and the superconscious. Consequentlydhyāna yoga develops the dynamic powers of the total mind. In this connection Swami Akhilananda states: 'Apart from its religious value, the practice of meditation has a tremendous influence in building up the total personality of man.

SAMĀDHI

Dhyāna reaches its culmination in samādhi. Dhāra?ā, Dhyāna and samādhi are the three consecutive stages of the same process of concentration of mind. Samādhi is the fixity ofthe mind.Patañjali's definition of samādhi(Y.S.III.3) has been translated by Swami Prabhavānanda in the words: " When , in meditation, the true nature of the object shines forth, not distorted by the mind of the perceiver, that is absorption(samādhi) ." Samādhiis generally classified as of two kinds : samprajñāta and asamprajñāta. In this first kind, mind takes up various aspect of prakrti for communion, with the result that consciousness of individuality still remains. In the second kind there is no substratum for meditation and the individuality is completely lost. In this stage there is no trace of cittav?tti except the residuum left by previous functions of citta(samskara). This is seedless Samādhi, the highest stage of Patañjala Yoga. In Samādhi complete conquest of an individual's past, of his unconscious is achived; his emotions are fully integrated and his intellect, emotions and will are coordinated.Thusapart from spiritual and psychic value, it has profound therapeutic significance. In the end, it may be asserted from yogic viewpoint that full spontaneity, full expressiveness, and full freedom remain unattained until the goal of yoga—that is Samādhi—is achieved.

Yoga psychology in its pursuit of discovery of self has made a thorough investigation into human personality. In this earnest search for its ultimate knowledge, it finally came to discover that essence of personality was a consciousness which is qualitatively superior to normal consciousness. This self-consciousnesswhich is an essential quality of self or personality. Yoga has been able to know that the true secret of personality lies in the discovery of puru?a or realization of the self.

Swami Siddheswarananda said, we should not imagine that meditation furnishes us with a means to evade our obligations,and offers us an escape from life. Meditation will prepare us, if we follow in practice the rules of yoga to fulfill, better than in the past, our individual duties and obligations. That is because we rebuild our character upon solid foundations. In this way, everyone becomes, according to one's disposition, a better citizen of the world and a more useful servant of humanity.

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AJHMC
ISSN : 0973-6212

Volume : 13 No. 1 & 2
February. 2026

Diversity in Engraved Inscriptions: An Epigraphic Perspective

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Date of Receipt: 27.12.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract:
Inscriptions, as textual or symbolic carvings on various materials, have been used across cultures for diverse purposes, reflecting the cultural, religious, and administrative needs of societies. They can be categorized by purpose (commemorative, religious, legal, administrative) or material (stone, metal, clay, organic). Each type serves unique functions, such as memorializing events, communicating legal decrees, or recording religious texts. Understanding these types aids in interpreting the Historical and social contexts of ancient civilizations, offering insights into their values and practices. The study aims to analyse the various types of inscriptions based on different materials. The study of inscriptions across different materials reveals the diverse methods by which ancient societies documented their history, beliefs, and daily practices.

Keywords: Inscriptions, Epigraphy, diversity in engraved inscriptions.

Introduction:
Inscriptions, conceived as deliberate and enduring textual interventions upon resistant materials, constitute one of the most direct and unmediated corpuses for historical inquiry. Unlike literary texts transmitted through manuscript copyists, inscriptions are often singular artifacts, fixed in time and space, encoding the intentions of their creators with a potency born of public display, legal sanctity, or religious perpetuity. The scholarly discipline of epigraphy, therefore, extends far beyond the decipherment of scripts and languages; it is fundamentally an interpretative engagement with the multifaceted dialogue between text, medium, function, and context. As the foundational sources for reconstructing the political, social, economic, and religious histories of pre-modern societies—particularly in the Indian subcontinent with its unparalleled epigraphic wealth—their systematic study demands a nuanced analytical framework.

This paper proceeds from the premise that a critical understanding of any inscription is predicated on a dual-axis classification: one of **purpose** and another of **materiality**. The first axis interrogates the *raison d'être* of the epigraphic act. Was it intended to command, to commemorate, to donate, to sanctify, or to label? A royal *praśasti* (eulogy), for instance, operates within a distinct discursive realm of power and legitimacy compared to a merchant's votive record on a temple pillar or a detailed land grant on copper plates. Each genre follows its own conventions, employs a specific rhetorical or formulaic lexicon, and projects a particular vision of the social order it inhabits.

The second, interdependent axis is that of the **medium**. The choice of material—be it lithic, metallic, ceramic, or organic—is seldom arbitrary. It is a conscious decision laden with implications for cost, durability, audience, portability, and symbolic resonance. The imperishability of stone commands public authority for decrees and memorials; the malleability and security of copper facilitate complex, sealed legal documents; the modest clay sealing authenticates a mundane transaction. This material dimension is not a passive backdrop but an active constituent of the inscription's meaning and function.

This introduction argues that a synthetic analysis, which rigorously correlates typological function with physical medium, is essential for unlocking the full historiographic potential of epigraphic sources. By examining *why* an inscription was

created and *on what* it was inscribed, we move past a purely textual reading toward a more holistic understanding of the artifact as a performative object within its cultural landscape. This approach illuminates the pragmatic and symbolic considerations of ancient agencies, reveals the infrastructure of communication and record-keeping, and ultimately provides a richer, more textured understanding of historical processes.

The present study will explore this typological and material framework, demonstrating how such a methodology refines our interpretation of inscriptions. It will delineate major functional categories—commemorative, donative, administrative-legal, religious, and label inscriptions—and examine their characteristic dialogues with preferred media, drawing upon key exemplars from the Indian epigraphic tradition. In doing so, it aims to establish a structured paradigm for reading these vital historical documents, not merely as repositories of information, but as dynamic monuments of past thought, action, and expression.

Nature and Definition of Inscriptions: Terminology and Significance

The term 'inscription' denotes a textual or symbolic record deliberately affixed to a durable material substrate through engraving, carving, incision, or other permanent marking techniques. As epigraphist D. C. Sircar classically defines it, an inscription is, in essence, *"any writing engraved on some object"* (Sircar 1965: 1). The material carriers of such texts are diverse, encompassing rock faces, cave walls, architectural members, stone pillars and slabs, metallic plates and vessels (notably copper, but also gold, silver, and iron), terracotta seals and tablets, baked bricks, ivory, wood, and coinage. This material durability is the defining characteristic that distinguishes inscriptions from texts recorded on perishable media like palm leaf, paper, or cloth.

Etymologically, the English word 'inscription' derives from the Latin verb *inscribere*, meaning 'to write upon' or 'to inscribe', itself a compound of the prefix 'in' ('in', 'on') and the verb *scribere* ('to write'). This linguistic origin underscores the fundamental action of impressing writing onto a surface, a process intended to confer permanence and public or archival authority upon the recorded message.

Within the scholarly discourse of South Asian historiography, inscriptions are recognized not merely as written records but as tangible artefacts of historical communication. They represent one of the oldest and most direct forms of documented expression, serving a spectrum of intentions —commemorative, donative, administrative, legal, and religious. As primary sources, they offer an unmediated conduit to the socio-cultural, political, and economic structures of past societies, often preserving data absent from literary or manuscript traditions. Their value lies in their contextual fixity; unlike manuscripts that circulate and are copied, an inscription typically remains anchored to its original spatial and functional context, providing critical evidence for topography, patronage, and institutional history.

The systematic study of these records constitutes the discipline of epigraphy. While in common parlance 'inscription' and 'epigraphy' are sometimes conflated, a precise distinction is maintained in academic usage: 'inscription' refers to the physical object and its text, whereas 'epigraphy' (from the Greek *epigraphein*, 'to write upon') denotes the critical, holistic science of studying such inscriptions. Epigraphy involves the technical tasks of decipherment, paleographic analysis, and textual editing, as well as the interpretative work of historical, linguistic, and cultural contextualization (Salomon 1998: 1-4). Thus, inscriptions are the evidentiary corpus, and epigraphy is the methodological framework that transforms them into historical evidence.

In summary, inscriptions are non-portable or deliberately preserved writings whose material form is integral to their function and meaning. Their analysis, through the rigorous methodologies of epigraphy, is indispensable for reconstructing the contours of pre-modern Indian history, offering insights into languages, chronological frameworks, administrative practices, religious endowments, and the very articulation of power and memory in the ancient world.

Types of Inscriptions:

Inscriptions are primarily categorized based on three key themes. Such as-

A. Based on ownership
B. Based on written content
C. Based on 'Object-surface' or material used.

A. Based on ownership:

This classification hinges on the patron or authority commissioning the inscription, which directly shapes its purpose, language, and public reach. The primary division is between **official** (state/royal) and **private** inscriptions. Official edicts, like the Aśokan rock and pillar edicts, were issued by ruling authority to promulgate law, commemorate victories, or enact policy, serving as instruments of propaganda and administration across the empire. Private inscriptions, commissioned by individuals, families, guilds, or religious groups, typically record donations, construction of temples, or personal devotional acts. The patron's identity is crucial for contextualizing the inscription's historical and social significance.

B. Based on written content: Inscriptions are categorized based on subject matter of writing. Such as-

I) Administrative Inscriptions- Administrative inscriptions served as the official records of state governance and legal authority. Issued by rulers or high officials, they functioned as public decrees, land grants, tax regulations, and bureaucratic orders. Common forms include royal edicts on rocks or pillars (e.g., Aśokan proclamations) and copper-plate charters documenting territorial grants or village assignments. These inscriptions provide critical evidence of political hierarchy, fiscal systems, territorial administration, and legal frameworks. By codifying decisions in permanent form, they reinforced state power and ensured transactional transparency, making them indispensable for reconstructing the operational mechanics of pre-modern Indian states, such as seen in the detailed Gupta-era copper-plate grants.

In Aśoka's edicts, the appointment of three types of administrative officials (Dharmamahāmātra?, Rājukā?, Prādeśikā?) and their duties have been mentioned. Noted there, -

Sarvatra ca janasathekaromi (.)ya ca ki? cimukhatoāñapayāmisvaya? dāpaka? vāsrāvā paka? vāyavāpunamahāmātresuājācikeāropita? b havatitāyaathāyavivādonījhatīvasantoparisāya? ā nantara? pa?vedeta me sarvatrasarvekāle (.)

*(*Translation in English:*This is a royal decree declaring that the king acts everywhere for the people's welfare. It commands that any order he gives verbally—whether for issuing a grant, creating a written record, or any legal matter entrusted to his high officials—must have any resulting dispute or case investigated and settled by the council. That resolution must then be reported back to him immediately, everywhere and at all times. The edict establishes a system of direct royal oversight and accountability over all administrative and judicial functions.)*

ii)Donative Inscriptions- Donative inscriptions form the largest corpus of Indian epigraphic sources. These records primarily document acts of religious or charitable giving—*dāna*—by individuals, families, guilds, or rulers. Typically engraved on temple walls, pillars, or copper plates, they detail gifts of land, money, livestock, or commodities to deities, Brahmanas, or monastic communities. The standard formula includes the donor's lineage, the donee, the object gifted, and often the religious merit sought. Beyond recording piety, they are invaluable for reconstructing socio-economic history, land tenure systems, and the political geography of patronage networks, as seen in the prolific land-grant copper plates of the Gupta and post-Gupta periods.

In Copper-plate inscription of Dharmapāla, Pāla raja Dharmapāla donated four villages to 'Lātadeśiya' Brahmins to establish a temple of Lord Nanna-Nārāya?a.The textual reference is –

Tatra prati??hāpita-bhagavann-annanārāya?a-bha??ārakāyatat-pratipālaka-lā?a-dvijadevārcakādi-pādamūla-

sametāyapūjopasthānādi-karma?ecaturogrāmānatratya-talapā?aka-sametāndadātu deva iti.

*(*Translation in English:*Therefore, for the worship and maintenance services of the installed Lord Annanārāya?a-Bha??āraka (the deity) together with the attending group—including its protectors, the Lā?a Brahmins, the temple priests, and others stationed at its feet—may the king grant four villages here, along with their accompanying hamlets and territories.)*

iii)Eulogistic Inscriptions-Praśasti inscriptions are a formal literary genre of panegyric, composed primarily to glorify a ruler, dynasty, or patron. Far more than simple praise, they are sophisticated political instruments designed to legitimize authority, sanctify power through divine analogies, and project an idealized vision of kingship for contemporaries and posterity. A classical praśasti follows a set structure: opening invocations, mythical genealogy of the ruler, detailed accounts of his virtuous qualities (*gu?a*) and martial victories (*vijaya*), descriptions of public works and charitable acts, and concluding benedictions. While they celebrate specific deeds like temple construction or reservoir excavation, their core function is to embed the patron within a cosmic and dharmic order. Examples like the Allahabad Pillar inscription of Samudragupta or the Aihole inscription of Pulakeshin II are not merely historical records but curated literary monuments, blending historical fact with poetic convention to create an enduring legacy. Their highly stylized Sanskrit offers invaluable, if idealized, insights into political ideology, courtly culture, and the self-perception of pre-modern Indian states.
Example: Emperor Samudra Gupta's war-feat is praised in 'Eran Praśasti',
"Yasyorjjita? samarakarmaparīkrame??ha?
p?thvyā? yaśa?suvipulamparibhramatiḥ
vīryā?iyasyaripavaś ca ra?orjjitāni
svapnāntare?vapivicintyaparitrasantiḥ "

*(*Translation in English: *The verse proclaims the glory of a sovereign whose martial deeds, achieved through fierce and expansive prowess in battle, have generated a vast and radiant fame that circulates triumphantly across the entire earth. Furthermore, it declares that the enemies of this ruler, having been overpowered by his might in combat, are so haunted by the memory of his valor that they contemplate it even in the intervals of their dreams and are consequently seized with terror.)*

iv)BusinessInscriptions-Business or Mercantile Inscriptions record commercial, artisan, and guild activities, offering direct evidence of pre-medieval economic history. A premier example is the Mandasor Inscription (c. 436-473 CE) of Kumaragupta I, which documents the migration and activities of a guild of silk-weavers (*tantuvāya*). While framed within a royal *praśasti*, it uniquely praises the guild's skill, detailing their relocation from Lā?a to Mandasor, their prosperity, and their voluntary funding of a magnificent Sun temple. The famous verse extolling their self-woven silk—"clothing that rivals the moon's beams"—highlights artisan pride and commodity quality. Such inscriptions illuminate guild organization, long-distance trade, urban economies, and the socio-economic agency of non-state actors.Praise of self-made silk cloth found in Mandasor inscription of Kumara Gupta I. It is recorded there, -
Nārījanośriyamupaitinatāvadagrayā?
yāvannapa??amaya-vastra-yugānidhatte |
*(*Translation in English:*The verse states that a woman does not attain the foremost beauty or splendor until she adorns herself with pairs of garments made of silk. It presents an elegant, conditional praise, asserting that the highest degree of grace and radiance (śrī) is intrinsically linked to and enhanced by the wearing of fine silk cloth.)*

C. Based on 'Object-surface' or material used:
Inscriptions classified into various types based on the materials, onto which they are engraved, with each material offering distinct advantages and characteristics that influence the durability,

visibility, and purpose of the inscription. The choice of material often reflects the cultural context, technological capabilities, and intended function of the inscription, whether it be for permanent public display, religious purposes, or practical administrative use. Below are the different types of inscriptions categorized by material:

1. Cave Inscriptions:

Cave inscriptions represent some of the earliest forms of written communication, offering a glimpse into the lives, beliefs, and practices of ancient societies. Carved or painted on the walls of natural caves, these inscriptions often date back thousands of years and encompass a variety of purposes, from religious and ritualistic expressions to records of daily life and symbolic art. They are found across different regions of the world, including Europe, India, Africa, and the Americas, each reflecting the cultural and Historical contexts of their creators.

The content of cave inscriptions can range from simple symbols and marks to more elaborate scripts and pictorial representations. In some instances, they documented the deeds of rulers or the presence of travellers, acting as a form of territorial claim or commemorative record. The materials and techniques used, such as chiselling into rock or painting with natural pigments, contributed to the preservation of these inscriptions over millennia. As primary Historical sources, cave inscriptions provide valuable insights into early human societies, helping to bridge the gap between prehistoric art and the development of written language.

Example: The Gopika Cave Inscription Or Nāgārjuni Hill

Cave Inscription II of Anantavarman.

It highlights early Sanskrit use in royal records.

They provide insights into religious patronage and Jain

monastic life.

Time: 5th or 6th century CE.Language: Sanskrit. Script: Late Brāhmī.

2. Rock Inscriptions:

Rock inscriptions are carved or engraved texts found on natural rock surfaces or carved monuments, often serving as Historical records, religious declarations, or commemorative messages. These inscriptions, found worldwide,

date back to ancient civilizations such as those in India, Egypt, and Mesopotamia. Made using tools to chisel or etch the rock, they have endured over millennia, providing valuable insights into the cultural, social, and political aspects of their time. Notable examples include Emperor Ashoka's edicts in India, which spread Buddhist teachings, and the Rosetta Stone, which played a crucial role in deciphering Egyptian hieroglyphs.

Example: The Junagadh rock inscription of Rudradaman,

also known as the Girnar Rock inscription of Rudradaman.

Time: C. 150 A.D.Language: Sanskrit.Script: Brāhmī

3. Stone Slab Inscriptions:

Stone slab inscriptions are carved texts on flat stone surfaces, commonly used for official, religious, or commemorative purposes. These inscriptions often appear on memorials, temple walls, or tombstones, recording Historical events, legal decrees, dedications, or religious teachings. Ancient civilizations, such as those in India, Greece, and China, used stone slabs for their durability, ensuring the preservation of important messages over centuries. Techniques like chiselling or engraving were employed to inscribe texts, often in local scripts.

Example:Stone Slab Edict of Aśoka- Bairāt Inscription

(Select Inscription vol. I p. 77)

Time: C.273-32 B.C., Language-Prakrit,

Script- Brāhmī

4. Stone Pillar Inscriptions:

Stone pillar inscriptions are Historical records carved onto stone pillars, often used by ancient civilizations to commemorate significant events, rulers, laws, or religious edicts. These inscriptions, found in various cultures such as India, Egypt, and Greece, provide valuable insights into the political, social, and cultural aspects of the time. They serve

as enduring monuments, preserving important messages and decrees for posterity, and are vital sources for understanding ancient history and archaeology.

Example: Seven major pillaredicts of Aśoka:DelhiToprā Version.
(1st pillar edicts) (Select Inscription vol. I p. 53)
Language: Prakrit, Script: Brāhmī

5. Iron Pillar Inscriptions:

Iron pillar inscriptions are texts engraved on iron structures, often serving as Historical records or commemorative markers. One famous example is the Iron Pillar of Delhi, dating back to the Gupta period (around the 4th century CE). The inscription on this pillar is dedicated to King Chandragupta II, praising his military conquests and accomplishments. Such inscriptions offer insights into ancient metallurgy, history, and cultural achievements, reflecting the sophistication of early civilizations in ironwork and inscription techniques.
(Select Inscription vol. I p. 275)
Time: 5th Century A.D.
Language: Sanskrit, Script: Northern Brāhmī

6. Copperplate Inscriptions:

Copper plate inscriptions are ancient texts engraved on copper plates, commonly used in South and Southeast Asia to record grants, land transactions, royal edicts, and religious donations. These inscriptions date from as early as the 4th century CE and provide essential insights into the political, social, and economic history of the regions. Notable examples include the copper plates of the Maurya and Gupta empires in India, which reveal details about rulers, their policies, and the administrative practices of the time. These artifacts are crucial for understanding Historical narratives and the evolution of script and language in ancient societies.

Example: Nālandā copper plate inscription of Samudragupta (Select Inscription vol. I p. 260)
Time: 5th Century A.D.
Language: Sanskrit
Script: Northern Brāhmī

7. Inscriptions on Coin:

Inscriptions on coins are Engraving or markings that provide valuable information about the issuing authority, date, and purpose of the me. These inscriptions often include the name of the ruler, titles, religious symbols, and sometimes even slogans or motifs that reflect the culture and values of the time. Coins with inscriptions have been found in various ancient civilizations, such as Greek, Roman, Indian, and Chinese, serving as important artefacts for historians. They offer insights into economic practices, trade, political authority, and the artistic styles of different eras. The study of these inscriptions helps to understand the Historical context and societal structures of ancient societies.

Examples:

A) Silver coin-

Example: Silver coins of Azes I (Select Inscription vol. I p. 110)
Time: c.10-35A.D.
Language: Prakrit
Script: Kharo?ṭhī

B) Copper Coin-

Example: Copper coins of KujulaKadphises(Select Inscription vol. I p. 123)
Time: c.25-55 A.D.
Language: Prakrit
Script: Kharo?ṭhī

C. Gold coin-

Example: Gold coin of Wema Kadphises II (Select Inscription vol. I p. 124)
Time: c.55-75 A.D.
Language: Prakrit
Script: Kharo?ṭhī

8. Gold Plate Inscriptions:

Gold-plated inscriptions are Engravingfound on objects coated with a layer of gold, often used in jewelry, religious artifacts, or ceremonial items. These inscriptions typically convey messages of devotion, commemoration, or status, reflecting cultural beliefs and practices. They are valuable for understanding Historical art and craftsmanship.

Example: Maunggun Gold Plate Inscription (Select Inscription vol. I p. 462)
Time: 6th Century A.D.
Language: Pāli, Script: Southern Brāhmī

9. Stone Plaque Inscriptions:

A plaque is a flat, typically rectangular or square piece of material, often made of metal, stone, or wood, that bears an inscription, design, or image. Plaques are commonly used for commemorative purposes, such as memorials, dedications, or honors, and can be displayed on walls, monuments, or as standalone items.

Example: Mahāsthān Fragmentary stone plaque Inscription (Select Inscription vol. I p. 82)
Time: 3rd century B.C.
Language: Prakrit, Script: Brāhmī.

10. Casket Inscriptions:

Casket inscriptions are Engraving or writings found on decorative boxes or containers, often used to hold valuable items, relics, or personal mementos. These inscriptions typically include names, dates, dedications, or significant messages that reflect the cultural, religious, or personal significance of the casket. Common in various cultures, such as in ancient Egypt, where caskets held mummified remains, or in medieval Europe for keepsakes, these inscriptions provide insights into the customs, beliefs, and artistic styles of the time.

Example: Shinkot Steatite Casket Inscription of the time of Menander. (Select Inscription vol. I p. 102)
Time: c.115 B.C.-90 B.C.
Language: Prakrit
Script: Kharo?ṭhī

11. Tablet Inscriptions:

Tablet inscriptions are Engraving or writings found on flat, often rectangular, surfaces made of materials like clay, stone, or metal. These inscriptions serve various purposes, including recording Historical events, legal codes, religious texts, or administrative records. Prominent examples include the Babylonian clay tablets, which document laws such as the Code of Hammurabi, and the Rosetta Stone, which features multiple scripts. Tablet inscriptions are crucial for understanding ancient languages, cultures, and societal structures, providing valuable insights into the thoughts and practices of past civilizations.

Example: The Mathurā Votive Tablet of the time of sodasa (Select Inscription vol. I p. 118)
Time: A.D. 15
Language: Prakrit, Script: Brāhmī

12. Seal Inscription:

Seal inscriptions are Engravingfound on seals, which are small, often cylindrical objects made from materials like stone, metal, or clay, used to mark documents, goods, or property. These inscriptions typically include symbols, names, or motifs that represent the owner or issuing authority, serving as a form of identification or authentication. Seal inscriptions are significant in various ancient cultures, including Mesopotamia, the Indus Valley Civilization, and ancient Egypt, where they were used for administrative and trade purposes. They provide valuable insights into social hierarchies, trade networks, and cultural practices, contributing to our understanding of Historical governance and commerce.

Example: Bhitāri seal of Kumār Gupta II or III (Select Inscription vol. I p. 321)
Time: 5th -6th century A.D.
Language: Sanskrit,Script: Brāhmī.

13.Ivory Inscriptions:

Ivory inscriptions are Engravingfound on ivory objects, such as carvings, tablets, or decorative items. These inscriptions can include texts, symbols, or decorative motifs, often reflecting cultural, religious, or political significance. Common in various ancient civilizations, such as the Indus Valley, China, and Europe, ivory inscriptions are prized for their artistry and craftsmanship. They provide valuable insights into social practices, trade, and the aesthetic values of the cultures that produced them. Additionally, they serve as important artefacts for understanding Historical contexts and the use of ivory in art and daily life.

Example: Arslan Tash Ivory Inscription
Time: c.800 B.C. (Found in 1928 in Arslan Tash in Northern Syria)
Language: Aramaic Language
Script: Aramaic

14.Terracotta pot Inscriptions:

Terracotta pot inscriptions are Engraving or

markings foud on clay pots, often used in ancient cultures for storage, cooking, or ceremonial purposes. These inscriptions can include names, symbols, or decorative motifs, and they may serve various functions, such as identifying ownership, recording content, or denoting cultural or religious significance. Commonly found in archaeological sites from civilizations such as the Indus Valley, Greece, and ancient Rome, these inscriptions provide valuable insights into daily life, trade practices, and social customs.

Example: Terracotta pot Inscriptions of Han Dynasty found in Hunan Province

Time: c.206 B.C.-220 A.D., Language: Old Sanskrit

15. Image Inscriptions:

Image inscriptions are textual elements incorporated within visual art, such as paintings, sculptures, or photographs. They often provide context, interpretation, or commentary on the depicted subject, enhancing the viewer's understanding. Common in various cultures, image inscriptions can include titles, dates, quotes, or descriptions, merging visual and textual storytelling.

Example: Parkham Image Inscriptions

(Select Inscription vol. I p. 94)

Time: C. 150 B.C.

Script: Brāhmī

Conclusion:

Inscriptions play a crucial role in preserving the legacy of past civilizations. Each material's unique properties influenced the style, purpose, and longevity of the inscriptions, reflecting cultural and technological advancements. From the enduring cave and rock inscriptions that bridge the gap between prehistoric art and written language, to the detailed records found on metal objects and coins, these artifacts provide critical Historical data. They not only highlight the evolution of language and script but also demonstrate how ancient civilizations used inscriptions to preserve their legacies. The categorization of inscriptions serves as a valuable framework for understanding the varied expressions of early human societies, emphasizing the importance of material culture in the study of history and archaeology. Through continued research and preservation efforts, inscriptions remain vital resources for unravelling the complexities of ancient civilizations.

The methods used to create inscriptions vary depending on the material and the cultural context. Common techniques include carving and chiseling, etching,stamping and impressing,engraving. The study of inscriptions can be challenging due to the deterioration of materials over time, incomplete records, and undeciphered scripts. Factors such as weathering, vandalism, and the loss of context can complicate the interpretation of inscriptions.

There are so many types of Inscriptions found in India and world-wide, like as Gravestone Inscription, Memorial Inscription, Tombstone Inscription, Grave headstone Inscription, Ring Inscription, Brick Inscription, Bark Inscription, Bronze plate Inscription etc.Inscriptions are also classified based on importance like Minor or Mejor Inscription, based on dynasty, such as Maurya Inscription, Gupta Inscriptions etc. These Epigraphical sources for constructing Historical knowledge is highly needed.

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AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

A Pilot Study on the Chrono-nutritional Status of Adolescents of Budge Budge, West Bengal

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Date of Receipt: 25.05.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract

Technological advancements and globalization have significantly influenced dietary behaviors, contributing to the growing burden of chronic diseases in low- and middle-income countries like India. Adolescents, undergoing rapid physical and psychological changes, are particularly vulnerable to these shifts. This pilot study assessed the nutritional status of adolescents in public schools in Budge Budge, South 24 Parganas. Eighty-six adolescent students aged 10–18 years were selected through convenience sampling from two government schools. Assessment of chrononutritional status included reduced Morningness - Eveningness questionnaire (rMEQ), physical activity index questionnaire, anthropometric measurements and body composition analysis. Gender disparities were noted. 38.71% of adolescent girlsand 88.89% of boys were underweight, whereas 19.35% of girls were obese and 11.11% of boys were overweight.33.87% of girls were sedentary whereas only 16.67% of boys were sedentary. 16.67% of girls and 24.2% of boys were evening persons. These findings highlight the need for school-based nutrition interventions aimed at promoting healthy dietary behaviors and addressing gender-specific risks to improve adolescent health outcomes in India. Further studies with larger populations will potentially guide the development of health promotion strategies to prevent and treat chronic diseases based on an individual's chronotype.

Keywords: Chronotype, dietary pattern, macronutrient intake

1. Introduction

Chrono-nutrition, a rapidly evolving field of study, explores the intricate interplay between the timing of food intake, internal biological clocks of the body, and subsequent health outcomes [1]. The human body operates on a 24-hour cycle known as the circadian rhythm, which influences various physiological processes, including hormone secretion, metabolism, and sleep-wake patterns [1], [2]. This internal clock is orchestrated by a hierarchical circadian system, with the suprachiasmatic nucleus in the hypothalamus serving as the master pacemaker [3]. Peripheral clocks, located within various tissues and organs such as the gut, liver, endocrine organs, adipose tissue, and skeletal muscle, possess their own intrinsic biological rhythms but remain synchronized with the central circadian pacemaker in the suprachiasmatic nucleus [4]. The timing and regularity of eating habits are pivotal factors in determining the phase of these peripheral clocks. Predictable environmental factors, including light, temperature, diet, exercise, and noise, play a crucial role in maintaining a balanced circadian rhythm, thereby promoting optimal health [5]. Adolescence, a critical period of growth and development, is marked by significant hormonal and physiological changes, including alterations in circadian rhythms [6]. This age group often experiences lifestyle changes that can disrupt their internal clocks, such as irregular sleep schedules, increased social activities, and altered dietary habits [7]. Dietary habits of adolescents have shifted towards irregular eating patterns, frequent snacking, and increased consumption of processed foods, which are often coupled with decreased physical activity [5]. This misalignment between modern lifestyles and our

intrinsic circadian rhythms is thought to play a role in the rising prevalence of metabolic disorders, including obesity, type 2 diabetes, and cardiovascular disease. Emerging research suggests that aligning food intake with circadian rhythms could have profound implications for preventing and managing these conditions, especially in vulnerable populations like adolescents. The primary role of the circadian clock is to synchronize physiological processes with predictable environmental cues, thereby enabling organisms to anticipate and prepare for recurring events such as periods of food availability [1].There is a scarcity of data focusing on the chrono-nutritional status of adolescent students of Budge Budge, an industrial belt of the South 24 Parganas district of West Bengal.So, prior to starting the extensive research, this pilot study aims to assess the chrono-nutritional status of adolescents in Budge Budge.

2.Methodology

The study population consisted of 86 adolescents (62 girls and 24 boys), selected through convenience sampling from two public schools in Budge Budge. Minimum 10% of the planned sample projected for the larger parent study was included for the pilot study [8].Informed consent was secured from both the adolescent participants and their parents or legal guardians, emphasizing the voluntary nature of participation and the confidentiality of their data. This study was carried out in adherence to the Helsinki declaration and was approved by the Institutional Ethics Committee for Human Research of the University of Kalyani. Those subjects who have any chronic illness or any serious ailment or suffering from chronic diseases were excluded from this study.Data collection involved a multi-faceted approach, integrating questionnaires, anthropometric measurements, and body composition analysis.The Reduced Morningness-Eveningness Questionnaire (rMEQ) was utilized to assess the subjective chronotype of participants [9]. This questionnaire provides a continuous measure of an individual's preference for morning or evening activities, allowing for the classification of participants into distinct chronotypes [10]. Physical activity levels were evaluated using a validated physical activity index [11]. Body composition was assessed through direct measurements using a body fat analyzer. In addition to these primary measures, socio-demographic data, including age, sex, ethnicity, and socioeconomic status, were collected to account for potential confounding variables and to explore potential subgroup differences in the relationships between chronotype, physical activity, and body composition. SPSSversion 26.0 was used to analyze the data statistically.

3. Results& Discussion

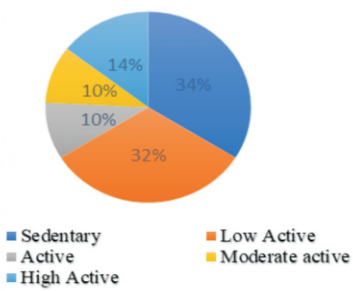
The evaluation of nutritional status in adolescent girls, utilizing BMI as a primary indicator, reveals a multifaceted landscape of undernutrition and overnutrition [12]. WHO growth reference data for 5-19 years was used for the classification of BMI standard [13].A significant proportion, specifically 39%, falls under the underweight category, indicating a potential deficiency in nutrient intake necessary for optimal growth and development [12]. Conversely, 37% of the adolescent girls exhibit a normal BMI, suggesting adequate nutritional status within this segment of the population [14]. However, it is crucial to acknowledge that a normal BMI does not necessarily equate to optimal health, as it does not account for micronutrient deficiencies or body composition [15]. Furthermore, the prevalence of overweight and obesity among adolescent girls is a growing concern, with 5% classified as overweight, 11% as obese class 1, and 8% as obese class 2. The coexistence of undernutrition and overnutrition within the same population underscores the complexity of nutritional challenges facing adolescent girls, necessitating targeted interventions that address both ends of the spectrum.

Socioeconomic factors, such as food insecurity, poverty, and limited access to healthcare, may also contribute to undernutrition in this population. Conversely, the rising rates of overweight and obesity among adolescent girls are likely driven by sedentary lifestyles, increased consumption of energy-dense foods, and marketing of unhealthy food products.

Table 1: Average of quantitative variables

Variables	Girls (N=62) Mean ±SD	Boys (N=24) Mean ±SD
Age (Years)	14.95 ± 1.58	12.56 ±1.24
Weight (Kg)	48.32 ±12.82	40.2 ±7.01
Height (cm)	152.74 ± 5.77	154.1 ± 9.95
Body Mass Index (Kg/m^2)	20.63 ± 4.98	16.96 ± 2.95
Whole body fat (%)	24.53 ± 5.39	14.7 ± 3.99
Resting Metabolism (Kcal/day)	1103.69±183.53	1181.33 ± 94.30

Fig 1: Percentage distribution of activity levelamong adolescent girls



The distribution of activity levels within adolescent girls reveals a multifaceted spectrum of engagement in physical exertion, highlighting the diverse lifestyle choices and physiological capacities present. A significant portion, 34%, is classified as sedentary, indicating a predominant lack of physical activity integration into their daily routines, potentially leading to various health concerns associated with inactivity [16]. A smaller segment, 14%, is identified as highly active, suggesting a consistent and vigorous commitment to physical exercise and movement, which likely contributes to enhanced cardiovascular health, musculoskeletal strength, and overall well-being [17]. The low active group constitutes 32% of the population, representing individuals who engage in some physical activity but not at a sufficient intensity or duration to meet recommended guidelines for optimal health benefits; this group may benefit from targeted interventions to increase their activity levels. The 10% of adolescent girlsare categorized as physically active, who experiences some health benefits from their activity but could further enhance their well-being through increased intensity or frequency of exercise.

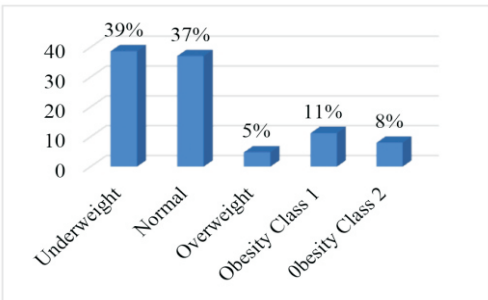


Table 2: The percentage distribution of chronotypes as determined by the rMEQ

Chronotype	Girls (%)	Boys (%)
Morning Person	12.9	16.67
Intermediate Person	62.9	66.67
Evening Person	24.2	16.67

Fig 2: Nutritional status of adolescent girls based on BMI

The distribution of chronotypes within the studied population, as determined by the rMEQ, reveals a heterogeneous composition characterized by varying degrees of preference for morning or evening activity patterns. 13% of the population is identified as morning persons, demonstrating a tendency to exhibit peak alertness and activity levels during the early hours of the day, aligning with the typical societal work and school schedules [9]. 24% of the population identifies as evening persons, exhibiting a proclivity for heightened cognitive and physical performance during the later hours of the day, often resulting in a misalignment with conventional daytime routines [6]. The largest segment of the population, comprising 62%, falls into the intermediate category, representing individuals whose circadian rhythms do not strongly favor either morning or evening activity,allowing for greater flexibility in adapting

to different schedules [18]. This distribution underscores the inherent biological variability in human circadian rhythms, highlighting the importance of considering individual chronotypes in various contexts, such as optimizing work schedules, educational practices, and therapeutic interventions [19].

Analysis of variance (ANOVA) was employed to investigate the potential relationship between an individual's chronotype, as measured by the rMEQ, and their whole body fat percentage [20]. The statistical analysis yielded a p-value of 0.76, indicating a lack of statistically significant association between these two variables [21]. The result suggests that an individual's preference for morningness or eveningness is not a significant predictor of their overall body fat composition. While previous research has indicated that circadian rhythm disruptions can impact metabolic processes and energy balance [21], our findings suggest that the specific manifestation of chronotype, as a continuum of morningness to eveningness, does not exert a discernible influence on whole body fat percentage within the studied population. This non-significant association may be attributed to various factors, including the complex interplay of genetic, environmental, and lifestyle factors that influence body composition.

Furthermore, it is plausible that the impact of chronotype on body fat percentage is mediated by other variables, such as sleep duration, meal timing, and physical activity patterns. These factors, which were not directly assessed in this analysis, may interact with chronotype to influence metabolic processes and ultimately affect body fataccumulation.It is important to acknowledge that the lack of a significant finding does not necessarily negate the potential for a clinically relevant association between these two variables [22].The exploratory findings could be studied on a larger sample for confirmative statistics. Chrono-nutrition patterns or timing of food consumptions, sleep and dietary patternof participants might be examined in the extensive research.

4. Conclusion

A key limitation of our study is the use of whole body fat percentage as the sole measure of body composition. This metric provides a general assessment of overall adiposity, but fails to capture the regional distribution of fat, which may be more strongly associated with chronotype. Visceral fat, located around the internal organs, has been strongly linked to metabolic dysfunction and may be particularly influenced by disruptions in circadian rhythms. Examining the relationship between chronotype and regional fat depots, such as visceral and subcutaneous fat, could yield more nuanced and informative insights into the connection between circadian biology and body composition. Therefore, future studies should consider employing more advanced techniquesto assess regional fat distribution and elucidate the potential relationship between chronotype and specific fat depots.

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AJHMC
ISSN : 0973-6212

Volume : 13 No. 1 & 2
February. 2026

Temporal Dimensions of Digital Screen Exposure: Ramifications for Psycho-cognitive Functioning Among Male Office Employees of Corporate Sector

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Date of Receipt: 23.05.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Abstract

The proliferation of digital technology in contemporary corporate environments has significantly altered workplace dynamics, necessitating a comprehensive investigation into the relationship between screen exposure time and employee well-being. This Ergonomic study examined the effects of prolonged digital screen use on both mental health outcomes and cognitive performance metrics among 400 male office workers (aged between 25 to 65 years) across four corporate sectors of West Bengal. Data were collected through anonymous random sampling. Mental health status was evaluated using General Health Questionnaire 12 (GHQ-12) and Depression Anxiety Stress Scale 21 (DASS-21), while cognitive function assessment employed standardized measures including the ruler drop test for reaction time and single letter cancellation test for attention and visuospatial processing capabilities of office workers. Study revealed that prolonged screen exposure time (SET) exhibited robust affirmative associations with elevated psychological distress indices, manifestations of mental stress, anxious symptomatology, and depressive indicators. Neurocognitive evaluations revealed that augmented periods of visual interface interaction corresponded significantly with compromised response latency and attentional capacity among office workers. These findings contribute to the emerging body of occupational health literature by elucidating specific thresholds at which digital exposure becomes detrimental to worker well-being and productivity, thereby informing evidence-based workplace policies and ergonomic interventions designed to optimize both employee health and organizational performance.

Key words: Screen exposure time (SET), Mental health, Cognitive function, Office workers

1. Introduction

The widespread incorporation of digital technology in modern workplaces has significantly reshaped corporate practices. Office employees now experience prolonged screen exposure, averaging 6–8 hours daily across digital platforms [1]. This screen-centered work pattern raises concerns about potential psycho-cognitive effects, particularly among male office workers, a major segment of the corporate workforce [2].

Digital screen exposure involves engagement with various devices, such as desktop computers, laptops, tablets, and smartphones, which emit differing levels of blue light and demand continuous visual and cognitive effort [3]. Key temporal factors—including duration, frequency, timing, and long-term exposure—serve as important determinants of potential psycho-cognitive outcomes [4]. Although technological progress has substantially improved workplace productivity, growing evidence indicates that extended screen use may adversely affect multiple psycho-cognitive functions [5].

Technological reliance, along with increasing job demands and expectations of continuous digital availability, has normalized prolonged screen exposure [6], [7]. Organizational cultures that emphasize long working hours and constant accessibility further reinforce this trend [8]. Male employees may experience specific psycho-cognitive effects of screen use, as evidence suggests

gender-based differences in technology use, stress responses, and expressions of psychological distress [9].

Although awareness of screen-related health effects has increased, research addressing the temporal aspects of digital screen exposure among male corporate employees remains scarce. Most existing studies have concentrated on children, adolescents, or general adult populations, [10], with limited emphasis on occupational settings and gender-specific factors. Additionally, the predominance of cross-sectional designs restricts the ability to establish causal inferences and assess temporal patterns [11].

The present study aims to explore research gaps by examining the association between the duration of digital screen exposure and psycho-cognitive functioning among male corporate office employees. Given their high occupational reliance on digital devices and distinct technology use patterns, this group warrants focused analysis. The study seeks to identify exposure thresholds that may impair optimal functioning and to guide evidence-based workplace policies and interventions.

2. Methodology

2.1. Study concepts and participants

The research involved 400 male office workers aged 25-65 from four corporate sectors in West Bengal. Participants worked standard daytime hours at computer workstations for minimum 7 hours daily, five days weekly. The study excluded shift workers, manual labourers, and those with less than one year experience. Selection employed randomized, anonymous methods, excluding individuals with chronic or hereditary conditions. Research materials were provided in English with Bengali and Hindi translations. The study protocol complied with Helsinki Declaration guidelines and received approval from the University of Kalyani's Institutional Ethics Committee for Human Research.

2.2. Evaluation of Demographic Data and Screen Exposure Time

Participants completed a structured interview after providing informed consent. The interview gathered demographic data (age, residence, marital status, parental status, employment duration) and health behaviours (alcohol use, smoking, medical history, medications). Screen exposure information was collected, including daily usage time across devices (phones, televisions, computers) and technical specifications such as display size, resolution, and font preferences.

2.3. Evaluation of psycho-cognitive wellbeing

i. The General Health Questionnaire-12 (GHQ-12), developed by Goldberg (1972) [12], a concise instrument comprising twelve items, was employed to evaluate the overall mental well-being and detect prevalent non-psychotic psychological disturbances among office workers.

ii. Depression Anxiety Stress Scale: The Depression Anxiety Stress Scale (DASS-21), developed by Lovibond and Lovibond (1995) [13], was administered to assess occupational stress, anxiety, and depressive symptoms among corporate employees. Results derived from questionnaire responses was utilized to evaluate the intensity of psychological distress exhibited within this population.

iii. The Single Letter Cancellation Test (SLCT) [14] was administered to evaluate vigilance levels, arousal states, and motivational factors among office workers through a task requiring visual identification and elimination of designated letters within a character matrix. The analytical procedure incorporated both the frequency of errors and the quantity of omitted letters.

iv. The measurement of office personnel's response latency to stimuli, defined as reaction time, was conducted utilizing the ruler drop test [15].

2.4. Statistical analysis

The mental health metrics and cognitive information were expressed as mean values with corresponding standard deviations, and as percentages where appropriate. Analyses were conducted to determine potential correlations between various parameters, followed by multiple

linear regression analysis. Relationships between different variables were evaluated using Spearman's correlation coefficient. Regression relationships were subsequently represented using standardized coefficients (β) with their respective Standard Errors (SE). Statistical significance was established at $p<0.05$ or below for all analyses. The statistical computations were performed using SPSS software (Version 26.0, SPSS Inc., Chicago, IL).

3. Results

The present study comprised 400 male office workers (mean age: 33.25 ± 7.16 years; mean job experience: 8.87 ± 5.98 years). Three-quarters were married and had children. Most participants were smokers (82%) and 65% consumed alcohol.

Our observational study examined digital screen exposure among office workers across three device categories. Office workstations predominantly featured Full HD (1920×1080) and WUXGA (1920×1200) monitors ranging from 19-27 inches, with 24-inch displays being most prevalent. Text was typically rendered at 9-22 point font sizes, with many users adopting dual-monitor or ultrawide configurations to enhance productivity. Mobile device analysis revealed Android phones averaging 5.5-6.7 inch screens and iPhones measuring 6.2-6.3 inches, both commonly displaying Full HD+ resolution (approximately 1080×2400 pixels) with default body text sized between 14-17 scale-independent pixels. Television exposure was minimal among office personnel, primarily involving LED and Smart TV technologies.

[Figure 1 near here]

The analysis indicates significant screen time ($p<0.05$) on mobile phones and desktop computers during working days, with mobile phone usage remaining consistently high during non-working days.

[Figure 2 near here]

Office personnel were classified into three groups based on cumulative SET duration: minimal i.e. Group A (59.25% of workers) with less than 4 hours of daily screen exposure, moderate Group B (33.75%) with 4-8 hours of exposure, and extensive Group C (7%) with more than 8 hours of daily screen exposure as shown in Figure 2.

Comparative analyses were then performed across these three categories of office workers.

[Figure 3 near here]

Group A, Group B, and Group C showed varying patterns of normal, mild, moderate, and severe distress levels. Group A demonstrates the highest proportion of mild distress, while Group C exhibits the greatest prevalence of severe distress. The data illustrates a potential association between increased screen exposure duration and elevated psychological distress severity among office personnel.

[Figure 4 near here]

Depression severity was assessed using DASS 21 scale with categories ranging from Normal to Extremely Severe. Group A showed predominantly normal depression levels, while Group C demonstrated a marked increase in extremely severe depression. Group B exhibited an intermediate pattern with the highest proportion of moderate depression. The data suggested a positive correlation between prolonged screen exposure and depression severity among office personnel.

[Figure 5 near here]

Analysis predominance of anxiety severity showed that Group A exhibited predominantly normal anxiety levels, while Group C showed a substantial increase in extremely severe anxiety. Group B demonstrated an intermediate distribution with the highest proportion of moderate anxiety. The findings indicate a progressive increase in anxiety severity with prolonged screen exposure duration among office workers.

[Figure 6 near here]

Severity of stress among office workers stratified by Screen Exposure Time (SET) duration where Group A demonstrated predominantly normal stress levels, while Group C exhibited a substantial proportion of extremely severe stress. Group B showed an intermediate pattern with the highest prevalence of moderate stress. The results reveal a clear dose-response relationship between increased screen exposure duration and stress severity among office personnel.

[Figure 7 near here]

Result depicted that Group A showed the fastest

median reaction time whereas, Group B demonstrated intermediate performance, and Group C exhibited the slowest median reaction time. The box plots display quartiles, median values (horizontal lines), means (×), and outliers (individual points). Here, Group C showed the greatest variability in reaction times with several outliers. The data suggested a progressive decline in cognitive performance with increased screen exposure duration among office personnel.

[Figure 8 near here]

Similarly, in **Figure 8** Group A showed several outliers with higher error rates, while Group C demonstrated the greatest variability in error frequency. The data indicated a progressive increase in cognitive errors with prolonged screen exposure duration among office personnel.

[Figure 9 near here]

All groups show some degree of variability with outliers present, particularly in Groups A and B. The data reveals a progressive increase in attention-related omissions with prolonged screen exposure duration among office personnel.

[Table 1 near here]

All measured parameters including Depression Score, Anxiety Score, Stress Score, GHQ-12 Score, Reaction Time (sec), Errors, and Omissions showed statistically significant differences between groups ($p<0.001$). Progressive deterioration in psychological well-being and cognitive performance was observed with increasing screen exposure duration.

[Table 2 near here]

All psycho-cognitive parameters showed statistically significant positive associations with screen exposure duration. Depression score demonstrated the strongest association, followed by anxiety score and stress score. Cognitive performance measures including reaction time, number of errors, and number of omissions also showed significant deterioration with increased screen exposure. The results indicate that prolonged screen exposure is a significant predictor of adverse psycho-cognitive outcomes in office workers.

Discussion

The present study provides compelling evidence for a dose-response relationship between digital screen exposure time and deteriorating psycho-cognitive parameters among office workers. These findings align with the growing body of literature documenting the adverse effects of prolonged digital device usage on mental health and cognitive performance in occupational settings.

The observed progressive increase in psychological distress across screen exposure groups corroborates previous research by Thomée et al. (2011) [16], who demonstrated significant associations between intensive computer and mobile phone use and mental health symptoms in young adults. Similarly, our findings are consistent with the longitudinal study by Saunders and Vallance (2017) [17], which identified screen time as a significant predictor of psychological distress in working populations. The particularly pronounced effects observed in Group C (>8 hours daily exposure) support the threshold hypothesis proposed by Madhav et al. (2017) [18], suggesting that excessive screen time beyond 6-8 hours daily may trigger cascading psychological deterioration.

The escalating severity of depression, anxiety, and stress symptoms with increased screen exposure duration reflects the multifaceted impact of digital technology on mental health. These findings parallel the systematic review by Lissak (2018) [19], which highlighted the bidirectional relationship between screen time and mental health disorders. The neurobiological mechanisms underlying these associations may involve dysregulation of neurotransmitter systems, particularly dopamine and serotonin pathways, as suggested by research on digital addiction and mood disorders [20]. Furthermore, the chronic activation of the hypothalamic-pituitary-adrenal axis due to prolonged screen-based cognitive demands may contribute to the observed stress-related symptoms [21].

The cognitive performance deficits observed across reaction time, error rates, and attention-related omissions provide empirical support for the cognitive load theory in digital environments. These findings resonate with the research by Ralph et al. (2014) [22], who documented similar patterns of cognitive deterioration among information workers

exposed to prolonged computer-based tasks. The increased reaction times and error rates observed in high-exposure groups may reflect the cumulative effects of mental fatigue, visual strain, and reduced cognitive flexibility associated with sustained digital device interaction [23].

The attention-related deficits, particularly the increase in omission errors, align with research on continuous partial attention syndrome described by Firat (2013) [24]. Prolonged exposure to multiple digital interfaces may compromise selective attention mechanisms, leading to reduced vigilance and increased susceptibility to attention lapses. These cognitive impairments have significant implications for workplace productivity and safety, particularly in occupations requiring sustained attention and rapid decision-making capabilities.

The occupational health implications of these findings are substantial. The high prevalence of workers in the moderate and extensive exposure categories (40.75% combined) suggests that a significant proportion of the modern workforce may be at risk for screen-related psycho-cognitive impairments. These findings support the implementation of workplace interventions targeting digital wellness, including regular screen breaks, ergonomic adjustments, and digital detox periods as recommended by the American Optometric Association (2017) [25].

From a public health perspective, these results contribute to the emerging understanding of technology-related health risks in the digital age. The dose-response relationship identified in this study provides valuable insights for developing evidence-based guidelines for healthy screen use in occupational settings. The findings also highlight the need for comprehensive workplace mental health programs that address technology-related stressors alongside traditional occupational hazards.

Conclusion

The findings of the present ergonomic study provide robust empirical evidence of a statistically significant and graded dose–response association between cumulative digital screen exposure duration and adverse psycho-cognitive outcomes among office workers, whereby incremental increases in daily screen exposure were consistently linked with progressive elevations in psychological distress and concomitant deterioration in cognitive performance indices, including reaction time, error frequency, and attention-related omissions.These findings underscore the urgent need for evidence-based workplace interventions targeting digital wellness. Organizations should implement comprehensive strategies including regular screen breaks, ergonomic modifications, and digital detox protocols to mitigate technology-related health risks and preserve employee psychological well-being and cognitive performance in increasingly digitized work environments.

Acknowledgements

This research work was supported by Swami Vivekananda Merit cum Means (SVMCM) Scholarship (ID: WBP211640331770) and Personal Research Grant (PRG), the University of Kalyani provided to AB and SS respectively

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Figures and Tables

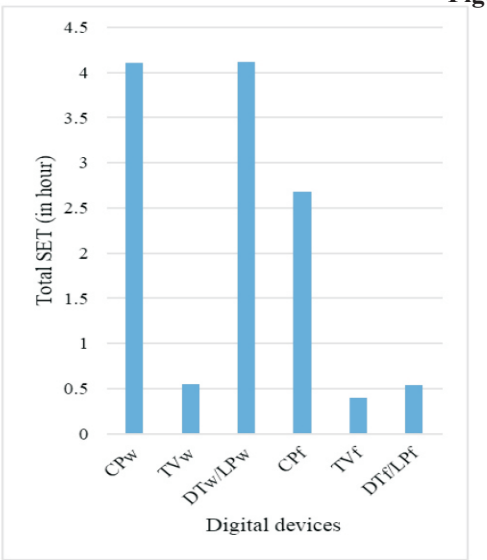

Figure 1 Average daily screen exposure time across various digital devices for office workers on both workdays and non-workdays

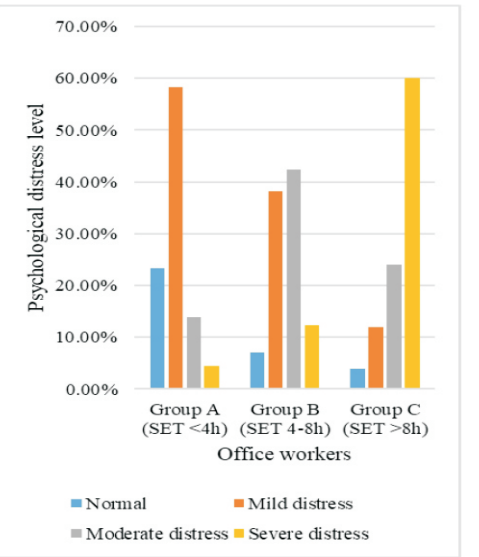

Figure 3 Percentage distribution of psychological distress levels among office workers categorized by SET

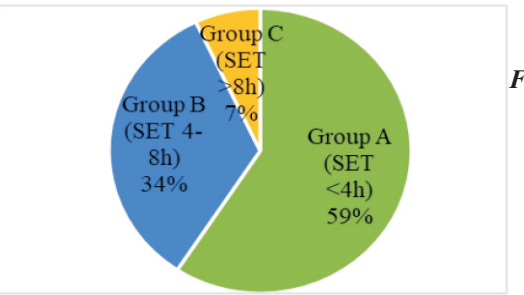

Figure 2 Distribution of office personnel by daily screen exposure time (SET) duration

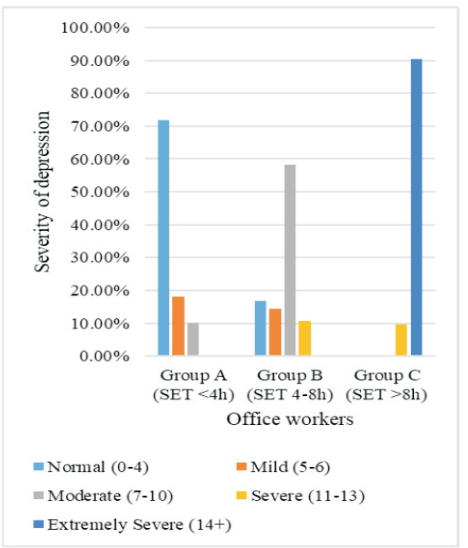

Figure 4 Percentage distribution of severity of depression among office workers categorized by SET

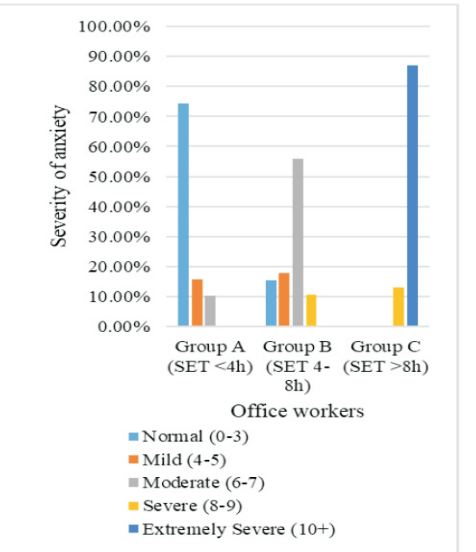

Figure 5 Percentage distribution of severity of anxiety among office workers categorized by SET

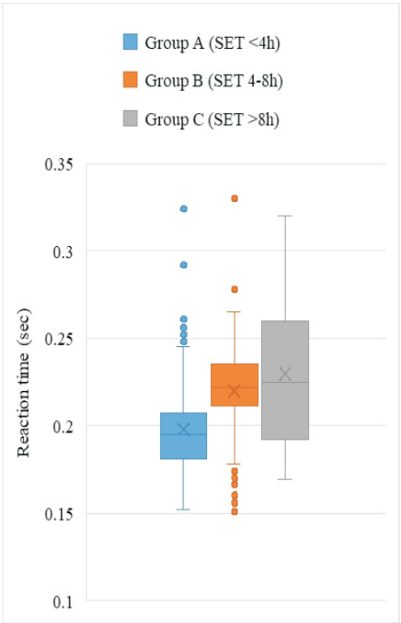

Figure 7 Box plot comparison of reaction time across office workers categorized by SET

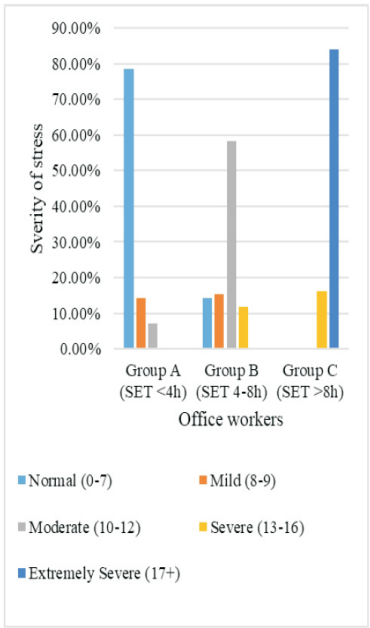

Figure 6 Percentage distribution of severity of stress among office workers categorized by SET

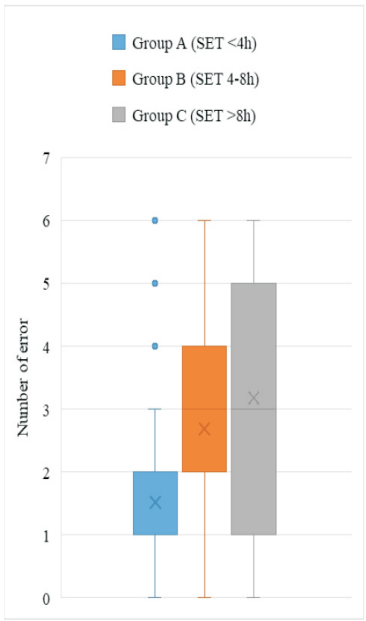

Figure 8 Box plot comparison of number of errors across office workers categorized by SET

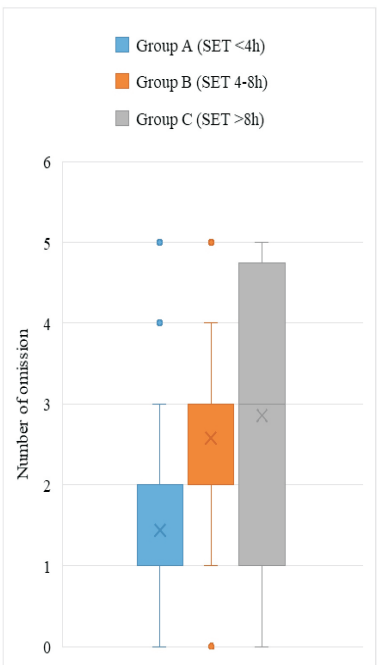

Figure 9 Box plot comparison of number of omissions across office workers categorized by SET

Table 2 Linear Regression Analysis to determine the effect of SET on Psycho-cognitive Parameters of Office workers

Psycho-cognitive Parameters	β±SE	T value	95% CI for β
Depression score	1.87±0.03	48.03	1.80 to 1.95
Anxiety Score	0.45±0	48.64	0.43 to 0.47
Stress Score	0.43±0.01	43.52	0.41 to 0.45
Psychological distress score	0.13±0.01	10.28	0.11 to 0.16
Reaction time	43.33±4.43	9.77	34.61 to 52.05
Number of errors	0.82±0.08	9.62	0.65 to 1
Number of omission	0.90±0.09	9.65	0.71 to 1.08

The table presents standardized regressior coefficients (β±SE), t-values, and 95% confidence intervals for β.

Table 1 Comparison of psycho-cognitive parameters across office workers categorized by SET

Psycho-cognitive parameters	Group A (SET <4h)	Group B (SET 4-8h)	Group C (SET >8h)	P value	Significance level
Depression Score	4.85±2.97	14.01±3.28	20.42±0.82	p<0.001	S
Anxiety Score	4.6±2.97	13.75±3.33	20.17±0.88	p<0.001	S
Stress Score	5.18±3.10	14.65±3.57	20.57±0.77	p<0.001	S
GHQ-12 Score	17.14±9.79	25.4±6.72	26.28±12.69	p<0.001	S
Reaction Time (sec)	0.19±0.02	0.21±0.02	0.22±0.03	p<0.001	S
Errors	1.51±1.34	2.68±1.41	3.17±2.08	p<0.001	S
Omissions	1.43±1.23	2.57±1.33	2.85±1.76	p<0.001	S

Data presented as mean ± standard deviation. Significance level: S = Significant (p<0.001)

AJHMC
ISSN : 0973-6212
Volume : 13 No. 1 & 2
February. 2026

Heavy Eye Syndrome: Case Report of A Patient And Discussion Related to It!

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Date of Receipt: 31.05.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

Introduction:'Heavy Eye' syndrome (HES) is a cause of acquired esotropia in high myopia. (8). Heavy eye syndrome, myopic strabismus fixus, and convergent strabismus fixus interchangeable terms.HES presents with a progressive, usually large-angle esotropia and hypotropia causing limited abduction and supraduction (10) It is not seen in childhood. Patients typically have high myopia of -18.00D or more. Some may present with concerns about appearance of the eye. (8)The older and more myopic the patient,more likely the patient will have an acquired esotropia. (8)Main differential diagnosis is with "sagging eye syndrome (SES)" which is mostly seen in non-myopic elderly population and presents with esotropia worse at distance along with degenerative changes such as, bilateral blepharoptosis, and deepening of the lid sulci (6)

AIM: To assess the cause of heavy eye syndrome in a high myopic cataract patient. and to rehabilitate and document its treatment in a stepwise manner

Materials &methods: This was a retrospective study.A 68-year-old underprivileged female from a village in Hooghly district approached us with unaided vision right eye of counting fingers close to face, and left eye perception of light only with faulty perception of rays. Functional blindness prompted her to report to us.

On examination we found that both eyes had advanced cataract with severe abduction restriction in both eyes, esotropia andhypotropia (Fig 1)

Fig 1: Bilateral esotropia and hypotropia, with advanced cataract

She had a history of high myopic glasses. And her last spectacle power available was in right eye -20DS-1.5Dcyl ,and in left eye-20.0DS -2.0Cyl which were long discarded as her eyes slowly got squinted. She reported progressive esotropia with age as she graduated from college. Over the years severe squinting imposed social stigma, joblessness and extreme poverty inspite of her basic educational background.

The affected eyes were so tightly fixed in an esotropic and hypotropic position that movement of the eyes in any other direction was little. Fig 2 3

Fig 2: fixed in an esotropic and hypotropic position the movement of the eyes in any other direction was restricted

It was difficult evaluation due to movement restriction with no fundal view in any eye USG B scan showed posterior staphyloma in both eyes .Functionally blind she was taken for Right eye Small incision cataract surgery withposterior chamber intra ocular lens . Post operative vision recovery in right eye was 6/24, unaided improving to 6/18 with glasses . Her Left eye was also operated and she gained 6/36 vision . But she had a definitive head tilt with chin up and could not see in straight gaze .Fig 3

To rehabilitate her we planned Squint correction . Right eye squint surgery was done under peribulbar

anesthesia.The Superior rectus and lateral rectus muscles were exposed after fixing the globe. We avoided taking scleral bites due to thin sclera and inadvertent accidents.A Myopexy (Fig4) was done after splitting Superior Rectus (SR) and Lateral Rectus(LR)muscles . Superior Rectuswas split into lateral 2/3rd and medial 1/3rd .LateralRectus muscle was split into superior 1/3rd and inferior 2/3rd.Mersilk sutures are used to suture thesplit muscles from insertion to the equator as much was reachable.The overlying conjunctiva was stitched .

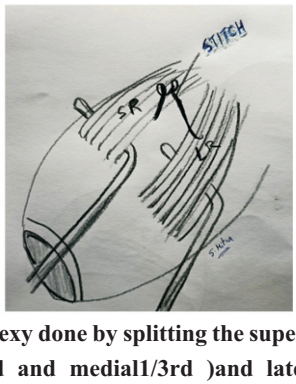

Fig 4 : Myopexy done by splitting the superior rectus (lateral 2/3rd and medial1/3rd)and lateral Rectus muscles (superior 1/3rd and inferior 2/3rd) and suturing them with Mersilk suture

Results: The patient regained a straight gaze without head tilt or chin lift. Fig 5

Fig 5: 1 month Post operative after Right eye squint surgery

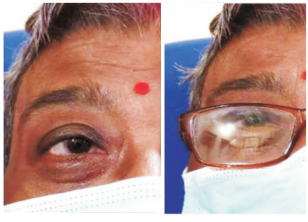

Fig 6: Picture after one year with straight gaze

After 1 year her vision in right eye was unaided 6/18, N6 with correction. With small angle esotropia stable for 1 year. She had straight gaze without head tilt or chin lift. (Fig 6)She was overjoyed and was actively reading, writing and socializing.

Discussion : Hypothesis: Heavy eye syndrome(HES)is result of Lateral Rectus(LR) and Superior Rectus(SR) shifts, by the elongated posterior portion of the eyeball in high myopia. Inferior shift of LR causes less abduction & more infraduction. Nasal shift of SR causes less supraduction & more adduction.So HES shows esodeviation and hypodeviation No definitive diagnostic criteria for HES (9)

Main differential diagnosis …. "sagging eye syndrome (SES)" in non-myopic elderly population with esotropia worse at distance along with bilateral blepharoptosis, deepening of the lid sulci (6).

Different approaches to correct HES tried with varying success. Yamaguchi et al. demonstrated the efficacy of loop myopexy±medial rectus recession (7)Akbari et al. modified this procedure by using two sutures for muscle belly union which resulted in favourable outcomes.(4)

In our case ignorance and poverty, delayedtreatment ,till the patient was functionally blind. First cataract surgery was done to restore vision . Phacoemulsification avoided as coaxiality was poor Myopexy between the lateral third of superior rectus and superior third of lateral rectus with Mersilk ,is simple , cost effective, avoids scleral puncture and gives satisfactory result to restore aesthetically acceptable result

Conclusion :Hence, we conclude that heavy eye syndrome from progressive myopia impacts the life and livelihood of the patient, more in remote districts of West Bengal due to absence of awareness or restricted medical attention. So progressive myopia screening and aggressive treatment is required in early childhood as in later stage of life, rehabilitation though possible is after a loss of many years of patient's normal life and livelihood. Modified Myopexy technique to correct heavy Eye Syndrome (HES) gave satisfactory results. It has not been reported from anywhere in India to the best of our knowledge.

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AJHMC
ISSN : 0973-6212

Volume : 13 No. 1 & 2
February. 2026

Nutritional Vulnerability and Dietary Inadequacies among Male Brick Manufacturing Workers of West Bengal: A Comprehensive Analysis

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Date of Receipt: 22.05.2025 **Date of Acceptance: 24.02.2026** **Date of Publication: 28.02.2026**

ABSTRACT

Brickfield workers are a nutritionally and socioeconomically vulnerable work group in India. A cross-sectional survey was conducted to evaluate and compare the nutritional status, dietary intake, food security and psychological status of local workers (LW, n=40) and migratory workers (MW, n=60) who were employed in brickfields in West Bengal. Data were collected through anthropometric measurements (height, weight, BMI, MUAC), blood pressure, 24-hour dietary report, and validated screening tools such as GAD-7, PHQ-9, and HFIAS questionnaire. The differences in various variables between LW and MW were studied using statistical analysis. MW were found to have lower height, weight, MUAC and BSA than the LW ($p<0.05$). Although the MW had higher median energy intake, neither group had sufficient intake of micronutrients especially calcium, iron, vitamin B_{12} and folate as compared to the recommended dietary allowances (RDA). Another finding showed MW experienced an increased level of food insecurity and moderate levels of psychological distress. The results showedthe co-occurrence of caloric adequacy and micronutrient deficiency (hidden hunger) and psychosocial vulnerability among migrant labourers. It is necessary to focus on reasonable, culturally specific dietary interventions and nutrition education to enhance their health outcomes.

Keywords: Migratory workers, Food insecurity, Micronutrient deficiencies, Hidden hunger, Mental health.

1.INTRODUCTION

India is the second highest manufacturer of brick in the world where more than 240 billion bricks are produced every year. There are over 150,000 brick kilns across the country that hire a workforce of above 8 million directly. There are around 10,000 brickfields
in West Bengal which have more than 1.5 million employees [1]. The heavy workloads, pollution,psychological stress, high physical activity, and other occupational health problems are frequently experienced by the workers at Brickfield [2]. The brick field workers in developing countries did heavy Manual Material Handling (MMH) activities, including pulling, pushing, carrying bricks, clay preparation, lifting, bending, stretching, drying, and burning bricks as the major processes in producing bricks [3]. Anthropometric assessment is important in determining the nutritional status, as it reveals the conditions like malnutrition, overweight, obesity, muscle wasting.Proper nutrition is essential for physical fitness and work load. Inadequate nutrition led to higher risk of malnutrition, health morbidities, fatigue, decreased work efficiency, diminished endurance, and productivity [4, 5]. Despite these challenges, limited evidence on the nutritional and psychological health condition of brick field workers in India is available. This paper aims tocomprehensively evaluate, criticallyanalyse and compare the nutritional and mental health of local and migratory male brickfield workers.

2.METHODOLOGY

1.1. Study Design and Participants

A cross-sectional study was done on 100 adult (18-60 years) male brickfield workers of brickfields in

Nadia district of West Bengal. Respondents have been divided into local workers (LW; n = 40) and migratory workers (MW; n = 60). A purposive sampling method was used to recruit participants because of the migratory and inaccessibility nature of this occupational population. People with chronic illnesses were the exclusion criteria. All subjects gave informed consent in written form. There were anonymity and confidentiality maintained.

1.2. Data Collection Tools

1.2.1. Questionnaire study

General health was assessed by using the Standardised General Health Questionnaire. Socio-economic status was determined using Modified Kuppuswamy Scale [6]. Mental health was evaluated by using Generalized Anxiety Disorder-7 (GAD-7) and Patient Health Questionnaire-9 (PHQ-9) [7]. Food insecurity was measured with Household Food Insecurity Access Scale (HFIAS) [8].

1.2.2. 24-hour dietary recall method

The 24-hour dietary recall method was used to assess nutrient intake of the participants thoroughly. It estimated their calorie, macronutrient and micronutrient intake based on the Indian Food Composition Table 2017 [9].

1.2.3. Physical parameters assessment

Height was measured using a standard anthropometric rod and weight with a calibrated weighing machine. MUAC was measured with a measuring tape [10].

1.2.4. Blood pressure measurement

A calibrated sphygmomanometer and stethoscopewere used to measure blood pressure [10].

1.3. Statistical analysis

The Kolmogorov-Smirnov test indicated non-normal distribution.To summarize the data, descriptive statistics (median, IQR, range) were used. For group comparisons, Mann-Whitney U test was performed.$p<0.05$ indicated statistically significant results. Correlations between variables were also assessed.

2. RESULTS & DISCUSSION

Most of the LW and MW belonged to the upper-lower socioeconomic group that demonstrated the common economic vulnerability among this population (Table 1).

Table 1: Socio- economic status of LW and MW.

Socio-economic class	Score Range	LW		MW	
		N	%	N	%
Upper	26 - 29	0	0	0	0
Upper Middle	16 - 25	0	0	0	0
Lower Middle	11 - 15	0	0	0	0
Upper Lower	5 - 10	36	90	55	91.7
Lower	<5	4	10	5	8.3

Table 2 showed detailed socio-demographic data, such as occupational profile, working hours, use of substances, income distribution and health morbidities. LW were older and had greater work experience. On the other hand, MW were younger and reported higher use of tobacco. Highermusculoskeletal problems and weakness were experienced by both the groups.

Table 2: Social and demographic profile of LW and MW.

Variables	LW		MW	
	N	%	N	%
Age (Years)	42.5 ± 18.5 (Median ± IQR)		29 ± 13.25 (Median ± IQR)	
Job Category				
Brick moulder	32	80	24	40
Brick carrier	2	5	36	60
Soil cutter	6	15	0	0
Other Occupation				
Mason	2	5	19	31.67
Construction Helper	5	12.5	11	18.33
Farmer	34	85	47	78.33
Toto Driver	2	5	0	0
Work	15.5 ±		5 ± 8	

Experience (Years)	14.75 (Median ± IQR)		(Median ± IQR)	
Work Duration				
< 10 hour/ day	15	37.5	26	43.33
> 10 hour/ day	25	62.5	34	56.67
Smoking status				
Smoker	31	77.5	22	36.67
Non-smoker	9	22.5	38	63.33
Alcohol Consumption				
Alcoholic	23	57.5	32	53.33
Non-alcoholic	17	42.5	28	46.67
Chewing Tobacco				
Yes	2	5	41	68.33
No	38	95	19	31.67
Marital Status				
Married	35	87.5	52	86.67
Unmarried	5	12.5	8	13.33
No. of Children in family				
0	1	2.5	17	28.33
1- 2	26	65	30	50
3- 5	13	32.5	12	20
6- 9	0	0	1	1.67
Monthly family income (Rupees)				
< 10,000	5	12.5	6	10
10,000- 20,000	26	65	44	73.33
> 20,000	9	22.5	10	16.67
Health problems				
Pain in hand	7	17.5	7	11.67
Pain in wrist	5	12.5	1	1.67
Pain in leg	12	30	14	23.33
Pain in upper back	1	2.5	0	0
Pain in lower back	4	10	9	15
Headache	0	0	1	1.67
Weakness	20	50	3	5
Dizziness	15	37.5	2	3.33
Cold	11	27.5	1	1.67
Indigestion	22	55	12	20

Anthropometric assessments showed significantly lower height, weight, BSA, and MUAC in MW compared to LW ($p < 0.05$), indicating poor nutritional status of the MW (Table 3). However, there was no significant difference in BMI and PI between the groups, suggesting that BMI alone might not adequately evaluate nutritional disparities. Systolic blood pressure was significantly higher among MW ($p<0.05$),reflecting occupational strain and psychosocial stress.

Table 3: presents data as median, IQR and range. Groups: Local Workers (n=40), Migratory Workers (n=60).

Variables	**LW**		**MW**		**Mann – Whitney U Value**	**Z-Score**	**p-value**	**Significance or not**
	Median ± IQR	**Range**	**Median ± IQR**	**Range**				
Height (cm)	162 ± 9.25	33	157 ± 6	27	785.5	-2.91	0.004	S
Weight (kg)	52.5 ± 8.5	33	50 ± 7.25	52	854.5	-2.43	0.01	S
BMI (kg/m²)	20.25 ± 2.86	10.39	19.78 ± 2.92	21.13	1009	-1.3	0.18	NS
BSA (m²)	1.59 ± 0.16	0.63	1.53 ± 0.12	0.64	783	-2.93	0.003	S
PI (kg/m³)	12.63 ± 1.49	7.11	12.62 ± 1.89	13.45	1133	-0.47	0.64	NS
MUAC (cm)	25.25 ± 3	10.5	23.5 ± 2.12	7.6	651.5	-3.85	0.0001	S
SBP (mmHg)	117 ± 13.25	136	121 ± 19	61	862.5	2.37	0.02	S
DBP (mmHg)	76.5 ± 9.25	44	78 ± 15.25	47	1131	0.48	0.63	NS

$p<0.05$: Statistically significant; S: Statistically Significant; NS: non-significant;BMI: Body Mass Index; BSA:Body Surface Area; PI: Ponderal Index; MUAC: Mid-Upper Arm Circumference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure.

Dietary analysis revealed significantly higher median energy and protein intake in MW than LW ($p < 0.05$)(Table 4). Significant differences were observed in consumption of calcium, phosphorus, zinc, and B-complex vitamins (B_1, B_3, B_9, and B_{12}) between the two groups. The comparative distribution of energy and macronutrient consumption was illustrated in Figure 1.

Despite MW consumed relatively adequate energy, there was considerable deficiencies in essential micronutrient consumptions in both groups. Calcium intake was markedly lower among MW ($p < 0.001$). Vitamin B_{12} consumption was critically low in both groups ($p < 0.001$) (Table 4). The overall pattern ofmicronutrient consumption was showed in Figure 2. These findings indicated a state of "hidden hunger" among the workers, where calorie intake was adequate but the diet lacked in essential micronutrients.

Figure 1: Energy & Macronutrient consumption among LW & MW

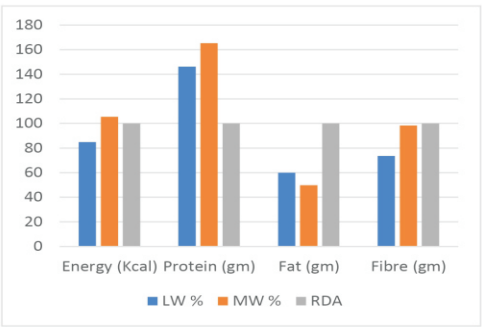

Figure 2: Micronutrient consumption among LW & MW

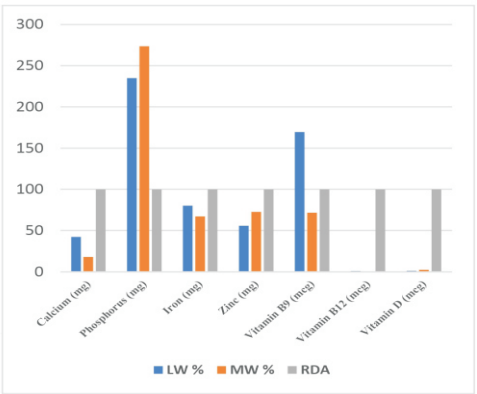

Table 4: Nutrient Consumption among LW and MW

Nutrients	LW			MW			Mann - Whitney U Value	p-value	Significance or not
	Median	IQR	RDA %	Median	IQR	RDA %			
Energy (Kcal)	2945.27	791.70	84.88	3662.27	896.43	105.5	346	< 0.0001	S
Protein (gm)	78.98	23.12	146.26	89.22	28.30	165.2	531	0.015	S
Fat (gm)	46.22	14.08	59.94	38.49	15.12	49.91	636	0.16	NS
Calcium (mg)	423.28	384.14	42.33	180.12	71.20	18.01	269	< 0.0001	S
Phosphorus (mg)	1409.25	406.78	234.87	1640.75	621.74	273.46	479	0.032	S
Iron (mg)	15.22	11.22	80.08	12.76	6.54	67.17	652	0.21	NS
Fibre (gm)	36.77	12.10	73.54	49.23	13.58	98.45	343	< .00001	S
Zinc (mg)	9.48	3.31	55.77	12.34	4.61	72.58	402	0.002	S
Vitamin B_3 (mg)	20.13	7.18	87.54	25.89	7.62	112.58	336	< .00001	S
Vitamin B_2 (mg)	0.69	0.41	21.65	0.70	0.24	22.01	744	0.73	NS
Vitamin B_1 (mg)	1.30	0.45	56.35	1.80	0.60	78.46	331.5	< .00001	S
Vitamin B_9 (mcg)	508.21	122 5.8	169.4	214.66	124.18	71.55	538	0.02	S
Vitamin C (mg)	77.19	89.36	96.49	86.74	39.88	108.4	728	0.62	NS
Vitamin D (mcg)	6.73	24.35	1.12	15.10	22.96	2.51	594	0.07	NS
Vitamin A (mcg)	126.03	962.11	12.6	163.51	198.91	16.35	775	0.97	NS
Vitamin B_{12} (mcg)	0.02	0.06	0.9	0	0	0	404	.0002	S

Mental health assessment showed MW experienced higher levels of moderate anxiety and depression compared to LW (Table 5). Food insecurity was prevalent in both groups. Mild to moderate food insecurity was more frequent among MW.

Table 5: Mental Health and Food Insecurity Level among LW and MW.

Variables	LW		MW	
	N	%	N	%
Anxiety Level				
Minimal Anxiety	12	30	25	41.67
Mild Anxiety	24	60	24	40
Moderate Anxiety	3	7.5	11	18.33
Severe Anxiety	1	2.5	0	0
Depression Level				
Minimal Depression	14	35	1	1.67
Mild Depression	26	65	45	75
Moderate Depression	0	0	14	23.33
Moderately Severe Depression	0	0	0	0
Severe Depression	0	0	0	0
Food Insecurity				
Food Secure	2	5	3	5
Mildly Food Insecure	30	75	48	80
Moderately Food Insecure	8	20	9	15
Severely Food Insecure	0	0	0	0
Dietary Diversity				
Low Diversity	0	0	1	1.67
Moderate Diversity	23	57.5	58	96.67
Good Diversity	17	42.5	1	1.67
Very High Diversity	0	0	0	0

The correlation analysis indicated strong positive correlations among anthropometric parameters and between energy and protein intake, whereas their associations with blood pressure variables were generally weak and not clinically substantial (Table 6).

Table 6: Correlation matrix of nutrition consumption with different physical parameters of the workers.

Variables	Age (Years)	Experience (Years)	Weight (Kg)	BMI (kg/m²)	BSA (m²)	MUAC (cm)	Energy Intake (Kcal)	Protein Intake (gm)	SBP (mmHg)
Experience (Years)	0.76								
Weight (Kg)	0.02	0.05							
BMI (kg/m²)	-0.08	-0.05	0.86						
BSA (m²)	0.07	0.10	0.95	0.67					
MUAC (cm)	0.10	0.15	0.68	0.49	0.71				
Energy Intake (Kcal)	-0.12	-0.04	0.004	0.05	-0.01	0.07			
Protein Intake (gm)	-0.11	0.00006	0.009	0.04	-7.29	0.08	0.99		
SBP (mmHg)	-0.20	-0.02	0.10	0.09	0.09	-0.02	0.02	-0.004	
DBP (mmHg)	0.06	-0.003	0.08	0.04	0.10	0.06	-0.03	-0.03	0.50

Similar literatures had documented chronic micronutrient deficiencies and nutrition insecurity among migrant labourers even with a sufficient caloric consumption [8; 11]. Poor and low-diversified diet, environmental pollution, exposure to extreme heat, and poor working environment were the factors for poor nutritional condition of the brickfield workers [12]. In addition, higher psychological vulnerability of migrant workers had been associated with poor economicand living conditions of migratory workers compared with locals[13]. The study highlighted a link between micronutrient deficiencies, food insecurity, and psychological distress, reflecting the multidimensional vulnerability of migratory male brickfield workers. These findings emphasized the need for integrated occupational health interventions to improve their dietary quality and provide psychological support.However, certain limitations remained in this study. Causal inference was precluded due to its cross-sectional design. The small sample size might limit generalizability. Dietary intake was assessed usingsingle 24-hour recall method without seasonal adjustment.

Moreover, the mental health and other associated conditions were evaluated based on the screening tools instead of diagnostic instruments which might affect the accuracy of classification.

4. CONCLUSION

This study revealed the substantial nutritional and health disparities in male brickfield workers in West Bengal, with migrant workers being more vulnerable compared to the local workers.Although their calorie intake was sufficient, their diets were poorly diversified and deficient in essential micronutrients. Migratory workers were more food insecure, anxious and depressed. Worse anthropometric indicators also pointed to a deteriorated nutritional condition. These results present the necessity of targeted interventions to enhance the quality of diet, food security, and mental health, particularly in migratory workers, with the help of culturally relevant education and mobile health services.

ACKNOWLEDGMENTS

The authors sincerely express their deepest gratitude to all participants for their invaluable contributions to this study.

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Manuscripts must align with the aims and scope of the journal. Submissions that fall outside the thematic focus may be rejected without external review.

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Language: All manuscripts must be submitted in English (UK/US consistency required).
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Font: Times New Roman, 12-point, double-spaced.
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The manuscript should typically include the following sections: Title Page (title, authors, affiliations, corresponding author contact)
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