

Routledge  
2020  
INDIA

Principal  
Pachhunga University College  
Aizawl : Mizoram



Coordinator  
Internal Quality Assurance  
Pachhunga University College  
A constituent college of Mizoram University

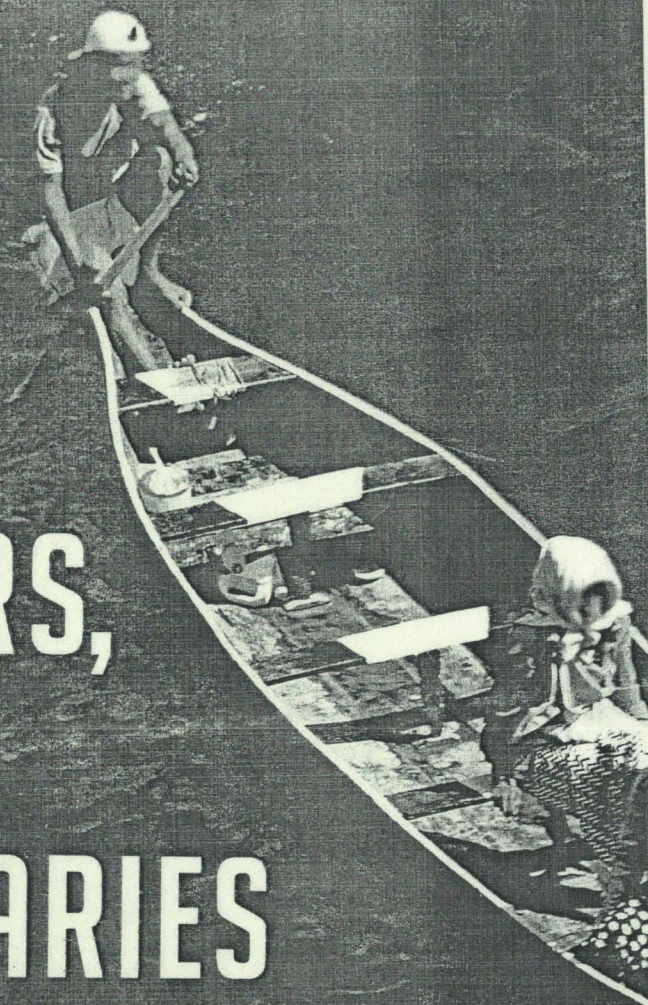
FIXED BORDERS,  
FLUID BOUNDARIES

Edited by  
Chandan Kumar Sharma  
and Reshmi Banerjee

# FIXED BORDERS, FLUID BOUNDARIES

Identity, Resources and Mobility  
in Northeast India

Edited by  
Chandan Kumar Sharma



an informa business

₹ 995

ISBN 978-0-367-67452-6

vi Contents

6 Ethnicity, immigration and conflict: the case of Bodoland Territorial Area Districts (BTAD) CIHNNITA BARUAH	81
7 "Outsiders" in Bodoland: categories of narratives and practice SABA SHARMA	97
8 Politics of land and citizenship in the Chittagong Hill Tracts of Bangladesh FARIBA ALAMGIR	111
PART 3 Borders and beyond	131
✓ 9 Accusations and belonging in the southwestern borderland of Mizoram N. WILLIAM SINGH	133
10 Ethnography in the Assam–Nagaland border: narratives of conflict PRAFULLA KR. NATH	150
11 Ambiguity, conflict and compliance: Myanmar's woes meet Northeast India RESHMI BANERJEE	170
12 Crossing over the Patkai mountains: ethnographic memoirs as ruptures and flows KAUSTUBH DEKA	188

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)

Glossary

200

201

  
Principal  
Pachhunga University College  
Aizawl : Mizoram

## Contributors

Fariba Alamgir is a postdoctoral research associate at the Centre for Development Studies, Department of Social and Policy Sciences, University of Bath, and an external associate at the School of International Development, University of East Anglia, UK. She holds a PhD in International Development from the University of Copenhagen and University of East Anglia. She has taught anthropology as a lecturer at University of Dhaka, Bangladesh. Her areas of research include politics of resource scarcity and access, property rights, governance and state formation, identity, marginalization and inequality in the context of people's struggles over rights and entitlements. She has also worked on environmental disaster, climate change, livelihood and health security issues focusing on understanding vulnerability and resilience of rural population.

Reshmi Banerjee is a political scientist based in London, UK, and is currently a visiting research fellow at the Institute of Social Sciences, New Delhi, India. She was previously an academic visitor at the Asian Studies Centre, St Antony's College (Oxford), a research associate at SOAS University of London, a postdoctoral fellow at the University of Indonesia and a researcher in the Indonesian Institute of Sciences (LIPI). She has been a visiting professor in Jamia Millia Islamia and a fellow in the Rajiv Gandhi Institute for Contemporary Studies and has taught at Delhi University and the University of Indonesia. She completed her MA, MPhil and PhD from the Centre for Political Studies, Jawaharlal Nehru University, New Delhi. With a specialization in food security, agricultural policies and cross-border studies on the Indo-Myanmar region, she is the author of *Land Conflicts across Frontiers: Contested Spaces in Myanmar and North East India* (2018), and has co-edited two books: *Gender, Poverty and Livelihood in the Eastern Himalayas* (2017) and *Climate Change in the Eastern Himalaya: Impact on Livelihoods, Growth and Poverty* (2015). She is currently pursuing another master's in museum cultures from Birkbeck, University of London.

Cihnnita Baruah is a doctoral research scholar at the Centre for the Study of Law and Governance, Jawaharlal Nehru University, New Delhi.

## 9 Accusations and belonging in the southwestern borderland of Mizoram

*N. William Singh*

On 13 April 2015, Amit Shah, the Bharatiya Janata Party (BJP) leader, visited Mizoram. During the visit, the Mizoram Zirlai Pawl (MZP) submitted a memorandum, which revealed the abnormal increase of Chakma population in the southwestern borderland of Mizoram. According to the students' body, population increase is due to the influx of illegal immigrants from Chittagong Hill Tracts (CHT), the border is porous and the unfinished project of border fencing escalated the influx.<sup>1</sup> The Chakma population figure in the memorandum is based on the registrar of headcounts<sup>2</sup> maintained by the MZP and the Young Mizo Association (YMA). The figures are not based on the figures as per the Census of India. The memorandum mentioned:

From 1901 till date, the Chakma population has increased by 44,004%, which is not a possible normal human reproduction. During the British rule, the Lushai hills (Mizoram) colonial administrators issued several orders – time after time – to control Chakma migrants in those orders.<sup>3</sup> During the second Census in 1911, there were 302 Chakmas in Mizoram. The population increased to 680 (225% growth) in 1921, then further to 836 (122.94% increase) in 1931. In the 1941 Census, their population skyrocketed to 5,088 (608% increase), then further to 15,297 (300.64% growth) in 1951. In 1961 Census, the figure rose to 19,327, and again to 22,392 in 1971, to 39,905 in 1981 and jumped to 80,000 in 1991. It is certain that they are roughly around 1,50,000. Mizoram has a little more than 10 lakhs [100,000] as per the 2011 Census. The population of Chakmas, who are not the indigenous people of Mizoram, has increased from a mere 198 in the first ever Census in 1901 to 80,000 in the 1991 Census”.<sup>4</sup>

The Mizo society claims that there is a big difference between the total number of Chakma population as per the official figures [Census 2001 and the Chakma Autonomous District Council (CADC) Demographic Registrar 2015] and the actual headcounts of Chakmas conducted by the Mizo civil society groups. The dominant society is of the opinion that the total number of the Chakma population is more than the official figures (Census 2001

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

# tidamtu rimawi



LALRAMMUANA SAILO

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

**tidamtu rimawi**  
**- Lalrammuana Sailo**

*Published by*  
 Mizoram Images Publication  
 D/V – 20. New Capital Road  
 Dinthar II, Aizawl.  
 Mizoram. Pin - 796001  
 email- mizoramimages@gmail.com

Publishing year : 2020

Price : 150

Copyright @ Mizoram Images Publication

Printed at:



Lois Bet  
 Print & Publication  
 Chanmari, Aizawl  
 Ph: 2349250/2349970

*Coordinator*  
 Internal Quality Assurance Cell  
 Pachhunga University College  
 (A constituent college of Mizoram University)

*tidamtu rimawi*

**A chhunga thu leh hlate**

I. Lawmthu	vii
II. Thuhmahruai	ix
III. Ka hla-hrilte	
1. Van zawl mawitu	2
Heaven's beautifier	
2. Khuangchawi thla	
October	
3. Chhawrthla	
Light of the world	
4. Nang leh mi dang	
You and others	
5. Beiseina	10
Hope	
6. Mi pe a	
You have given me	
7. Thuchah	
A message	
8. Khawhar in	
Mournful house	
9. Inthup	20
Concealed	
10. Sazu	
Rat	
11. Martar thlana mit tui	
12. Lawm a kim lo	
Incomplete happiness	
13. Pawnfen	32
Skirt	



*Principal*  
 Pachhunga University College  
 Aizawl : Mizoram

Lockdown Literature from Mizoram  
 Edited by Margaret L. Pachuau

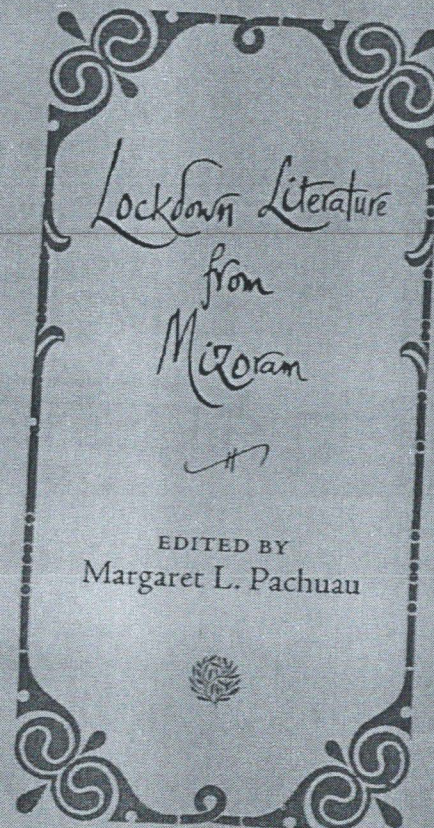
First edition: 2020

© respective authors, who assert their moral right to be  
 identified as the owner of their intellectual property.

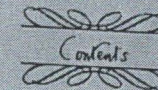
ISBN 978-81-949985-5-6

*Writers Workshop books are  
 published by Dr. Ananda Lal from  
 C-552 Lake Gardens, Calcutta 700045,  
 India. Layout and lettering by P. Lal  
 with a Sheaffer calligraphy pen.  
 Printed by Abhijit Nath at 128  
 Lake Gardens, Calcutta 700045.  
 This is a limited edition. Gold-  
 embossed, hand-stitched, hand-posted  
 & hand-bound by Talamiah Mohiuddin  
 with handloom saree cloth & wire  
 & designed in India, to provide  
 visual beauty & the intimate  
 texture of book-feel. WW bindings  
 are not concealed behind ephemeral  
 glossy jackets. Each WW publication  
 is a hand-crafted artifact.*

*www.writersworkshopindia.co*



EDITED BY  
 Margaret L. Pachuau



## Contents

AFRA LALAWMPUII  
 Siren Silenced / 11

GIDEON LALMUANPUIA  
 A Good Life / 12  
 Playing God / 13  
 Life's Lesson / 14  
 When Nations Dorth Fall / 15  
 Parasite Eve / 16

HANNAH LALILANPUH  
 Touch-Me-Not / 17  
 Behind Locked Doors / 18  
 Reevaluation / 19

HENRY LALMAWIZUALA  
 Confined, secluded and isolated / 20  
 Pandemic Jam / 22  
 One day / 23

JANE MARY JOSEPH  
 Silence / 24  
 The Reclamation / 26

JANET LAWMSANGZUALI  
 The Leveller / 27  
 Walls / 28  
 The Virus King / 28



**Coordinator**  
 Internal Quality Assurance Cell  
 Pachhunga University College  
 (A constituent college of Mizoram University)



**Principal**  
 Pachhunga University College  
 Aizawl : Mizoram

## HENRY LALMAWIZUALA

*Confined, secluded and isolated**Confined, secluded and isolated.*

Privacy warranted and solitude guaranteed.  
 Leisure served with endless time at our disposal.  
 The mind is at unrest, volatile and alarmingly sensitive.  
 News delivered at a damning pace  
 Through emerging pundits and overnight experts.  
 Plagiarized contents consumed wholeheartedly.  
 Social hotspots transformed into picturesque evanescence,  
 A canvas for the untrained eye.  
 Normality now a distant dream, thrown over the horizon, swept  
 under the rug.  
 Nature reclaims. Nature heals.  
 Humanity endures, shocked, livid, resilient.  
 Nations are shaken, big and small, as the unseen enemy strikes.

*Confined, secluded and isolated.*

Homegrown remedies and traditional sages,  
 Interspersed with specificity claimed,  
 Over hatted research and forced opinions.  
 Outrageous claims and unwarranted suppositions,  
 Mantras to stop the invading opposition!  
 Theories are propounded and debunked.  
 The illogical becomes logical.  
 The questionable attempted through an act of desperation,  
 Reasoning discarded as fear sets in.  
 Seers emerge foretelling the supposed truth.  
 Heroes are redefined, frontlines are manned but not with guns.  
 Courage is empty, hope lingers, as the unwanted enters our realm.

*Confined, secluded and isolated.*


Newfound authority emboldening the idle minds,  
 Professing borrowed ideologies and suppressing reasons,  
 Driven with unclear directives, imposing gratuitous detentions.  
 Flammable selves preventing fires,  
 Living on borrowed time,  
 Enjoying freedom unwillingly sacrificed,  
 Society repurposed as the new order is implemented.  
 The masses look to their leaders, the leaders into the void.  
 The world tries to grasp the new reality, the old clings on  
 persistently.  
 Uncertainty threatens the future.  
 Ignorance triggers blind optimism.  
 Deeper still it burrows, the bold uninvited guest.

*Confined, secluded and isolated.*

Discovering hidden skills and talents long forgotten,  
 Dusty boardgames reclaimed for a purpose,  
 Images posted in obligation,  
 Home menus flaunted across unwanted eyes,  
 Beer belly replaced by lockdown belly.  
 Visually sound, physically distraught,  
 Separated outside by fear, inside by gadgets,  
 Conversations are online, memories in the cloud.  
 Relationships tested and maintained virtually,  
 Lost intimacy, awkwardly gained.  
 Futures no longer planned but dictated through mandates,  
 All seems lost as the pandemic offers a toast.

  
**Coordinator**  
 Internal Quality Assurance Cell  
 Pachhunga University College  
 (A constituent college of Mizoram University)



  
**Principal**  
 Pachhunga University College  
 Aizawl : Mizoram

# CHERCHĪNGKĪM

## HNAM ZAI LEH LAM ZIR ZAUNA



Edited by  
Darchuailova Renthlei  
V. Lalberkhawpuimawia

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

## Representing Tribal Identity of Mizo in Hlado and Bawh hla

Dr. Zoramdinthara\*

**Sawihawna:** Mizoten hlado leh bawh hla kan neih tan hun hi rin dan mai lo chuan hriat hleih theih a ni lo. Chutih rual chuan heng hla tuipuitute leh a chhuitute sawi dan erawh a inhlat lo viau thung. C. Lalsiamthanga chuan, 'Hlado pawh hi pi pu nunchan zirnaa lo tel, tawngkam leh mi chham atanga thangtharin kan hriat a nih avangin, hriat dan a in ang lo thluah a, a bul a bal chhui pawh a har hle,' tiin hlado tobul, a lo chhuah hun ni leh thla chiang taka sawi mai a har thu chu sawi (52). Lalthangliana pawhin, 'Than dang leh Run kam vela an awm lai khan ramsate chu an thlawhhma leh thlaite tichhetu an nih avang leh a ei atan an duh bawh thin avangin an tihlum thin ngein a rinawm a, chu vangin Hlado hi a chhuak awm e. Tin, Len dang an lo chhuah hnu hian, a chi chia awm hranga intihbuai leh indo an chin tak avangin Bawh hla hi a chhuak ve leh ta niin a lang,' tiin a sawi bawh (34-35).

Heng hrilhfhahna hian hlado leh bawh hla lo chhuah hun awm ang chu rin zawn theih mah se, run leh than dang inkara pipute an chen laia eng tik ni leh thlaa chhuak nge tih chi min hrilh thei bik lem lo. R.L. Thanmawia chuan, 'Hla upa pawh tak a ni a, a hla tangin Run kuam vela an chen lai, AD 1450 - 1500 bawr velah khan hlado hi an nei ngei tawh niin a hriat....Bawh hla hi pasalthat hla, a chhama chham chi bawh a ni. Run kuam vel leh Lentlang vela kan pi pute an awm lai AD1500 vel atanga an neih tan anih a rinawm,' tiin a sawi.

\*Assistant Professor, Department of Mizo, PUC

Coordinator

Internal Quality Assurance Cell  
Pachhunga University College

(A constituent college of Mizoram University)



bawh (123). Rin dan leh ngaihdan mai mah nise, Thanmawia thusawi atanga thil lang chiang tak chu kum 1450-1500 inkar hian hlado leh bawh hla chu a chhuak tih kan chhui dawn thei a ni. K. Zawla chuan Mizo hnahtlak zingah chuan Pawihovin hla an nei hmian, Luseiho chu Pawiho zirtir niin a ngai a, chu chuan hlado pawh hi pawihho chin chhuah a ni mai awm mang e tih ngaihtuahna pawh mi tak rilruah chuan a riak nghet viau mai. K. Zawla thusawi ti nghet tur hian R. Doliana chuan he ti hian a sawi a: 'Hlado hi chham mi a ni a, sak ve chi a ni lo. Pawh lam hlado vek a ni a, kan pipute hian an lo tawmpui mai a ni,' tiin a sawi (234). Lalruanga chuan heng hla lo chhuah hun hi a sawr zim a ta viau mai. A ngaihdan chuan, 'Hlado leh bawh hla hi Mizo hla upa pawl ber a ni. Kan pi leh pute Run lui kama am awm lai 1460 AD vela chhuak a ni a,' tiin a sawi. (1)

Heng hrilhfhahna hrang hrang kan tarlan atanga thil chiang tak awm chu, heng hla pahnihte hi kum 1450 - 1500 A.D vel bawra chhuak, pi puten an tuipui em em hla a ni.

Hlado leh bawh hla te hi kan hnam nunzia leh kan chin dan hrang hrangte pho langtu a ni kan tih rualin, eng nge tribal nihphung (tribal identity) chu ni ang le? Tribal tia kan sawi mai thin hi social group pakhat hnam peng hrang hrang awm, hun eng ngemaw ti laia pem kual thin, hman peng hrang hrangte chu khawilai hmun emaw a cheng, tawng hrang hman leh culture thuhmun leh tawng penhle hman hrang hrang nei hnam hi a ni ber. Tin, ramsa kah leh thah te, punkhawm te leh lo neih te hi tribal hnam zia langsar tak a ni bawh. Oxford Dictionary chuan, 'Tribal chu mipui awm khawm, chhungkua, hnam emaw mipui vantlang khawtlang nun, eizawna, inrelbawl dan, inzawna leh thlahtu pawh thuhmun niin a sawi' (Robinson 1504). Tin, tribal mite nun leh khawsak dan chu hniam tak, hnam chin dan pawh hrang, nunphung mawl mang tak, mihring pawh tlem te leh thing leh maute nen pawh inhne hnai tak anni (Polunin 20).

Principal  
Pachhunga University College  
Aizawl : Mizoram

Mizo Thu leh Hlaa  
**THANGTHARTE  
KHAWVEL**  
[RECENT TRENDS OF MIZO LITERATURE]

Edited by

LALTLANMAWIA  
(Matlana Vuite)

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

**BUNG HNIHNA-  
DRAMA KAIHHNAWIH**

1. Mizo Lemchan- Quo Vadis? - 89  
- F.Lalzuithanga
2. Mizo Lemchan (Drama) Than Chhoh Dan - 100  
- Lalzarzova
3. Zephyr Drama (Social Satirical Drama) - 107  
- V.L. Muanpuia Chawngthu

**BUNG THUMNA-  
NOVEL KAIHHNAWIH**

1. Mizo Novelist-te Hnuhma - 133  
- PC. Lalngaihuala
2. Mizo Novel Ziarang - 147  
- JH. Lalrinzuala
3. Revisiting Lalengmawia Ralte: A Study of his Novels - 160  
- Dr. Zoramdinthara

**BUNG LI-NA-  
SOCIAL MEDIA KAIHHNAWIH**

1. Social Media leh Mizo Fiction - 181  
- Nununa Renthlei
2. Social Media-in Mizo Poetry-a Nghawng a Neih Dan - 204  
- Lalrammuana Sailo
3. Youtube-a Mizo Pasaltha Thawnthute Zir Chianna - 214  
- V. Lalberkhawpuimawia
4. Thangthar, Thu leh Hlaa Tuite leh Social Media - 229  
- Laldinliana
5. Evolution of Mizo Language - 237  
- Lalnuntluanga

**BUNG NGA-NA-  
MAFAA HAUHNARSULHNU HUANG**

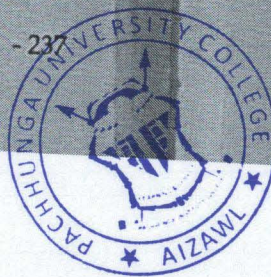
1. Mizo Literature tana Mafa-a Hauhna Hnathawh - 245  
- Rohmingthanga Ralte
2. Zofate Zaihla Zèmpui Mafa-a - 258  
- Zoramtharmawia (Zawra Ralte)

**THU BELH**

1. Seminar Programme - 278
2. Seminar Report - 280

**Coordinator**

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



5

**Principal**  
Pachhunga University College  
Aizawl : Mizoram

# REVISITING LALENGMAWIA RALTE: A STUDY OF HIS NOVELS

- Dr. Zoramdinthara  
Assistant Professor  
Department of Mizo, PUC

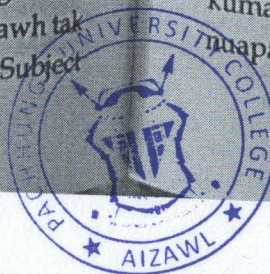
## Pian leh murna:

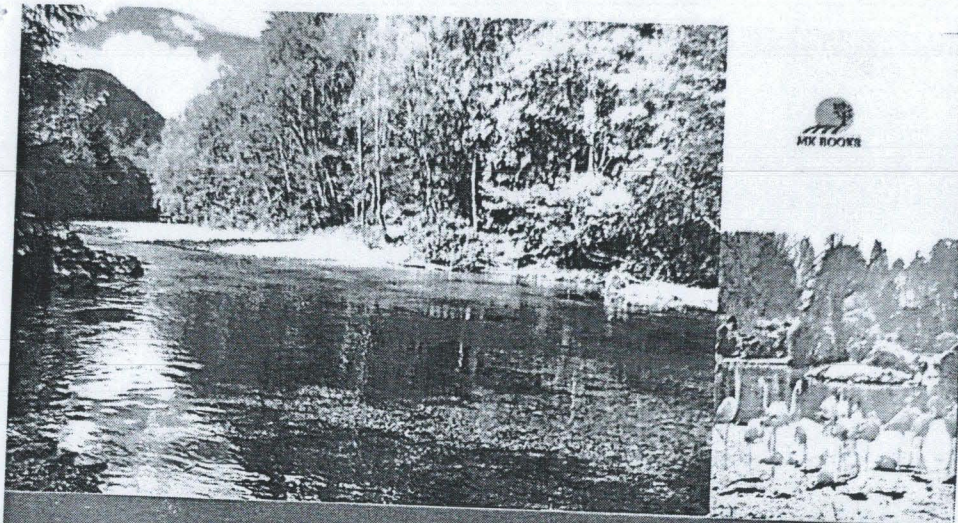
Lalengmawia Ralte hi ni 14<sup>th</sup> October 1947 khan Biate-ah a piang a. Zirna pawh he khua atanga bul tanin, Primary leh Middle School pawh tha takin a pass a. Amaherawhchu, rambuai khan a nan tak hlauh avangin High School chu a zo thei ta lo a ni. He mi hnu hian Aizawl lamah eizawnna kawng dapin a tla thla ve rawih a. District Council hnuaiah Peon hna thawkin eizawnna kawng a zawh chho tan a. Ni 17<sup>th</sup> October 1974 khan Lalrokimi nen inneiin Venghlui, Aizawlah hian an inbengbel zui ta a ni. A vanneih asiamin nupui a neih hnu kum 1975 khan Primary School zirtirtu hna a hmu a, Venghlui Primary School-ah a thawk zui ta nghe nghe a ni. Mi taima leh invawng tak a nih avangin a thil tih tawhah chuan taima taka ti zel mi a ni a. Chuvang chuan khawtlang leh sawrkarah pawh dinhmun pawimawh tak tak heng- Member, Mizoram Publication Board, Subject

Expert Committee MBSE bakah Secretary, Young Mizo Association chanvo te pawh a lo chelh tawh a ni. Tin, kum 1987 khan Venghlui Kohhran Upa atan nemngheh a ni nghe nghe. A eizawnna kawnga a thawh that em avangin kum 2004 khan India rama zirtirtu tha chawimawina *National Award for Teacher* 2004 chu hlan a ni bawh. Kum 34 chhung zet zirtir hna a thawh hnuin kum 2009 khan sawrkar hna atangin a chawl a. Ni 9<sup>th</sup> April 2020 khan a lei kum te a lo chhiar zo ve ta a ni.

## Lemchan leh essay lama a sulhnu:

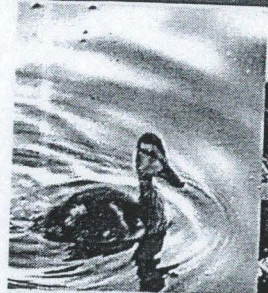
Thu leh hla ziah lamah hian a inhmang hma hle. Kum 1969 chho vel khan nuam ti takin essay leh article ziaik tan a. Hei hian a tuina hmasa leh a rilrua awm fo thin chu essay leh article ziah a ni e ti pawhin a sawi theih awm e. Article leh essay hi za chuang ziaik tawhin, heng a article leh essay-te hian rambuai lai khan chhiar a hlauh hle nghe nghe a ni. Mizo lemchan hrang hrang Engmawia hian a lo ziah avangin Mizo thu leh hla huangah chuan 'lemchan ziaktu' ti pawhin kan sawi thei ang. A lemchan ziah zingah *Nausen Vang* (1988), *Khawiah Nge* (1988) leh *Thelhriat* te hi a lar zual an ni. *Khawiah Nge* tih lemchan hi Bible-a kan hmuh- khawchhak mifingte pathum chanchin tlur bingna a ni a. *Nausen Vang* lemchan hi Lal Isua bethlehema khua a piana an vahvaih dan leh lal Heroda-in nausen rawng taka a suat tak dan tar lanna lemchan a ni thung. Tin, kum 1982 kuma a ziah *Khawdur Kara Chhimbal* leh kum 1989 kuma a ziah *Ka Nu Min Hrilh Rawh* a ziah *Thapang* lemchan thawnthu a ziah *Ka Nu Min Hrilh Rawh*





# INTEGRATED WATERSHED MANAGEMENT FOR SUSTAINABLE DEVELOPMENT

Dr. Ashutosh Singh



## INTEGRATED WATERSHED MANAGEMENT FOR SUSTAINABLE DEVELOPMENT

Dr. Ashutosh Singh

*Assistant Professor,*

(Department of Geography)

Pachhunga University College, Aizawl

(An only constituent college of Mizoram University)

*V. S. S.*

Coordinator

Internal Quality Assurance Cell

Pachhunga University College

(A constituent college of Mizoram University)

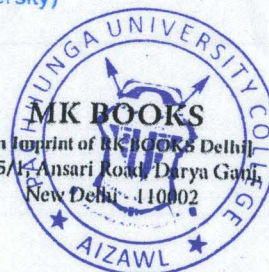
*J. S.*

Principal

Pachhunga University College  
Aizawl : Mizoram



[An imprint of MK BOOKS Delhi]  
4215/15 Ansari Road, Darya Gah,  
New Delhi - 110002



## Contents

Foreword	vii-viii
List of Table	xi-xiii
List of Illustrations	xv-xvii
<b>Introduction</b>	<b>xix-xxxix</b>
Review of Literature, Hill Area Development Planning: A Chronology, Planning Issues in Hilly Area, Watershed as the Planning Unit, Integrated Watershed Management, Components of Watershed Management, Land Management, Water Management, Biomass Management, Sustainability, Statement of the Problem, Objectives of the Study, Methodology, An outline of the Study.	
<b>Chapter 1: The Study Area Profile</b>	<b>1-23</b>
Location and Extent, Structure and Relief, The Krol Belt, The Almora Dudatoli Crystalline Mass, Drainage System, Climatic Characteristics, Soils, Natural Vegetation, Himalayan Sub Tropical Pine Forest, Temperate Moist Broad Leaved Forests, Fauna .	
<b>Chapter 2: Demographic Characteristics</b>	<b>24-46</b>
Population Growth, Population Distribution, Population Density and Change, Sex Composition, Literacy, Occupational Structure, Migration, Concluding Remark	
<b>Chapter 3: Land, Water and Biomass</b>	<b>47-86</b>
Land, Land Use, Agriculture, Types of Cultivation, Cropping Pattern, Cropping Pattern in the Kharif (Barsati) Season, Cropping Pattern in Rabi (Ghimi) Season, Irrigation, Horticultural Practices, Livestocks, Water,	

  
**Coordinator**  
 Internal Quality Assurance Cell  
 Pachhunga University College  
 (A constituent college of Mizoram University)

(v)

Underground Water, Irrigation Project in Upper Kosi Watershed, Present Condition of Kosi Drainage System, Water Flow Rate in River Kosi, Biomass, Timber and Non-Timber Forest Biomass Produce, Biomass Calculation, Forest Biomass Withdrawn, Concluding Remark.

## Chapter 4: Settlement and Infrastructural Facilities 87-143

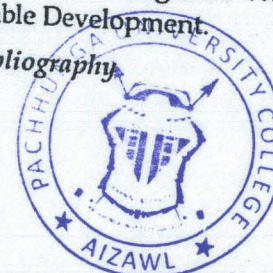
Factors Influencing the Type of Settlements, Size and Density of Settlements, Spacing of Settlements, Types of Settlement in Upper Kosi Watershed, Fragmented, Isolated Dwellings, Loosely Compact, Partially Agglomerated, House Types, Building Material of Houses, Case Study of Sample Villages, Resource Utilization Perception in Sample Villages, Perception on Benefit from Resource Conservation, Resource Degradation and Peoples Responses, Deforestation, Soil Erosion, Water Resource Degradation, Perception on Government Policy and Livelihood Security, Infrastructural Facility, Transportation, Power, Health, Literacy and Education, Banking and Postal Facility, Marketing Facility, Drinking Water and Irrigation.

## Chapter 5: IWM for Sustainable Development 144-171

Land Use Planning, Proposed Land Use Plan, Agricultural Resource Planning, Water Resource Planning, Head Water Region Measures, Watershed Measures, Biotic Measures, Mechanical Measures, Forest Biomass Resource Planning, Scope of Industrial Development in Upper Kosi Watershed, Forest based Industrial Potentialities, Livestock Based Industrial Potentialities, Agricultural Based Industrial Potentialities, The Tourist Industry and Its Potentialities, Integrated Watershed Management for Sustainable Development.

## Selected Bibliography

172-190



  
**Principal**  
 Pachhunga University College  
 Aizawl : Mizoram

## CHAPTER-1

# The Study Area Profile

### Location and Extent


The Upper Kosi watershed is situated in Almora district and extending from 29° 32' 10" N to 29° 52' 25" N and 79° 30' 28" E to 79° 44' 55" E covering an area of 462.81 km<sup>2</sup>. The whole region is mountainous with successive mountain range and river valley. The altitude varies between 1,000m to 2,750m above mean sea level. In the north, the study area is separated by Birrachuwakot Dhar from the Gomti river basin. This range is higher in the northwestern part i.e. above 2520 meters in elevation, and acts as the source of the Kosi River. Towards the north east, the demarcation range includes the upper parts of the Kausani reserved forest and follows 1800 meters contour approximately up to jogipatal and finally joins Binasar (2050 mts). It is bordered in the west by Ranikhet Tehsil, in the south by the Nanital District, in the east by the Lamgada block of district Almora and in the north by Garun town of Bageshwar district (Fig. 1.1 A and B). There are two development blocks in the watershed Hawalbagh and Takula covering 234 revenue villages and a small north - west part of Almora city.

### Structure and Relief

Geologically the watershed falls in the Lesser Himalayan region, which lies roughly to the south of the main central thrust, characterized by the existence of unfossiliferous sediments of Pre-

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

Search for keywords, authors, titles, ISBN

Advanced Search (/search/advance-search?context=ubx)

Petroleum & Oil Industries (<https://www.taylorfrancis.com/search/subject-SCEB040225&context=ubx>)

Show Path

Book



## Advances in Petroleum Technology

Edited By Subrata Borgohain Gogoi

Edition	1st Edition
First Published	2020
eBook Published	26 November 2020
Pub. Location	New York
Imprint	Jenny Stanford Publishing
DOI	<a href="https://doi.org/10.1201/9781003049937">https://doi.org/10.1201/9781003049937</a> ( <a href="https://doi.org/10.1201/9781003049937">https://doi.org/10.1201/9781003049937</a> )
Pages	504
eBook ISBN	9781003049937
Subjects	Economics, Finance, Business & Industry, Engineering & Technology

Share 66 Citation

ABSTRACT

TABLE OF CONTENTS



Policies

Journals

Corporate

Help & Contact

Connect with us



(<https://www.linkedin.com/company/taylor-&-francis-group/>)



(<https://twitter.com/tandfnewsroom?lang=en>)



(<https://www.facebook.com/TaylorandFrancisGroup/>)



(<https://www.youtube.com/user/TaylorandFrancisGroup/>)

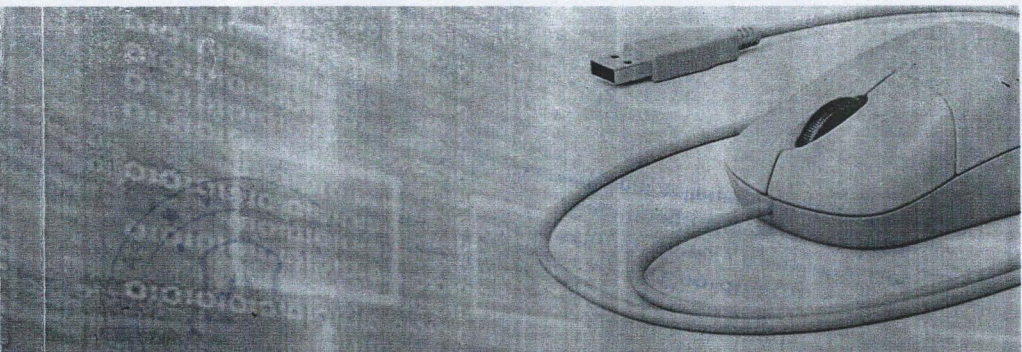

Registered in England & Wales No. 3099067  
5 Howick Place | London | SW1P 1WG

© 2021 Informa UK Limited

*Subrata Borgohain Gogoi*  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



*Subrata Borgohain Gogoi*  
Principal  
Pachhunga University College  
Aizawl : Mizoram



# **COMPUTER PROGRAMMING IN C**



**L. Thangmawia**

## Computer Programming in C

L.Thangmawia

### SOUTH EASTERN BOOK AGENCIES

No.14, Hengrabari Housing Road,  
Dispur, Guwahati-781 006.  
Mob:- +91 98491 06622, +91 99542 02135.  
Email:- southeasternbook@gmail.com

### Branch Offices:-

No. G6/195, Sector 16,  
Rohini, Delhi - 110085.  
Mob:- +919818435279.  
Email:- dbc2003@rediffmail.com

H No. CC-62/2420-2421 (SFCERA-10),  
Mother Teresa Lane, P.O. Kaloor,  
Kochi - 682017 KERALA.  
PH:- +91484-2337870, Mob:- +919447300752.  
Email:- sbcbook@rediffmail.com

ISBN:- 978-9-389-26202-5

© 2020, L.Thangmawia

*All rights reserved. Except for brief quotations in critical articles or reviews, no part of this work may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the copyright owners*

Published by:- C. Sasi Kumar for South Eastern Book Agencies

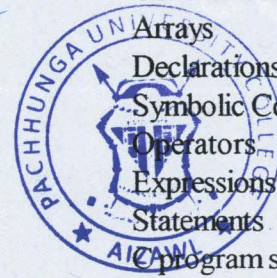
  
Principal  
Pachhunga University College  
Aizawl : Mizoram

## CONTENTS

Preface	vii
Foreword	ix

### Chapter 1

<b>Fundamentals of C language</b>	<b>1</b>
Getting started with C	1
The C character set	2
Identifiers	3
Keywords	3
Data types	4
Constants and Variables	7
Arrays	14
Declarations	16
Symbolic Constants	20
Operators	22
Expressions	34
Statements	36
C program structure	38
Header files	39
Process of compiling and running a C program	41



  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



# PUBLIC POLICY IN INDIA

*[Signature]*  
Principal  
Pachhunga University College  
Itanagar, Mizoram



*[Signature]*  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)

**FURQAN AHMAD**



ISBN : 978-81-87393-62-7

2020

Copyright © : Department of Political Science

part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system, without permission in writing from the publisher & author.

Published by

ADROIT PUBLISHERS 4675/21, Ganpati Bhawan, Ansari Road,  
Daryaganj, New Delhi-110 002 Phone : 011-23266030  
adroitpublishers@gmail.com  
C/O Vajra books, Thamel, Jyatha,  
Kathmandu, Nepal | KTM: +977-9808357451

*This book has been published under UGC SAP-DRS-1 programme, copyright belongs to the Department of Political Science*

Typeset in Garamond Premier Pro by Arun, Akriti Graphic  
Solution, Delhi-110081 E-mail: arun263923@gmail.com  
Ph: 9999414390

Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



Principal  
Pachhunga University College  
Aizawl : Mizoram

## Contents

- Preface ..... vii
1. Democracy and Development in Post-Colonial India Revisiting ..... 1  
Policy-making During the Nehru Era  
*Surya Narayan Misra*
2. Public Policy Actors In India Since The 1990S: Changing Role ..... 13  
*Minarul Islam Biswas*
3. India's National Health Policy 2017 A Critical Review..... 23  
*Rumki Basu*
4. Redesigning India's Rural Economy by Rural Road Connectivity ..... 42  
by Pradhan Mantri Gram Sadak Yojna  
*Pooja Paswan*
5. Urban Sanitation in Slums: A Study in Solid Waste..... 59  
Management Policy Implementation  
*Vanshree Agarwal*
6. Digital India: An Initiative to Transform the Nation ..... 73 ✓  
*T. Sadashivam*
7. Choice Based Credit System in Universities and Colleges: ..... 96  
An Analysis  
*Neeru Snehi*
8. Right to Inclusive and Quality Education of Muslim Children: ..... 112  
A Quagmire of Identity, Security and Exclusion  
*Nuzhat Parveen Khan & Muzaffar Hussain Mir*
9. Gender and Development- A Study of Maternal & Child Health.... 125  
Care Policies in Odisha  
*Padmalaya Mahapatra*

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

## Digital India: An Initiative to Transform the Nation

T. Sadashivam<sup>6</sup>

### Abstract

*India is going through a significant transformation in the past more than one decade in terms of economic growth, demographic change, rapid urbanization etc. However, one important transformation which not only affects us, but the whole humanity is the rapid technological advancements. In today's world, any country's growth, progress and development depend upon the adoption of Digital Technology with particular focus on governance; and without it, we cannot respond to the changing needs of the society (i.e. to deliver public services economically, efficiently and effectively). As we progressed, our focus from 'Government' to 'Governance', or as the present Modi Government says, 'Minimum Government and Maximum Governance', to accelerate the latter we need to adopt Digital Technology.*

*In this context, this paper attempts to examine various digital initiatives under the Digital India Programme initiated by Narendra Modi led government in 2015, and its current implementation status.*

**Keywords:** *Digital Technology; Digital India; Sustainable Development Goals; Common Services Centres.*

### Introduction

Mankind has seen a number of transformations in society, which changed the face of humanity. However, the one transformation which we are experiencing more or less throughout the world is the adoption of 'Digital Technology'. So, it is not wrong to call the present time as 'Digital Age', the impact of which is felt in almost all aspects of an individual's life, from the way individuals interact with each other, express their feelings, share ideas to managing their daily activities like health and finances etc (Kachhal, 2018). The one such field, where digital

6. Assistant Professor, Department of Public Administration, Pachhunga University College, Aizawl, Mizoram.



Rajib Roychowdhury • Shuvasish Choudhury  
Mirza Hasanuzzaman • Sangeeta Srivastava  
Editors

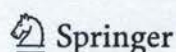
**Editors**  
Rajib Roychowdhury  
Department of Vegetables and Field Crops,  
Institute of Plant Sciences  
Agricultural Research Organization  
(ARO) – The Volcani Center  
Rishon LeZion, Israel

Shuvasish Choudhury  
Plant Stress Biology & Metabolomics  
Laboratory, Central Instrumentation  
Laboratory (CIL)  
Assam (Central) University  
Silchar, Assam, India

Mirza Hasanuzzaman  
Department of Agronomy, Faculty of  
Agriculture  
Sher-e-Bangla Agricultural University  
Dhaka, Bangladesh

Sangeeta Srivastava  
Division of Crop Improvement  
ICAR-Indian Institute of Sugarcane  
Research  
Lucknow, Uttar Pradesh, India

# Sustainable Agriculture in the Era of Climate Change



ISBN 978-3-030-45668-9 ISBN 978-3-030-45669-6 (eBook)  
<https://doi.org/10.1007/978-3-030-45669-6>

© Springer Nature Switzerland AG 2020  
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.  
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.  
The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

x	Contents	
9	Role of Heat Shock Proteins (HSPs) and Heat Stress Tolerance in Crop Plants	211
	Zeba Khan and Durre Shahwar	
10	Assessment of Irradiation Stress in Crop Plants with Modern Technical Advances	235
	Indraneel Saha, Debabrata Dolui, Arijit Ghosh, Bipul Sarkar, Arnab Kumar De, and Malay Kumar Adak	
11	Antioxidants: Responses and Importance in Plant Defense System	251
	Narendra Kumar, Hukum Singh, and Satish Kant Sharma	
12	Reactive Oxygen Species and Antioxidant Defence Systems in Plants: Role and Crosstalk Under Biotic Stress	265
	Koushik Biswas, Sinchan Adhikari, Avijit Tarafdar, Roshan Kumar, Soumen Saha, and Parthadeb Ghosh	
13	Climate Change-Induced Heavy Metal (or Metalloid) Stress in Crop Plants and Possible Mitigation Strategies	293
	Navin Kumar, Shilpi Paul, and Shekhar Mallick	
14	Arsenic-Induced Stress and Mitigation Strategies in Plants	327
	Iti Sharma	
15	Arsenic Tolerance and Signalling Mechanisms in Plants	341
	Sudhakar Srivastava and Vaishali Yadav	
16	Heme Oxygenase 1(HO1): An Enzyme of Plant System and Its Role Against Various Abiotic Stresses	355
	Khushbu Verma and Afroz Alam	
17	Role of Plant Growth-Promoting Rhizobacteria (PGPR) for Crop Stress Management	367
	Ashutosh Kabiraj, Krishnendu Majhi, Urmil Halder, Moitri Let, and Rajib Bandopadhyay	
18	Plant Tissue Culture and Crop Improvement	391
	Kiranmai Chadipiralla, Pachipala Gayathri, Vemula Rajani, and Pichili Vijaya Bhaskar Reddy	
19	Abiotic and Biotic Stress Research in Plants: A Gizmatic Approach of Modern Omics Technologies	413
	Nilofer Sheikh, Dina Barman, and Kaushik Bhattacharjee	
20	Involvement of Microbes in Different Abiotic Stress Environments of Cropping Lands	441
	Muhammad Zulqurnain Haider, Farah Saeed, Aqsa Ali, Qasim Ali, Noman Habib, Muhammad Tariq Javed, Muhammad Azeem, Nacem Iqbal, Shafaqat Ali, Imran Khan, Faisal Mahmood, Youcai Xiong, and Muhammad Afzaal	

Contents	xi
✓ 21 Molecular Insight of Plant–Pathogen Interaction	481
Anil Kumar, Chunoti Changwal, Alkesh Hada, and Prashant Kumar Singh	
22 Role of miRNAs in Abiotic and Biotic Stress Management in Crop Plants	513
Narayanan Nair Anjali and Kalluvettankuzhy Krishnannair Sabu	
23 Recent Transgenic Approaches for Stress Tolerance in Crop Plants	533
Krishna Kumar Rai and Avinash Chandra Rai	
✓ 24 Improvement of Crop's Stress Tolerance by Gene Editing CRISPR/CAS9 System	557
Avinash Singh, Rajib Roychowdhury, Toolika Singh, Wenjing Wang, Deepanker Yadav, Ajay Kumar, Arpan Modi, Avinash Chandra Rai, Sandeep Ghughe, Anil Kumar, and Prashant Kumar Singh	
25 Application of Bioinformatics for Crop Stress Response and Mitigation	589
Anubhab Laha, Priyanka Chakraborty, Chiranjib Banerjee, Anindya Sundar Panja, and Rajib Bandopadhyay	
26 Nanobiotechnological Applications for Crop Improvement	615
Rachna Gupta and Parth Malik	
27 Agrobiodiversity and Advances in the Development of Millets in Changing Environment	643
D. A. Paul	
Index	675



*Katter*  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)

*[Signature]*  
Principal  
Pachhunga University College  
Aizawl : Mizoram

## Chapter 21 Molecular Insight of Plant–Pathogen Interaction



Anil Kumar, Chunoti Changwal, Alkesh Hada, and Prashant Kumar Singh

**Abstract** Plants are constantly exposed to a broad range of potential pathogens and pests and therefore have developed a highly sophisticated immune system to perceive and prevent such threats. Plants use pattern recognition receptors (PRRs) as well as nucleotide-binding and leucine-rich repeat to monitor nonself and damaged-self and altered-self patterns as signs of potential danger. PRRs of plants stimulate local and systemic immunity after pathogen-/microbe-associated molecular patterns (P/MAMPs) have been recognized. Then, a cascade of response begins that, through the identification of PAMPs, results in plant immunity known as PAMP-triggered immunity (PTI). Successful pathogens bypass PTI by expressing a suite of effector protein that destroys or interferes with host defense system. Recent developments have revealed novel PRRs, their respective ligands, and pathways affecting PRR activity and signaling. To quickly identify microbial patterns and their cognate PRRs, innovative approaches have emerged. Here, in this chapter, we illustrate known PAMPs and effectors of various pathogens such as bacteria, fungi, nematode, and viruses recognized by plant receptors reported till date. We have also discussed different approaches for identifying PAMPs, effectors, and PRRs. Eventually, we highlight the evolving biotechnological potential of the use of PRRs to enhance the wide spectrum and possibly long-lasting resistance of disease in plants.

A. Kumar (✉)  
Department of Entomology, Nematology and Chemistry Units, Agricultural Research  
Organization (ARO) - Volcani Center, Rishon LeZion, Israel

C. Changwal  
Division of Plant Physiology, ICAR-Indian Agricultural Research Institute, New Delhi, India

A. Hada  
Department of Biotechnology, National College (Autonomous), Tiruchirappalli, India

P. K. Singh  
Institute of Plant Sciences, Agricultural Research Organization (ARO) - The Volcani Center,  
Rishon LeZion, Israel

Department of Biotechnology, Pachhunga University College, Mizoram Central University,  
Aizawl, Mizoram, India

© Springer Nature Switzerland AG 2020  
R. Roychowdhury et al. (eds.), *Sustainable Agriculture in the Era of Climate  
Change*, [https://doi.org/10.1007/978-3-030-45669-6\\_21](https://doi.org/10.1007/978-3-030-45669-6_21)

481

## Chapter 24 Improvement of Crop's Stress Tolerance by Gene Editing CRISPR/CAS9 System



Avinash Singh, Rajib Roychowdhury, Toolika Singh, Wenjing Wang,  
Deepanker Yadav, Ajay Kumar, Arpan Modi, Avinash Chandra Rai,  
Saandeep Ghughe, Anil Kumar, and Prashant Kumar Singh

**Abstract** There is an urgent need to enhance agriculture productivity to feed the world's ever-increasing population on the one hand and stresses reducing global agriculture productivity on the other hand. Hence there is only one way to boost global agriculture productivity through innovative breeding technology that can provide access to food security worldwide. Moreover, the availability of fully

A. Singh · T. Singh  
Department of Biochemistry and Molecular Biology Section, Medical University of South  
Carolina, Charleston, SC, USA

R. Roychowdhury  
Department of Vegetables and Field Crops, Institute of Plant Sciences, Agricultural Research  
Organization (ARO) - The Volcani Center, Rishon LeZion, Israel

A. Modi · A. C. Rai · S. Ghughe  
Institute of Plant Sciences, Agricultural Research Organization (ARO) - The Volcani Center,  
Rishon LeZion, Israel

W. Wang  
State Key Laboratory of Cotton Biology, Henan Key Laboratory of Plant Stress Biology,  
School of Life Science, Henan University, Kaifeng, Henan, China

D. Yadav  
Department of Botany, Guru Ghasidas Vishwavidyalaya, Bilaspur, Chhattisgarh, India

A. Kumar  
Department of Entomology, Nematology and Chemistry Units, Agricultural Research  
Organization (ARO) - Volcani Center, Rishon LeZion, Israel

A. Kumar  
Department of Entomology, Institute of Plant Protection, Agricultural Research Organization  
(ARO) - The Volcani Center, Rishon LeZion, Israel

P. K. Singh (✉)  
Institute of Plant Sciences, Agricultural Research Organization (ARO) - The Volcani Center,  
Rishon LeZion, Israel

Department of Biotechnology, Pachhunga University College, Mizoram Central University,  
Aizawl, Mizoram, India  
e-mail: singhyk@pcollege.edu.in

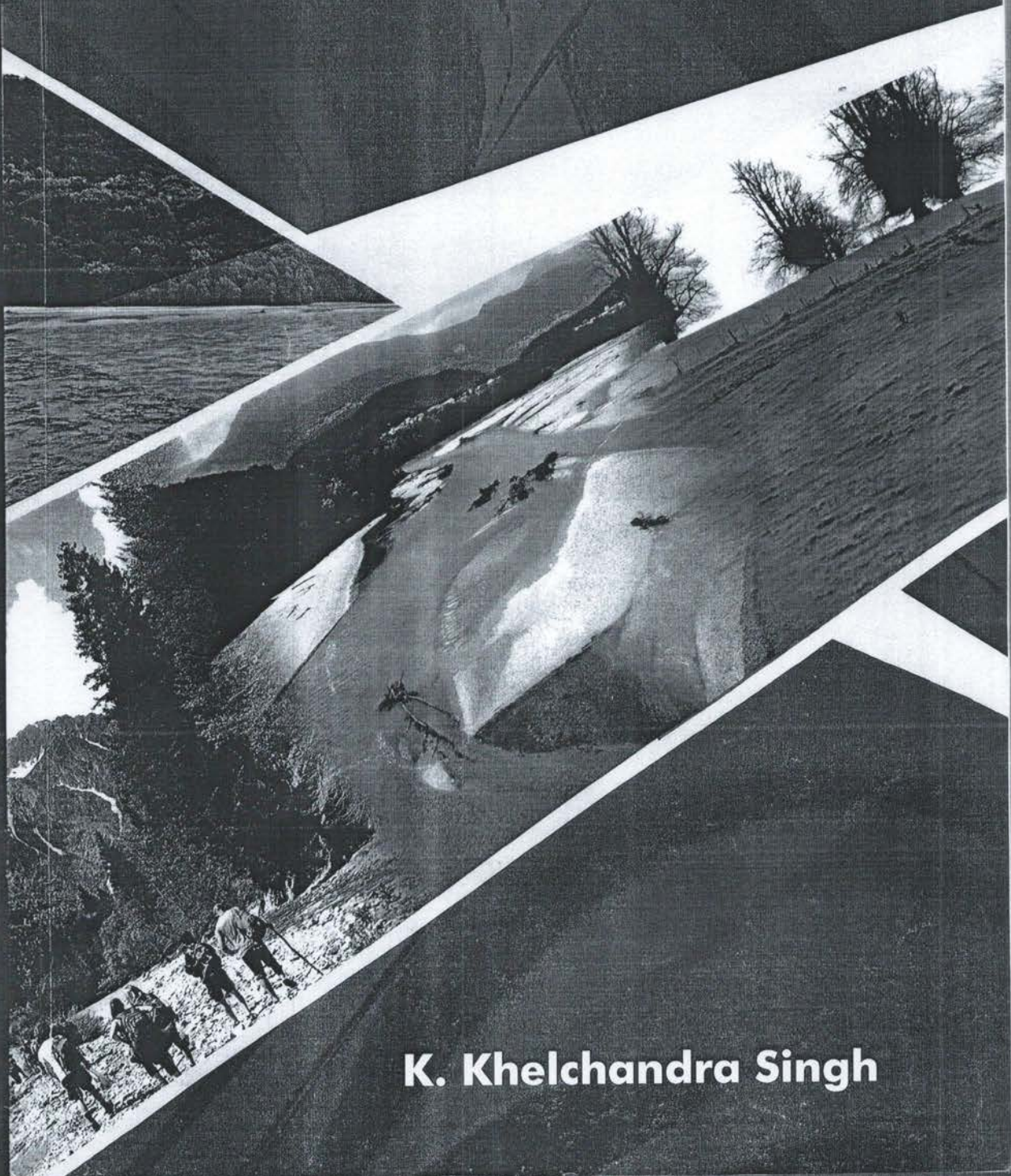
© Springer Nature Switzerland AG 2020  
R. Roychowdhury et al. (eds.), *Sustainable Agriculture in the Era of Climate  
Change*, [https://doi.org/10.1007/978-3-030-45669-6\\_24](https://doi.org/10.1007/978-3-030-45669-6_24)

557

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



# **ADVANCES IN ENVIRONMENTAL RESEARCH OF NORTHEAST INDIA**



**K. Khelchandra Singh**

*Advances in Environmental Research of Northeast India*

By K. Khelchandra Singh

**SOUTH EASTERN BOOK AGENCIES**

No.14, Hengrabari Housing Road,  
Dispur, Guwahati-781006.

Mob:-+919849106622, +919954202135.

Email:-southeasternbook@gmail.com

**Branch Offices:-**

No.G6/195, Sector16, Rohini, Delhi-110085.

Mob:-+919818435279.

Email:-dbc2003@rediffmail.com

HNo.CC-62/2420-2421(SFCERA-10),

Mother Teresa Lane, P.O. Kaloor, Kochi-682017, KERALA.

PH:-+91484-2337870, Mob:-+919447300752.

Email:-sbcbook@rediffmail.com

ISBN:978-93-89262-10-0

©Editor 2020

*All rights reserved. Except for brief quotations in critical articles or reviews, no part of this work may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the copyright owner*

Published by:- C. Sasi Kumar for South Eastern Book Agencies, Guwahati

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

- 63 12. Comparative Study on the Growth and Yield of Maize (*Zea Mays* L.) under different Agroforestry Systems in Mizoram, India  
*P.C. Vanlalhluna, Tawnenga and Lalnunmawia* 137
- 75 13. Taxonomic study of Lamiaceae Family in Mizoram University Campus  
*Lalnunmawia, Elizabeth Vanlalruati Ngamlai, S.D. Khomdram and P.C. Vanlalhluna* 143
- 84 14. Pattern of decomposition in the Invasive Species *Tithonia Diversifolia*  
*Angom Sarjubala Devi, Mary Lalremruati and H. Lalramnghinhlova* 154
- 92 15. Documentation of Non-Timber Forest Products (NTFPs) in Aizawl Market  
*Lallawmkimi, Hilda Lalrinpuui, K. Khelchandra Singh and Kalendra C. Das* 161

### SECTION 3

#### Environmental Awareness, Traditional Knowledge

- 103 16. Environmental Awareness of D.M. College of Science Students Imphal, Manipur, India  
*Khuraijam Usha* 171
- 11 17. A Study of Traditional Foods of Mizo Community in Aizawl City  
*Kalendra C Das, Lallawmkimi, H. Lalrinpuui and K. Khelchandra Singh* 198

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

*Advances in Environmental Research of Northeast India*

Editor: K. Khelchandra Singh

ISBN: 978-93-892-6210-0

## **A STUDY OF TRADITIONAL FOODS OF MIZO COMMUNITY IN AIZAWL CITY**

**\*Kulendra C Das, Lallawmkimi, Hilda Lalrinpuii, K. Khelchandra Singh**

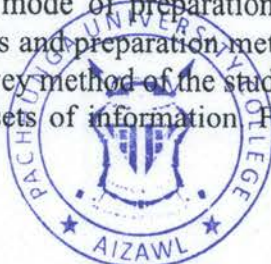
Department of Environmental Science, Pachhunga University College,  
Mizoram University, Aizawl-796001, Mizoram, India

(\*Corresponding Author: drkulendradas@pucollege.edu.in)

### **Abstract**

Traditional foods are those eaten by people from generation to generation or which have been consumed many generations. Traditional foods and beverages may be produced as homemade, by restaurants and small manufacturers, and by large food processing plant facilities. The foods and dishes of Mizo has a characteristic blend of Chinese and north Indian cuisine; thereby giving it a distinct flavor and taste. With rapid urbanization and modernization, some of the traditional items are being slowly replaced western food or some others have been retaining their prominence in the society. Many reported works on edible bio-resources and fermented foods of Mizoram but there were little reports on the traditional food along with their ingredients and mode of preparation. Hence, this paper highlights types, ingredients and preparation method of traditional food in Mizo society. The survey method of the study was based on the primary and secondary data sets of information. Forty-two traditional Mizo food

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

# SECTION 5

## Climate Change, Solid Waste Management, Environmental Protection Laws

23. Assessment of Farmer's Perspective towards Impact of Climatic Variables  
*Irene Lalnipari Sellate and Lalnunthuanga* 299
24. Influence of Rainfall on Water Discharge and Water Level Pattern of River Barak in Silchar City, Assam, India  
*Mohit Kumar and B.P. Mishra* 306
25. Municipal Solid Waste Management: A Case Study of Mokokchung Town  
*Imchasunep Jamir and Sangyu Yaden* 313
26. Study of Solid Waste Generated and Management in Pachhunga University College Campus, Aizawl  
*Hilda Lalrinpuii, K. Khelchandra Singh, Kulendra C. Das and Lallawmkimi* 328
27. Impact of Composting of Different Types of Solid Wastes on Soil Quality  
*Mary Lalremruati, Laltanpuiarenthlei, Ruthi Laltanpuii and Angom Sarjubala Devi* 340
28. Revisiting Current State of Climate Change Law with Special Reference to Climate Change Law of India  
*Yumnam Premananda Singh* 349

  
Coordinator

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

*Advances in Environmental Research of Northeast*  
Editor: K. Khelchandra Singh  
ISBN: 978-93-892-62-6-2

**STUDY OF SOLID WASTE GENERATED AND  
MANAGEMENT IN PACHHUNGA UNIVERSITY COLLEGE  
CAMPUS, AIZAWL**

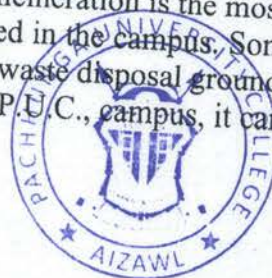
**\*Hilda Lalrinpuii, K. Khelchandra Singh, Kulendra C. Das and  
Lallawmkimi**

Department of Environmental Science, Pachhunga University College,  
Mizoram University, Aizawl-796001, Mizoram, India  
(\*Corresponding Author: [hilda\\_rini@rediffmail.com](mailto:hilda_rini@rediffmail.com))

**Abstract**

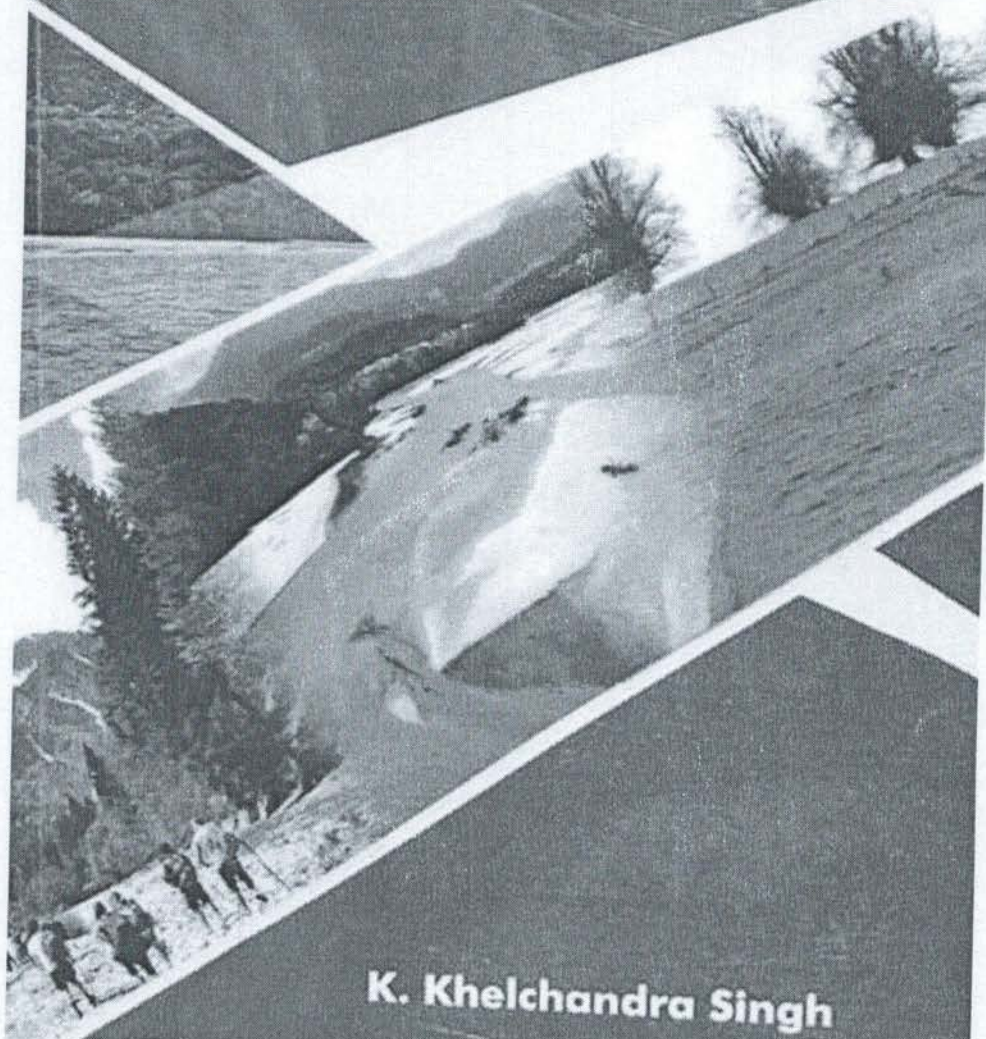
Pachhunga University College generate a large amount of waste which are a results of daily classroom activity and practical work. Wastes are also created as by-products of edible and packaging waste. Predominantly the waste consists of plastics, paper, glass, metals, food waste, garden waste, textile, electronic/electrical, hazardous wastes. It is necessary to study the waste and source for proper management and disposal. Solid waste management is an important sector that requires an immediate attention in the current context. The main aim of the study was to access the present condition of the solid waste management in the College Campus. This study includes characterization of the waste generated and source of waste generation, and examining the current solid waste management system of the campus. The Solid waste collected for five weeks from different buildings of the college campus and is measured by sort and weight method. The waste products are collected by assigned personnel's and dumped into incineration pond after office hours. Incineration is the most common disposal method of solid waste generated in the campus. Some wastes are also disposed in the municipal solid waste disposal ground. Over the period of study, the solid wastes within P.U.C., campus, it can be seen that the waste

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

# ADVANCES IN ENVIRONMENTAL RESEARCH OF NORTHEAST INDIA



**K. Khelchandra Singh**

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

SECTION 6

Multidisciplinary

29	Environment and Business	
	<i>Ch. Nalbi Devi</i>	128
30	Level of Socioeconomic condition on growth among the Sekmai Girls, Manipur	
	<i>Thounaojam Kanon Devi</i>	136
	Index	147

  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

*Advances in Environmental Research of Northeast India*

Editor: K. Khelchandra Singh

ISBN: 978-93-892-6210-0

## ENVIRONMENT AND BUSINESS

*Ch. Nalini Devi*

Department of Commerce, Pachhunga University College, Aizawl-796001,  
Mizoram, India

(Corresponding Email: [nalinidevi72@gmail.com](mailto:nalinidevi72@gmail.com))

### Abstract

Every developmental process is directly or indirectly related with the environment. Sometimes it affected the nature in terms of land, water, air, forest, inhabitants and many other things. Therefore, we need a developmental process or cycle. The United Nations Environmental Program established in 1972, the mission of this program is "to provide leadership and encourages partnership in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life without compromising that of future generations". Many International summits have highlighted about environmental conservation as well as sustainable developmental process. United Nations Millennium Development Goals 2000 clearly mentioned about ensuring environmental sustainability and eradication of poverty through sustainable development process. For achieving economic development goals, we need industrialization process. The Government of India has announced 'startup India' (2015) initiative for creating a conducive environment for startup in India. The main objectives of this paper is to study the relationship between environmental law and new business units and to analyze the positive impact of startup business in sustainable development. In India, efforts are being made for an effective environmental management system in a sustainable manner from different angles. Looking through industrialization process, the entrepreneurs have a very important role for environmental conservation as well as wellbeing of the society. One of the important issues in India is waste management chain; about 75% of municipal garbage is dumped without processing. So, it affects in

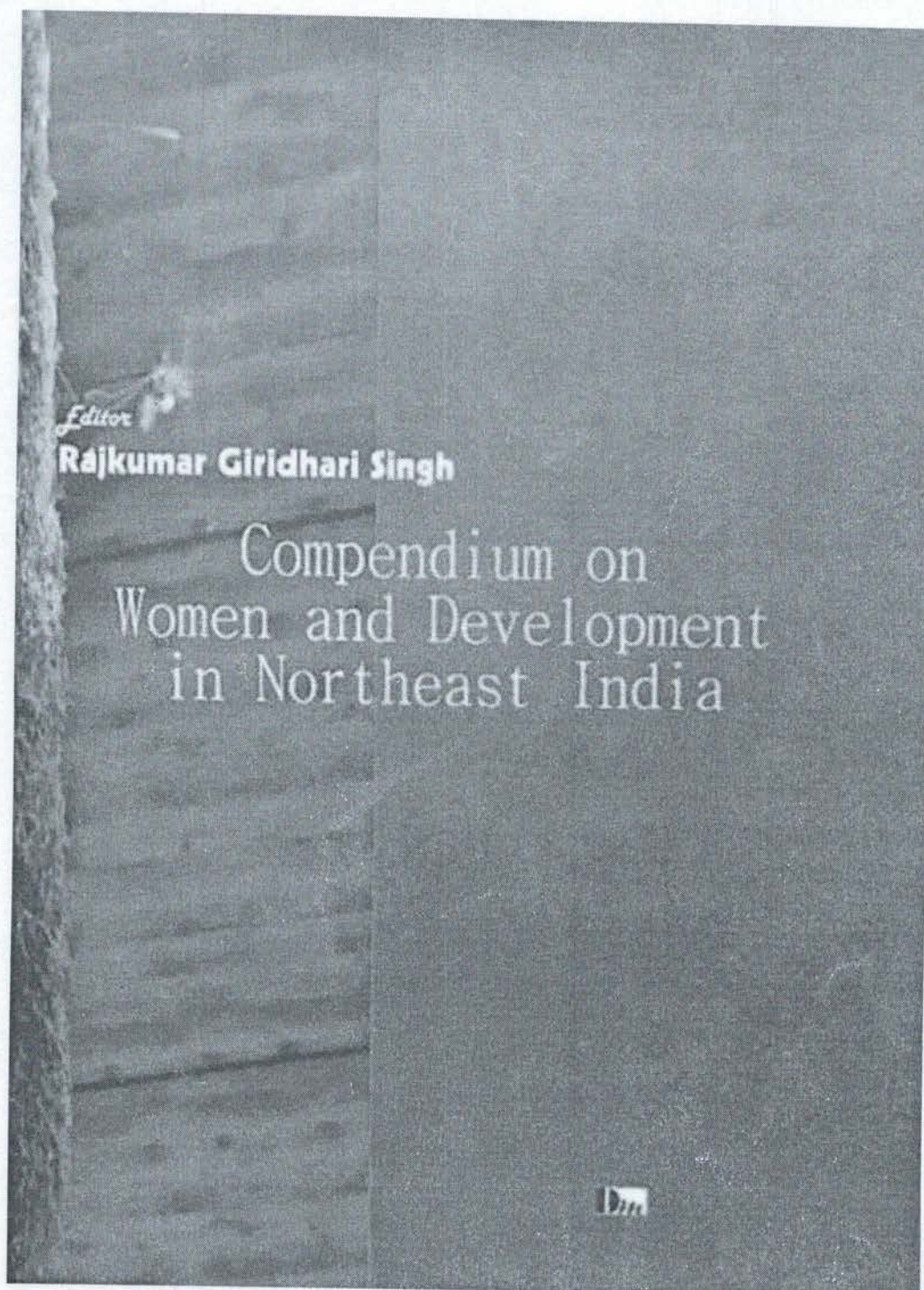


Coordinator

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



Principal  
Pachhunga University College  
Aizawl : Mizoram



  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



**Principal**  
Pachhunga University College  
Aizawl : Mizoram

## Contents

List of Contributors	xi
Preface	xiii
Introduction - Rajkumar Giridhari Singh	iv
1. Gender Equality and Women Empowerment - Rev. R.L. Hnuni	1
2. Role of Formal Education on Rural Women Entrepreneurship: A Study of Lunglet and Kolasib Districts - T.H. Lalrokhawma & K. Lalromawia	12
3. Role of Mizo Women in Nation Building - Ayangham Shyamsiah & T. Lalremruata	24
4. Financial Contribution of Women in Religious Organization: A Study of Mizoram Presbyterian Church - Ronald Lalnunmawia Royte & Bidhu Kanti Das	34
5. Analytical Issues of Working Women in Manipuri Society - Ch. Nalini Devi	42
6. Comparative Study of Women Health and Nutrition in Northeast India with Special Reference to Mizoram and Nagaland - Lalhming Sengi & Lalchhanhuma	52
7. When Working Mothers Speak! - Lalrinchhant	59
8. Women and Nation-Building: A Perspective from North-East India - Minakshi Buragohain	66

  
**Coordinator**  
 Internal Quality Assurance Cell  
 Pachhunga University College  
 (A constituent college of Mizoram University)



  
**Principal**  
 Pachhunga University College  
 Aizawl : Mizoram

## Analytical Issues of Working Women in Manipuri Society

— Ch. Nalini D.

### Introduction

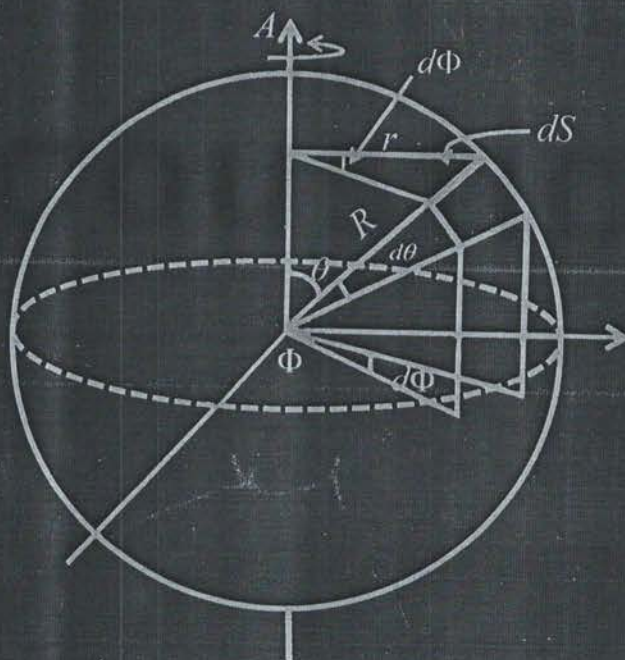
Manipur is one of the states in north east India and it has a geographical area of 22,267 sq km. The state has 357 kms. long international border with Myanmar to the south and 562 km long border with Nagaland, Assam and Mizoram. As per projection population of Manipur in 2020 is 34.37 lakhs.<sup>1</sup> According to 2011 census, the total population is 27,21,144 comprising 13,69,754 males and 13,51,392 females. The population of female is also half of the population. The status of women differs from one society to another depending on the prevalent norms and values. The women's status in society is related to social & cultural traditions, stages of economic development, educational levels, attitudes of society towards women, socio-religious taboos associated with women, women's attitudes, awareness towards their position and political attainment of women in society. Manipur has witnessed the significant role played by women in the past as well as at present in various fields of Manipuri society. In Meitei proverb it is said "a man who does not go to Louang (means man folk are mainly responsible for the safeguard for the country) and a woman who does not go to the market, both are worthless". In other words, "Fruit of knowledge is from father and grandfather, the reserved wealth is from mother & grandmother". The above proverb shows the importance of both men and women in

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

# Properties of Matter, Oscillations and Acoustics



Lalrintluanga Sailo  
Lalrinthara Pachuau

**Properties of Matter, Oscillations and Acoustics**  
Lalrintluanga Sailo and Lalrinthara Pachuau

**Published by:**

Govt. Serchhip College & Pachhunga University College.

Rs. 300.00

© 2020 by Lois Bet Print and Publication, Aizawl. All rights reserved.  
No part of this book may be reproduced in any form, by mimeograph or  
any other means, without permission in writing from the publishers.

ISBN- "978-93-89490-10-7"

Printed at:



Lois Bet

Print & Publication, Chanmari, Aizawl

Ph : 2349250 / 2349970

  
**Coordinator**

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

## CONTENTS

*Title Page*

*Contents*

*Preface*

<b>Chapter – 1: Laws of Motion and Coordinate Systems</b>	<b>1-23</b>
1.1 Newton's Laws of Motion	- 1
1.1.1 First law of Motion	
1.1.2 Second law of Motion	
1.1.3 Third law of Motion	
1.2 Cartesian Coordinate System	- 3
1.2.1 Components of Velocity and Acceleration in Cartesian System	
1.3 Plane Polar Coordinate System	- 4
1.3.1 Unit vectors in Plane Polar Coordinates	
1.3.2 Components of Velocity in Plane Polar Coordinates	
1.3.3 Components of Acceleration in Plane Polar Coordinates	
1.4 Spherical Polar Coordinate System	- 8
1.4.1 Unit vectors in Spherical Polar Coordinates	
1.4.2 Velocity in Spherical Polar Coordinates	
1.4.3 Acceleration in Spherical Polar Coordinates	
1.5 Coriolis Force and Uniformly Rotating Frame	- 14
1.5.1 Consequences of Coriolis force	
<b>Chapter – 2: Conservation Laws and Gravitation</b>	<b>24-61</b>
2.1 Center of Mass	- 24
2.1.1 Centre of Mass of a Two Particle System	
2.1.2 Motion of A System of Particles	
2.2 Collision	- 28
2.2.1 Coefficient of Restitution or Coefficient of Resilience	
2.2.2 Laboratory system	
2.2.3 Center of Mass system	
2.3 Elastic Collision In One Dimension	- 30
2.3.1 Laboratory Frame	
2.3.2 Center of Mass Frame	
2.4 Perfectly Inelastic Collision in One Dimension	- 33
2.4.1 Laboratory Frame	
2.4.2 Center of Mass System	

*Coordinator*  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



*Principal*  
Pachhunga University College  
Aizawl : Mizoram

# CHERCHĠŦKĠM

## HNAM ZAI LEH LAM ZIR ZAUNA



Edited by  
Darchuailova Renthlei  
V. Lalberkhawpuimawia

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

6. Chawngchen Zai Nihphung Zirna	
- Vanlaltana Kiangte .....	117
7. Mizo Hla Hluia Khawl Thil Lo Langte	
- Remlalthlamuanpuia & Thang Sian Thuang .....	127
8. Darpawngi Zai: Portrait Gallery	
- Lahlimpuii .....	135
9. Darlenglehi Zai: Hmangaihna leh Lunglenna	
- Rohmingthanga Ralte.....	147
10. Lalvunga Zai	
- Lalrinkimi .....	156
11. Mizo Hla Hluia Naupang Hlate	
- H. Lalawmpuii .....	166
12. Mizo Hla Hluia Satire Ziarang	
- V. Lalberkhawpuimawia .....	173
13. Awithangpa Lunglenna	
- Laltlanmawia .....	182
14. Awithangpa Khawtlang Nun Sawhkhawk	
- PC. Lalngaihzualla .....	198
15. Hausiampa Zai	
- Lalzarzova .....	205
16. Hrangchhawni Zai	
- Lalrammuana Sailo .....	215
17. Ral Run Zai	
- F. Lalzuithanga .....	222
18. Hausiampa Zai Ziarang leh Kallhmang	
- VL. Muanpuia Chawngthu .....	237
19. Puma Zai leh A Nghawng	
- Sangkima .....	246
20. Chai Hla Pahnih	
- Lalrammawia .....	

## Hrangchhawni Zai

Lalrammuana Sailo\*

### 1. Hrangchhawni chanchin Tlangpui

John Milton-a epic poem ropui tak pakhat Paradise Lost-a character pakhat Setana chuan 'Vanrama hna thawktu leh mi naran nih ai chuan Hremhmuna roreltu nih pawh a hlu zawk (tlar 263) tiin larna leh ropuina hlutzia a lo sawimawi a; mi lar nih duh vangin mi thenkhat chu an a der a, thenkhatin mi mit fukna nih tum vangin tuai nih an thlang bawh. Hrangchhawni erawh larna leh hming thanna a duh hrim hrim vang pawh ni lovin a zai thiamna leh a lam thiamnate chuan mi thinlung a khawih a; a hunlaia mi nawlpui lam dan leh awm dan ang ni loa a awm ngam chu thu leh hla leh rimawi khawvelah kan hriatrengnaa a cham chhan pakhat a ni.

Hrangchhawni hi Mizoten Kristian sakhua an hmelhriat tan lai, Puma zai leh a siperten mi tam tak a sawi nghin lai bawh utangaa zai chiam leh a lam thiam vanga tlang hriat a ni. Kum 1884 velah Hmawngkawn khuua piang nia hriat a ni a; a pa Thangchhuahzova leh a nu Zakhuppi te an inthen avangin fahrah nun retheihthlak tak chu a naupanlai hun ticheptu pakhat nia sawi a ni.

Hla thenkhat chu a phuahtu sawi tel miah lo pawha hah, ngaihnawm leh thui taka zir theih a awm laiin, Hrangchhawni zai erawh a phuahtu damlai nunte sawi tel loh chuan a kalh a kim lo. Hla phuah thiam a nihna te, a zai thiam te, a zah loh theihna te, rual kawm a thiamna te hi a larpui hle. A hun lai hmeichhe dangte ang lo taka zu hmun sa hmuna

\*Asst. Professor, Mizo Department, PUC

*Uttet*  
-1-1

Coordinator

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



*Uttet*  
Principal

Pachhunga University College  
Aizawl : Mizoram

Mizo Thu leh Hlaa

# THANGTHARTE KHAWVEL

[RECENT TRENDS OF MIZO LITERATURE]



Edited by

LALTLANMAWIA  
(Matlana Vuite)



*Matlana Vuite*

Coordinator

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)

*John*

Principal  
Pachhunga University College  
Aizawl : Mizoram

**BUNG HNIHNA-  
DRAMA KAIHHNAWIH**

1. Mizo Lemchan- Quo Vadis? - 89  
- F.Lalzuithanga
2. Mizo Lemchan (Drama) Than Chhoh Dan - 100  
- Lalzarzova
3. Zephyr Drama (Social Satirical Drama) - 107  
- V.L. Muanpuia Chawngthu

**BUNG THUMNA-  
NOVEL KAIHHNAWIH**

1. Mizo Novelist-te Hnuhma - 133  
- PC. Lalngaihzuale
2. Mizo Novel Ziarang - 147  
- JH. Lalrinzuale
3. Revisiting Lalengmawia Ralte: A Study of his Novels - 160  
- Dr. Zoramdinthara

**BUNG LI-NA-  
SOCIAL MEDIA KAIHHNAWIH**

1. Social Media leh Mizo Fiction - 181  
- Nununa Renthlei
- ✓ 2. Social Media-in Mizo Poetry-a Nghawng a Neih Dan - 204  
- Lalrammuana Sailo
3. Youtube-a Mizo Pasaltha Thawnthute Zir Chianna - 214  
- V. Lalberkhawpuimawia
4. Thangthar, Thu leh Hlaa Tuite leh Social Media - 229  
- Laldinliana
5. Evolution of Mizo Language  
- Lalnuntluanga

  
Coordinator

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram

# SOCIAL MEDIA-IN MIZO POETRY-A NGHAWNG A NEIH DAN

(Kum 2000 hnu lam Mizo poetry behchhana chhuina)

- Lalrammuana Sailo  
Assistant Professor, PUC

## Thuhmahruai:

Social media hi khawl thiamna (computer technology) hmanga inkawm khawmna, ngaihdan inhrilh tawna, thlalak leh video te inthawn tawna hmanrua a ni a. Sawi fiah vak ngai loin kan hre thiam mai awme. Tun dinhmuna social mediaa kan hmelhriat lar zualte zingah Facebook, Youtube, Instagram, Twitter, Telegram, Pinterest, Snapchat te leh a dang tam tak a la awm thei ang. Mi malin emaw pawlin emaw website siama thu leh hla an dahnate pawh social media huang chhungah kan khung thei a. Facebook a rawn lar chhoh hmaa Mizo zinga social media lar tak pakhat chu misual.com a ni a. Misual.com-ah hian thlalak te, thu ziaak hrang hrangte dah luh niin chhiartu leh sawi zuitu pawh a ngah mhin hle a. Amaherawhchu he social media lun tak thin hi rei tak chhung a thi hman a, tunah



# PREDICTIVE ANALYTICS USING STATISTICS AND BIG DATA: CONCEPTS AND MODELING

Krishna Kumar Mohbey  
Arvind Pandey  
Dharmendra Singh Rajput

Bentham Books

CONSENT FOR PUBLICATION	28
CONFLICT OF INTEREST	28
ACKNOWLEDGEMENTS	29
REFERENCES	29
CHAPTER 3 ON MEAN ESTIMATION USING A GENERALIZED CLASS OF CHAIN TYPE ESTIMATOR UNDER SUCCESSIVE SAMPLING	31
Shashi Bhushan, Nishi Karzogi and Shatija Pandey	
INTRODUCTION	31
SAMPLING METHODOLOGY	32
Sample Structure and Notations	32
FORMULATION OF THE PROPOSED GENERALIZED CLASS	33
IMPORTANT SPECIAL CASES OF CASES OF CLASS OF ESTIMATOR FOR UNMATCHED PROPORTION	35
IMPORTANT SPECIAL CASES OF CLASS OF ESTIMATOR FOR MATCHED PROPORTION	36
MEAN SQUARE ERROR OF THE PROPOSED GENERALIZED CLASS	38
ANALYTICAL STUDY	40
OPTIMAL REPLACEMENT POLICY	40
EFFICIENCY COMPARISON	41
NUMERICAL STUDY	43
CONCLUSION AND INTERPRETATION	44
CONSENT FOR PUBLICATION	45
CONFLICT OF INTEREST	45
ACKNOWLEDGEMENTS	45
REFERENCES	45
CHAPTER 4 LOG-TYPE ESTIMATORS OF POPULATION MEAN UNDER RANKED SET SAMPLING	47
Shashi Bhushan and Anoop Kumar	
INTRODUCTION	47
LITERATURE REVIEW	49
PROPOSED ESTIMATORS	52
Theoretical Comparison	58
Simulation Study	61
Results of the Simulation Study	63
CONCLUSION	63
CONSENT FOR PUBLICATION	63
CONFLICT OF INTEREST	63
ACKNOWLEDGEMENTS	63
APPENDIX I	69
REFERENCES	73
CHAPTER 5 ANALYSIS OF BIVARIATE SURVIVAL DATA USING SHARED INVERSE GAUSSIAN FRAILTY MODELS: A BAYESIAN APPROACH	75
Arvind Pandey, Shashi Bhushan, Lalpawinawha and Shikhar Tyagi	
INTRODUCTION	75
GENERAL SHARED FRAILTY MODEL	78
INVERSE GAUSSIAN FRAILTY	79
BASELINE DISTRIBUTIONS	80
PROPOSED MODELS	81

## CHAPTER 5

### Analysis of Bivariate Survival Data using Shared Inverse Gaussian Frailty Models: A Bayesian Approach

Arvind Pandey<sup>1</sup>, Shashi Bhushan<sup>2</sup>, Lalpawinawha<sup>3\*</sup> and Shikhar Tyagi<sup>1</sup>

<sup>1</sup>Department of Statistics, Central University of Rajasthan, India

<sup>2</sup>Department of Mathematics and Statistics, Dr. Shakti Lal Misra National Rehabilitation University, Lucknow, India

<sup>3</sup>Department of Statistics, Pachhunga University College, Mizoram, India

**Abstract:** Frailty models are used in the survival analysis to account for the unobserved heterogeneity in individual risks of disease and death. The shared frailty models have been suggested to analyze the bivariate data on related survival times (e.g., matched pair experiments, twin or family data). This paper introduces the shared Inverse Gaussian (IG) frailty model with baseline distribution as Weibull exponential, Lomax, and Logistic exponential. We introduce the Bayesian estimation procedure using Markov Chain Monte Carlo (MCMC) technique to estimate the parameters involved in these models. We present a simulation study to compare the actual values of the parameters with the estimated values. Also, we apply these models to a real-life bivariate survival data set of McGilchrist and Aisbett [1] related to the kidney infection data, and a better model is suggested for the data.

**Keywords:** Bayesian model comparison, Inverse gaussian frailty, Lomax distribution, Logistic exponential distribution, MCMC, Shared frailty, Weibull exponential distribution.

#### INTRODUCTION

The statistical analysis of time-to-event, event-history, or duration data plays an essential role in medicine, epidemiology, biology, demography, engineering, actuarial science, and other fields. In the past several years, medical research concerning the addition of random effects to the survival model has substantially increased. The random effect model is a model with a continuous random variable presenting excess risk or frailty for individuals or families. Sometimes due to the

\*Corresponding author Lalpawinawha: Department of Statistics, Pachhunga University College, Mizoram, India. Tel: +91-9862307640, E-mail: ralte.lalpawinawha08@gmail.com.

  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram



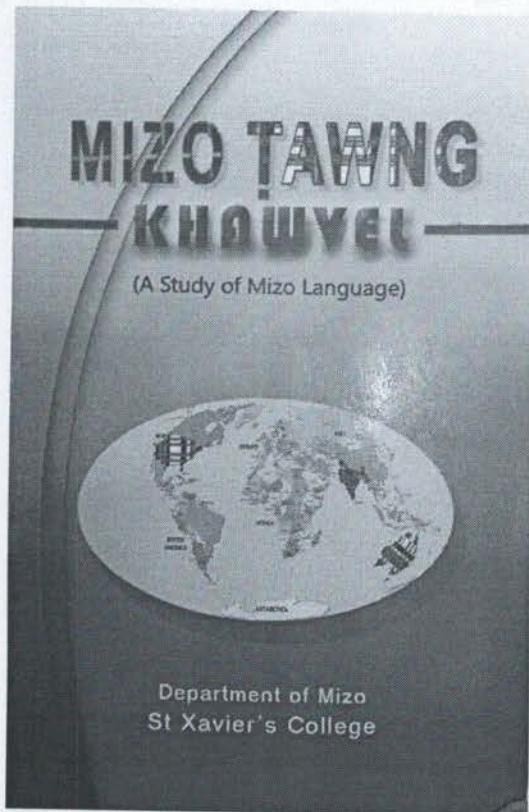
Hnam Zai leh Lam Zir Chianna	
<b>A chhunga thu awmte</b>	
1. Thuhmahrui .....	vi
<b>HNAM LAM ZIRZAUNA</b>	
1. Chhawm Nun Tlak 'Chawnglaizawn' .....	3
- H. Laldinnawia .....	
2. Gangte Lam Leh Mizo Hnam Lam Inkungkaiha .....	14
- Lalzuitluanga .....	
3. Rallu Lam (Sarlamkai/Solakia) .....	23
- Prof. KC Varughesa .....	
4. Chheih Zai leh Lam .....	32
- Darchuailova Renlei .....	
5. Solakia Zirzauna .....	50
- H. Purnawii .....	
6. Tlangam leh Zai .....	54
- T. Zathanghara & Vannethluanga .....	
<b>HNAM ZAI ZIR ZAUNA</b>	
1. Mizo Hla Hlui: History Tukverh Ajangin .....	66
- B. Lalhanghiana .....	
2. Representing Tribal Identity of Mizo in Bawhla & Hlado .....	76
- Dr. Zoramshihara .....	
3. Chai Hla Zirchianna .....	85
- H. Lalawngui .....	
4. Thiam Hla .....	98
- Omega Vanlaldunta .....	
5. Mizo Hmetchhiate Hlimthla: Darpawngi Zai Ajang Thliena .....	110
- E. Lalnunpui .....	

Hnam Zai leh Lam Zir Chianna	
3	
<b>Chhawm Nun Tlak 'Chawnglaizawn'</b>	
H. Laldinnawia*	
<b>Hnam lām (folk dance):</b>	
<p>Mihring awm tith atangin lām hi mihring nunah a bet ve ngal a; nuthing nun phan chhoh dan ang zelin lam pawh hi a danglam thin. 'Lām hi arts tawng tawng hringchhuaku a ni' (dance is the mother of all arts) tih a ni nghe nghe (Sachs iii). Pipute nunphung, an chet vel dan emaw, hmanlai mite nunphung chhuina (folklore) hi 'mipui marphu' (pulse of the people) emaw 'khawtlang nun hausakna' (wealth of society) tūn an sawi a thin (Reddy 288). Folklore zinga pawimawh rak hnam lām (folk dance) hi mipui innee lawmna te, kut ni vangthiaah te, buhbal thar awanga lawmthu sawina te leh thihna leh lusuna entir nan te an hman thin.</p> <p>Hetih rual hian ranchhuak hlawhtliena avang te, indonnaa hnehtu nih lawmna atan te, sik leh sa her vel lawmna atan te, chhiatna leh ramhuai hlaub dawna atan te lam hi entir a ni thin. Folk dance hi mipui lām (folk dance is a dance done by the folk) an ti. (Dinnawia 228). Chuvang chuan a ranchhuak te chauh leh eizawna atana hmanre chauh lamna ni lovin, mipui vangtlang lamna a ni a, chawimawina leh lawmnan uma lamna a ni ngat lem baw lo. A tlangpui thian mipui an lawmna leh himna, lungngalima leh mangana, lawmthu sawina leh jawngtaina atana an hman thin a ni (Khokar 8).</p> <p>Hnam khat emaw ram bung khat emaw chhunga mipui in awmte kalhman neia lam an entir thin hi 'folk dance'.</p> <p>*Asst. Professor, Department of Mizo, PUC</p>	



Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)

Principal  
Pachhunga University College  
Aizawl : Mizoram



10. Lai Tawng Tobul, Hmasawn Dan leh Tan Duhmun  
-L.H Hauheng..... 145
11. Mara Tawng : Tobul Leh Hmasawn Dan  
-H.Parmawil..... 153
12. Mizo Tawng Thuziak Hmasate  
-Lalrammuana Sailo..... 163

#### THEN THUMNA: LINGUISTIC APPROACH

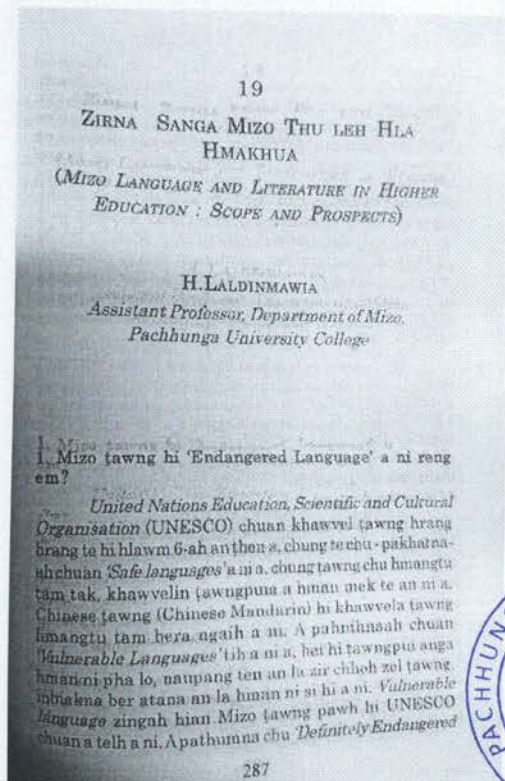
13. Mizo Tawng Grammar: Trends & Tendencies  
-Darchuailova Renthlei..... 175
14. Mizo Tawng Thluk: Khaw! Hmanga Bih Chianna  
-Dr. Laltleipui & R.Lalruatdiki..... 209
15. Thubet Tel leh Thubet Tel Lea Mizo Tawng  
Thumal Thar Siam Dan  
-Dr. R. Zothanliana..... 239

#### THEN LINA: THEMATIC APPROACH

16. Tawng leh Hnam Inpumkhatna  
-Lalrammawia Ngente..... 243
17. Mizo Tawng Zofate Inpumkhat Nan  
-Prof. C.Vanlalhraia..... 256
18. Eighth Schedule-a Mizo Tawng Telh  
Chungchang: Dan Mit atanga Thlirna  
-Prof. Runkhuma Colney..... 270
19. Zirna Sanga Mizo Thu leh Hla Hmakhua  
-H.Laldinmawia..... 287

#### THUBELH HUANG (APPENDICE)

- Appendix-I Seminar Programme / Sessions..... 301  
Appendix-II Seminar Minute..... 304



19

### ZIRNA SANGA MIZO THU LEH HLA HMAKHUA

(MIZO LANGUAGE AND LITERATURE IN HIGHER  
EDUCATION : SCOPE AND PROSPECTS)

H.LALDINMAWIA

Assistant Professor, Department of Mizo,  
Pachhunga University College

1. Mizo tawng hi 'Endangered Language' a ni reng em?

United Nations Education, Scientific and Cultural Organisation (UNESCO) chuan khawvel tawng hrang hrang te hi hlawn 6-ah an then a, chung te chu - pakhat na - hchuan 'Safe languages' a ni a, chung tawng chu hmangtu tam tak, khawvelin tawngpua a hman mek te an ni a. Chinese tawng (Chinese Mandarin) hi khawvela tawng hmangtu tam hera ngaih a ni. A pahnihsah chuan 'Vulnerable Languages' ti a ni a, hai hi tawngpui anga hmanini pha lo, naupang ten an la zir chih zel tawng. Inbiakna ber atana an la hman ni si hi a ni. Vulnerable language zingah hian Mizo tawng pawh hi UNESCO chuan a telh a ni. Apathumna chu Definitely Endangered



*[Signature]*  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(constituent college of Mizoram University)

*[Signature]*  
Principal  
Pachhunga University College  
Aizawl : Mizoram

# ADVANCES IN ENVIRONMENTAL RESEARCH OF NORTHEAST INDIA

K. Khelchandra Singh

*Advances in Environmental Research of Northeast India*  
By K. Khelchandra Singh

**SOUTH EASTERN BOOK AGENCIES**  
No.14, Hengrabari Housing Road,  
Dispur, Guwahati-781006.  
Mob: +919849106622, +919954202135.  
Email: south-easternbook@gmail.com

**Branch Offices:-**  
No.G6/195, Sector16, Rohini, Delhi-110085.  
Mob: +919818435279.  
Email: dbc2005@rediffmail.com  
H.No.CC-62/2420-2421 (SPCERA-10),  
Mother Teresa Lane, P.O. Kaloor, Kochi-682017, KERALA.  
PH: +91484-2337870, Mob: +919447300752.  
Email: sbcbbook@rediffmail.com

ISBN: 978-93-89262-10-0  
©Editor 2020

*All rights reserved. Except for brief quotations in critical articles or reviews, no part of this work may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of the copyright owner.*

Published by:- C. Sasi Kumar for South Eastern Book Agencies, Guwahati

## CONTENTS

Preface

iii

List of Contributors

v

### SECTION I

#### Environmental Pollution, Environmental Sustainability, Monitoring of Soil and Water Environments

1. Enhancing Environment Friendly Crude Oil Recovery in High Water Cut Oil Wells  
Dhrubajyoti Neog 3
2. Comparative Analysis of the Water Quality Status of Surface Water in the Vicinity of Aizawl, Mizoram, India  
K. Khelchandra Singh, Kulendra C. Das, Lallawmkimi, Hilda Lalrinpuit and Subhasish Das 12
3. Major Ion Chemistry of the Kameng River of Arunachal Pradesh, India  
Bidyut Bikash Sharma and Hari Prasad Sarma 29
4. Measurement of natural Radioactivity Using NaI (TI) Detector in Soil Samples of Oil Exploration areas in Mizoram, India  
Remlalsiana, Vanramlawma, Hmingchungmungo, Laldingngheta, L.Z.Chhangte Z.Pachuan, B.Zoliana, B.K Sahoo and B.K Sahoo

Coordinator

Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



*Advances in Environmental Research of Northeast India*  
Editor: K. Khelchandra Singh  
ISBN: 978-93-892-6210-0

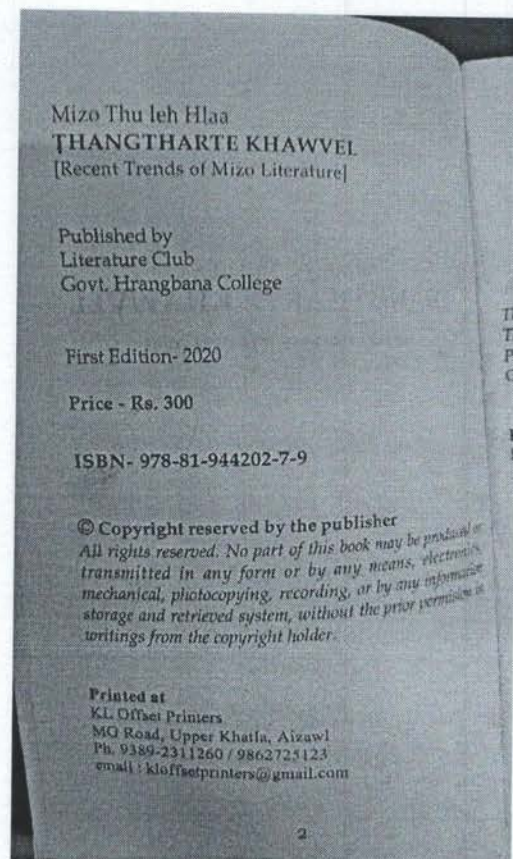
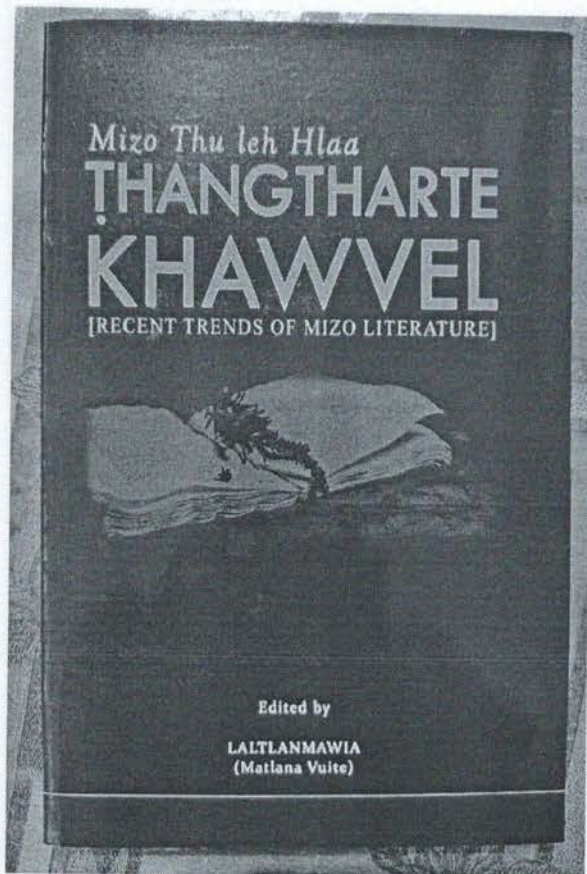
## COMPARATIVE ANALYSIS OF THE WATER QUALITY STATUS IN THE VICINITY OF AIZAWL, MIZORAM, INDIA

\*K. Khelchandra Singh, Kulendra C. Das, Lallawmkimi, Hilda Lalrinpuit  
and Subhasish Das  
Department of Environmental Science, Pachhunga University College,  
Mizoram University, Aizawl-796001, Mizoram, India  
(\*Corresponding Author: k.k.singh@pucollege.edu.in)

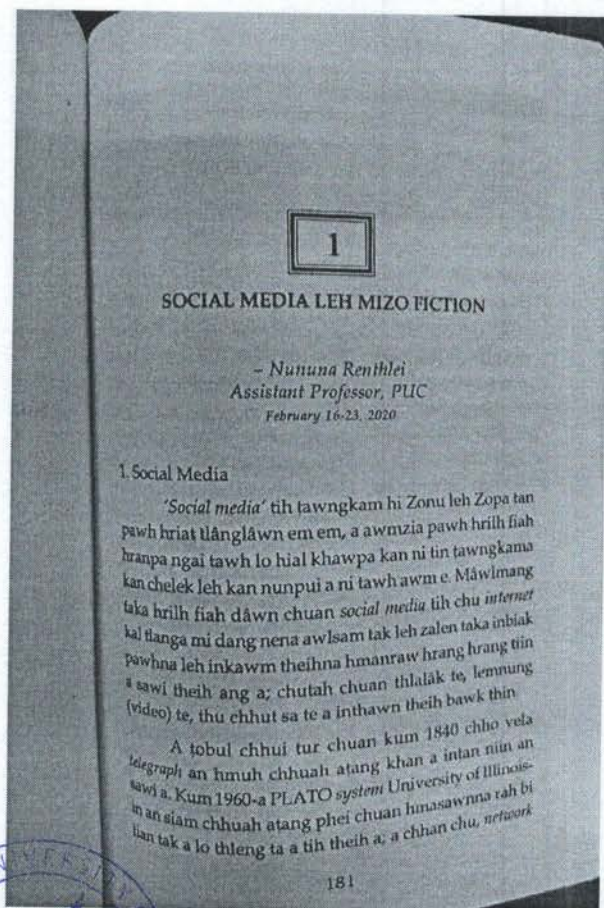
### Abstract

The present study has been carried out to evaluate the water quality collected from selected disturbed and undisturbed areas located in and around Aizawl city. There are twelfth (12) sampling sites, out of these eight (8) sites are located in disturbed areas and remaining four (4) sites are in undisturbed areas. Following water quality parameters were analysed namely Water Temperature, Turbidity, Total Dissolved Solids, pH, Electrical Conductivity, Dissolved Oxygen, Dissolved Free Carbon Dioxide, Chloride, Alkalinity, Total Hardness and Biological Oxygen Demand. The different physico-chemical parameters were analysed using standard methods. The variation of water quality parameters showed that Water Temperature ranges of 12 °C to 20 °C (mean of 17.08°C); Turbidity varied from 0.92 to 10.61 NTU with a mean value of 3.88 NTU; Total Dissolved Solids ranged from 0.01 to 0.85 mg/l (mean of 0.20 mg/l); pH varied from 6.44 to 7.73 (mean of 7.11); Electrical Conductivity varied from 78.70 to 883.75 µS/cm (mean of 349.51 µS/cm). Dissolved Oxygen varied from 3.40 to 9.20 mg/l with a mean value of 6.08 mg/l; free Carbon dioxide ranges from

Principal  
Pachhunga University College  
Aizawl : Mizoram



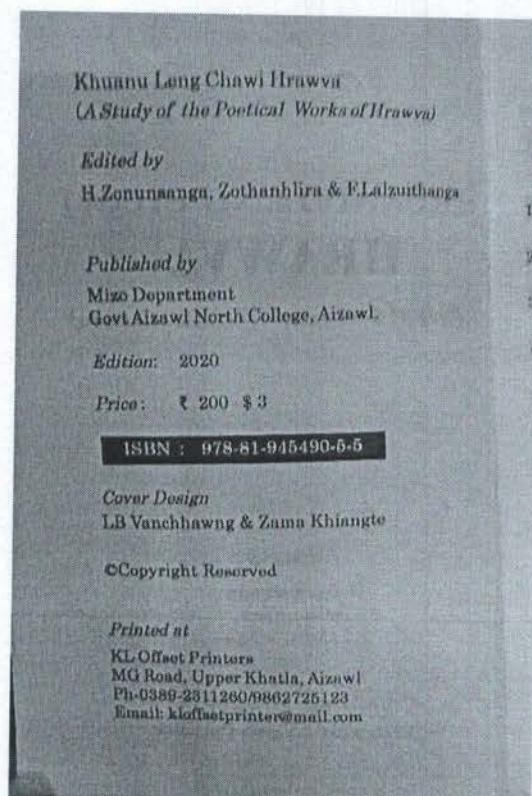
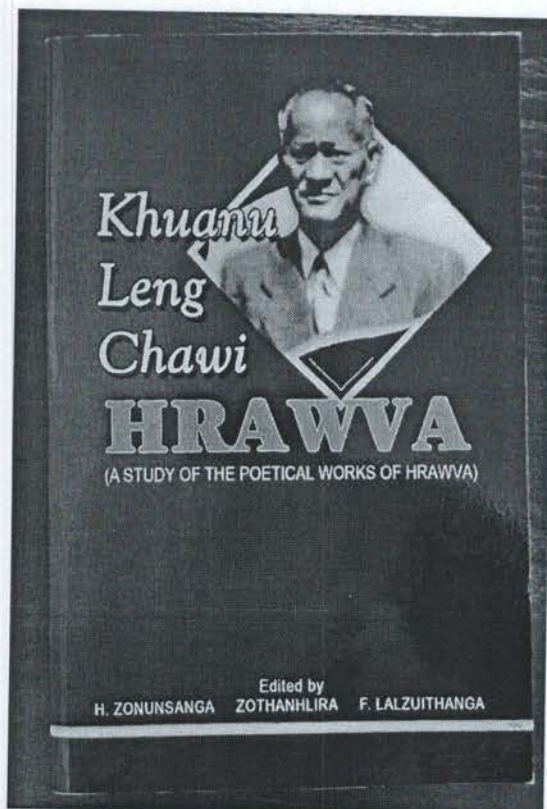
<b>BUNG HNIHNA- DRAMA KAIHHNAWIIH</b>	
1. Mizo Lemchan- Quo Vadis? - F. Lalzuithanga	- 89
2. Mizo Lemchan (Drama) Than Chhoh Dan - Lalzarzova	- 100
3. Zephyr Drama (Social Satirical Drama) - V.L. Muanpuia Chawngthu	- 107
<b>BUNG THUMNA- NOVEL KAIHHNAWIIH</b>	
1. Mizo Novelist-te Hnuhma - P.C. Lalngaihzuale	- 133
2. Mizo Novel Ziarang - J.H. Lalrinzuale	- 147
3. Revisiting Lalengmawia Ralte: A Study of his Novels - Dr. Zoramdinthara	- 160
<b>BUNG LI-NA- SOCIAL MEDIA KAIHHNAWIIH</b>	
1. Social Media leh Mizo Fiction - Nununa Renthlei	- 181
2. Social Media-in Mizo Poetry-a Nghawng a Noh Dan - Lalramnuana Sailo	- 204
3. Youtube-a Mizo Pasaltha Thawnthute Zir Chianua - V. Lalberkhawpuimawia	- 214
4. Thangthar, Thu leh Hlaa Tuite leh Social Media - Laldinllana	- 229
5. Evolution of Mizo Language - Lalnunluanga	- 237



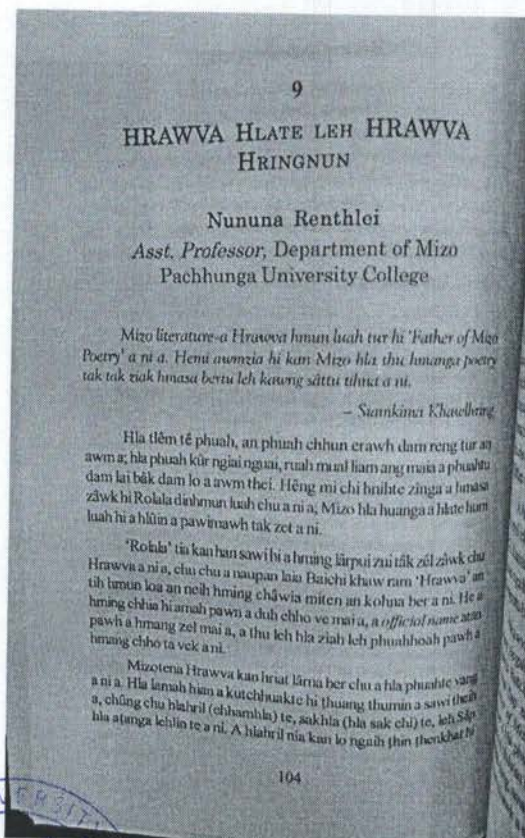
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



**Principal**  
Pachhunga University College  
Aizawl : Mizoram



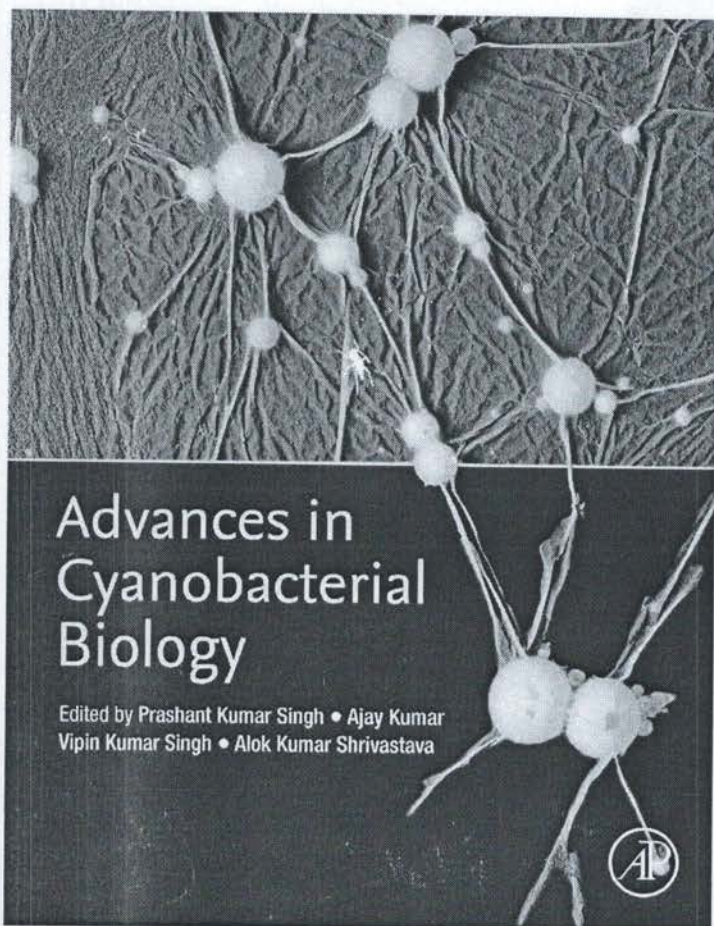
Thu Awmta	
i) Foreword from Principal.....	05
ii) Thuhma - Co-ordinator .....	07
1. Sawi Hawna (Keynote Speech) by Dr. J. Khuma.....	13
2. Mizo Hlaa Hrawva Dinmun by C. Vanlallawma.....	19
3. Hrawva, Mizo Poetry-a Sulsutu by Lalramliana.....	31
4. Hrawva- Romantic Poet by Prof. R. Thangvunga.....	39
5. Hrawva leh A Hlate by C. Chhuanvawra.....	46
6. Hrawva Hla Lehlinte by VLC Vanlalhratrenga .....	65
7. Hrawva Hunpui Hlate Bih Chianna by Vanlalana Khiangte.....	79
8. Hrawva Krimas Hlate by HC Lalnunthara.....	94
9. Hrawva Hlate leh Hrawva Hringnun by Nununa Renthlei.....	104
10. Hrawva Hlarua by VL Muanpuia Chawngthu.....	117
11. Hrawva Hlaa Mizona by Lalldanmawia.....	126



  
Coordinator  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



  
Principal  
Pachhunga University College  
Aizawl : Mizoram



# Advances in Cyanobacterial Biology

Edited by Prashant Kumar Singh • Ajay Kumar  
Vipin Kumar Singh • Alok Kumar Shrivastava



ACADEMIC PRESS  
An imprint of Elsevier

*Ketty*  
**Coordinator**  
Internal Quality Assurance Cell  
Pachhunga University College  
(A constituent college of Mizoram University)



*Principal*  
**Principal**  
Pachhunga University College  
Aizawl : Mizoram

Academic Press is an imprint of Elsevier  
135 London Wall, London EC2Y 5AS, United Kingdom  
325 B Street, Suite 160, San Diego, CA 92101, United States  
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States  
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom  
Copyright © 2010 Elsevier Inc. All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: [www.elsevier.com/permissions](http://www.elsevier.com/permissions).

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

## Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

## British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

## Library of Congress Cataloguing-in-Publication Data

A catalog record for this book is available from the Library of Congress

ISBN: 978-0-12-839331-1

For information on all Academic Press publications  
visit our website at <http://www.elsevier.com/books-and-journals>

Publisher: Charlotte Cockle  
Acquisitions Editor: Nancy Maragoglio  
Editorial Project Manager: Redding Morse  
Production Project Manager: Prem Kumar Kallumoorthy  
Cover Designer: Christian Bilbow  
Typeset by MPS Limited, Chennai, India



## Advances in Cyanobacterial Biology

Edited by

**Prashant Kumar Singh**

Department of Vegetables and Field Crops, Institute of Plant Sciences, Agricultural Research Organization, The Volcani Centre, Rishon LeZion, Israel

**Ajay Kumar**

Department of Post-harvest Science, Agricultural Research Organization, The Volcani Centre, Rishon LeZion, Israel

**Vipin Kumar Singh**

Department of Botany, Institute of Sciences, Banaras Hindu University, Varanasi, India

**Alok Kumar Shrivastava**

Department of Botany, Mahatma Gandhi Central University, Motihari, India

## Contents

List of contributors	xiii	2.3 Selective molecular markers for cyanobacterial diversity	23
1. Cyanobacterial imprints in diversity and phylogeny	1	2.3.1 16S ribosomal RNA gene as a phylogenetic marker gene	24
Swati Mishra		2.3.2 rpoB as an alternative phylogenetic marker gene	24
1.1 Introduction	1	2.3.3 nifH as an alternative phylogenetic marker gene	24
1.2 Biodiversity of cyanobacteria	1	2.4 Polyphasic characterization for the cyanobacterial diversity and recent developments	25
1.3 Morphological diversity-based classification	2	2.5 Conclusion and future prospects	27
1.4 Habitat heterogeneity-based classification	3	Acknowledgments	27
1.5 Taxonomy of cyanobacteria	3	References	27
1.5.1 Different taxonomic approaches	3	3. Cyanobacteria in tropical and subtropical marine environments: bloom formation and ecological role	35
1.5.2 Current taxonomic status	4	Kolchar M. Rajaneesh, Ravidas Krishna Nall, Rajdeep Roy and Priya M. D'Costa	
1.5.3 Comparison of different taxonomic approaches	5	3.1 Introduction	35
1.6 Phylogenetic analysis	5	3.2 Cyanobacterial distribution around the Indian waters	36
1.6.1 16S rRNA gene as a phylogenetic marker	6	3.2.1 Prochlorococcus and Synechococcus	36
1.6.2 Various other phylogenetic markers	6	3.2.2 Trichodesmium	38
1.6.3 A comparison between polyphasic and different phylogenetic approaches	7	3.3 Cyanobacterial diazotrophs	38
1.6.4 Phylogenetic analysis of heterocyst-forming cyanobacteria	8	3.4 Interactions between heterotrophic bacteria and cyanobacteria	39
1.7 Cyanobacterial systematics: current challenges and future projections	8	3.4.1 The "phycosphere" of cyanobacteria: interactions with prokaryotes	39
1.8 Recent developments in cyanobacterial phylogenetic taxonomy	8	3.4.2 Unicellular, free-living cyanobacteria	39
1.9 Conclusion	9	3.4.3 Filamentous, nonheterocyst-forming cyanobacteria	40
Acknowledgments	11	3.4.4 Filamentous, heterocyst-forming cyanobacteria	40
References	11	3.4.5 Unicellular symbiotic cyanobacteria	41
Further reading	15	3.4.6 Cyanobacteria-heterotrophic bacteria interactions: biotechnological potential	41
2. Cyanobacterial diversity: molecular insights under multifarious environmental conditions	17	3.5 Conclusion	42
Nidhi Kumari and Lal Chand Rai		Acknowledgments	42
2.1 Introduction	17	References	42
2.2 Molecular methods to examine cyanobacterial diversity	18	Further reading	46
2.2.1 PCR-based DNA profiling methods	19		
2.2.2 PCR-independent/genome-based DNA profiling methods	22		

# Microbe Mediated Remediation of Environmental Contaminants

Edited by

Ajay Kumar

Vipin Kumar Singh

Pardeep Singh

Virendra Kumar Mishra

Woodhead Publishing is an imprint of Elsevier  
The Officers' Mess Business Centre, Royston Road, Duxford, CB22 2QH, United Kingdom  
50 Hampshire Street, 9th Floor, Cambridge, MA 02139, United States  
The Boulevard, Langford Lane, Kidlington, OX5 1GB, United Kingdom

Copyright © 2022 Elsevier Inc. All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: [www.elsevier.com/permissions](http://www.elsevier.com/permissions).

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

## Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

## British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

## Library of Congress Cataloguing-in-Publication Data

A catalog record for this book is available from the Library of Congress

ISBN: 978-0-12-832199-1 (print)

ISBN: 978-0-12-832197-1 (online)

For information on all Woodhead Publishing publications  
visit our website at <https://www.elsevier.com/books-and-journals>



WP

WOODHEAD  
PUBLISHING

An imprint of Elsevier

*Kathey*

Coordinator

Internal Quality Assurance Cell

Pachhunga University College

(A constituent college of Mizoram University)

viii Contents

16. Microbial systems as a source of novel genes for enhanced phytoremediation of contaminated soils	177
Sonal Srivastava, Vandana Anand, Pallavi Singh, Aditi Roy, Sushree Pallavi, Vidisha Bist, Jasvinder Kaur, Subhi Srivastava, Ratna Khatyar and Suchi Srivastava	
16.1 Introduction	177
16.2 Different soil contaminants and their impact on human health	178
16.3 Tool for detoxification of contaminated soil	181
16.4 Plant-microbe interaction as detoxification strategy	187
16.5 Microbial genes as potential biotechnological strategies for phytoremediation	188
16.6 Conclusion	192
References	192
17. Bioremediation potential of methylophilic bacteria	199
Deen Dayal Giri, Sandeep Kumar Singh, Ajay Giri, Himanshu Dwivedi and Ajay Kumar	
17.1 Introduction	199
17.2 Mechanism of carbon assimilation	199
17.3 Bioremediation of simple organic compounds	200
17.4 Conclusion	204
References	204
18. Advancement in bioinformatics and microarray-based technologies for genome sequence analysis and its application in bioremediation of soil and water pollutants	209
Jyoti Singh, Madhuri Gupta, Kaushalendra Kumar Singh, Ajay Kumar, Deepanker Yadav, Wang Wenjing and Prashant Kumar Singh	
18.1 Introduction	209
18.2 Mechanism of bioremediation	209
18.3 Genome sequencing	210
18.4 Application of microarray technique in genome sequence analysis	212
18.5 Advancement in microarray technology	212
18.6 Applications of microarray technologies for genome sequencing	215
18.7 Single nucleotide polymorphisms	215
18.8 Clinical diagnostics	215
18.9 Forensic detection	215
18.10 Pharmacogenomics	215
18.11 Variation in the human genome	216
18.12 Expression analysis of plants and microbes through microarray	216
18.13 Microarray for proteomics	217
18.14 ChIP-seq	217
18.15 Role of microarray-based technologies and bioinformatics in bioremediation	218
18.16 Conclusion	220
Acknowledgment	221
References	221
19. Application of plant-microbe systems in bioremediation of metalloid-contaminated soils	227
Megha Barot, Arpan Modi and Ajay Kumar	
19.1 Introduction	227
19.2 Remediation strategies	228
19.3 Bioremediation	229
19.4 Phytoremediation	230
19.5 Mechanism of plant- and microbe-assisted remediation	231
19.6 Conclusion and future prospects	236
References	237
Further reading	240
20. Microbe-based bioreactor system for bioremediation of organic contaminants: present and future perspective	241
Akhilshwar Kumar Srivastava, Rajesh Kumar Singh and Divya Singh	
20.1 Introduction	241
20.2 Use of microbial bioreactors	242
20.3 Factors affecting performance of microbial bioreactor	243
20.4 Microbial bioreactors in bioremediation	245
20.5 Bioremediation organisms	249
20.6 Bioremediation of pollutants using bioreactors	250
20.7 Genetic engineering	250
20.8 Conclusion	251
References	251
21. Microbial biofilms for the remediation of contaminated water	255
Monika Singh, Shweta Pandey, Ajay Kumar and K.D. Pandey	
21.1 Introduction	255

Publisher: Charlotte Cockle  
Acquisitions Editor: Nancy Marsiglio  
Editorial Project Manager: Alice Grant  
Production Project Manager: Surya Narayanan Jayachandran  
Cover Designer: Mark Rogers  
Typeset by MPS Limited, Chennai, India



Principal  
Pachhunga University College  
Aizawl : Mizoram

## Chapter 18

# Advancement in bioinformatics and microarray-based technologies for genome sequence analysis and its application in bioremediation of soil and water pollutants

Jyoti Singh<sup>1</sup>, Madhuri Gupta<sup>1</sup>, Kaushalendra Kumar Singh<sup>1</sup>, Ajay Kumar<sup>2</sup>, Deepanker Yadav<sup>3</sup>, Wang Wenjing<sup>4</sup> and Prashant Kumar Singh<sup>5</sup>

<sup>1</sup>Department of Botany, Institute of Sciences, Banarus Hindu University, Varanasi, India, <sup>2</sup>Surat Vallabhbhai Patel University of Agriculture and Technology, Meerut, India, <sup>3</sup>Department of Zoology, Pachhunga University College, Mizoram University, Aizawl, India, <sup>4</sup>Agriculture Research Organization, Ministry of Agriculture and Rural Development, Volcani Center, Rishon LeZion, Israel, <sup>5</sup>State Key Laboratory of Cotton Biology, Henan Key Laboratory of Plant Stress Biology, School of Life Science, Henan University, Kaifeng, China, <sup>6</sup>Department of Biotechnology, Pachhunga University College, Mizoram University, Aizawl, India

## 18.1. INTRODUCTION

Modern agricultural practices in combination with industrialization have dramatically enforcing world toward environmental pollution in the environment, which implies negative impact on normal ecosystem functioning (Megharaj et al., 2011). Burning of fossil fuels (coal, petroleum, diesel, and hydrocarbons) and application of fertilizers, pesticides, insecticides, and herbicides are the major players contributing to environmental pollution. Most of the fertilizers and biocides used in agriculture are readily water-soluble and runoff from the contaminated sites. Frequent cycling by volatilization and condensation these contaminants also precepted in the form of rain, fog, and snow (Dubus et al., 2009). Moreover, on migration, these pollutants reach to soil or as dust and contribute further to the natural ecosystem's pollution (Lopez-Ibanez and Vazquez, 2003). Therefore our soil, air, and water resources are heavily polluted with various pollutants that prime worsening of soil and water quality. Notwithstanding above, by leaching and runoff these pollutants also contaminate our surface and underground water. These pollutants negatively affect the human health and also hazardous environment. Furthermore, currently, chemical pesticides are frequently used in agriculture to enhance crop productivity worldwide and are also a major factor influencing natural environmental. Bioremediation is an effective, economical, and eco-friendly way to check out these environmental hazards by natural degradation mediated by microorganisms and/or plants (Pierzynski et al., 1994). Nowadays various techniques such as genomics, transcriptomics, proteomics, metabolomics, lipidomics, phenomics, bioinformatics, and sequencing are employed to identify and understand the mechanism of natural bioremediation in different environments (Chakraborty et al., 2012). The microarray-based technologies in combination with bioinformatics are useful in documentation of unprecedented microbes and their mechanism of bioremediation and to uncover the gene and their products in a cell involved in the process. Metagenomics and whole-genome sequencing have generated novel possibilities to explore the microorganism mediated remediation. The present chapters high spot the role of microarray-based technologies and bioinformatics to understand the bioremediation and future perspectives.