2022-23

Aquatic Sciences (2022) 84:46
https://doi.org/10.1007/s00027-022-00880-5

Aquatic Sciences

RESEARCH ARTICLE

Exploring the ecosystem health of a tropical Indian estuary using mass-balanced ecosystem model

Sreekanth Giri Bhavan[1] · Baban Ingole[2] · Nabyendu Rakshit[3] · Asha Giriyan[4] · Fraddry D'souza[4] · Shalita Dourado[4] · Trivesh Mayekar[1] · Purva Rivonkar[1] · Renjith VishnuRadhan[5] · Chakurkar Eakanath Bhanudasrao[1]

Received: 18 September 2021 / Accepted: 23 June 2022

Abstract

Estuaries provide life support to aquatic biota and livelihood support to fishermen and local inhabitants. However, the ecosystem function of estuaries is impaired due to anthropogenic stressors and hence, the assessment of ecosystem health using ecological indicators will deliver the status of stability, maturity, and integrity of an estuary. In this paper, we compiled comprehensive ecological data into an Ecopath model from 2018 to 2019 for a tropical Indian estuary, Mandovi (ME) located along the western coast of India. The functional groups (22) identified in the food web ranged from primary producers (trophic level (TL) = 1) to dolphins (TL 4.4). The indices: biomass/total system throughput (0.01), primary production/respiration (11.04), and primary production/ biomass (35.7) showed that the estuary is a developing ecosystem far from maturity. The ME food web is an immature, complex and organized trophic network with a medium rate of recycling (Finn's Cycling Index = 9.75%), high total system throughput (17,132.33 tons km^{-2} $year^{-1}$), low ascendency (19,610 tons km^{-2} $year^{-1}$), high relative ascendency (47.8%), moderate connectance (0.36), and omnivory indices (0.26). The health indices: eco-exergy index (21,471.33 gm detritus equivalent m^{-2}) and system robustness (0.153) showed that the ecosystem is immature but resilient to unexpected perturbations in the ecosystem. The ecological indicators were compared with other global estuaries, and the environmental indices were developed for the ME. Based on the ecological indices, the estuarine system is immature, moderately developed, and not well organized in terms of its ecological components. The study also indicates that an ecological approach would be more appropriate and essential in analyzing tropical transitional waters' health and sustainability.

Keywords Eco-exergy · Ecopath model · Ecosystem health · Robustness · Tropical estuary · Trophic organization

Introduction

Estuaries are essential to coastal livelihoods and possess ecological, biological, environmental, cultural, educational, and socio-economic values (Costanza et al. 1997). Estuarine ecosystems, which are transitional, highly productive, and diverse, help aquatic species by assimilating nutrients, diversifying habitats, maintaining biodiversity, and serving as a nursery, a source of food, and a shelter. Estuaries also help in carbon sequestration and flood and storm surge control (Costanza et al. 1997) and support a variety of fisheries of high economic value—making them the most threatened ecosystems on earth (Beck et al. 2001; Selleslagh et al. 2009). The quantification of materials, biomass, or energy flow through various ecological compartments and energy efficiency in the ecosystem's assimilation, transfer, and dissipation offers crucial insights into its structure and functioning (Christensen et al. 2005). Therefore, analyzing

✉ Sreekanth Giri Bhavan
gbsree@gmail.com

1 ICAR-Central Coastal Agricultural Research Institute, Old Goa, Goa 403402, India

2 ESSO-National Centre for Polar and Ocean Research, Vasco-da-Gama, Goa 403804, India

3 Department of Zoology, Gushkara Mahavidyalaya, Purba Bardhaman, Gushkara, West Bengal 713128, India

4 The Energy and Resources Institute (TERI), Southern Regional Centre (SRC), Alto-St. Cruz, Tiswadi, Goa 403 005, India

5 Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, Maharashtra 400076, India

Published online: 11 July 2022

Table 2 Basic parameters of the mass-balanced trophic model for Mandovi estuary (Biomass in t km^{-2} $year^{-1}$)

Groups	Trophic level	Biomass	P/B	Q/B	EE	P/Q	KSI	RTI
Dolphins	4.51	0.005	0.04	13.2	0.06	0	− 0.8	0.2
Birds	4.46	0.004	0.08	20.1	0.09	0	− 0.1	0.7
Large pelagics	4.22	0.016	2.1	6.9	0.71	0.3	− 0.9	0.1
Large benthic carnivores	4.11	0.014	4.9	14	0.73	0.35	− 0.5	0.6
Cephalopods	3.85	0.51	3.9	11.5	0.53	0.34	− 0.5	0.5
Bentho-pelagics	3.82	0.23	2.9	8.3	0.69	0.35	− 0.2	0.8
Piscivores	3.82	0.25	2.3	7.6	0.58	0.3	− 0.3	0.6
Medium benthic carnivores	3.79	0.27	3.8	10.6	0.74	0.36	− 0.3	0.7
Rays and skates	3.73	0.002	1.7	7.1	0.73	0.24	− 2.4	0
Small benthic carnivores	3.31	0.3	4.1	19.1	0.81	0.21	− 0.3	0.9
Crabs	3.01	0.58	7.2	23.3	0.62	0.31	− 0.5	0.7
Jellyfish	2.96	1.22	4.86	21.4	0.41	0.23	− 0.6	0.3
Shrimps	2.71	1.34	6.8	20.6	0.79	0.33	− 0.3	0.7
Benthic omnivores	2.65	7.1	3.2	12.5	0.53	0.26	− 0.4	0.8
Clupeids and anchovies	2.44	4.1	7.3	22.4	0.85	0.33	− 0.2	0.9
Heterotrophic benthos	2.38	18.6	3.4	12.7	0.63	0.27	− 0.4	0.8
Mackerel	2.21	0.41	6.4	19.6	0.46	0.33	− 0.8	0.2
Sessile benthos	2.15	18.1	7.3	32.8	0.91	0.22	− 0.2	0.7
Zooplankton	2.08	5.1	23.5	83.2	0.88	0.28	− 0.3	0.8
Benthic producers	1	103.2	11.2		0.09		− 1.2	0.2
Phytoplankton	1	63.7	91.62		0.22		− 0.1	0.8
Detritus	1	480			0.09			

P/B production/biomass, *Q/B* consumption/biomass, *EE* ecotrophic efficiency, *P/*Q production/consumption, *KSI* keystone species index, *RTI* relative total impact

benthos (0.83), bentho-pelagic (0.82), benthic omnivores (0.82), phytoplankton (0.81), and zooplankton (0.81) had the highest relative total impact (RTI) (Table 2). Considering the MTI and RTI values, these groups, thus, emerged as the keystone groups in the ME, forming the major links in transferring energy from the base trophic levels to the higher levels.

Ecosystem properties and indicators

In the ME, the net primary production (7920 t km^{-2} $year^{-1}$) was high enough to support rich biomass of medium trophic levels such as zooplankton, pelagic fish (clupeids and anchovies), small benthic carnivores, benthic omnivores, and heterotrophic benthos, which indicated a bottom-up control in the food web. Higher net primary production (t km^{-2} $year^{-1}$) is recorded from other tropical estuaries in India—Vellar, 12,300; Hooghly-Matlah, 9160; and Zuari, 10,162 and also from other estuaries around the world: Río de la Plata, 20 810; Sine-Saloum, 11 815; the Seine, 7680 (Rybarczyk and Elkaïm 2003); and Cameroon, 7105. However, the value was low (4959) in Ulhas estuary, India (Lal et al. 2021).

Diversity and biomass of benthos groups are also considered indicators of estuarine health (Sivadas et al. 2011, 2016; Gaonkar et al. 2013; Ingole et al. 2014). The diverse benthic groups (heterotrophic benthos, small benthic carnivores, benthic omnivores), provide food sources for most of the benthic carnivorous groups. Small benthic carnivores and benthic omnivores form the major secondary consumer groups, carrying energy from base groups to top benthic predators (Mohamed et al. 2008; Sreekanth et al. 2020a). Therefore, the benthos compartments provide a significant link between detritus and benthic carnivores or omnivores (Ingole et al. 2014).

Ecosystem maturity and stability

The primary ecosystem statistics of EwE and ENA indices cover all the attributes of the ME ecosystem (Table 3). The total system throughput, ascendency, relative ascendency, and FCI are the indices of an ecosystem related to its degree of maturity (Odum 1971). Total system throughput is the sum of consumption (SC), exports (SE), respiration (SR), and flows to detritus (SFD). For ME, the flows to detritus (46%) and exports (42%) seem to be the significant contributors to the TST—as they were in the Zuari estuary (SFD, 43% and SE, 38%) and indeed in most of the tropical, subtropical, and temperate estuaries. System size seems to

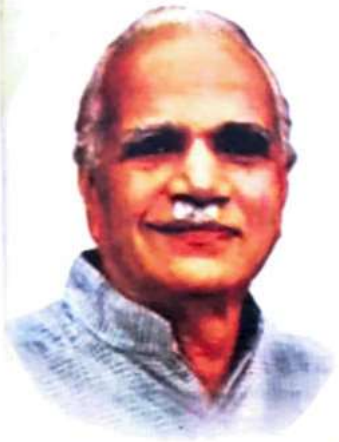
channel macrotidal estuaries: a comparison with other French estuaries. Estuar Coast Shelf Sci 81(2):149–159
Selleslagh J, Lobry J, Amara R, Brylinski JM, Boët P (2012) Trophic functioning of coastal ecosystems along an anthropogenic pressure gradient: a French case study with emphasis on a small and low impacted estuary. Estuar Coast Shelf Sci 112:73–85
Shetye SR (2011) Indian estuaries: dynamics, ecosystems, and threats. Natl Acad Sci Lett 34(7–8):229–237
Shetye SR, Dileep Kumar M, Shankar D (2007) Mandovi and Zuari estuaries. CSIR-National Institute of Oceanography, Goa, India, p 157
Shirodkar PV, Deepthi M, Vethamony P, Mesquita AM, Pradhan UK (2012) Tide dependent seasonal changes in water quality and assimilative capacity of anthropogenically influenced Mormugao harbor water. Indian J Geo-Mar Sci 41(4):314–330
Sivadas S, Ingole BS, Nanajkar M (2011) Temporal variability of macrofauna from a disturbed habitat in Zuari estuary, west coast of India. Environ Monit Assess 173(1):65–78
Sivadas SK, Nagesh R, Gaonakr UK, Mukherjee I, Ramteke D, Ingole BS, Gupta GVM (2016) Testing the efficiency of temperate benthic biotic indices in assessing the ecological status of a tropical ecosystem. Mar Poll Bull 106:62–76
Sreekanth GB, Chakraborty SK, Jaiswar AK, Zacharia PU (2018) A inventory on the coastal finfish and shellfish species of Zuari estuary, southwest coast of India. Indian J Geo-Mar Sci 47(5):945–958
Sreekanth GB, Jaiswar AK, Zacharia PU, Pazhayamadom DG, Chakraborty SK (2019) Effect of environment on spatio-temporal structuring of fish assemblages in a monsoon-influenced tropical estuary. Environ Monitor Assess 191(5):305
Sreekanth GB, Chakraborty SK, Jaiswar AK, Zacharia PU, Mohamed KS, Francour P (2020a) Trophic network and food web characteristics in a small tropical monsoonal estuary: a comparison with other estuarine systems. Indian J Geo-Mar Sci 49(5):774–789
Sreekanth GB, Sri Hari M, Jaiswar AK, Shivkumar HB, Manikandan B, Chakurkar EB (2020b) Fish composition and assemblage structure in 4 tropical monsoonal estuaries from India: a functional trophic guild approach. Estuar, Coast Shelf Sci. https://doi.org/10.1016/j.ecss.2020b.106911
Sreekanth GB, Chakraborty SK, Jaiswar AK, Zacharia PU, Mohamed KS (2021a) Modeling the impacts of fishing regulations on a monsoon-influenced tropical estuary along the west coast of India using Ecosim model. Environ Dev Sustain 23:17745–17763
Sreekanth GB, Rivonkar P, Mayekar TS, Giriyan A, D'souza F, Dourado S, Ingole B, Chakurkar EB (2021b) Inventory of fisheries resources using participatory research approach in Mandovi estuary in central western coast of India. J Environ Biol 42(5):1257–1263
Sruthy S, Ramasamy EV (2017) Microplastic pollution in Vembanad Lake, Kerala, India: the first report of microplastics in lake and estuarine sediments in India. Environ Pollut 222:315–322
Sundar D, Shetye SR (2005) Tides in the Mandovi and Zuari estuaries, Goa, west coast of India. J Earth Syst Sci 114(5):493–503
Ulanowicz RE, Goerner SJ, Lietaer B, Gomez R (2009) Quantifying sustainability: resilience, efficiency and the return of information theory. Ecol Complex 6(1):27–36
Ulanowicz RE, Puccia CJ (1990) Mixed trophic impacts in ecosystems. Coenoses 5(1):7–16
Ulanowicz RE (2012) Growth and development: ecosystems phenomenology, Springer Science and Business Media, December 6, 2012
Vassallo P, Fabiano M, Vezzulli L, Sandulli R, Marques JC, Jørgensen SE (2006) Assessing the health of coastal marine ecosystems: a holistic approach based on sediment micro and meio-benthic measures. Ecol Ind 6(3):525–542
Vijith V (2014) Physical oceanography of the Mandovi and Zuari, two monsoonal estuaries in Goa, central west coast of India. Doctoral dissertation in Marine Science, Goa University, p 141
VishnuRadhan R, Sagayadoss J, Seelan E, Vethamony P, Shirodkar P, Zainudin Z, Shirodkar S (2015) Southwest monsoon influences the water quality and waste assimilative capacity in the Mandovi estuary (Goa state, India). Chem Ecol 31(3):217–234

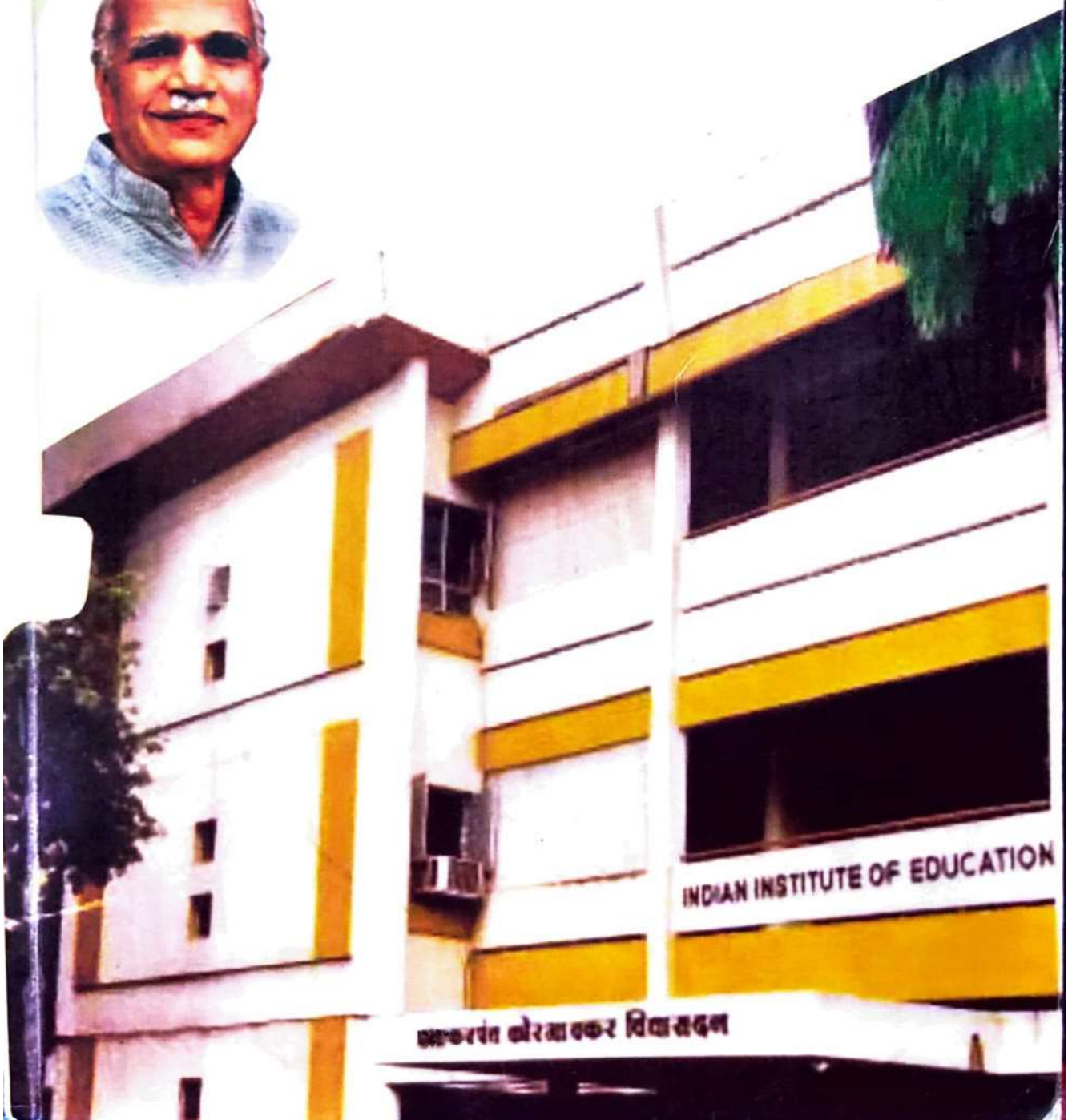
UGC CARE LISTED PERIODICAL
ISSN 2278-6864

शिक्षण आणि समाज

Education and Society

Multidisciplinary Special Issue
September 2022
Part - I





Index

Spatial Analysis A New Research Methodology in Economics An Application in the Study of Women's Empowerment in India

Dr. Papita Dutta

Assistant Professor in Economics, Gushkara Mahavidyalaya, Gushkara, Purba Bardhaman, West Bengal, India

Abstract

This paper has taken an attempt to conduct a spatial analysis of empowerment of the Indian women using state level spatial data generated from NFHS-4 reports, 2015-16. This study computed a women's empowerment index for each state considering geometric mean of six indicators found in NFHS report. These are; the percentage of women having decision making power in the family, labour force participation rate of the women, percentage of women having physical asset like land, house, etc., percentage of women having own bank account, percentage of women having own mobile, and percentage of women using hygienic method during menstrual period . We start with a spatial exploratory analysis using box map give the signal of spatial pattern of women's empowerment of the Indian states. Global Moran's I statistic value suggests that there is significant spatial autocorrelation for the variable state level women's empowerment index across the Indian states. Local Moran'I analysis using Local Indicators of Spatial Association (LISA) map suggests the presence of significant spatial clusters in several regions in India in respect of women's empowerment level

Keywords: LISA cluster map, Moran's I statistic, Spatial Analysis, Women's Empowerment

Introduction

In capability approach, empowering women is an important component of the process of inclusive development. Literally, empowerment means giving power to powerless in a particular situation. In UNDP Human Development Report, 1995, women's empowerment has been defined as the expansion of choices for women and an increase in the women's ability to exercise choices. Empowerment is the power of decision making i.e. autonomy (Jejeebhoy, 1995). Alsop, et al. (2005) state that empowerment is the enhancing an individual's or group's capacity to make choices and transform those choices into desired actions and outcomes.

Existing literature has explored empowerment of women as a multidimensional aspect which has many indicators and socio-economic and demographic determinants. It has some developmental outcomesthrough improving income, child education, health and

happiness. However, how the empowerment level of women of a [illegible] affects the empowerment level of women of it adjacent location [illegible] analysed in the literature. This study has tried to meet this gap.

Literature review and Objectives

In order to assess the impact of women's empowerment [illegible] understand the determinants of it quantification of the empowerment [illegible] women is important. Different studies have measured women [illegible] empowerment in different ways. Some studies (Sen, 1999, Malhotra et al. 2002, Sridevi, 2005, Dutta, 2017) have attempted to measure the degree of empowerment considering several dimensions of women empowerment. The degree of empowerment definitely makes impact on personal and social welfare which in turn enhances empowerment. The identification of the linkage between women's empowerment and development outcomes is the main contribution of the instrumentalist advocacy of women's empowerment. They have recognized women as the agent of change.

There are several studies which have explored the determinants of women's empowerment. We find that education, income, employment level, urbanisation, different government programs like microfinance, cash transfer programs etc. In this state level cross-section study all covariates cannot be considered for analysis and after all this is not our purpose. Against this back drop we have set two objectives as follows.

First, this study explore the position of the Indian states in respect of the level of women's empowerment. We thus compute a comprehensive index of state level women's empowerment index for each state.

Second, an attempt has been taken to exude the spatial distribution and nature of spatial autocorrelation of women's empowerment among the Indian states.

Methodology and data

Women's empowerment Index

State level Women's Empowerment Index (SWEI) for each state has been computed using six state level indicators mentioned by National Family and Health Survey (NFHS) report, 2015-16. These are; the percentage of women having decision making power in the family, labour force participation rate of the women, percentage of women having physical asset like land, house, etc., percentage of women having own bank account, percentage of women having own mobile, and percentage of women using hygienic method during menstrual period. SWEI has been constructed calculating the geometric mean of the selected indicators.

Spatial Autocorrelation Analysis

[illegible] the spatial distribution of women's empowerment [illegible] the box map with hinge of 1.5 has been plotted for [illegible] tion rate based on the state level scale map of India. [illegible] characteristics of SWEI has been analysed conducting [illegible] spatial autocorrelation test by using Moran's index [illegible] study contiguity weight matrix has been computed. [illegible] known in Chase, it considers neighbour those that have [illegible] including both common boundaries and common [illegible] the GMI fails to provide a local pattern of association [illegible] across the spatial units. In order to explore the [illegible] in respect of SWEI we compute the local Moran's [illegible] Local Indicators of Spatial Association (LISA)

[illegible] data for the variables for computing state level women's [illegible] and urbanization rate have been collected from the [illegible] Health Survey (NFHS) report-4, 2015-16. We have used [illegible] for the Indian state boundaries from a repository developed [illegible] A basic shapefile is a non-topological format for storing [illegible] regarding the geometric location. Geographic locations in a [illegible] represented by points, lines, or polygons. Using the software [illegible] have merged the excel data file containing state level variables [illegible] this study collected from NFHS-4 reports.

Findings and Discussion

First, we discuss the basic information regarding the indicators of [illegible] empowerment and the urbanisation. Table 1 displays that [illegible] only 87 per cent in average) of ever married women take part in the [illegible] decision making process. In average 40 per cent of women in [illegible] own physical assets like land, house etc. However, there is [illegible] variation across the states in respect of physical asset holding by [illegible] women. In an average 54 percentage women of Indian states holds [illegible] account with lowest disparity among disparities of the indicators [illegible] women's empowerment. More than half of the ever married women [illegible] of the states use their own mobile phone. However, only one fourth of [illegible] women in Indian states participate in workforce with wide disparity [illegible] among the states. Therefore, women's workforce participation has low [illegible] mean and high variance. In respect of this indicators Indian women are [illegible] less empowered.

Among the ever married women two third of the women in the states [illegible] have hygienic practices during menstrual periods with a high variation [illegible] the states. Therefore, values of the indicators of state level women's

empowerment except decision making power in household have the disparity. In order to address the influence of this disparity in index of empowerment this study has considered the geometric mean of the indicators as state level women's empowerment index. The descriptive statistics of the state level women's empowerment indicates empowerment of the women of the states in average is low (0.48) which varies widely across the states from 0.35(Bihar) to 0.60 (Manipur). Thus we have to traverse a long journey for achieving the state of complete women's empowerment. It also indicates the partial failure of the existing policies and programs for empowering women in Indian states. We should, therefore, re-examine the effectiveness of the existing policies or find out other factors behind the low mean and moderate variance of women's empowerment. In literature, the spatial distribution and autocorrelation of women's empowerment in Indian states has not been explored yet. This study has been designed for exploring the spatial distribution, autocorrelation of the empowerment of women of a state.

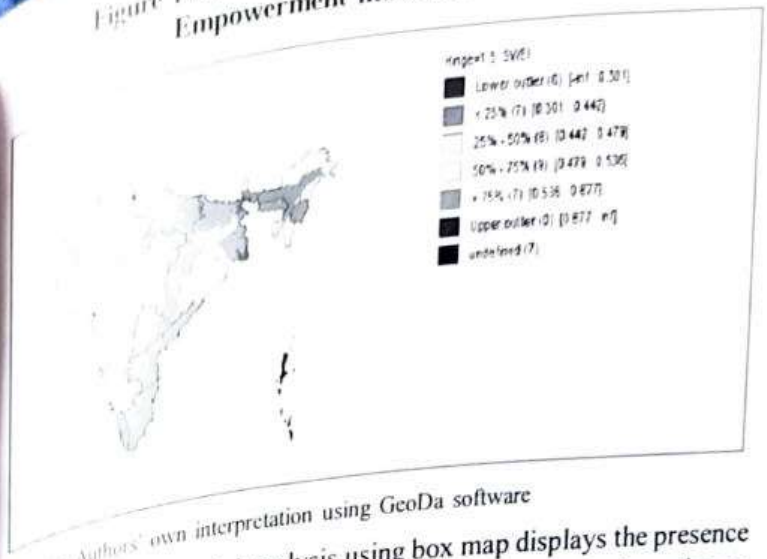
Table 1: Description of the Indicators and Women's Empowerment Index (N=29)

Variable in percentage	Mean	Median	Std Dev	CV
women having household decision making power	87.31	89.1	6.01	6.88
women who own asset either in terms of land or house	39.83	35.2	14.7	36.9
women holding bank account	54.6	56.6	12.5	22.89
women having access to mobile	53.07	47.9	15.58	29.35
workforce participation rate for women	24.97	22.8	8.85	35.44
women who have hygienic practices during menstrual periods	66.09	67.5	17.55	26.55
State level Women's Empowerment Index	0.48	0.47	0.06	12.5
Population residing in Urban area	34.54	32.2	13.31	38.52

Source: Authors' computation based on secondary data

The box map shows that seven states namely Bihar, Madhya Pradesh, Uttar Pradesh, Rajasthan, West Bengal, Chattisgarh and Assam belong to lower quartile of the distribution of women's empowerment. The box map shows that there is a geographical connection among the states such that state with low level of empowerment is surrounded by a state with low level of empowerment. Thus the spatial exploratory study using box map indicates the possibility of spatial cluster of the states in respect of women's empowerment.

Figure 1 Box map for the State Level Women's Empowerment index in 2015-16

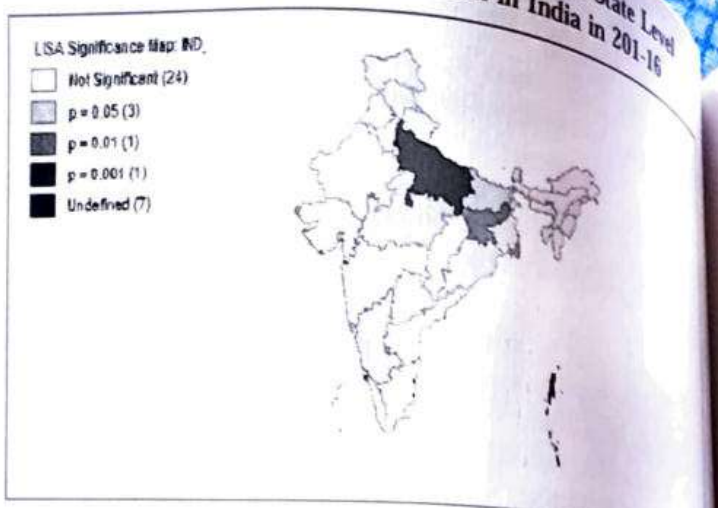


Source: Authors' own interpretation using GeoDa software

The exploratory spatial analysis using box map displays the presence of spatial cluster in respect of women's empowerment. In order to examine the statistical significance of the spatial clusters for state level women's empowerment we have computed global Moran's I (GMI) statistic for the spatial data of women's empowerment. The results of the global autocorrelation analysis, the GMIis found 0.382 with pseudo p=0.001, indicatethat spatial clustering for State Level Women's Empowerment Index (SWEI) in India is statistically significant.

In order to further explore the cluster type of SWEI, we have conducted a local autocorrelation analysis for SWEI and found a LISA cluster significance map depicted in figure 4. Figure 4 shows that that the significant spatial clusters of SWEI are mainly of two types: high–high and low–low, among which high–high type is mainly distributed in southern India, particularly Karnataka. The low–low types are mainly located in north eastern regions, such as Uttar Pradesh, Madhya Pradesh, Bihar and Jharkhand. This analysis suggest that the significant spatial dependence of the Indian states in respect of the state Level Women's Empowerment Index. In order to gauge the spatial dependence of the states we have to move on the spatial regression analysis.

Figure 5 LISA ClusterSignificance Map of State Level Women's Empowerment Index in India in 201-16



Source: Author's own interpretation from spatial data of Indian states using GeoDa software

Concluding Remarks

The study has taken an attempt to explore the new dimension of the analysis of women's empowerment. Using the state level secondary data a comprehensive index of women's empowerment of the Indian states have been computed using a standard methodology and explore the position of the states in respect of women's empowerment. The spatial distribution of the state level women's empowerment index presented in box map shows that women's empowerment level of the states are not spatially complete random, there is a prominent spatial pattern of women's empowerment. This observation has been confirmed by the GMI statistics indicating the presence of spatial autocorrelation for the SWEI. In other words it confirms the presence of spatial cluster of the women's empowerment level. The LMI analysis using LISA cluster map shows locations of the significant spatial clusters of women's empowerment. Our systematic analysis reveals that higher the women's empowerment level of states accelerate the women's empowerment of the neighbor state in India. So far, the study has a limitation such that it is based on small sample for the year 2015-16. This limitation restricts us to include more covariates of women's empowerment live education, income, castes etc. one can overcome this limitation considering the panel data analysis of more than one round data of NFHS in India for the same variables.

References

- Alkire, S. and N. Heinsohn (2005). Measuring Empowerment in Practice: Structuring Analysis and Framing Indicators. World Bank Policy Research Working Paper 3510, February 2005
- Anselin, L. (1988). Spatial Econometrics: Methods and Models. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Anselin, L. (1995). Local Indicators of Spatial Assocation-LISA. Geographical Analysis. Vol. 27, pp 93–115. doi: 10.1111/j.1538-4632.1995.tb00338.x
- Anselin L. (2005). Exploring Spatial Data with GeoDaTM : A Workbook. Center for Spatially Integrated Social Science available at http://www.csiss.org
- Datta, P. (2017). Deprivation of Women in Northeast India: An Exploratory Study in U.K. De et al. (eds.) Inequality, Poverty and Development in India, Springer Nature. pp. 223-236
- International Institute for Population Sciences (IIPS) and ICF. (2017). National Family Health Survey (NFHS-4), 2015-16: India. Mumbai: IIPS available at: http://www.iipsinda.org
- Jejeebhoy, S. J. (1995). Women's Education, Autonomy, and Reproductive Behaviour: Experience from Four Developing Countries.International Studies in Demography, IUSSP, Oxford: Clarendon Press
- Jejeebhoy, S. J. (2000). Women's Autonomy in Rural India: Its Dimensions, Determinants and the Influence of Context.inH. Presser and G. Sen, (eds.) Women's Empowerment and Demographic Processes: Moving Beyond Cairo, New York. Oxford University Press.
- Maldonado, J.H., C. Gonzaler-Vega and V. Romero, (2003). The Influence of Microfinance on the Education Decision of Rural Households: Evidence from Bolivia. Paper presented at the Annual Meeting of the American Agricultural Economic Association, Montreal, Canada 2003.pp. 27-30
- Sen, A. (1999). Development as Freedom.Oxford University Press, Oxford
- Sridevi, T.O. (2005). Empowerment of Women: A Systematic Analysis.IDF Discussion Paper. Retrieved from: http//www.idfresearch.org /pdf /0411.p.d.f
- Tiwari, Anju. (2020). India-State-and-Country-Shape-File-Updated-Jan-2020 available at: https://github.com/AnujTiwari/India-State-and-Country-Shapefile-Updated-Jan-2020
- United Nations Development Programme (1995). Human Development Report 1995.Oxford University Press, New York

■

©2022 The Academy of Environmental Biology, India
Journal of Ecophysiology and Occupational Health, *Vol 22(3), DOI: 10.18311/jeoh/2022/31007, 141-154, September 2022*
ISSN (Print): 0972-4397
ISSN (Online): 0974-0805

Protective Potential of Vitamin C and E against Organophosphate Toxicity: Current Status and Perspective

Prem Rajak[1*], Sumedha Roy[2], Abhratanu Ganguly[1], Moutushi Mandi[3], Anik Dutta[4], Kanchana Das[3], Sayantani Nanda[1], Saurabh Sarkar[5], Salma Khatun[6], Siddhartha Ghanty[1] and Gopal Biswas[3]

[1]Department of Animal Science, Kazi Nazrul University, Asansol, West Bengal - 713340, India; prem.rjk@gmail.com
[2]Cytogenetics Laboratory, Department of Zoology, The University of Burdwan, West Bengal - 713104, India (author previously associated with this affiliation)
[3]Toxicology Research Unit, Department of Zoology, The University of Burdwan, Purba Bardhaman, West Bengal - 713104, India
[4]Post Graduate, Department of Zoology, Darjeeling Govt. College, Darjeeling, West Bengal - 734104, India
[5]Department of Zoology, Gushkara Mahavidyalaya, Gushkara, West Bengal - 713128, India
[6]Krishna Chandra College, Hetampur, Birbhum, West Bengal - 731124, India

Abstract

Pesticides are an integral part of our daily life, used in agricultural fields, store rooms, residences and educational institutions to kill or repel pests. Several chemical subtypes of these compounds are available, of which organophosphate (OP) is major one. These are broad spectrum pesticides used to kill insect pests. OPs are useful but indeed they are most frequent reasons of pesticide poisoning across the globe. OP inhibits acetylcholinesterase activities that results in continuous hyper-excitable state of nicotinic and muscarinic receptors at neuromuscular junctions. Intentional or unintentional exposure to OPs causes abdominal pain, diarrhea, vomiting, muscular weakness, dementia, Central Nervous System (CNS) dysfunction and even death. Besides acetylcholinesterase inhibition, OPs are also known to trigger ROS generation within the cellular machinery which results in Oxidative Stress (OS). Free Radicals (FRs) are neutralized by antioxidant-defense system of the body. Vitamin C and vitamin E are the major exogenous antioxidants that scavenge a large amount of free radicals by donating their own electrons to FRs. This phenomenon reduces ROS and hence, OS is prevented. Therefore, vitamin C and E can be considered for daily dietary intake which might be providing prophylactic advantage against OP induced OS and pathophysiology in human beings.

Keywords: Ascorbic Acid, Organophosphates, Oxidative Stress, ROS, Tocopherol

1. Introduction

Our environment is full of various ubiquitous stressors such as UV radiation, pathogens, allergens, and different chemical pollutants. Pesticides are among the major chemical pollutants that have become an integral part of the ecosystem and affect mammals along with other non-target organisms. These are formulated to kill or repel pests to reduce economic loss[1,2]. These chemicals are in one way beneficial in increasing crop production through crop protection and reduction in need for man-power in farms and store houses. But, increasing rate of pesticide resistance due to frequent usage creates an open competition among the manufacturers to synthesize more effective and potent pesticides which might have greater side effects on human and other living creatures. Pesticide exposure has emerged as a global public health issue because of their wide-spread application, unintentional exposure, and release into environment[3,4]. Such chemicals are known to cause environmental pollution that exerts human health-issues resulting from acute and chronic exposure. Approximately among the 3 million cases of pesticide poisoning reported every year across the world, more than 250,000 deaths occur as per reports of World Health Organization[5]. The high rate of pesticide poisoning might be due to irrational use, little or

*Author for correspondence

no knowledge about the side effects and, most importantly lack of adequate safety information on the pesticide packages[6]. Despite of such a high number of death cases, there is still a huge demand of these chemicals around the world.

Majority of pesticides belongs to four categories such as organochlorine, Organophosphates (OPs), pyrethroids, and carbamates. Organochlorine pesticides (OCPs) are synthetic organic compounds widely used all over the world. These agents are categorized under Persistent Organic Pollutants (POPs) and composed of carbon, hydrogen, and chlorine atoms. OCPs bind to neuronal sodium channels to increase their permeability for sodium ions. This increased permeability facilitates uncoordinated discharge of neurons which harms central nervous system of target pests. Common OCPs used in India and other developing countries like China, Pakistan, Sri Lanka, and Bangladesh include Aldrin, Dieldrin, Chlordane, DDT, Diazion, Endosulfan, Lindane, and Methoxychlor. OCPs are used to control soil insects such as termites, rice water weevil, wireworms, corn rootworm, and grasshoppers. OP Pesticides are synthetic pesticides actively released into environment. These compounds are esters of phosphoric acid or thiophosphoric acid and works by inhibiting Acetylcholine Esterase (AChE) in synaptic sites of central and peripheral nervous system. This leads to accumulation of acetylcholine at synaptic junctions of neurons resulting in hyperexcitability of nerve fibers followed by paralysis and death of target pests. Acephate, Chlorpyrifos, Parathion, Malathion, Dichlorvos, Diazinon, and Tetrachlorvinphos are popular OP pesticides in developing countries of South Asia. OP pesticides are applied to control pests like fire ants, saw flies, caterpillars, termites, aphids, and leaf miners. Pyrethroids are organic compounds similar to the natural insecticide Pyrethrin produced from the flowers of pyrethrums (*Chrysanthemum cinerariaefolium* and *C. coccineum*). Pyrethroids prevent closure of the voltage gated sodium channels in the axonal membranes. This leads to permanent depolarization of axonal membrane and paralysis of the target animal. Common Pyrethroids include Cypermethrin, Permethrin, Deltamethrin, and Bifenthrin. These pesticides are used to control cockroaches, fleas, and termites in houses and other buildings. Carbamates are the N-methyl Carbamates derived from Carbamic acid (NH_2COOH). They cause carbamylation of AChE at neuronal synapses and neuromuscular junctions. Carbamates reversibly bind with AChE at synaptic region leading to paralysis and death of the target pests Aldicarb, Methomyl, Carbofuran, Trimethacarb, Carbaryl, Oxamyl, Ethienocarb, Propoxur, and Fenobucarb are common agents under this category. Carbamates are effective against aphids, thrips, lygus, mites, nematodes, fleahoppers, leafminers, and spiders.

OPs are commonly used pesticides as well as phosphoric acid derivatives of amides, esters, or thiol groups. These chemicals are extensively used in horticulture, agriculture, veterinary-medicine, forestry, and also for the control of some vector-borne diseases. OPs like malathion is frequently used to control ticks and mites[7]. In agricultural-sector, OPs are extensively implicated in eradication of pests including locusts, aphids, leaf-miners, fire-ants, thrips, and caterpillars. These pesticides augment both quantity and quality of agricultural-products[8]. OPs namely tris-(2-chloro,1-methyl-ethyl)-phosphate, tris-(2-chloroethyl)-phosphate, tri-n-butylphosphate, tri-iso-butylphosphate, triphenylphosphate and tris-(butoxyethyl)-phosphate are admired flame-retardants and plasticisers at public places[9]. Due to massive use of OP chemicals, their residues have been detected in drinking-water, grains, vegetables, fruits, soft-drinks, and other food items and hence, it provokes a global health concern[10]. OPs are cholinesterase inhibitors and known to amplify free radical generation and therefore sub-cellular Oxidative Stress (OS). OS is involved in onset of a number of diseases like atherosclerosis, inflammatory diseases, cardiovascular maladies, neurological disorders, and others. Therefore, the community should work to minimize the usage of harmful pesticides including OPs, at the same time their side effects to restrict adverse impacts on human health.

Vitamin C (ascorbic acid) and vitamin E (alpha-tocopherol) are the major exogenous antioxidants that scavenge a large amount of free radicals by donating their own electrons to FRs[11]. This phenomenon reduces Reactive Oxygen Species (ROS) and hence, OS is prevented. Therefore, vitamin C and E can be considered for daily dietary intake which might be providing prophylactic advantage against OP induced OS and pathophysiology in human beings.

The present literature aims to present the OP induced health hazards in human and other animals along with a discussion on protective potential of vitamin C and vitamin E in it.

2. OP Pesticides

OP pesticides were introduced by German scientists in 1938 and have been used as nerve poisons and chemical weapon during World War II[12]. At present, they are available commercially worldwide for domestic and industrial use[13,14]. Nearly half of all insecticides used in the world belong to OP category and hence they pose a greater risk of threat on health of humans[15]. Human may be exposed to OP pesticides through inhalation, ingestion or skin contact[16]. OP toxicity is a major cause of morbidity and mortality in most of developing

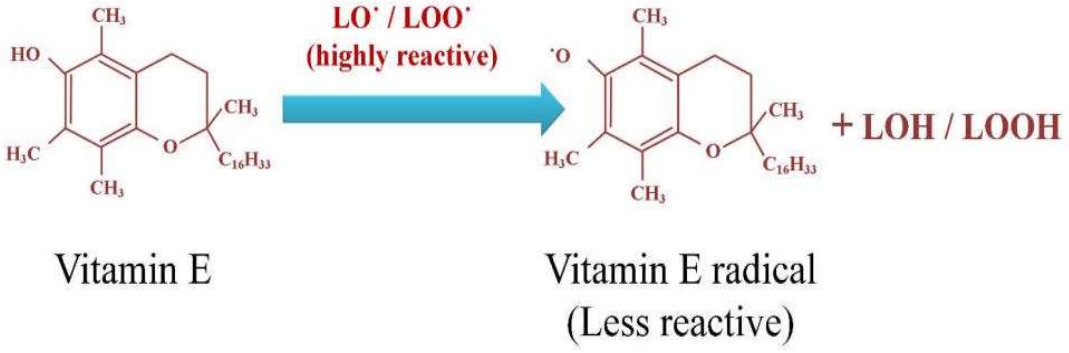


Figure 2. Vitamin E as a chain breaker during lipid peroxidation. Free radical like ˙OH attacks polyunsaturated fatty acids (PUFA) of biological membranes and generates lipid alkoxy radical (LO˙) or lipid peroxyl radicals (LOO˙) which initiate a chain reaction that damages adjacent membrane-bound PUFA. Vitamin E neutralizes LO˙ and LOO˙ thereby terminating the chain reaction.

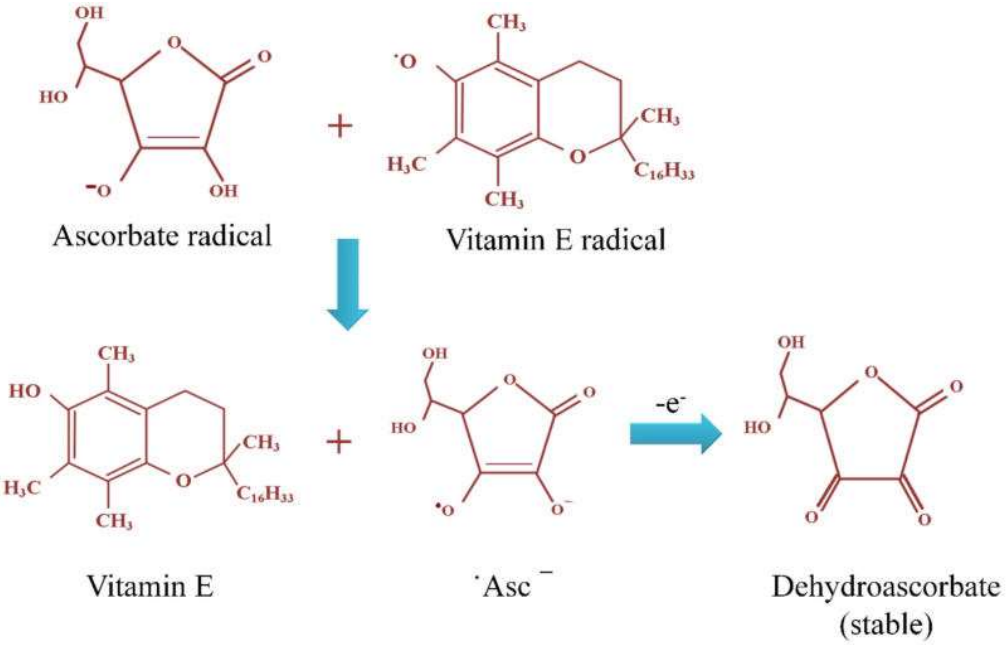


Figure 3. Regeneration of vitamin E (α-Tocopherol). Ascorbate through de-protonation converts vitamin E radical into its more stable configuration i.e., α-tocopherol. Upon loss of one electron, ˙Asc⁻ changes into dehydroascorbate which is stable.

79. Dutta M, Rajak P, Khatun S, Roy S. Toxicity assessment of sodium fluoride in Drosophila melanogaster after chronic sub-lethal exposure. Chemosphere. 2017; 166:255-66. https://doi.org/10.1016/j.chemosphere.2016.09.112 PMid:27700992
80. Rajak P, Ganguly A, Sarkar S, Mandi M, Dutta M, Podder S, Khatun S, Roy S. Immunotoxic role of organophosphates: An unseen risk escalating SARS-CoV-2 pathogenicity. Food Chem Toxicol. 2021; 149:112007. https://doi.org/10.1016/j.fct.2021.112007 PMid:33493637 PMCid:PMC7825955
81. Ghanty S, Mandi M, Ganguly A, Das K, Dutta A, Nanda S, Biswas G, Rajak P. Lung surfactant proteins as potential targets of prallethrin: An in silico approach. Toxicol. Environ Health Sci. 2022; 14(1):89-100. https://doi.org/10.1007/s13530-021-00119-0 PMCid:PMC8788395
82. Rajak P, Roy S, Pal AK, Paramanik M, Dutta M, Podder S, Sarkar S, Ganguly A, Mandi M, Dutta A, Das K, Ghanty S, Khatun S. In silico study reveals binding potential of rotenone at multiple sites of pulmonary surfactant proteins: A matter of concern. Curr Res Toxicol. 2021; 4:2:411-423. https://doi.org/10.1016/j.crtox.2021.11.003 PMid:34917955 PMCid:PMC8666459
83. Dutta M, Rajak P, Roy S. Determination of chronic median lethal concentration of sodium fluoride in Drosophila melanogaster and exploring effect of sub-lethal concentrations on differential hemocyte count. Proc. Zool Soc. 2019; 72:111-117. https://doi.org/10.1007/s12595-017-0235-x
84. Sarkar S, Rajak P, Roy S. Toxicological evaluation of a new lepidopteran insecticide, flubendiamide, in non-target Drosophila melanogaster Meigen (Diptera: Drosophilidae). IJT. 2018; 12(3): 45-50. https://doi.org/10.32598/IJT.12.3.477.1
85. Rajak P, Khatun S, Dutta M, Mandi M, Roy S. Chronic exposure to acephate triggers ROS-mediated injuries at organismal and sub-organismal levels of Drosophila melanogaster. Toxicol Res (Camb). 2018;7(5):874-887. https://doi.org/10.1039/C8TX00052B PMid:30310664 PMCid:PMC6116822
86. Rajak P, Dutta M, Roy S. Effect of acute exposure of acephate on hemocyte abundance in a non-target victim Drosophila melanogaster. Toxicol Environ Chem. 2014; 96:768-76. https://doi.org/10.1080/02772248.2014.980131
87. Rajak P, Roy S. Heat Shock Proteins and Pesticide Stress. In: Asea, A., Kaur, P. (eds) Regulation of Heat Shock Protein Responses. Heat Shock Proteins. Springer, Cham. 2018; 13. https://doi.org/10.1007/978-3-319-74715-6_2
88. Sutcu R, Altuntas I, Buyukvanli B, Akturka O, Ozturka O, Koylu H, Delibas N. The effects of diazinon on lipid peroxidation and antioxidant enzymes in rat erythrocytes: role of vitamins E and C. Toxicol Ind Health. 2007; 23(1):13-7. https://doi.org/10.1177/0748233707076758 PMid:17722735
89. Akturk O, Demirin H, Sutcu R, Yilmaz N, Koylu H, Altuntas I. The effects of diazinon on lipid peroxidation and antioxidant enzymes in rat heart and ameliorating role of vitamin E and vitamin C. Cell Biol Toxicol. 2006; 22(6):455-61. https://doi.org/10.1007/s10565-006-0138-5. https://doi.org/10.1007/s10565-006-0138-5 PMid:16964585
90. Sulak O, Altuntas I, Karahan N, Yildirim B, Akturk O, Yilmaz HR, Delibas N. Nephrotoxicity in rats induced by organophosphate insecticide methidathion and ameliorating effects of vitamins E and C. Pestic Biochem Phys. 2005; 83(1):21-8. https://doi.org/10.1016/j.pestbp.2005.03.008
91. Ambali SF. Shittu M, Ayo JO, Esievo KA, Ojo SA. Vitamin C Alleviates Chronic Chlorpyrifos Induced Alterations in Serum Lipids and Oxidative Parameters in Male Wistar Rats. Am J Pharmacol Toxicol. 2011; 6(4):109-118. https://doi.org/10.3844/ajptsp.2011.109.118
92. Bhatti GK, Bhatti JS, Kiran R, Sandhir R. Alterations in Ca^{2+} homeostasis and oxidative damage induced by ethion in erythrocytes of Wistar rats: ameliorative effect of vitamin E. Environ Toxicol Pharmacol. 2011; 31(3):378-86. https://doi.org/10.1016/j.etap.2011.01.004 PMid:21787708

UGC-CARE List

Sr.No.	Journal Title	Publisher	ISSN	E-ISSN	UGC-CARE coverage year	Details
24	Kiranavali	Sanskrit Research Foundation	0975-4067	NA	from June - 2019 to Present	View
28	Korean Journal of Mathematics					

The New Trivandrum Sanskrit Series
Vol. XIV. Book. III -IV

JULY - DECEMBER 2022

किरणावली

Sanskrit Research Foundation
Thiruvananthapuram

SRFT

ISSN 0975-4067

KIRAṆĀVALĪ

Journal of Sanskrit Research Foundation

The New Trivandrum Sanskrit Series
Vol.XIV. Book. III &IV
JULY-DECEMBER
2022

Contents

DOI 10.5281/zenodo.7930480

जनकल्याणे नीतिशतकस्य माहात्म्यम्

समीरणः रायः[1]

काव्यस्य साहित्यस्य वा मूलभूते प्रयोजने द्वे, अलौकिकानन्दानुभूतिः शिक्षा च। मनुष्याणां सर्वतः उन्नतेः प्रयत्नस्य पूर्णप्रतिफलनं संस्कृतसाहित्ये परिलक्ष्यते। प्राचीनभारतीयसभ्यतायाः संस्कृतेश्च समुन्नायको वेदवेदाङ्गादिः शास्त्रम्। मनुष्यजीवनस्य उत्कर्षः अपकर्षश्च एतेषां शास्त्राणामुपरि आधारितः। अस्मिन् मनुष्यजीवने केन सह कीदृशः व्यवहारः काङ्क्षितः, किं कर्तव्यम्, केमकर्तव्यम्, कः सन्मार्गः, कण्टकाकीर्णः मार्गः कः, कस्मात् आदर्शजीवनस्य प्राप्तिर्भवति – एतेषां प्रश्नानां निश्चितं निराकरणमस्ति नीतिशास्त्रे। कविना भर्तृहरिणापि शतकत्रये स्फुटतया अनुरूपः प्रयासः क्रियते। शतकत्रयान्तर्गतः शृङ्गारशतकं व्यक्तिजीवनेन सह, वैराग्यशतकं परमार्थजीवनेन सह तथा नीतिशतकं सामाजिकजीवनेन सह सम्बन्धयुक्तम्। शतकत्रयं मूलतः सत्य-शिव-सुन्दरतत्त्वं समन्वितम्। संस्कृतवाङ्मये शुक्र-विदुर-चाणक्य-भर्तृहरिप्रणीतेषु नीतिग्रन्थेषु भर्तृहरेः नीतिशतकस्य विशिष्टमेकं स्थानं वर्तते। अपूर्वेऽस्मिन् नीतिग्रन्थे कविना संसारस्य व्यवहारिकजीवनस्य सकलगूढं महत्त्वपूर्णं च विषयं चित्रितम्। नीतिशतके मनुस्मृतिः इव शिक्षा, महाभारतमिव उपदेशः, पुराणमिव रसास्वादनम्, दर्शनशास्त्रमिव तर्कयुक्तिः उपलभ्यते। मानवकल्याणे नीतिशतकोक्तनैतिकशिक्षायाः माहात्म्यमस्य शोधप्रबन्धस्य आलोच्यविषयः।

नी(प्रापणे/नये) धातोः उत्तर क्तिन् प्रत्ययोगे नीतिः शब्दो निष्पद्यते। कोशकारगणः विभिन्नेषु अर्थेषु शब्दस्यास्य प्रयोगं कृतवान्। यथा – निर्देशनम्, दिग्दर्शनम्, प्रबन्धः, आचारः, आचरणम्, आचारशास्त्रम्, व्यवहारः, कार्यक्रमः, औचित्यम्, नीतिकौशलम्, नीतिशास्त्रम्, शालीनता, बुद्धिमत्ता, योजना, उपायः, कूटनीतिः, राजनयः, अवाप्तिः, अधिग्रहणमित्यादयः। अतएव सकलप्रयोजनस्य सिद्धिदातृ एव नीतिशास्त्रम्। उच्यते च – "सर्वस्य लोचनं शास्त्रं नीतिविद्यां ददाति च।" नीतिशास्त्रस्य व्यवहारात् ऋते संसारस्य कोऽपि मनुष्यः सुखपूर्वकं जीवनयापयितुं समर्थो न भवति। नीत्याश्रयेण नराः सांसारिकसमस्यायाः समाधानं कर्तुं शक्नुवन्ति। नीतिवेत्ता व्यक्तिः कठिनतरकार्यमपि अनायासेनैव सम्पादयति, परन्तु नीतिहीनव्यक्तिः न कदापि साफल्यम् आप्नोति। अस्मिन् प्रसङ्गे महाकविकालिदासस्य रघुवंशमहाकाव्यस्य उक्तिः स्मरणीया – "काले खलु समारब्धाः फलं बध्नन्ति नीतयः।" (१२,६९) नीतिशतकं मुक्तकश्रेण्याः शतककाव्यम्। नामकरणानुसारेण अस्य शतसंख्यकश्लोकं काङ्क्षितं परन्तु अपरापरं शतककाव्यमिव अस्य ग्रन्थस्यापि श्लोकसंख्याविषये मतभेदं परिदृश्यते। नीतिशतकस्य प्रणेता सप्तमशतकस्य महाकविः

1 Samiran Ray, Assistant Professor, Department of Sanskrit, Gushkara Mahavidyalaya, Post - Gushkara. Dist - Purba Bardhaman.,Pin Code - 713128. West Bengal, Email-samiranray.ju@gmail.com

Toxicology and Applied Pharmacology 456 (2022) 116267

Contents lists available at ScienceDirect

Toxicology and Applied Pharmacology

journal homepage: www.elsevier.com/locate/taap

Synergistic action of organophosphates and COVID-19 on inflammation, oxidative stress, and renin-angiotensin system can amplify the risk of cardiovascular maladies

Prem Rajak [a,*], Sumedha Roy [b], Sayanti Podder [c], Moumita Dutta [d], Saurabh Sarkar [e], Abhratanu Ganguly [a], Moutushi Mandi [f], Anik Dutta [g], Sayantani Nanda [a], Salma Khatun [h]

[a] Department of Animal Science, Kazi Nazrul University, Asansol, West Bengal, India
[b] Cytogenetics Laboratory, Department of Zoology, The University of Burdwan, West Bengal, India
[c] The Orchid School, Pune, Maharashtra, India
[d] Departments of Environmental and Occupational Health Sciences, University of Washington, Seattle, WA, USA
[e] Department of Zoology, Gushkara Mahavidyalaya; Gushkara, Purba Bardhaman, West Bengal, India
[f] Toxicology Research Unit, Department of Zoology, The University of Burdwan, Purba Bardhaman, West Bengal, India
[g] Post Graduate Department of Zoology, Darjeeling Govt. College, West Bengal, India
[h] Department of Zoology, Krishna Chandra College, Hetampur, West Bengal, India

ARTICLE INFO

Editor: Lawrence Lash

Keywords:
Organophosphates
Cardiotoxicity
COVID-19
Renin-Angiotensin System

ABSTRACT

Organophosphates (OPs) are ubiquitous environmental contaminants, widely used as pesticides in agricultural fields. In addition, they serve as flame-retardants, plasticizers, antifoaming or antiwear agents in lacquers, hydraulic fluids, and floor polishing agents. Therefore, world-wide and massive application of these compounds have increased the risk of unintentional exposure to non-targets including the human beings. OPs are neurotoxic agents as they inhibit the activity of acetylcholinesterase at synaptic cleft. Moreover, they can fuel cardiovascular issues in the form of myocardities, cardiac oedema, arrhythmia, systolic malfunction, infarction, and altered electrophysiology. Such pathological outcomes might increase the severity of cardiovascular diseases which are the leading cause of mortality in the developing world. Coronavirus disease-19 (COVID-19) is the ongoing global health emergency caused by SARS-CoV-2 infection. Similar to OPs, SARS-CoV-2 disrupts cytokine homeostasis, redox-balance, and angiotensin-II/AT_1R axis to promote cardiovascular injuries. Therefore, during the current pandemic milieu, unintentional exposure to OPs through several environmental sources could escalate cardiac maladies in patients with COVID-19.

1. Introduction

Scientists and health workers across the world are racing together to halt the recent COVID-19 pandemic triggered by SARS-CoV-2 infection. The disease was first detected in Wuhan province of China in December 2019 and rapidly extended to 213 countries. There have been 611,421,786 confirmed cases with 6,512,438 casualties as of 23rd September 2022 (https://covid19.who.int/). Potent vaccines have been developed by different laboratories and the vaccination program is still continuing in several countries. However, it is to be noted that, vaccines usually does not provide 100% protection from re-infection. Therefore even after vaccination, people have to be serious about COVID-19 and need to follow the proper guidelines released by World Health Organization and local governing bodies to minimize the risk of re-infection. Unfortunately, many European, African, and Asian countries are suffering from subsequent waves of COVID-19 due to emergence of new variants of the virus. The B.1.1.7 (Alpha), B.1.351 (Beta), P.1 (Gamma), B.1.427 (Epsilon), B.1.429 (Epsilon), and B.1.617.2 (Delta) variants detected in many countries are classified as variants of concern. These variants are unusually divergent, each possessing a unique constellation of mutations of potential biological importance and hence can evade the immune barrier developed from a previous SARS-CoV-2 infection.

In majority of cases, virions entering through naso-oral opening first colonize broncho-pulmonary epithelium and fuel necroinflammation-mediated pulmonary ailments (Rajak et al., 2021a). From lungs,

* Corresponding author.
E-mail address: prem.rjk@gmail.com (P. Rajak).

https://doi.org/10.1016/j.taap.2022.116267
Received 9 August 2022; Received in revised form 26 September 2022; Accepted 4 October 2022
Available online 12 October 2022
0041-008X/

Table 3
Organophosphate exposure and symptoms of cardiovascular ailments in human.

Organophosphate compound	Type and location of study	Type of exposure	Number of individuals studied	Signs of cardiotoxicity	References
Phorate	Case report; India	Accidental exposure	01	Abnormal ECG with sinus tachycardia, non-specific ST-T wave changes and a corrected QTc interval of 430–500 msec; elevated levels of Creatine kinase-MB and troponin I.	Muthu et al., 2014
Chlorpyrifos, dichlorvos, Methylparathion, Dimethoate, Profenfos, Chlorpyrifos, Triazos	Hospital-based cross-sectional study; Nepal	Acute exposure	115	Patients diagnosed with sinus tachycardia (49.6%), Hypertension (20%), ECG abnormalities (18.26%), ventricular extrasystole (12.2%) and ventricular fibrillation (0.3%).	Laudari et al., 2014
Mevinphos, Parathion, Phosphamidon, Parathion, Malathion, Tamaron, Diazinon	Clinical study, Israel	Acute exposure	15	Altered ECG (Q-T prolongation) and malignant tachyarrhythmias.	Ludomirsky et al., 1982
Parathion	Case report, India	Acute exposure	01	Patient detected with sinus bradycardia, left ventricular failure and elevated level of troponin I.	Joshi et al., 2013
Dichlorvos, parathion, methamidophos, phoxim etc.	Clinical study, China	Acute exposure	98	52% of patients with acute myocardial injury as evidenced by elevated levels of troponin I, creatine kinase-Mb and N-terminal pro B-type natriuretic peptide.	Chen et al., 2019
Chloropyrifos, dichlorvos, diazinon, parathion, methidathion, phenothoate etc.,	Clinical study, Republic of Korea	Acute exposure	99	11.1% patients experienced abnormal ECG (fluctuation in ST); 34.3% of patients with detectable troponin I levels.	Cha et al., 2014
Not specified	Case report, India	Accidental exposure	01	ECG revealed atrial fibrillation.	Maheshwari and Chaudhary, 2017
Not specified	Cross-sectional study, India	Acute exposure	107	Patients detected with prolonged Q-Tc (62.6%), sinus tachycardia (33.6%), elevated ST segment (25.2%), inverted T wave (19.6%) and first degree heart block (8.4%) as well as atrial fibrillation (4.6%).	Paul and Bhattacharyya, 2012
Not specified	Clinical study, Egypt	Acute exposure	46	Elevated levels of serum creatinine kinase and cardiac trophonin I; abnormal ECG with sinus tachycardia ((34.78%) and sinus bradycardia ((19.56%); prolonged QTc ((32.61%) and PR (8.70%) intervals; elevated ST segment (15.22%).	Kharoub and Elsharkawy, 2008
Not specified	Clinical study, Iran	Occupational (71 patients), suicidal (26 patients) and accidental (3 patients) exposure	100	63% of patients presented abnormal ECG with Sinus tachycardia (31%), non-specific ST-T changes (24%) and atrioventricular arrhythmia.	Taromsari et al., 2013
Not specified	Case report, USA	Acute exposure	01	Patient experienced sinus bradycardia, A-V dissociation, idioventricular rhythms, multiform ventricular extrasystoles, and prolongation of the PR, QRS, and QT intervals. Polymorphic ventricular tachycardia was also detected.	Brill et al., 1984
Parathion	Case report, Turkey	Acute exposure	01	Elevated levels of cardiac injury markers (Troponin I, creatine kinase-Mb); alerted ECG demonstrating ST-segment elevation and AVF derivations accompanied by ST horizontal depression in DI-AVL leads.	Karasu-Minareci et al., 2012
Methyl-parathion; Propoxur; Sichlorvos; Monocrotophos; Malathion; Dichlorovos	Clinical study, Nepal	Acute exposure	37	Patients established electrocardiographical abnormalities (37.8%); sinus tachycardia (40.5%); sinus bradycardia (18.9%); hypertension (13.5%) and hypotension (10.8%)	Karki et al., 2004
Parathion	Case report, India	Acute exposure	01	Myocardial infarction	Kidiyoor et al., 2009

binding potential of rotenone at multiple sites of pulmonary surfactant proteins: a matter of concern. Curr Res Toxicol. 4, 411–423. https://doi.org/10.1016/j.crtox.2021.11.003.
Riphagen, S., Gomez, X., Gonzalez-Martinez, C., Wilkinson, N., Theocharis, P., 2020. Hyperinflammatory shock in children during COVID-19 pandemic. Lancet 395, 1607–1608.
Romano, M., Ruggiero, A., Squeglia, F., Maga, G., Berisio, R., 2020. A structural view of SARS-CoV-2 RNA replication machinery: RNA synthesis, proofreading and final capping. Cells 9, 1267.
Sadoshima, J., Izumo, S., 1993. Signal transduction pathways of angiotensin II-induced c-fos gene expression in cardiac myocytes in vitro. Roles of phospholipid-derived second messengers. Circ. Res. 73, 424–438.
Saka, W.A., Ayoade, T.E., Akhigbe, T.M., Akhigbe, R.E., 2020. Moringa oleifera seed oil partially abrogates 2,3-dichlorovinyl dimethyl phosphate (Dichlorvos)-induced cardiac injury in rats: evidence for the role of oxidative stress. J. Basic Clin. Physiol. Pharmacol. https://doi.org/10.1515/jbcpp-2019-0313.
Sala, S., Peretto, G., Gramegna, M., Palmisano, A., Villatore, A., Vignale, D., De Cobelli, F., Tresoldi, M., Cappelletti, A.M., Basso, C., Godino, C., Esposito, A., 2020. Acute myocarditis presenting as a reverse Tako-Tsubo syndrome in a patient with SARS-CoV-2 respiratory infection. Eur. Heart J. 41, 1861–1862.
Saquib, Q., Attia, S.M., Siddiqui, M.A., Aboul-Soud, M.A., Al-Khedhairy, A.A., Giesy, J.P., Musarrat, J., 2012. Phorate-induced oxidative stress, DNA damage and transcriptional activation of p53 and caspase genes in male Wistar rats. Toxicol. Appl. Pharmacol. 259, 54–65.
Sarcon, A., Liu, X., Ton, D., Haywood, J., Hitchcock, T., 2015. Advanced congestive heart failure associated with disseminated intravascular coagulopathy. J. Investig. Med. High Impact Case Rep. 3, 2324709615623298.
Sarkar, S., Rajak, P., Roy, S., 2018. Toxicological evaluation of a new lepidopteran insecticide, flubendiamide, in non-target drosophila melanogaster Meigen (Diptera: Drosophilidae). Iran. J. Toxicol. 12, 45–50.
Schäfer, M., Koppe, F., Stenger, B., Brochhausen, C., Schmidt, A., Steinritz, D., Thiermann, H., Kirkpatrick, C.J., Pohl, C., 2013. Influence of organophosphate poisoning on human dendritic cells. Chem. Biol. Interact. 206, 472–478.
Schernthaner, C., Lichtenauer, M., Wernly, B., Paar, V., Pistulli, R., Rohm, I., Jung, C., Figulla, H.R., Yilmaz, A., Cadamuro, J., Haschke-Becher, E., Pernow, J., Schulze, P. C., Hoppe, U.C., Kretzschmar, D., 2017. Multibiomarker analysis in patients with acute myocardial infarction. Eur. J. Clin. Investig. 47, 638–648.
Serebrovska, Z.O., Chong, E.Y., Serebrovska, T.V., Tumanovska, L.V., Xi, L., 2020. Hypoxia, HIF-1α, and COVID-19: from pathogenic factors to potential therapeutic targets. Acta Pharmacol. Sin. 41, 1539–1546.
Shah, A., 2020. Novel coronavirus-induced NLRP3 Inflammasome activation: a potential drug target in the treatment of COVID-19. Front. Immunol. 11, 1021.
Sharma, M., Gorstein, S., Aldrich, M.L., Hsu, D.T., Choueiter, N.F., 2020. Reversible myocardial injury associated with SARS-CoV-2 in an infant. JACC Case Rep. 2, 2348–2352.
Sheng, C.C., Sahoo, D., Dugar, S., Prada, R.A., Wang, T.K.M., Abou Hassan, O.K., Brennan, D., Culver, D.A., Rajendram, P., Duggal, A., Lincoff, A.M., Nissen, S.E., Menon, V., Cremer, P.C., 2020. Canakinumab to reduce deterioration of cardiac and respiratory function in SARS-CoV-2 associated myocardial injury with heightened inflammation (canakinumab in Covid-19 cardiac injury: the three C study). Clin. Cardiol. 43, 1055–1063.
Shi, S., Qin, M., Shen, B., Cai, Y., Liu, T., Yang, F., Gong, W., Liu, X., Liang, J., Zhao, Q., Huang, H., Yang, B., Huang, C., 2020. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. JAMA Cardiol. 5, 802–810.
Shin, H.M., Je, H.D., Gallant, C., Tao, T.C., Hartshorne, D.J., Ito, M., Morgan, K.G., 2002. Differential association and localization of myosin phosphatase subunits during agonist-induced signal transduction in smooth muscle. Circ. Res. 90, 546–553.
Siddiqi, H.K., Weber, B., Zhou, G., Regan, J., Fajnzylber, J., Coxen, K., Corry, H., Yu, X. G., DiCarli, M., Li, J.Z., Bhatt, D.L., 2020. Increased prevalence of myocardial injury in patients with SARS-CoV-2 viremia. Am. J. Med. S0002-9343 (20), 30933–30935. https://doi.org/10.1016/j.amjmed.2020.09.046.
Simoneschi, D., Simoneschi, F., Todd, N.E., 2014. Assessment of cardiotoxicity and effects of malathion on the early development of zebrafish (Danio rerio) using computer vision for heart rate quantification. Zebrafish 11, 275–280.
Singer, A.W., Jaax, N.K., Graham, J.S., McLeod Jr., C.G., 1987. Cardiomyopathy in Soman and sarin intoxicated rats. Toxicol. Lett. 36, 243–249.
Smith, E.G., Gordon, C.J., 2005. The effects of Chlorpyrifos on blood pressure and temperature regulation in spontaneously hypertensive rats. Basic Clin. Pharmacol. Toxicol. 96, 503–511.
Sungkaworn, T., Chatsudthipong, V., 2011. Oxidative stress increases angiotensin receptor type I (AT_1R) responsiveness by inducing receptor clustering. FASEB J. 25 https://doi.org/10.1096/fasebj.25.1_supplement.831.4, 831.4-831.4.
Taira, K., Aoyama, Y., Kawamata, M., 2006. Long QT and ST-T change associated with organophosphate exposure by aerial spray. Environ. Toxicol. Pharmacol. 22, 40–45.
Tang, N., Li, D., Wang, X., Sun, Z., 2020a. Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. J. Thromb. Haemost. 18, 844–847.
Tang, N., Li, D., Wang, X., Sun, Z., 2020b. Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. J. Thromb. Haemost. 18, 844–847.
Taromsari, M.R., Badsar, A., Aghajankhah, M., Poor, M.A., Porkar, N.F., Karkan, M.F., 2013. The study of electrocardiographic findings in patients with organophosphate poisoning. Iran. J. Toxicol. 6, 751–756.
Tipnis, S.R., 2000. A human homolog of angiotensin-converting enzyme. Cloning and functional expression as a captopril-insensitive carboxypeptidase. J. Biol. Chem. 275, 33238–33243.
Tryphonas, L., Veinot, J.P., Clement, J.G., 1996. Early histopathologic and ultrastructural changes in the heart of Sprague-dawley rats following administration of Soman. Toxicol. Pathol. 24, 190–198.
Tsai, C.Y., Chang, A.Y., Chan, J.Y., Chan, S.H., 2014. Activation of PI3K/Akt signaling in rostral ventrolateral medulla impairs brain stem cardiovascular regulation that underpins circulatory depression during mevinphos intoxication. Biochem. Pharmacol. 88, 75–85.
Varga, Z., Flammer, A.J., Steiger, P., Haberecker, M., Andermatt, R., Zinkernagel, A.S., Mehra, M.R., Schuepbach, R.A., Ruschitzka, F., Moch, H., 2020. Endothelial cell infection and endotheliitis in COVID-19. Lancet 395 (10234), 1417–1418.
Velmurugan, G., Venkatesh Babu, D.D., Ramasamy, S., 2013. Prolonged monocrotophos intake induces cardiac oxidative stress and myocardial damage in rats. Toxicology 307, 103–108.
Verdecchia, P., Cavallini, C., Spanevello, A., Angeli, F., 2020. The pivotal link between ACE2 deficiency and SARS-CoV-2 infection. Eur. J. Intern. Med. 76, 14–20.
Wallukat, G., Nissen, E., Morwinski, R., Müller, J., 2000. Autoantibodies against the beta- and muscarinic receptors in cardiomyopathy. Herz. 25, 261–266.
Wang, D., Hu, B., Hu, C., Zhu, F., Liu, X., Zhang, J., Wang, B., Xiang, H., Cheng, Z., Xiong, Y., Zhao, Y., Li, Y., Wang, X., Peng, Z., 2020. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA. 323, 1061–1069. https://doi.org/10.1001/jama.2020.1585.
Wang, L., 2020. C-reactive protein levels in the early stage of COVID-19. Med. Mal. Infect. 50, 332–334.
Wang, M., Zhang, J., Jiang, L.Q., Spinetti, G., Pintus, G., Monticone, R., Kolodgie, F.D., Virmani, R., Lakatta, E.G., 2007. Proinflammatory profile within the grossly normal aged human aortic wall. Hypertension 50, 219–227.
Watanabe, Y., Itoh, T., Shiraishi, H., Maeno, Y., Arima, Y., Torikoshi, A., Namera, A., Makita, R., Yoshizumi, M., Nagao, M., 2013. Acute effects of a sarin-like organophosphorus agent, bis(isopropyl methyl)phosphonate, on cardiovascular parameters in anaesthetized, artificially ventilated rats. Toxicol. Appl. Pharmacol. 272, 61–66.
Widmer, R.J., Lerman, A., 2014. Endothelial dysfunction and cardiovascular disease. Glob. Cardiol. Sci. Pract. 2014, 291–308.
Wolfler, A., Mannarino, S., Giacomet, V., Camporesi, A., Zuccotti, G., 2020. Acute myocardial injury: a novel clinical pattern in children with COVID-19. Lancet Child Adolesc. Health 4, e26–e27.
Wollert, K.C., Kempf, T., Peter, T., Olofsson, S., James, S., Johnston, N., Lindahl, B., Horn-Wichmann, R., Brabant, G., Simoons, M.L., Armstrong, P.W., Califf, R.M., Drexler, H., Wallentin, L., 2007. Prognostic value of growth-differentiation factor-15 in patients with non-ST-elevation acute coronary syndrome. Circulation 115, 962–971.
Worek, F., Kleine, A., Falke, K., Szinicz, L., 1995. Arrhythmias in organophosphate poisoning: effect of atropine and bispyridinium oximes. Arch. Int. Pharmacodyn. Ther. 329, 418–435.
Wu, X., Xie, W., Cheng, Y., Guan, Q., 2016. Severity and prognosis of acute organophosphorus pesticide poisoning are indicated by C-reactive protein and copeptin levels and APACHE II score. Exp. Ther. Med. 11, 806–810.
Yamazaki, T., Komuro, I., Yazaki, Y., 1999. Role of the renin–angiotensin system in cardiac hypertrophy. Am. J. Cardiol. 83, 53H–57H.
Yang, W., Liu, Z., Xu, Q., Peng, H., Chen, L., Huang, X., Yang, T., Yu, Z., Cheng, G., Zhang, G., Shi, R., 2017. Involvement of vascular peroxidase 1 in angiotensin II-induced hypertrophy of H9c2 cells. J. Am. Soc. Hypertens. 11, 519–529.e1.
Yavuz, T., Altuntas, I., Delibas, N., Yildirim, B., Candir, O., Corâ, A., Karahan, N., Ibrisim, E., Kutsal, A., 2004. Cardiotoxicity in rats induced by methidathion and ameliorating effect of vitamins E and C. Hum. Exp. Toxicol. 23, 323–329.
Yavuz, Y., Yurumez, Y., Ciftci, I.H., Sahin, O., Saglam, H., Buyukokuroglu, M., 2008. Effect of diphenhydramine on myocardial injury caused by organophosphate poisoning. Clin. Toxicol. (Phila) 46, 67–70.
Yu, Y., Yang, Y., Zhao, X., Liu, X., Xue, J., Zhang, J., Yang, A., 2017. Exposure to the mixture of organophosphorus pesticides is embryotoxic and teratogenic on gestational rats during the sensitive period. Environ. Toxicol. 32, 139–146.
Yurumez, Y., Yavuz, Y., Saglam, H., Durukan, P., Ozkan, S., Akdur, O., Yucel, M., 2009. Electrocardiographic findings of acute organophosphate poisoning. J. Emerg. Med. 36, 39–42.
Zafiropoulos, A., Tsarouhas, K., Tsitsimpikou, C., Fragkiadaki, P., Germanakis, I., Tsardi, M., Maravgakis, G., Goutzourelas, N., Vasilaki, F., Kouretas, D., Hayes, A., Tsatsakis, A., 2014. Cardiotoxicity in rabbits after a low-level exposure to diazinon, propoxur, and chlorpyrifos. Hum. Exp. Toxicol. 33, 1241–1252.
Zaninotto, M., Mion, M.M., Padoan, A., Babuin, L., Plebani, M., 2020. Cardiac troponin I in SARS-CoV-2-patients: the additional prognostic value of serial monitoring. Clin. Chim. Acta 511, 75–80.
Zbinden, G., Grimm, L., 1985. Thrombogenic effects of xenobiotics. In: Chambers, P.L., Cholnoky, E., Chambers, C.M. (Eds.), Receptors and Other Targets for Toxic Substances. Arch. Toxicol. Springer, Berlin, Heidelberg, p. 8. https://doi.org/10.1007/978-3-642-69928-3_19.
Zheng, Y.Y., Ma, Y.T., Zhang, J.Y., Xie, X., 2020. COVID-19 and the cardiovascular system. Nat. Rev. Cardiol. 17, 259–260.
Zhou, W., Chen, C., Chen, Z., et al., 2018. NLRP3: A novel mediator in cardiovascular disease. J Immunol Res 2018, 5702103.
Zima, A.V., Mazurek, S.R., 2016. Functional impact of ryanodine receptor oxidation on intracellular calcium regulation in the heart. Rev. Physiol. Biochem. Pharmacol. 171, 39–62.

Ecological Informatics 72 (2022) 101837

Contents lists available at ScienceDirect

Ecological Informatics

journal homepage: www.elsevier.com/locate/ecolinf

Zooplankton community of Bakreswar reservoir: Assessment and visualization of distribution pattern using self-organizing maps

Arnab Banerjee [a,*], Nabyendu Rakshit [b], Moitreyee Chakrabarty [c], Swagata Sinha [d], Sinchan Ghosh [a], Santanu Ray [e]

[a] Agricultural and Ecological Research Unit (AERU), Biological Sciences Division, Indian Statistical Institute, Kolkata, West Bengal, India
[b] Department of Zoology, Guskara Mahavidyalaya, West Bengal, India
[c] Post-graduate Department of Conservation Biology, Durgapur Government College, Durgapur, West Bengal, India
[d] Systems Ecology & Ecological Modelling Laboratory, Department of Zoology, Visva-Bharati University, Santiniketan, West Bengal, India
[e] Kerala University of Digital Sciences Innovation and Technology, Thiruvananthapuram, Kerala, India

ARTICLE INFO

Keywords:
Kohonen maps
Unsupervised learning
Freshwater zooplankton
Freshwater reservoir
Community pattern

ABSTRACT

Self-organizing maps, otherwise known as *Kohonen*-maps, are one form of unsupervised artificial neural networks that can produce two-dimensional plots from multidimensional data. This tool is especially useful in community pattern analyses and has been previously used in spatial pattern analysis with different perspectives. The present study aims to find zooplankton's community pattern in the Bakreswar reservoir ecosystem. Bakreswar reservoir is a freshwater ecosystem in the Birbhum district of West Bengal, India. The reservoir is primarily used to supply freshwater to the Bakreswar thermal power plant. However, the local villages around the reservoir depend on it for drinking water and fishing sustenance. The data used in this study was collected over two years from three different stations. Thus, in addition to describing the spatial pattern of community distribution of zooplankton groups, the temporal variation was also studied. It is observed in the study that the four major groups of zooplankton – Copepoda, Cladocera, Ostracoda, and Rotifera – react differently to the different environmental attributes. Primarily directed by the physical environmental factors, the effect of the chemical factors on the patterning is also evident from the study. Copepods are the dominant group in the system, closely followed by cladocerans and rotifers. But this observation changes at different stations and throughout the study period. The temperature profiles of the reservoir primarily direct the occurrence of ostracods and rotifers, whereas cladocerans and copepods are inclined more towards a chemical factor directive. Rotifers are dominant in the monsoon, whereas the post-monsoon and winter seasons show an increased presence of copepods and cladocerans. The overall observation that the reservoir's water quality is good, and the trophic structure is healthy is in accordance with previous studies as well.

1. Introduction

One of the significant goals of ecology as a discipline is the study of system-level organizations instead of the organism as an individual (Odum and Barrett, 1971). Comparable transcending or functional processes (e.g., energetics, evolution, diversity, and so on) can be observed through different levels of the organization, starting from the cellular level and continuing to the ecosphere (Barrett et al., 1997). However, there are marked differences in the holistic properties of such organizations compared to the individual component properties. A holistic hierarchical organization often gives rise to newer emergent (non-reducible) properties that cannot be explained simply by studying components only at that particular organization level (Odum and Barrett, 1971). Hence, it often becomes necessary to extend ecological studies at a community level to analyze the different controls of feedback mechanisms regulating their dynamicity. These controls are often loosely implemented at these levels – a characteristic property termed homeorhesis (Barrett et al., 1997; Odum and Barrett, 1971).

Community patterns vary with perturbations in the environmental composition; thus, it is an important aspect that might significantly impact the system's health in general (Hawkes, 1979). Community function largely depends on community structure and organization

* Corresponding author.
E-mail address: aranya.arnab@gmail.com (A. Banerjee).

https://doi.org/10.1016/j.ecoinf.2022.101837
Received 26 June 2022; Received in revised form 24 September 2022; Accepted 24 September 2022
Available online 30 September 2022

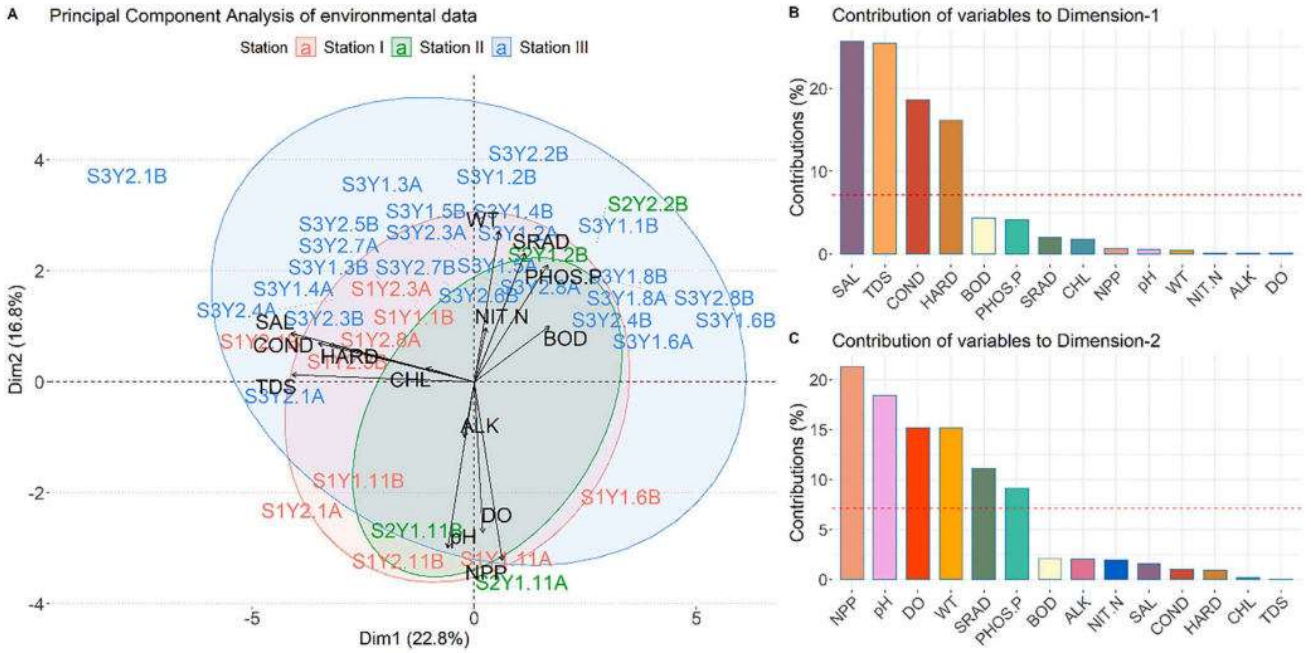


Fig. 6. Figure representing (A) PCA biplot for Env-data, (B) and (C) contribution of variables to dimensions 1 and 2 respectively for Env-data PCA.

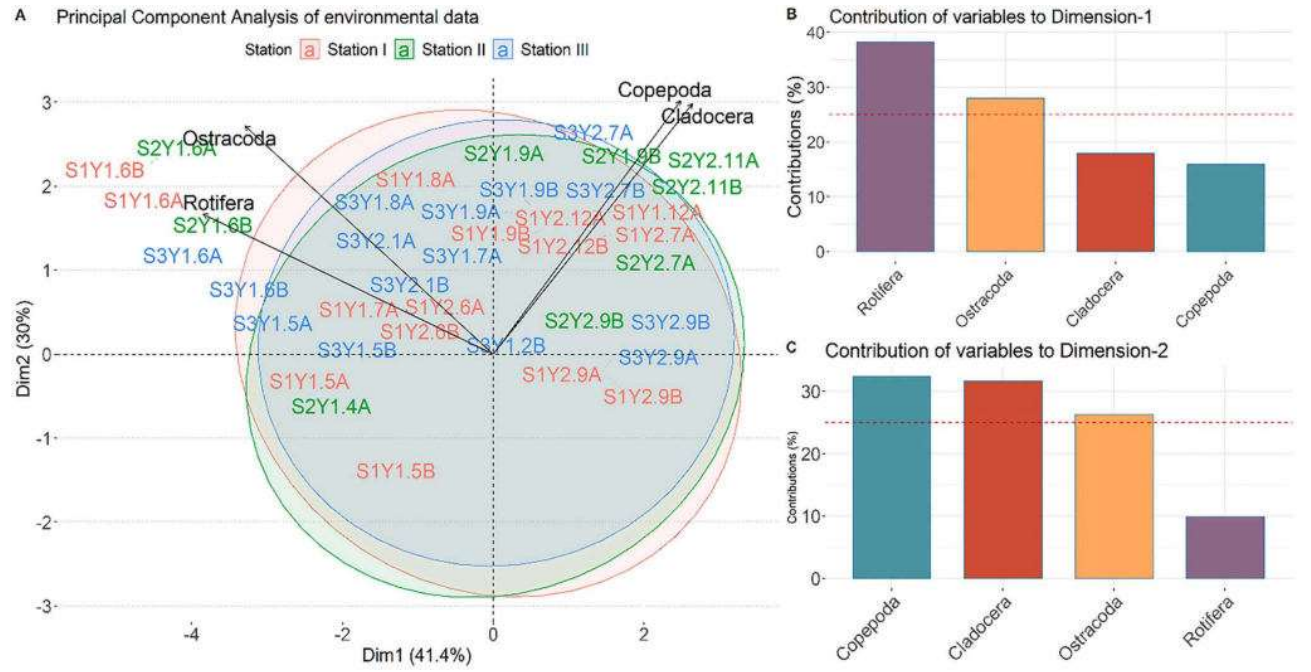


Fig. 7. Figure representing (A) PCA biplot for Zoop-data, (B) and (C) contribution of variables to dimensions 1 and 2 respectively for Zoop-data PCA.

descriptors are highly correlated among themselves. Four prime zooplankton groups – Copepoda, Cladocera, Rotifera, and Ostracoda-were collected over two years alongside environmental variable data. Before applying clustering and SOM workflow, this data was subjected to different tests, including correlation analysis, PCA, and collinearity tests. Results of correlation analysis (Figs. 3, 4, and 5) and PCA (Figs. 6 and 7) show a clear spatial ordination among the three stations.

Correlation analysis revealed that the different environmental factors have different effects on the distribution of zooplankton and, consequently, on their community structure. Figs. 3, 4, 15, and 17 and Table 3 establish that the factors (chemical) responsible for characterizing the data points are primary production, dissolved oxygen, alkalinity, salinity, nitrates, phosphates, and total dissolved solids. Solar irradiation and water temperature are the most important physical attributes, followed by air temperature and humidity. However, the latter two factors have been excluded from the final analyses following VIF extraction and adjustment. The atmospheric or air temperature had a high positive intercorrelation with water temperature. Hence, this

Vesanto, J., Alhoniemi, E., 2000. Clustering of the self-organizing map. IEEE Trans. Neural Netw. 11, 586–600. https://doi.org/10.1109/72.846731.
Vijanen, M., Holopainen, A.-L., Rahkola-Sorsa, M., Avinsky, V., Ruuska, M., Leppänen, S., Rasmus, K., Voutilainen, A., 2009. Temporal and spatial heterogeneity of pelagic plankton in Lake Pyhäselkä, Finland. Boreal Environ. Res. 14, 903–913.
Wehrens, R., Kruisselbrink, J., 2018. Flexible self-organizing maps in kohonen 3.0. J. Stat. Softw. 87 https://doi.org/10.18637/jss.v087.i07.
Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T., Miller, E., Bache, S., Müller, K., Ooms, J., Robinson, D., Seidel, D., Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K., Yutani, H., 2019. Welcome to the Tidyverse. J. Open Source Softw. 4, 1686. https://doi.org/10.21105/joss.01686.
Wicklum, D., Davies, R.W., 1995. Ecosystem health and integrity? Can. J. Bot. 73, 997–1000.
Wiegand, T., Moloney, K., 2013. A Handbook of Spatial Point Pattern Analysis in Ecology.
Yang, Y.F., Huang, X.F., Liu, J.K., 1998. Long-term changes in crustacean zooplankton and water quality in a shallow, eutrophic Chinese lake densely stocked with fish. Hydrobiologia 391, 195–203.

VOLUME 8 ISSUE 2 2022

ISSN 2454-3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 8, No. 2, 814-817 (2022)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Assessment of Groundwater and Surface-Water Resources of Gushkara in Purba Bardhaman (West Bengal, India) using the Water Quality Index

Roy Aparnita Nandi[1] and Paramanik Manas[2]*

[1]Department of Zoology, Gushkara Mahavidyalaya, Gushkara 713128, India
[2]Epidemiology, Vector Biology and Environmental Monitoring Research Units, Entomology Laboratory, Department of Animal Science, Kazi Nazrul University, Asansol, Paschim Bardhaman 713340, West Bengal, India

**Corresponding Author*

Received: 27th October, 2022; **Accepted:** 3rd December, 2022; **Published online:** 12th December, 2022

https://doi.org/10.33745/ijzi.2022.v08i02.098

Abstract: Survival of life on earth indispensably depends on water. Population explosion and its consequences resulted in the usable water sources being unusable in many regions. Regular monitoring of water quality becomes necessary to protect public health. The present study aimed to evaluate the water quality status of various water resources of Gushkara (West Bengal, India). The result showed that the status of the water quality index (WQI) of the studied surface-water sources is 'poor' or 'very poor' (ranges 50.582 - 87.969) whereas the groundwater and municipal water supply are rather safer (ranges 15.804 - 36.210). There is also an indication of faecal coliform contamination in surface-water sites. Overall water quality is better in winter than other two seasons. Some parameters in surface-water crossed the recommended level while some reached near that level. So immediate attention is necessary to rectify the situation.

Keywords: Water Quality Index, Ground and surface-water, Seasonal variation, Gushkara, Coliform

Citation: Roy Aparnita Nandi and Paramanik Manas: Assessment of groundwater and surface-water resources of Gushkara in Purba Bardhaman (West Bengal, India) using the Water Quality Index. Intern. J. Zool. Invest. 8(2): 814-817, 2022.

https://doi.org/10.33745/ijzi.2022.v08i02.098

Introduction

The amazing diversity of plants and animals on the globe is directly influenced by the sources of water. Today humans literally reached all the corners of the globe and explored all the possible places for establishing new habitats and activities. In the process, they explored and exploited almost all the resources of water. Most sources of freshwater are polluted to various degrees today and become unsuitable for their desired uses.

Globally, billions of people suffer and lose their lives every year from water-borne diseases (WHO, 2022). Standard drinking and usable groundwater and surface-water resources becoming scanty due to their indiscriminate unscientific use and

immediate attention (Mukherjee and Paramanik, 2022). The present study was conducted to understand the degree of water pollution, usability, and its seasonal variation at Gushkara. Analysis showed that the water quality parameters of the studied surface-water (ponds) are near or crossing the permissible limits in many cases. Contaminations from daily use, domestic, municipal, and/or agricultural sources are evident. Parameters of the groundwater (tube well and well) and the municipal supply are rather within safe limits. People use pond water for bathing, washing, and other domestic purposes, sometimes for drinking. WQI recommends immediate attention to the surface-water sources of the area.

Acknowledgements

The authors are grateful to the Aikatan Development Society, Gushkara for their support.

References

Addisie MB. (2022) Evaluating drinking water quality using water quality parameters and esthetic attributes. Air Soil Water Res. 5: 1-8.

APHA. (2012) Standard methods for the examination of water and wastewater. 22nd edition. American Public Health Association, Washington.

Kushwaha GJ, Pandey SM and Kumar P. (2022) Water quality assessment of river Kuwano, Basti (U.P.), using WQI and pollution indices. Ecol Environ Conserv. 28(3): 1576-1583.

Mukherjee S and Paramanik M. (2022) Impact of Durga idol immersion on water bodies with early and late removal of idols in Asansol, West Bengal, India. Intern J Zool Invest. 8(1): 152-161.

Paramanik M, Bhattacharjee I and Chandra G. (2012) Studies on breeding habitats and density of postembryonic immature filarial vector in a filarial endemic area. Asian Pacific J Tropical Biomed. 2(3): S1869-S1873.

Sharma M and Vyas V. (2022) Seasonal assessment of faecal contamination in groundwater in rural areas of Goharganj, district Raisen (Madhya Pradesh), India. Ecol Environ Conserv. 28: S173-S178.

Tyagi S, Sharma B, Singh P and Dobhal R. (2013) Water quality assessment in terms of water quality index. Am J Water Resour. 1(3): 34-38.

WHO. (2022) Drinking-water. https://www.who.int/news-room/fact-sheets/detail/drinking-water.

Economic Affairs, Vol. 67, No. 05, pp. 745-751, December 2022
DOI: 10.46852/0424-2513.5.2022.8

AESSRA

Research Paper

Multidimensional Deprivation: Cross-District Insights in West Bengal

Papita Dutta*[1] and Supravat Bagli[2]

[1]Gushkara Mahavidyalaya, Gushkara, Purba Bardhaman, West Bengal, India
[2]Presidency University, Kolkata, India

*Corresponding author: pdutta.economics@gmail.com (**ORCID ID**: 0000-0002-3068-5843)

Received: 23-08-2022 **Revised:** 24-11-2022 **Accepted:** 05-12-2022

ABSTRACT

This study explores the intensity and inequality of multidimensional deprivation (MD)across the districts of West Bengal, a north-eastern state in India. The measure of MD covers the dimensions of Knowledge, Health and Living condition with the respective indicators. We have clustered the districts in accordance with the selected indicators. An attempt has also been taken to gauge the inequality for deprivation indicators and for multidimensional deprivation index (MDI) applying the class of Atkinson measures. This study has used the data published by Directorate of Population Census of India 2011. It is reported that value of MDI ranges from 0.013 to 0.675 across the districts in West Bengal. Purulia is the most deprived district followed by Jalpaiguri, Maldah. On the other hand, Kolkata is the least deprived among the districts preceded by North 24 Parganas, Purba Mendinipur. The cluster analysis reveals that Kolkata is the distinct from the other districts of West Bengal. It is found that Darjeeling district and Jalpaiguri district form two separate clusters. The districts of Dakshin Dinajpur, Murshidabad, Uttar Dinajpur, Maldah, Birbhum, Bankura and Purulia are similar in terms of the indicators of multidimensional deprivation. The districts of West Bengal are, of course, not highly diverse in terms of multidimensional deprivation. However, inequality for MDI is higher than that for HDI of the districts.

HIGHLIGHTS

- Average value of multidimensional deprivation index for the districts in West Bengal is 0.42 with range 0.013 to 0.675. Purulia is the most deprived district in West Bengal followed by Jalpaiguri, Maldah, Uttar Dinajpur
- Geographical closeness of the districts in West Bengal does not ensure the closeness of the districts in respect of the socio-economic deprivation indicators.
- The districts of West Bengal are not highly diverse in terms of multidimensional deprivation.

Keywords: Cluster Analysis, multidimensional deprivation index, normalized inverse euclidian distance, population census

The well-being of a person is best seen as an index of the person's functionings (Sen, 1987). Deprivation may be viewed as the failure to achieve the socially desirable functionings of the person. Personal achievement of functionings depends on many factors. Thus, deprivation of an individual or a community or a region is associated with the multiple aspects like health, education and access to descent living condition. India has some flagship programs like Pradhan Mantri Jan Dhan Yojana (PMJDY), Swarnajayanti Gram Swarojgar Yojana (SGSY), National Rural Employment Guarantee Scheme (NREGS), Public Distribution System, Universal Health programmes to smooth the achievement of functionings of the common people. Despite

How to cite this article: Dutta, P. and Bagli, S. (2022). Multidimensional Deprivation: Cross-District Insights in West Bengal. *Econ. Aff.*, **67**(05): 745-751.

Source of Support: None; **Conflict of Interest:** None

where ε denotes the inequality aversion parameter, n stands for number of districts (19), x_i stands for the i^{th} indicator or index of deprivation. μ denotes the mean of x_i. The value of ε ranges from 1 indicating no preference for equality to minus infinite indicating extreme preference for equality. In this study the values of ε = 0.5, 0 and -1 have been considered for measuring inequality of the indicators and indices under consideration.

The data for the indicators of multidimensional deprivation for the districts in West Bengal have been collected from Population Census Report 2011, Government of India. Data for HDI of the district have been collected from West Bengal Human Development report, 2004, the Government of West Bengal. We have considered all the districts in West Bengal during the census year 2011 and census data for studying the intensity and inequality in multidimensional deprivation.

RESULTS AND DISCUSSION

Table 2 displays the descriptive statistics of the indicators and indices of MDI. Average illiteracy rate of the districts in West Bengal is 25.14 per cent in 2011which varies from 12.98 per cent to 49.93 per cent across the districts. In West Bengal 52.9 per cent households have no access to banking facilities. Median value of this indicator tells us that in half of the districts, 57 per cent or more households are deprived of banking facilities. Thus financial illiteracy is a serious deprivation among the districts of West Bengal. Although, intensity of financial illiteracy is higher than that of academic illiteracy, relative dispersion of financial illiteracy is lower than that of illiterate populations across the districts. We observe that in average 41.46 per cent households of the districts in West Bengal collect drinking water from unsafe source. Percentage of households having access to unsafe source of drinking water is highest in Darjeeling followed by Jalpaiguri and Purulia and it is lowest in South 24 Parganas district. There is a wide variation across the districts in terms of access to safe source of drinking water. Average percentage of households without improved sanitation facility in the districts of West Bengal is 46.22 per cent. We have observed that 88 per cent of households in Purulia district, which is highest among the districts in West Bengal, do not have access to improved sanitation. Access to improved sanitation is the highest in the district of Kolkata. In average 11.16 per cent households of the districts in West Bengal live in dilapidated house. It varies from 2.6 per cent to 16.6 per cent across the districts. In majority of the districts more than half of the households have no electricity or solar energy for lighting.

It is saddening that 82 per cent households of the districts in West Bengal have no access to improved fuel for cooking which ranges from 33 to 94 per cent. However, only 23 per cent households in average of the districts have no census assets. Thus poverty in terms of asset holding is not so serious in the districts of West Bengal. Therefore, from the analysis of individual indicator is it not sufficient to determine the relative position of the districts. We need a comprehensive index which covers multiple

Table 2: Description of the indicators of Deprivations in the districts of West Bengal

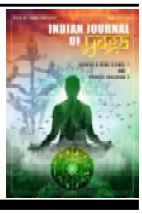
Indicators(%) /Index	Mean	Median	S D	CV	Skew	Max	Min
Illiterate population	25.14	25.03	8.05	32.04	0.34	40.93	12.98
Households having no access to banking facility	52.90	57.00	13.56	25.63	-0.44	73.50	16.20
Households use unsafe source of drinking water	14.46	8.20	15.67	108.34	2.03	60.10	2.60
Households have no improved sanitation facility	46.22	44.30	24.60	53.23	0.02	88.20	5.10
Households live in dilapidated residence	11.16	11.40	3.45	30.95	-0.74	16.60	2.60
Households have no access to electricity or solar power for lighting	46.59	50.60	19.18	41.16	-0.74	71.70	2.20
Households use dirty fuel for cooking	82.52	90.30	15.79	19.13	-0.83	94.30	33.80
Households do not have census asset	23.41	23.40	8.39	35.82	-1.93	36.30	3.60
HDI	0.58	0.60	0.09	14.94	0.33	0.78	0.45
MDI	0.42	0.46	0.17	39.80	-0.68	0.68	0.013

Source: *Authors' computation.*

Vol: 7, Issue: 1, 2022, P-ISSN: 0975-265X

Indian Journal of Yoga Exercise & Sport Science and Physical Education

journal homepage : www.jyesspe.in



Discussion

THE IMPACT OF RECREATIONAL GAMES IN OUR SOCIETY

Dr. Manisha Mondal

Associate Professor, Dept. of Physical Education, Gushkara Mahavidyalaya, Guskara, Purba Bardhaman

ARTICLE INFO

Article history :
Received: 15th December, 2022
Received in revised form
17th December, 2022
Accepted 29st December, 2022
Available online: 4th January, 2023

Keywords :
Recreational games,
physical fitness, society.

ABSTRACT

Recreational Games are these activities where the primary purpose of the activity in participation, with related goals of improved physical fitness, for and social involvement often prominent. It is less stressful, both physically nd mentally on the participants. These are lower expectations regarding both performance and commitment to the sports in the recreational games in one of the most important area and it also create positive inter-relationship to every person. Recreational games are often done for enjoyment, amusement or pleasure and are considered to be 'fun'. In our busy schedule, recreational games gives us oxygen and in this way our new generation can explore many things for the development of society.

Introduction

The significance of the saying has increased many and various side in today's fast life and competitive world where students are forced by both their guardians and the conglomerate of society and situations as a whole to devote increasing hours in academic study whether theoretical or practical and knowledge enhancing activities, so that they can stay ahead in the rat race. Add to that the present way of life where people mostly stay in small nuclear families and with parents working the viability of our own home as a pace where we can have recreational time has diminished.

Recreation and Recreational Games

Recreation is the refreshment of strength and spirit after wine. It is also leisure time activity. The "need to do something for recreation", is an essential element of human biology and psychology when we continue doing a work or performing an activity regularly and continuously for some hours, it gives us physical and mental fatigue and strain. Recreational activity relieves us of the feeling of fatigue, restores our energy and promote a sense of joy. Without recreation, life would be dull and miserable. Leisure activities mood, reduce stress and enhance a sense of wellness. In an increasingly complex world, more and more people are placing a high value on achieving the feelings of relaxation and peacefulness that contact with nature, recreation and exposure to natural open spaces bring. Recreational game involves participants in which the main function in providing fun and entertainment to participant. Recreational is a source of joy and provide relaxation for one's body and mind. Recreational games playing a very important role for all over age groups. The quality of life is determined with objective factors and also with subjective perception of factors which influence human life. Recreational actively play a very important role in subjective well-being because they provide opportunities to meet life values and needs. Through participation in leisure activities people build social relationships, feel positive emotions, acquire additional skills and knowledge and therefore improve their quality of live. Both physical & psychological benefits of leisure times with reduced level of stress, anxiety and depression,

Email :

DOI: https://doi.org/10.58914/ijyesspe.2022-7.1-2.4

improved mood and higher levels of positive emotions. Engaging in recreational activities can also lower blood pressure and heartbeat. It can improve the mental health of individuals and have the significance of regulating the body and mind, alleviating the stress of life and providing a pleasant experience. It encourages people to experience freedom, which often leads to feeling of control, competence and improved self-esteem. Engaging in pleasurable activities stimulate the production of neuro-chemicals that in turn improve physical health.

Physical Activity and Recreational Games

Exercise is a body activity than enhances or maintains physical fitness and overall health and wellness. It is performed for various reasons, to aid growth improve strength, develop muscles and the cardiovascular system, weigh loss or maintenance, improve health or simply for enjoyment. Recreational game takes most important place in our present and future life. We all know that leading an active life style in good for us. If you participate regular moderate physical activity – running, jumping, throwing, walking you can expect to enjoy numerous health & social benefits, including:

- Encourage social inter-relationship
- Improve concentration and learning
- Increase personal confidence and self-awareness
- Reduce feelings of depression and anxiety
- Enhance self-esteem
- Improve quality of life
- Improve a more positive educational environment
- Reduction of antisocial behavior

Those who are engaging different types of physical activity and recreational games, they have less time to enjoy the negative or unnecessary situation. All time they think the positive effects of society and try to increase the awareness of different types of values in human mind. Recreational games are developing a good mental attitude, which is very much essential in our positive thinking. Emotion, both happy and sad, can effect cognitive functionary along with your energy level and other aspects of your physical performance. On the other hand recreational game improves the life skill such as:

- Focus and self-control
- Critical thinking and problem solving
- Empathy & perspective taking
- Patience and confidence
- Communication & listening
- Creativity and connecting ideas

It also helps in boosting memory as there is more practical experience and the information can be soaked up wholly by the brain in a fresher and fascinating.

Group games and individual games are also helps moral development of students. One way to encourage moral development to teach students to play fairly. In educational situation moral development plays an important role for the future endeavor of every human being.

It also enhances peer relationship and inter-personal skills. Student can also excel in areas other than academic where they have an interest. Recreational activity can give a chance to discover talents other than academic excellence which can tater help on the career and life as a whole.

Conclusion

Without any doubt it can be said that recreational activities help in overall development of a student's physical, mental, social and emotional. Recreational activity is not only helps to gather knowledge but also to use it ethically to lead a healthy and better life in future. It teaches one to think with reason and line with more practical approach to life. It also enhances ones all round development, thus helping to achieve success in on endeavours.

Reference

1. Kumar S, "Minor Games", Khel Sahitya Kendra, New Delhi, 2014
2. Sendhil R, "Sociology in Sports", Sports Publication, New Delhi, 2014
3. Bhusan V, Sachdeva DR, "An Introduction to Sociology", Kitab Mahal, Allahabad, 2010
4. Mishra SC, "Recreational Physical Education", Sports Publication, New Delhi, 2006
5. Bucher CA, "Foundation of Physical Education, London, The C.V. Mosby Co., St. Louis Torranto, 1983

ROCK PEBBLES

MARCH - 2023 • Vol. XXVII • No. I

A Peer-Reviewed Journal of
Arts & Humanities

ROCK PEBBLES

A Peer-Reviewed Journal of Arts & Humanities

UGC - CARE listed vide Sl. No. 307, Gr. I

March - 2023 ✸ Vol. XXVII ✸ No. I

Correspondence Address

Head Office : NARANPUR, Post: KODANDAPUR, Via: DEVIDWAR
Dist.: JAJPUR, ODISHA, INDIA, PIN Code-755007
Regd. Office: Plot No: 2642/3054/3130, Ogalopada, Post - Janla, PS: Infovalley, Bhubaneswar, Odisha-752054
e-mail : rockpebbles2007@rediffmail.com / rockpebbles2010@gmail.com
website : www.rockpebblesindia.com
Cell - 9437009135 / 9437449490, WhatsApp-9861012630 / 7978238911

Gandhi, Ambedkar and Martin Luther King Junior: Three Pilgrims of Social Justice

Anand Mahanand

It is interesting to note that though the twentieth century witnessed the rise of two prominent dictators, Hitler and Mussolini, who ruthlessly suppressed their targeted people; it also gave rise to many committed leaders who fought selflessly for the emancipation of different oppressed communities. M.K. Gandhi, Dr B.R. Ambedkar and Martin Luther King Jr are good examples of these saviours. Gandhiji fought for the freedom of the Indian people and also for the emancipation of the dalits in India. Ambedkar struggled for the upliftment of the untouchables of India and Martin Luther King jr fought for the rights of the Negros in the U.S.A. Gandhiji's guiding force was the Bhagavad Gita, Ambedkar drew inspiration from Buddhism whereas Martin Luther King Jr was inspired by Christianity. Martin Luther King however was deeply inspired by Gandhiji. Ambedkar on the other hand was a critic of Gandhiji's approach to the dalits. The reason for Ambedkar's difference with Gandhiji's ideals was due to their convictions. Both Gandhiji and Ambedkar had love and concerns for the dalits but each of them had different approaches for their freedom. Gandhi believed in the goodness of hearts of human beings. He thought the oppression of the dalits would end when people listened to their conscience whereas Ambedkar was not sure of that but was convinced that laws made in favour of the oppressed would safeguard them. Gandhiji, Ambedkar and Martin Luther King all followed the path of non-violence in their respective struggles. For the title, I have taken the phrase from King's essay "Pilgrimage to Non-violence" and called these three crusaders pilgrims of non-violence. One finds a lot of similarities as well as differences among these three. In this paper, I would like to study the select writings and speeches of these leaders and explore some of the common grounds of leadership in them. I would also like to study the difference in their approach. This will hopefully help in understanding the life, ideas and activities of these three great leaders.

Keywords: Gandhiji, Ambedkar, Martin Luther King Junior, emancipation, oppression, freedom

Dr. B.R. Ambedkar: A Champion of Human Rights

Saroj Kumar Sarkar

Babasaheb Dr. B.R. Ambedkar, the Chief Architect of Indian Constitution was a scholar par excellence, a philosopher, a visionary, and a true champion of human rights. He led a number of social movements to secure human rights for the oppressed sections of Indian society. He stands as a symbol of struggle for social justice even today.

Hinduism is divided into four Varna and so many castes and sub-castes. Casteism, for hundreds of years has been a crucial problem in Indian society. It not only creates social discrimination, but brings social and economic injustice among the citizens as well. Though the very notion of *ChaturVarna* has been referred in the Rigveda but afterwards more than three thousand castes and sub-castes have come into existence after the Later Vedic Period. The Brahmin community who were educationally and economically superior to the other communities took the advantage to exploit and oppress the lower communities in course of time. The notion of Varna and caste gave birth to untouchability which is a great damnation to humanity. Dr. B.R. Ambedkar being a Dalit was victimized throughout his life by the upper caste Hindus in several times. So he fought against caste-system and Untouchability. He wanted abolition of social discrimination, torture and disgrace of Dalit. He also wanted to bring social justice in our society. His main aim was to establish equality, liberty and fraternity among the citizens of our country. He was a real humanist and social reformer, a champion of human rights.

Keywords: Human rights, Social justice, Casteism, Untouchables, Humanist

Introduction:

Bhimrao Ramji Ambedkar was born in a Mahar family on 14th April, 1891. His father served in the British Indian Army at the Mhow cantonment in Central Province. Unlike most of the children of his caste, young Bhim used to go to school

scheduled caste, scheduled tribes and backward caste. He made several provisions in the form of articles in Indian constitution for development and upliftment of depressed caste.

Poona Pact and Dalits' Rights.

In 1932, British Govt. announced the formation of a separate electorate for "Depressed Classes" in the Communal Award. Gandhi fiercely opposed a separate electorate for untouchables, saying he feared that such an arrangement would divide the Hindu community. Gandhi protested by fasting while imprisoned in the Yerwada Central Jail of Poona. Following the fast, Congress politicians and activists such as Madan Mohan Malaviya and Palwankar Baloo organized joint meetings with Ambedkar and his supporters at Yerwada. On 25 September 1932, the agreement known as Poona Pact was signed between Ambedkar (on behalf of the depressed classes among Hindus) and Madan Mohan Malaviya (on behalf of the other Hindus). The agreement gave reserved seats for the depressed classes in the Provisional legislatures, within the general electorate. Due to the pact, the depressed class received 148 seats in the legislature, instead of the 71 as allocated in the Communal Award earlier proposed by British Prime Minister Ramsay MacDonald. The text uses the term "Depressed Classes" to denote Untouchables among Hindus who were later called Scheduled Castes and Scheduled Tribes under India Act 1935, and the later Indian Constitution of 1950. In the Poona Pact, a unified electorate was formed in principle, but primary and secondary elections allowed Untouchables to choose their own candidates.[6]

Theory of Social justice and B.R. Ambedkar

Social justice means equal social opportunities available to everyone to develop their personalities associated with equality and social rights. According to Oxford Concise Dictionary of Politics, Social Justice is an emphasis on the foundational character of justice of social life. According to Ambedkar the root cause of social injustice to the Scheduled caste and scheduled tribes is the caste system in Hindu society. He did not propound any specific definition or theory of 'Social Justice'. His thoughts are expressed through writings and speeches published posthumously. We can extract basic principles of writings and speeches of Ambedkar, through which justice can be dispensed in the society. These are:

1. Establishing a society where individual becomes the means of all social purposes
2. Establishing a society, based on equality, liberty, and fraternity
3. Establishing political, economic, and social democracy
4. Establishing democracy through constitutional measures and
5. Establishing democracy by breaking monopoly of upper strata on political power.[7]

Works Cited:

Sarkar, Kalyan Kumar. *Bharatiya Rastrachintar Itihas*. P.395, Shree Bhumi Publishing Company, 2008.

http://ir.unishivaji.ac.in>jspui ,(Abolition of untouchability and upliftment of the untouchables, P.39.)

Keer, Dhananjoy. *Dr. B.R. Ambedkar: Life and Mission*, Popular Prakashan Ltd., 2011.

Ibid.

Ibid.

Ibid

www.researchgate.net

Teltumbde, Anand. *Ambedkar and Post Ambedkar Dalit Movement*. Pune, Sugawa Prakashan, 1997.

Pylee, M V. *India's Constitution*, S Chand & Company Ltd. 2009.

https://www.thehansindia.com/hans/opinion/news-analysis

Mr. Saroj Kumar Sarkar, Assistant Professor, Department of Political Science, Gushkara Mahavidyalaya, Purba Bardhaman, West Bengal

Applied Physics B (2023) 129:75
https://doi.org/10.1007/s00340-023-08014-x

Applied Physics B
Lasers and Optics

RESEARCH

An exact algebraic solution of two harmonic modes coupled through the angular momentum

Swapan Mandal[1,2] · Kartick Chandra Saha[1] · Dolan Krishna Bayen[1] · Norma Canosa[2] · Raul Rossignoli[2,3]

Received: 27 January 2023 / Accepted: 1 April 2023

Abstract
Starting from the Hamiltonian of two oscillators coupled through the angular momentum, we obtain the equations of motion involving the field operators for two harmonic modes. These operator differential equations of motions are found coupled to each other. The noncommuting nature of the operators are on the way for getting the exact analytical solution directly. To get rid of these problems and on the basis of physical and mathematical considerations, the solutions are assumed in terms of some constant (independent of time) coefficients. The coupled differential equations involving these coefficients are finally decoupled at the cost of fourth order differential equations. Finally, we obtain the exact analytical solutions of these coefficients and hence the field operators involving the oscillators. As an application of these solutions, we investigate the well known squeezing effects of the input coherent light interacting with the oscillators coupled through the angular momentum. It is to be remembered that we retain the nonconserving energy terms for investigating the dynamical behaviour of the oscillators coupled through the angular momentum.

1 Introduction

To explain the basic physics behind the natural phenomena, we rely on some basic models. For example, the model of a harmonic oscillator arises when a particle moves under the action of a restoring force. Perhaps the model of a harmonic oscillator is the most useful one among the physical models for the explanation of basic physics. It is because of that the model of harmonic oscillator finds huge applications in various branches of physics. These include mechanics, spectroscopy, field theory and in the acoustics. On the other hand, we know that the real physical problems demand more beyond the model of a simple harmonic oscillator. For example, the inclusion of damping and the anharmonicities make the model of the harmonic oscillator more realistic and relevant to the physical problems. In addition to these, the demand of the physical situations are met through the model of coupled oscillators. The problem of coupled harmonic oscillators are investigated in a great way [1–19]. We find few investigation, where the coupling between the anharmonic oscillators is also studied [13–15]. The wide range of applications of the model of the coupled harmonic oscillators have attracted Physicists, chemists, mathematician and engineers. The coupled classical oscillators are useful in the studies of coupled vibrations, beats, and resonances. The infrared optical activities of dimer-like molecules are estimated by using the coupled oscillator model which is not otherwise unavailable through the usual infrared spectroscopy [1]. The coupled oscillator model is found useful for investigating quantum statistical properties of radiation field [2], coherent state propagator [3], non invariance group of many particle system [4], nonadiabatic Berry's phase, quantum entanglement and quantum teleportation [5], quantum phase [6], and in the Josephson tunneling [7]. Now, depending upon the strength of the coupling we categorize

✉ Swapan Mandal
swapanvb@rediffmail.com

Kartick Chandra Saha
ksahaphysan98@gmail.com

Dolan Krishna Bayen
dolankrishna@gmail.com

Norma Canosa
canosa@fisica.unlp.edu.ar

Raul Rossignoli
rossigno@fisica.unlp.edu.ar

[1] Department of Physics, Visva-Bharati, Santiniketan 731235, India

[2] IFLP-CONICET and Departamento de Fisica, Universidad Nacional de La Plata, C. C. 67, 1900 La Plata, Argentina

[3] Argentina Comisión de Investigaciones Científicas (CIC), 1900 La Plata, Argentina

$$\lambda_1 = \frac{1}{2}\left[\sqrt{\left(\Omega_1^2+\Omega_2^2+2\kappa_1^2-2\kappa_2^2\right)+\sqrt{\left(\Omega_1^2+\Omega_2^2+2\kappa_1^2-2\kappa_2^2\right)^2-4\left\{\left(\Omega_1\Omega_2+\kappa_1^2-\kappa_2^2\right)^2-4\kappa_1^2\Omega_1\Omega_2\right\}}}\right]$$
$$\lambda_2 = \frac{1}{2}\left[\sqrt{\left(\Omega_1^2+\Omega_2^2+2\kappa_1^2-2\kappa_2^2\right)-\sqrt{\left(\Omega_1^2+\Omega_2^2+2\kappa_1^2-2\kappa_2^2\right)^2-4\left\{\left(\Omega_1\Omega_2+\kappa_1^2-\kappa_2^2\right)^2-4\kappa_1^2\Omega_1\Omega_2\right\}}}\right] \tag{18}$$

By putting the value of λ_i, the Eq. (18) assume the following forms

$$\lambda_1 = \frac{1}{2}\left[\sqrt{\left(\Omega_1^2+\Omega_2^2+2\xi^2\right)+\sqrt{\left(\Omega_1^2+\Omega_2^2+2\xi^2\right)^2-4\left\{\left(\Omega_1\Omega_2+\xi^2\right)^2-\xi^2\left(\Omega_1+\Omega_2\right)^2\right\}}}\right]$$
$$\lambda_2 = \frac{1}{2}\left[\sqrt{\left(\Omega_1^2+\Omega_2^2+2\xi^2\right)-\sqrt{\left(\Omega_1^2+\Omega_2^2+2\xi^2\right)^2-4\left\{\left(\Omega_1\Omega_2+\xi^2\right)^2-\xi^2\left(\Omega_1+\Omega_2\right)^2\right\}}}\right] \tag{19}$$

Now, the solutions of the parameter u_i are quite straightforward and are given by

$$u_i = A_i\cos\lambda_1 t + B_i\sin\lambda_1 t + C_i\cos\lambda_2 t + D_i\sin\lambda_2 t \tag{20}$$

where $i = 1, 2, 3$ and 4. Now, the explicit analytical expressions for the parameter $A_i,\ B_i, C_i,$ and D_i follow immediately

$$\begin{aligned}
A_1 &= \frac{\xi^2+\Omega_1^2-\lambda_2^2}{\left(\lambda_1^2-\lambda_2^2\right)},\ B_1 = -\frac{\ddot{u}_1(0)-i\Omega_1\lambda_2^2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
C_1 &= -\frac{\xi^2+\Omega_1^2-\lambda_1^2}{\left(\lambda_1^2-\lambda_2^2\right)},\ D_1 = \frac{\ddot{u}_1(0)-i\Omega_1\lambda_1^2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}\\
A_2 &= -\frac{i\kappa_1\left(\Omega_1+\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ B_2 = \frac{\ddot{u}_2(0)-\kappa_1\lambda_1^2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}\\
C_2 &= \frac{i\kappa_1\left(\Omega_1+\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ D_2 = -\frac{\ddot{u}_2(0)-\kappa_1\lambda_2^2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
A_3 &= 0,\ B_3 = -\frac{2i\kappa_1\kappa_2\Omega_2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
C_3 &= 0,\ D_3 = \frac{2i\kappa_1\kappa_2\Omega_2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}\\
A_4 &= \frac{i\kappa_2\left(\Omega_1-\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ B_4 = -\frac{\ddot{u}_4(0)+\lambda_2^2\kappa_2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
C_4 &= -\frac{i\kappa_2\left(\Omega_1-\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ D_4 = \frac{\ddot{u}_4(0)+\lambda_1^2\kappa_2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}
\end{aligned} \tag{21}$$

In an identical manner, the solutions for v_i are obtained and are given by

$$v_i = A_i'\cos\lambda_1 t + B_i'\sin\lambda_1 t + C_i'\cos\lambda_2 t + D_i'\sin\lambda_2 t \tag{22}$$

where

$$\begin{aligned}
A_1' &= \frac{i\kappa_1\left(\Omega_1+\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ B_1' = -\frac{\ddot{v}_1(0)+\kappa_1\lambda_2^2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
C_1' &= -\frac{i\kappa_1\left(\Omega_1+\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ D_1' = \frac{\ddot{v}_1(0)+\kappa_1\lambda_1^2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}\\
A_2' &= \frac{\xi^2+\Omega_2^2-\lambda_2^2}{\left(\lambda_1^2-\lambda_2^2\right)},\ B_2' = -\frac{\ddot{v}_3(0)-i\Omega_2\lambda_2^2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
C_2' &= -\frac{\xi^2+\Omega_2^2-\lambda_1^2}{\left(\lambda_1^2-\lambda_2^2\right)},\ D_2' = \frac{\ddot{v}_3(0)-i\Omega_2\lambda_1^2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}\\
A_3' &= -\frac{i\kappa_2\left(\Omega_1-\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ B_3' = -\frac{\ddot{v}_3(0)+\kappa_2\lambda_2^2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
C_3' &= \frac{i\kappa_2\left(\Omega_1-\Omega_2\right)}{\left(\lambda_1^2-\lambda_2^2\right)},\ D_3' = \frac{\ddot{v}_3(0)+\kappa_2\lambda_1^2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}\\
A_4' &= 0,\ B_4' = \frac{2i\Omega_1\kappa_1\kappa_2}{\lambda_1\left(\lambda_1^2-\lambda_2^2\right)}\\
C_4' &= 0,\ D_4' = -\frac{2i\Omega_1\kappa_1\kappa_2}{\lambda_2\left(\lambda_1^2-\lambda_2^2\right)}
\end{aligned} \tag{23}$$

28. A.S.M. de Castro, V.V. Dodonov, Phys. Rev. A **89**, 063816 (2014)
29. C.K. Law, Phys. Rev. Lett. **73**, 1931 (1994)
30. V.V. Dodonov, A.B. Klimov, D.E. Nikonov, J. Math. Phys. **34**, 2742 (1993)
31. M.T. Jaekel, S. Reynaud, J. Phys. I (France) **2**, 149 (1992)
32. J. Wei, E. Normann, Proc. Am. Math. Soc. **15**, 327 (1964)
33. J. Wei, E. Normann, J. Math. Phys. **4**, 575 (1963)
34. S. Mandal, J. Perina, Phys. Lett. A **328**, 144 (2004)
35. B. Sen, S. Mandal, J. Mod. Opt. **52**, 1789 (2005)
36. A. Pathak, S. Mandal, Mod. Phys. Lett. B **17**, 225 (2003)
37. S. Mandal, Mod. Phys. Lett. B **16**, 963 (2002)
38. S. Mandal, Opt. Commun. **240**, 363 (2004)
39. S. Mandal, J. Perina, Phys. Lett. A **328**, 144 (2004)
40. M. Alam, S. Mandal, M.R. Wahiddin, Opt. Int. J. Light Electron Opt. **157**, 1035 (2018)
41. R. Loudon, P.L. Knight, J. Mod. Opt. **34**, 709 (1987)
42. R. Loudon, *The Quantum Theory of Light*, 2nd edn (Oxford, 1983)
43. D.F. Walls, Nature **306**, 141 (1983)
44. R. Hanbury-Brown, R.Q. Twiss, Nature **177**, 27 (1956)
45. H.J. Kimble, M. Dagenais, L. Mandel, Phys. Rev. Lett. **39**, 691 (1977)
46. F. Diedrich, H. Walther, Phys. Rev. Lett. **58**, 203 (1987)
47. R. Short, L. Mandel, Phys. Rev. Lett. **51**, 384 (1983)
48. T. Basche, W. Moerner, M. Oritt, H. Talon, Phys. Rev. Lett. **69**, 1516 (1992)
49. P. Grangier, G. Roger, A. Aspect, A. Heidmann, S. Reynaud, Phys. Rev. Lett. **57**, 687 (1986)
50. S.L. Mielke, G.T. Foster, L.A. Orozco, Phys. Rev. Lett. **80**, 3948 (1998)
51. D.F. Walls, Nature **280**, 451 (1979)

Advances in Redox Research 7 (2023) 100061

Contents lists available at ScienceDirect

Advances in Redox Research

journal homepage: www.elsevier.com/locate/arres

Full Length Article

In silico targeting of lipoxygenase, CYP2C9, and NAD(P)H oxidase by major green tea polyphenols to subvert oxidative stress

Prem Rajak[a,*], Abhratanu Ganguly[a], Moutushi Mandi[b], Anik Dutta[c], Saurabh Sarkar[d], Sayantani Nanda[a], Kanchana Das[b], Siddhartha Ghanty[a], Gopal Biswas[b]

[a] Department of Animal Science, Kazi Nazrul University, Asansol, West Bengal, India
[b] Toxicology Research Unit, Department of Zoology, The University of Burdwan, Purba Bardhaman, West Bengal, India
[c] Post Graduate Department of Zoology, Darjeeling Government College, West Bengal, India
[d] Department of Zoology, Gushkara Mahavidyalaya, West Bengal, India

ARTICLE INFO

Keywords:
Green tea
Catechins
Oxidative stress
Lipoxygenase
CYP2C9
NAD(P)H oxidase

ABSTRACT

Oxidative stress (OS) is a phenomenon caused by an imbalance between free-radical production and antioxidant activity within the body. Status of endogenous antioxidants is not always sufficient to mitigate the oxidative damage. In this case, exogenous antioxidants could help to minimize free-radical production and subsequent OS. Green tea is rich in several phenolic compounds that have strong antioxidant properties. However, their mechanism of action is still unclear. Hence, the present study aims to investigate binding affinities of six green tea polyphenols such as catechin, epicatechin, epicatechin gallate, epigallocatechin, epigallocatechin gallate, and gallocatechin for common ROS producers such as Lipoxygenase (LOX), CYP2C9, and NAD(P)H oxidase (NOX). Results indicated that polyphenols interacted with binding pockets of these enzymes through hydrogen bonds and other stable interactions such as van der waals, Pi-Pi, Pi-alkyl, and alkyl. All polyphenols showed varied binding affinities. Among them, epigallocatechin gallate and epigallocatechin showed the highest binding affinities for the ROS producers. Findings of the present study suggest that, apart from free radical scavenging activity, green tea polyphenols may directly interact with binding pockets of LOX, CYP2C9, and NOX to dampen ROS production and OS. However, studies involving animal models are required for additional validation of results.

1. Introduction

Oxidative stress (OS) is an imbalance between oxidant and antioxidant molecules in a biological system. Such an imbalance can be detrimental to various essential macromolecules like proteins, lipids, and nucleic acids with respect to their structure and biological functions. The role of OS is inevitable in the pathophysiology of human beings. Oxidants injure cells in several ways, contributing to various diseases, including atherosclerosis, chronic obstructive pulmonary disease (COPD), Alzheimer's disease, and cancer [1].

Oxidant-antioxidant imbalance is triggered by the disproportionate production of reactive species derived from oxygen and nitrogen. Production of these species is aggravated by stress, UV radiations, exposure to xenobiotics, infections, and pathological conditions [2–14]. Antioxidants may neutralize free radicals and prevent OS [15,16]. Nonetheless, scavenging superoxide radicals ($O_2^{\bullet-}$), hydroxyl radicals ($^{\bullet}OH$), peroxynitrite ($ONOO^-$), nitric oxide ($^{\bullet}NO$), and the hypohalous acids (HOX) by exogenous small molecules may not be enough if the source is not being targeted. Various enzymes have been considered as the sources of reactive species. Among them, Lipoxygenase (LOX), Cytochrome P450 (CYP2C9) and NAD(P)H Oxidase (NOX) are the sounding ones.

Lipoxygenase is a family of non-heme iron-containing enzyme that catalyses formation of hydroperoxides via oxidation of polyunsaturated fatty acids (PUFA) [17]. These enzymes are 700 amino acid long and classified into 5(S)-, 8(S)-, 12(S)-, and 15(S)-. Metabolites of PUFA profoundly impact the progression of inflammation and cancer. Therefore inhibition of PUFA metabolizing enzymes such as LOX could have therapeutic implications against such diseases.

Cytochrome P450 is a diverse group of enzymes that catalyzes oxidation–reduction reactions. They are involved in the biotransformation of various drugs and xenobiotics via phase I reactions. Therefore CYP450 plays a vital role in maintaining human physiology [18]. It is to

Abbreviations: ALA, alanine; ARG, arginine; ASN, asparagine; ASP, aspartic acid; CYS, cysteine; GLU, glutamic acid; GLY, glycine; HIS, histidine; LEU, leucine; LYS, lysine; MET, methionine; PHE, phenylalanine; PRO, proline; SER, serine; THR, threonine; TRP, tryptophan; TYR, tyrosine; VAL, valine.

* Corresponding author.
E-mail address: prem.rjk@gmail.com (P. Rajak).

https://doi.org/10.1016/j.arres.2023.100061
Received 23 November 2022; Received in revised form 27 December 2022; Accepted 20 January 2023
Available online 21 January 2023

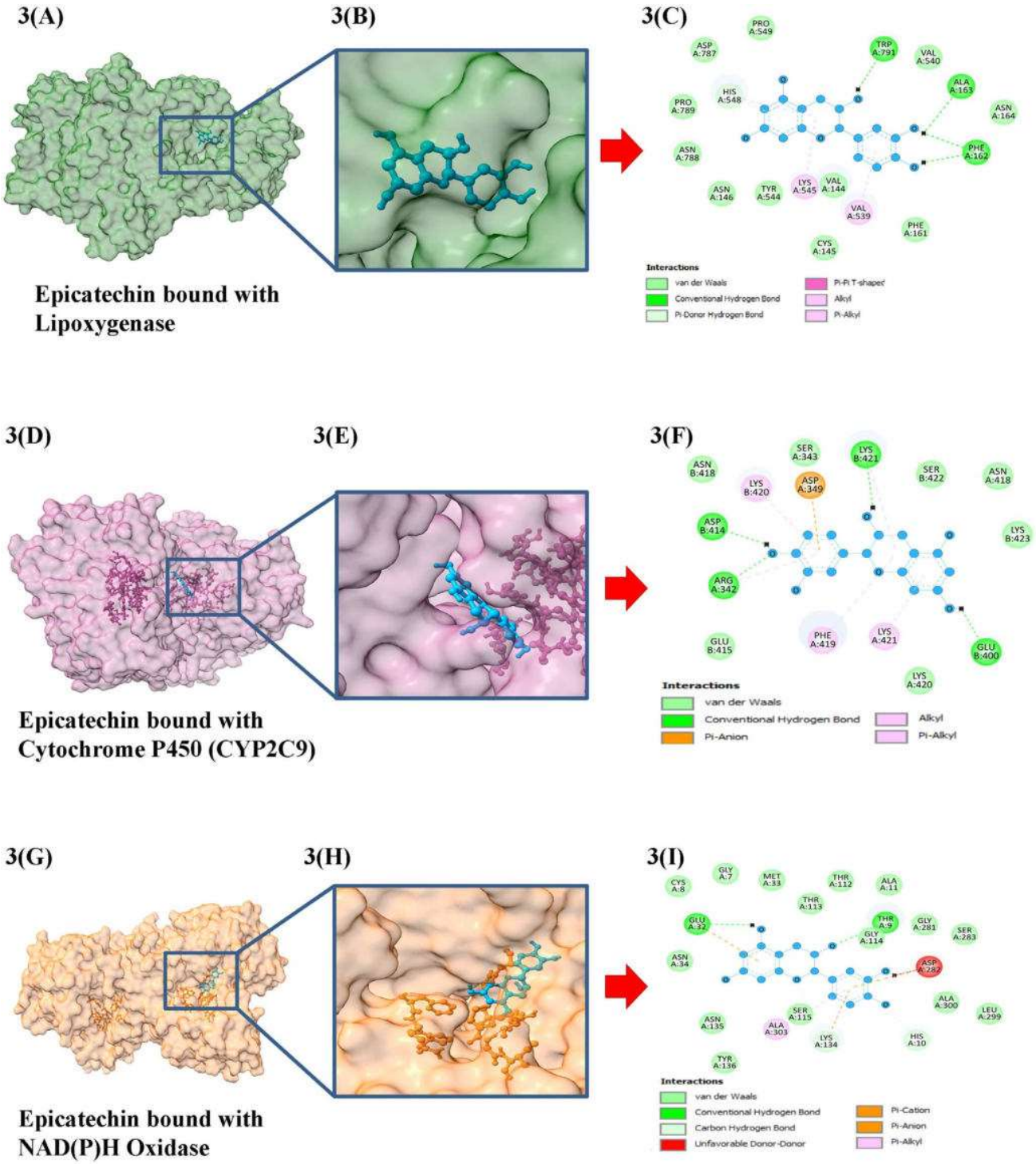


Fig. 3. Interaction between epicatechin and ROS producing enzymes. Epicatechin interacted with the binding pockets of LOX, CYP2C9, and NOX using hydrogen and various hydrophobic interactions. The first panel of the figure indicates the position where green tea polyphenol binds with the enzyme. The middle panel shows the enlarged view of the binding pocket where polyphenol interacted with the concerned enzyme. The last panel demonstrates the amino acids of ROS generating enzymes that established hydrogen and various hydrophobic interactions.

organophosphate toxicity: current status and perspective, J. Ecophysiol. Occup. Health 22 (2022) 141–154, doi:10.18311/jeoh/2022/31007.
[17] A.R. Brash, Lipoxygenases: occurrence, functions, catalysis, and acquisition of substrate, J. Biol. Chem. 274 (1999) 23679–23682, doi:10.1074/jbc.274.34.23679.
[18] A. Veith, B. Moorthy, Role of cytochrome p450s in the generation and metabolism of reactive oxygen species, Curr. Opin. Toxicol. 7 (2018) 44–51, doi:10.1016/j.cotox.2017.10.003.
[19] C.R. Lee, J.A. Goldstein, J.A. Pieper, Cytochrome P450 2C9 polymorphisms: a comprehensive review of the *in-vitro* and human data, Pharmacogenetics 12 (2002) 251–263, doi:10.1097/00008571-200204000-00010.
[20] A.R. Cross, A.W. Segal, The NADPH oxidase of professional phagocytes—Prototype of the NOX electron transport chain systems, Biochim. Biophys. Acta 1657 (2004) 1–22, doi:10.1016/j.bbabio.2004.03.008.
[21] J. Doussiere, J. Gaillard, P.V. Vignais, Electron transfer across the O2- generating flavocytochrome b of neutrophils. Evidence for a transition from a low-spin state to a high-spin state of the heme iron component, Biochemistry 35 (1996) 13400–13410, doi:10.1021/bi960916b.
[22] M. Shinohara, W.H. Shang, M. Kubodera, S. Harada, J. Mitsushita, M. Kato, H. Miyazaki, H. Sumimoto, T. Kamata, Nox1 redox signaling mediates oncogenic Ras-induced disruption of stress fibers and focal adhesions by down-regulating Rho, J. Biol. Chem. 282 (2007) 17640–17648, doi:10.1074/jbc.M609450200.
[23] L.C. Mangum, A. Borazjani, J.V. Stokes, A.T. Matthews, J.H. Lee, J.E. Chambers, M.K. Ross, Organochlorine insecticides induce NADPH oxidase-dependent reactive oxygen species in human monocytic cells via phospholipase A2/arachidonic acid, Chem. Res. Toxicol. 28 (2015) 570–584, doi:10.1021/tx500323h.
[24] S.M. Chacko, P.T. Thambi, R. Kuttan, I. Nishigaki, Beneficial effects of green tea: a literature review, Chin. Med. 5 (2010) 13, doi:10.1186/1749-8546-5-13.
[25] S.C. Forester, J.D. Lambert, Antioxidant effects of green tea, Mol. Nutr. Food Res. 55 (2011) 844–854, doi:10.1002/mnfr.201000641.
[26] C. Manach, A. Scalbert, C. Morand, C. Rémésy, L. Jiménez, Polyphenols: food sources and bioavailability, Am. J. Clin. Nutr. 79 (2004) 727–747, doi:10.1093/ajcn/79.5.727.
[27] M. Afzal, A.M. Safer, M. Menon, Green tea polyphenols and their potential role in health and disease, Inflammopharmacology 23 (2015) 151–161, doi:10.1007/s10787-015-0236-1.
[28] J. Bernatoniene, D.M. Kopustinskiene, The role of catechins in cellular responses to OS, Molecules 23 (2018) 965, doi:10.3390/molecules23040965.
[29] S. Mandel, T. Amit, L. Reznichenko, O. Weinreb, M.B. Youdim, Green tea catechins as brain-permeable, natural iron chelators-antioxidants for the treatment of neurodegenerative disorders, Mol. Nutr. Food Res. 50 (2006) 229–234, doi:10.1002/mnfr.200500156.
[30] V.L. Truong, W.S. Jeong, Cellular defensive mechanisms of tea polyphenols: structure-activity relationship, Int. J. Mol. Sci. 22 (2021) 9109, doi:10.3390/ijms22179109.
[31] J. Intra, S.M. Kuo, Physiological levels of tea catechins increase cellular lipid antioxidant activity of vitamin C and vitamin E in human intestinal caco-2 cells, Chem. Biol. Interact. 169 (2007) 91–99, doi:10.1016/j.cbi.2007.05.007.
[32] F. Dai, W.F. Chen, B. Zhou, Antioxidant synergism of green tea polyphenols with alpha-tocopherol and L-ascorbic acid in SDS micelles, Biochimie 90 (2008) 1499–1505, doi:10.1016/j.biochi.2008.05.007.
[33] O. Trott, A.J. Olson, AutoDock Vina: improving the speed and accuracy of docking with a new scoring function, efficient optimization, and multithreading, J. Comput. Chem. 31 (2010) 455–461, doi:10.1002/jcc.21334.
[34] P. Rajak, S. Roy, A.K. Pal, M. Paramanik, M. Dutta, S. Podder, S. Sarkar, A. Ganguly, M. Mandi, A. Dutta, K. Das, S. Ghanty, S. Khatun, In silico study reveals binding potential of rotenone at multiple sites of pulmonary surfactant proteins: a matter of concern, Curr. Res. Toxicol. 2 (2021) 411–423, doi:10.1016/j.crtox.2021.11.003.
[35] S. Ghanty, M. Mandi, A. Ganguly, K. Das, A. Dutta, S. Nanda, G. Biswas, P. Rajak, Lung surfactant proteins as potential targets of prallethrin: an in silico approach, Toxicol. Environ. Health Sci. 14 (2022) 89–100, doi:10.1007/s13530-021-00119-0.
[36] P.K. Maurya, S.I. Rizvi, Protective role of tea catechins on erythrocytes subjected to OS during human aging, Nat. Prod. Res. 23 (2009) 1072–1079, doi:10.1080/14786410802267643.
[37] S. Roychoudhury, A. Agarwal, G. Virk, C.L. Cho, Potential role of green tea catechins in the management of OS-associated infertility, Reprod. Biomed. Online 34 (2017) 487–498, doi:10.1016/j.rbmo.2017.02.006.
[38] H. Raza, A. John, *In vitro* protection of reactive oxygen species-induced degradation of lipids, proteins and 2-deoxyribose by tea catechins, Food Chem. Toxicol. 45 (2007) 1814–1820, doi:10.1016/j.fct.2007.03.017.
[39] Y. Steffen, T. Schewe, H. Sies, Epicatechin elevates nitric oxide in endothelial cells via inhibition of NADPH oxidase, Biochem. Biophys. Res. Commun. 359 (2007) 828–833, doi:10.1016/j.bbrc.2007.05.200.
[40] O.K. Afolabi, F.A. Aderibigbe, D.T. Folarin, A. Arinola, A.D. Wusu, OS and inflammation following sub-lethal oral exposure of cypermethrin in rats: mitigating potential of epicatechin, Heliyon 5 (2019) e02274, doi:10.1016/j.heliyon.2019.e02274.
[41] A. Moreno-Ulloa, L. Nogueira, A. Rodriguez, J. Barboza, M.C. Hogan, G. Ceballos, F. Villarreal, I. Ramirez-Sanchez, Recovery of indicators of mitochondrial biogenesis, OS, and aging with (-)-epicatechin in senile mice, J. Gerontol. A Biol. Sci. Med. Sci. 70 (2015) 1370–1378, doi:10.1093/gerona/glu131.
[42] M. Maeda-Yamamoto, K. Ema, M. Monobe, Y. Tokuda, H. Tachibana, Epicatechin-3-O-(3″-O-methyl)-gallate content in various tea cultivars (Camellia sinensis L.) and its *in vitro* inhibitory effect on histamine release, J. Agric. Food. Chem. 60 (2012) 2165–2170, doi:10.1021/jf204497b.
[43] X. Shi, J. Ye, S.S. Leonard, M. Ding, V. Vallyathan, V. Castranova, Y. Rojanasakul, Z. Dong, Antioxidant properties of (-)-epicatechin-3-gallate and its inhibition of Cr(VI)-induced DNA damage and Cr(IV)- or TPA-stimulated NF-kappaB activation, Mol. Cell. Biochem. 206 (2000) 125–132, doi:10.1023/a:1007012403691.
[44] B. Fu, Q. Zeng, Z. Zhang, M. Qian, J. Chen, W. Dong, M. Li, Epicatechin Gallate Protects HBMVECs from Ischemia/Reperfusion Injury through Ameliorating Apoptosis and Autophagy and Promoting Neovascularization, Oxidative Med. Cell. Longev. 2019 (2019) 7824684, doi:10.1155/2019/7824684.
[45] C.C. Huang, W.B. Wu, J.Y. Fang, H.S. Chiang, S.K. Chen, B.H. Chen, Y.T. Chen, C.F. Hung, (-)-Epicatechin-3-gallate, a green tea polyphenol is a potent agent against UVB-induced damage in HaCaT keratinocytes, Molecules 12 (2007) 1845–1858, doi:10.3390/12081845.
[46] S. Valcic, J.A. Burr, B.N. Timmermann, D.C. Liebler, New oxidation products of (-)-epigallocatechin gallate and (-)-epigallocatechin from their reactions with peroxyl radicals, Chem. Res. Toxicol. 13 (2000) 801–810, doi:10.1021/tx000080k.
[47] P. Ambigaipalan, W.Y. Oh, F. Shahidi, Epigallocatechin (EGC) esters as potential sources of antioxidants, Food Chem. 309 (2020) 125609, doi:10.1016/j.foodchem.2019.125609.
[48] P. Ambigaipalan, W.Y. Oh, F. Shahidi, Lipophilized epigallocatechin (EGC) and its derivatives: inhibition of oxidation of β-carotene-linoleate oil-in-water emulsion and DNA strand scission, J. Food Drug. Anal. 28 (2020) 356–364, doi:10.38212/2224-6614.1240.
[49] T.S. Chen, S.Y. Liou, H.H. Lin, M.Y. Hung, C.C. Lin, Y.M. Lin, K.H. Lin, V.V. Padma, C.H. Yao, W.W. Kuo, C.Y. Huang, Oral administration of green tea Epigallocatechin-3-gallate reduces OS and enhances restoration of cardiac function in diabetic rats receiving autologous transplantation of adipose-derived stem cells, Arch. Physiol. Biochem. 127 (2021) 82–89, doi:10.1080/13813455.2019.1614631.
[50] H.T. Yao, C.C. Li, C.H. Chang, Epigallocatechin-3-gallate Reduces Hepatic OS and Lowers CYP-Mediated Bioactivation and Toxicity of Acetaminophen in Rats, Nutrients 11 (2019) 1862, doi:10.3390/nu11081862.
[51] E. Tak, G.C. Park, S.H. Kim, D.Y. Jun, J. Lee, S. Hwang, G.W. Song, S.G. Lee, Epigallocatechin-3-gallate protects against hepatic ischaemia-reperfusion injury by reducing OS and apoptotic cell death, J. Int. Med. Res. 44 (2016) 1248–1262, doi:10.1177/0300060516662735.
[52] Y. Wang, B. Wang, F. Du, X. Su, G. Sun, G. Zhou, X. Bian, N. Liu, Epigallocatechin-3-gallate attenuates OS and inflammation in obstructive nephropathy via NF-κB and Nrf2/HO-1 signalling pathway regulation, Basic Clin. Pharmacol. Toxicol. 117 (2015) 164–172, doi:10.1111/bcpt.12383.
[53] Y. Liang, K.W.K. Liu, S.C. Yeung, X. Li, M.S.M. Ip, J.C.W. Mak, (-)-Epigallocatechin-3-gallate reduces cigarette smoke-induced airway neutrophilic inflammation and mucin hypersecretion in rats, Front. Pharmacol. 8 (2017) 618, doi:10.3389/fphar.2017.00618.
[54] G.W. Plumb, S. de Pascual-Teresa, C. Santos-Buelga, J.C. Rivas-Gonzalo, G. Williamson, Antioxidant properties of gallocatechin and prodelphinidins from pomegranate peel, Redox Rep 7 (2002) 41–46, doi:10.1179/135100002125000172.
[55] D.H. Park, J.Y. Park, K.S. Kang, G.S. Hwang, Neuroprotective Effect of Gallocatechin Gallate on Glutamate-Induced OS in Hippocampal HT22 Cells, Molecules 26 (2021) 1387, doi:10.3390/molecules26051387.
[56] N.R. Vendidandala, T.P. Yin, G. Nelli, V.R. Pasupuleti, S. Nyamathulla, S.I. Mokhtar, Gallocatechinsilver nanoparticle impregnated cotton gauze patches enhance wound healing in diabetic rats by suppressing OS and inflammation via modulating the Nrf2/HO-1 and TLR4/NF-κB pathways, Life Sci. 286 (2021) 120019, doi:10.1016/j.lfs.2021.120019.

International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 20-05-2023, Accepted: 06-06-2023, Published: 21-06-2023
Volume 8, Issue 6, 2023, Page No. 34-37

Bizarre Insect (Order: Strepsiptera; Kirby, 1813) with a unique biology

Sukhendu Roy*
Department of Zoology, Gushkara Mahavidyalaya, Guskara, Purba Bardhaman, West Bengal, India

Abstract
Strepsiptera comprise a group of inquisitive, obligate endoparasitoids. The parasitoids of Strepsiptera are enthralling insects, whose neotenic females completely endoparasitoid, laying eggs in or on other insects while free-living adult males with a very short lifespan. They are widespread in most terrestrial ecosystems and exhibit vast ecological and biological diversity with many specific types of adaptations. The insects termed as macrynobiont refers for lengthening the life of the host. Since some of the hosts are pests of crops like, rice, corn, oil palm, areca nuts, coconuts mangoes etc. they have the effectiveness for use as biocontrol agents.

Keywords: strepsiptera, endoparasitoid, macrynobiont

Introduction
The Strepsiptera (Greek strepsi, “twisted”; pteron, “wing”) commonly known as “stylops” encompass a group of entomophagous, obligate endoparasitoids with very unique morphology, biology, genetics and host–parasitoid relationship. They are cosmopolitan in distribution; largest numbers of species have been reported from the Australasian realm followed by the Oriental region. Owing to the endoparasitic life, the parasitoids are not easily noticed and remain an enigma to the entomologists. The males comprises unique hind wings with simple pattern of wing venation, fore wing reduced to look like a club like appendages termed as pseudohaltere, legs, rasp berry like eyes and flabellate antennae, superficially similar to flies, even though their mouths are not used for food, instead they are modified into sensory structures. They are non feeder, short–lived, usually surviving two to four hours. The male copulatory organ or aedaegus is minute and unique according to the different families of the order. Neotenic female except family Mengenillidae remains inside the host and completely endoparasitoid. Adult females are neotenic endoparasite projected inside a host body (rather than typical adult insects), 2–5 mm in length and without antennae, mouthparts, eyes, wings, legs and external genitalia. The cephalothorax encompasses of fused head, prothorax and mesothorax that obtruded through the host's synovial membrane, leaving the female's abdominal part inside the host’s body [6]. Virgin females are said to discharge a pheromone from the Nassonow organ which the male employments to find them with the help of the Hofender’s organ.

The families of Strepsiptera that are widespread in distribution are: Corioxenidae, Elenchidae, Halictophagidae and Stylopidae. The genera of parasitoids are restricted to the prevalence of the distribution of the hosts though the hosts in most cases are more widely distributed biogeographically than the parasitoids. Approximately 646 species [15, 16, 17, 18]. They are Corioxenos Blair, 1936; Dundoxenos Luna de Carvalho, 1956; Trizocera Pierce, 1909; Viridopromontorius Luna de Carvalho, 1985; Coriophagus Kinzelbach, 1971a; Halictophagus Curtis, 1832; Tridactylophagus Subramanian, 1932; Elenchus Curtis, 1831; Myrmecolax Westwood, 1861; Lychnocolax Bohart, 1951; Stichotrema Hofeneder, 1910a; Paraxenos Saunders, 1872 and Pseudoxenos Saunders, 1872.

Methods used for observation
The insects were completely inspected under a zoom stereoscopic trinocular magnifying instrument (demonstrate Olympus SZX16, Japan and CARL ZEISS Stemmi 2000–C, Germany) for discovery of outward injuries or patches showing ‘stylopisation’ on the both sides of host abdomen. Such host insects were sacrificed with two fine needles in insect saline water (0.67%) for procuring male adults and different larval stages, pupae, and gravid females with eggs or with triungulins. They come out from abdomen with a slight pressure in the saline water.

Biology
They have displayed one of the foremost unconventional and complex life cycles with extraordinary sexual dimorphism. The free living males have unique hind wing with least venation and the fore wing reduced to form pseudohaltere. The males also have legs, eyes, and flabellate antennae externally comparable to flies, in spite of the fact that their mouthparts are not utilized for nourishing, or maybe they are altered as tactile structures. They are short–lived, as a rule surviving two to four hours [4]. Females except family Mengenillidae remain inside the host. In most Strepsiptera the male pupates and extrudes while female extrudes and gets to be mature but some incidence where the male extrudes and pupates in fifth instar host nymph. These nymphs don't actually appear to signal the start of a molting cycle [6]. Premature host parasitized by male puparia eventually die due to fungal growth on empty puparia left after the adult males coming out [14]. Only the cephalothorax is visible from the outside (Fig-1); the rest of the cylindrical body remains inside the host and lacks all the features of an adult insect [3]. Males mate by disrupting the female's brood canal. Sperm exceeds through the opening of brood canal by a process known as hypodermic insemination [12]. Each female thus turns out many first instar larvae termed as triungulins that come out from the brood opening, which projects outside the host’s body (Fig 2). These first instar

Discussion

Impacts of stylopisation were examined prior on Hymenoptera. The foremost noteworthy changes due to stylopisation are that male hymenoptera tends to take after ordinary females and the pollen basket is diminished in females and males show a marked development. The interchange of characters in stylopised host has been referred to as "intersexes" [13]. Like hymenoptera parasitized Delphacidae (Hemiptera) (Table-1) were also thought to be "intersexes" [10, 11]. Stylopisation is known to cause numerous recognizable morphological, behavioral, dispersal and physiological changes within the hosts, even

- Driving to the arrangement of intersexes by alteration of the genitalia. The results of stylopisation incorporate changes in antennae, wings, facial colouration, pilosity, pollen collecting apparatus and length of the digestive tract.
- Stylopisation can too disable ovarian egg improvement, and cause lessening of egg number, essential, auxiliary and tertiary sexual characters and fertility of the host.
- Stylopised host insects frequently ended up less active and may gotten to be unfit of setting up nests within the case of a few Hymenoptera [20].

Although Strepsiptera is an endoparasite, it has a wide host range relative to its species abundance and requires a mobile host to complete its life cycle. Strepsiptera parasitizes a wide range of hosts belonging to the seventh order of insects. The most common host species are Hymenoptera and Hemiptera.

Table 1: Records of stylopised Hemipteran host in India.

Host	Family &subfamily	Position of stylopisation
Atkinsoniella opponens (Walker, 1851)	Cicadellidae	Stylopisation mark on 6th to 9th sternite segments. There was no stylopisation encountered in the tergite segment till now.
Exitianus nanus (Distant, 1908)	Cicadellidae	Only one stylopised host was observed. Stylopisation took place at the lateral portion of the 7th sternite.
Exitianus indicus (Distant, 1908)	Cicadellidae	Stylopisation mark was found at 7th to 8th sternite segments.
Cofana spectra (Distant, 1908)	Cicadellidae	Stylopisation marks were observed on two different locations. One type encountered at the 5th to 6th tergite segments, considered as a male stylops and another one was encountered at the 6th to 9th sternite segments, considered as female stylops. Both types of stylopisation marks noticed on 15 numbers of specimens.
Nilaparvata lugens (Stål, 1854)	Delphacidae	Only two stylopised BPH were observed. Both stylopisation were encountered at the 4th abdominal tergite.
Sogatella furcifera (Horváth, 1899)	Delphacidae	Stylopisation marks were observed on two different locations. One type encountered at the 6th to 8th tergite segments, considered as a male stylops and another one was encountered at the 6th to 9th sternite segments, considered as female stylops.

At the early stage of host development Strepsiptera are not very active but have a exclusive immune avoidance mechanism. They form a pupal bag in the host cuticle. Strepsiptera are accounted to exercise control over the population level of host insect pests. The rate of parasitism fluctuates from 10% to 65% depending on several factors including temperature, humidity, rainfall and locations. Strepsiptera have the potential to be successful bio-control specialists but it is very difficult to practical implementation due to their low searching ability. Still such a venture is already in progress in Papua New Guinea where the female Strepsiptera, *Stichotrema dallatorreanum* Hofeneder is being used as a biocontrol agent for the long-horned grasshopper *Segestidea novaeguineae* [19]. Various questions almost hereditary qualities, sex deciding instruments, host location, various host spectrum, and change of host physiology in this baffling arrange of bizarre insect order still stay unanswered. One key feature is that, when parasitized by Strepsiptera, the host's life cycle is lengthened as long as they require to mature. This difference between strepsipterans suggests a trichotomous hypothesis concerning insect parasitoids, and the term macrynobiont (*macryno,* "lengthen"; *bionts*, "life"), refer for lengthening the life of the host due to Strepsiptera [8].

Acknowledgement

I wish to express my sincere gratitude to my guide Prof. Niladri Hazra, Department of Zoology, The University of Burdwan. I am also grateful to my Principal Dr. Sudip Chatterjee, Gushkara Mahavidyalaya, Purba Bardhaman, West Bengal, India for his kind cooperation.

References

1. Borror DJ, Johnson CA. Introduction to the Study of Insects (6 ed.) 1989. Brooks Cole.
2. Esaki T, Hashimoto S. Bericht über die Reispflanze schä digende Zikaden und deren natürliche Feinde. Sitzungsberichte der Gesellschaft Naturforschender Freunde,1940:25:72–94.
3. Guisti F, Dallai L, Beani L, Manfredini F, Dallai R. The midgut ultrastructure of the endoparasite *Xenos vesparum* (Rossi) (Insecta, Strepsiptera) during post–embryonic development and stable carbon isotopic analysis of the nutrient uptake. Arthropod Structure & Development,2007:36:183–197.
4. Kathirithamby J, Hamilton WD. More covert sex: the elusive females of Myrmecolacidae (Strepsiptera). Trends in Ecology & Evolution,1992:7**:**349–351.
5. Kathirithamby J, Taylor SJ. A new species of *Halictophagus* (Insecta: Strepsiptera: Halictophagidae) from Texas, and a checklist of Strepsiptera from the United States and Canada. Zootaxa,2005:1056:1–18.
6. Kathirithamby J. Review of the order Strepsiptera. Systematic Entomology, 1989:14:41–92.
7. Kathirithamby J. Morphology of the female Myrmecolacidae (Strepsiptera) including the *apron*, and

an associated structure analogous to the peritrophic matrix. Zoological Journal of the Linnean Society,2000:128:269–287.
8. Kathirithamby J. Host–parasitoid associations in Strepsiptera. Annual Review of Entomology,2009:54:227–249.
9. Kathirithamby J, Ross L, Johnston SJ. Masquerading as self: Endoparasitic Strepsiptera enclose themselves in host–derived epidermal "bag". Proceedings of the National Academy of Sciences,2003:100:7655–7659.
10. Otake A, Somasundram PH, Abeykoon MB. Studies on populations of *Sogatella furcifera* Horvath *Nilaparvata lugans* (Stål) (Hemiptera: Delphacidae) and their their parasites in Sri Lanka. Applied Entomology and Zoology, Tokyo,1976:11:284–294.
11. Raatikainen M. The effects of different sexes of the parasites *Elenchus tenuicornis* (Kirby) on the morphology of the *Javesella pellucida* (F.) (Homo. Delphacidae). Suomen Hyonteistieteellinen Aikakauskirja,1966:32:138–146.
12. Resh VH, Cardé RT. "Strepsiptera". Encyclopedia of Insects. Academic Press, 2003, 1094–1096.
13. Salt G. The effects of stylopisation Aculeate Hymenoptera. Journal of Experimental Zoology,1927:48(1):223–331.
14. Silvestri F. Studi sugli 'Strepsiptera' Insecta. III. Descrizione e biologia di 6 specie italiane di Mengenilla. Bulletin de la Société Philomathique de Paris, 1943: 32:197–282.
15. Roy S, Hazra N. First record of a new species of the genus Viridopromontorius Luna de Carvalho (Strepsiptera: Corioxenidae: Corioxeninae) from India, with a revised key to Corioxenidae. Zootaxa,2016a:4154(5):567–573.
16. Roy S, Hazra N. Two new species of Halictophagidae (Insecta: Strepsiptera) including the first record of genus Coriophagus Kinzelbach from India. Zootaxa,2016b:4189(1):581–587.
17. Roy S, Hazra N. Two new species of Myrmecolacidae (Strepsiptera) with first record of the genus Stichotrema Hofeneder from India. Annales de la Société entomologique de France,2017:53(5):334–343.
18. Hui P, Mukherjee B, Hazra N. A new species of the genus Tridactylophagus Subramaniam, 1932 from West Bengal, India with a tentative phylogeny and world key to known males (Strepsiptera: Halictophagidae). Zootaxa,2023:5230(3):296-304.
19. Kathirithamby J, Simpson S, Solulu T, Caudwell R. Strepsiptera parasites Ð novel biocontrol tools for oil palm integrated pest management in Papua New Guinea. International journal of pest management,1998:44(3):127-133.
20. Mazumdar A. Twisted Winged Endoparasitoids - An Enigma for Entomologists. Resonance – Journal of Science Education,2004:9(10):19-24.

SAMJAPTAK সংশপ্তক
A Bengali Peer-Reviewed & Refereed Journal
ISSN: 2454-4884
পঞ্চম বর্ষ ।। দ্বিতীয় সংখ্যা
মূল্য - ২০০/-

সংশপ্তক

বিশেষ সংখ্যা
অন্নদাশঙ্কর রায়ের সাহিত্য
ও
অন্যান্য প্রবন্ধ

সম্পাদক
উত্তম দাস

সংশপ্তক , SAMSAPTAK

Peer-Reviewed & Refereed Journal

২০২৩ ,জুন

2023 , June

Vol.8, Issue- II

অষ্টম বর্ষ ।। দ্বিতীয় সংখ্যা

ISSN-2454-4884

ISSN-2454-4884

মানবকল্যাণে শ্রীমদ্ভাগবত পুরাণের প্রাসঙ্গিকতা

ইন্দ্রাণী লাহা

সারসংক্ষেপ -

এই জগতে ঈশ্বরসৃষ্ট সর্বশ্রেষ্ঠ জীব হল মানুষ। বহু বহু জন্মের পর দুর্লভ এই মনুষ্যজন্ম লাভ করে মানব জীবনের উদ্দেশ্য নির্ধারণ করা প্রত্যেকটি মানুষের প্রয়োজন। এবং সেই উদ্দেশ্য যেন যথার্থ মঙ্গল প্রদ হয়। এই পার্থিব জগতে ক্ষণিক ইন্দ্রিয় ভোগে আসক্ত হয়ে তাদের প্রকৃত উদ্দেশ্য ভুলে মায়ার কবলে কবলিত হয়ে ত্রিতাপ জ্বালা ভোগ করছে। এই অনিবার্য দুঃখের হাত থেকে মুক্তি দিতে পারে মহাজন নির্দেশিত পথ। বেদ পুরাণাদি বিভিন্ন ধর্মশাস্ত্র মানুষকে সঠিক দিশা দেখাতে পারে। মানবকল্যাণকারী এমনই এক গ্রন্থ হল শ্রীমদ্ভাগবত পুরাণ। মহর্ষি বেদ ব্যাস রচিত সংস্কৃত ভাষায় দ্বাদশ স্কন্ধে বিভক্ত ১৮০০০ শ্লোক সমন্বিত এই গ্রন্থখানি। সমগ্র মানবসমাজকে যথার্থ আধ্যাত্মিক শিক্ষায় শিক্ষিত করে তুলতে পারে এই গ্রন্থখানি। পরম পুরুষ পরমেশ্বর ভগবান শ্রীকৃষ্ণের কথায় পরিপূর্ণ এই গ্রন্থখানি জীবের যাবতীয় শোক ও মোহ দূরীভূত করে। ভগবানে ভক্তিই জীবের একমাত্র কর্তব্য এবং তাঁর প্রতি ঐকান্তিক শরণাগতিই মানবজীবনকে সার্থক করবে। মানুষের সাথে অন্যান্য জীবের পার্থক্য হল মানুষ উন্নতচেতনা সম্পন্ন জীব সে সমস্ত কিছু যুক্তি ও বুদ্ধি দিয়ে বিচার বিবেচন করে সিদ্ধান্ত গ্রহণ করে। তাই তারা যদি ধর্মাচরণে প্রবৃত্ত না হয়ে পশুর ন্যায় আহার, নিদ্রা, ভয়, মৈথুনেই মত্ত হয়ে থাকে তাহলে পশুর সাথে তার প্রভেদ কোথায়? তাই মহাভারতে বলা হয়েছে –

"ধর্মেন হীনা পশুভিঃ সমানা।"

ভাগবতেও বলা হয়েছে সমস্ত মানুষের পরম ধর্ম হল অধোক্ষজ ভগবান্ শ্রীকৃষ্ণের প্রতি অহৈতুকী ভক্তি ও প্রীতি লাভ করা তাহলেই আত্মা যথার্থ প্রসন্নতা লাভ করবে।

বর্তমান কলিযুগের মানুষ হল স্বল্পায়ু, মন্দমতি, অলস, কলহপরায়ণ, নিরন্তর রোগব্যাধির দ্বারা জর্জরিত। কলিকাল দোষের সমুদ্র হলেও এর একটি মহৎ গুণ আছে তা হল হরিনাম সংকীর্ত্তনের দ্বারাই ভগবানকে প্রসন্ন করা যায়। শ্রীচৈতন্য মহাপ্রভু এই কলিকালে আবির্ভূত হয়ে নিজে আচার ও প্রচার করে সমগ্র জগদ্বাসীকে শিক্ষা দিয়ে গেছেন। আজ সারা বিশ্বে এই ভাগবতধর্ম ব্যাপকভাবে প্রচারিত হচ্ছে। পাশ্চাত্যের ধনী দেশগুলিও মানসিক শান্তির খোঁজে ভারতবর্ষে এসে এই ভাগবত ধর্ম গ্রহণে ব্রতী হয়েছে। তাই আমরা যদি এই পুণ্যভূমি ভারতবর্ষে জন্মগ্রহণ করেও এই ধর্ম গ্রহণে ব্রতী না হই তাহলে তা আমাদেরই দুভার্গ্যের পরিচায়ক।

সূচক শব্দঃ ঈশ্বর, ধর্ম, মঙ্গল, মানবকল্যাণ, আত্মা, সাম্প্রদায়িক, ভক্তি, পরমাত্মা, প্রচারকার্য।

মূল প্রবন্ধ-

ভারতবর্ষ হল পুণ্যভূমি। সাধু মহাপুরুষগণের পবিত্র চরণরজে অভিষিক্ত এই ভূমি। আমাদের সৌভাগ্য যে আমরা ভারতবর্ষে জন্ম গ্রহণ করেছি। এই পবিত্রভূমিতে জন্মগ্রহণ করে আমরা যদি কল্যাণকর কর্মে যুক্ত হতে না পারি তাহলে সেটা আমাদেরই দুর্ভাগ্য। আধ্যাত্মিক সাম্যবাদ হল সমগ্র মানব সমাজের ঐক্য সাধন করা। এই আদর্শকে সফল করার কথা মহান চিন্তাশীল মানুষেরা উপলব্ধি করেছেন। আর এই কার্য্য সফল করার ক্ষেত্রে শ্রীমদ্ভাগবতের অবদান অনস্বীকার্য। সমগ্র মানব সমাজে শান্তি, সমৃদ্ধি ও মৈত্রীর প্রতিষ্ঠা করবে ভাগবতের এই অমূল্য বানী।

মানুষ হল উন্নতচেতনা সম্পন্ন জীব। অন্যান্য প্রাণীদের সাথে মানুষের পার্থক্য হল মানুষ সব কিছু যুক্তি, বুদ্ধি দিয়ে বিচার বিবেচনা করে সিদ্ধান্তে উপনীত হয় কিন্তু অন্য প্রাণীরা তা পারে না। মানুষের মনেই প্রশ্ন জাগে আমি কে? এই জগতের

সৃষ্টি কর্ত্তা কে? তাঁকে কি দেখা যায়? জগতে এত দুঃখ কেন? এই দুঃখের নিবৃত্তি কিভাবে হবে? ইত্যাদি নানা প্রশ্নের উত্তরের সন্ধানে সে অজানার উদ্দেশ্যে পাড়ি দেয়।

যুগে যুগে মহাপুরুষগণ তাদের সাধনালব্ধ জ্ঞানের দ্বারা মানুষকে সঠিক পথের নির্দেশ দিয়েছেন এবং শান্তির বাণী শুনিয়েছেন। শ্রীমদ্ভাগবত হল এমনই এক শাস্ত্রগ্রন্থ যা শুধু পারমার্থিক বিজ্ঞানই নয় পরন্তু মানুষের কর্তব্য ও ধর্ম সম্পর্কেও অবহিত করে।

ভাগবতের প্রথমেই শ্রীল ব্যাসদের সেই পরমসত্যস্বরূপ পরমেশ্বরের ধ্যান করেছেন –

"ওঁ নমো ভগবতে বাসুদেবায়
জন্মাদ্যস্য যতোऽন্বয়াদিতরতশ্চার্থেষ্বভিজ্ঞঃ স্বরাট্
তেনে ব্রহ্ম হৃদা য আদিকবয়ে মুহ্যন্তি যৎসূরয়ঃ।
তেজোবারিমৃদাং যথা বিনিময়ো যত্র ত্রিসর্গোऽমৃষা
ধাম্না স্বেন সদা নিরস্তকুহকং সত্যং পরং ধীমহি" [১]।।

অর্থাৎ ভগবান্ শ্রীকৃষ্ণই যে আদি পুরুষ, পরমেশ্বর ভগবান্ তাঁর থেকেই সমস্ত কিছুর প্রকাশ। গীতাতেও ভগবান্ বলেছেন তাঁর থেকে মহৎ আর কিছু নেই। তিনিই জড় ও চেতন জগতের সমস্ত কিছুর উৎস স্বরূপ। এই তত্ত্ব যারা অবগত হয়ে শুদ্ধ ভক্তিসহ আমার ভজনা করেন। তিনিই হলেন যথার্থ জ্ঞানী।

"অহং সর্বস্য প্রভবো মত্তঃ সর্বং প্রবর্ততে।
ইতি মত্বা ভজন্তে মাং বুধাভাবসমন্বিতাঃ" [২]।।

ব্রহ্মসংহিতায় বলা হয়েছে —

"ঈশ্বরঃ পরমঃ কৃষ্ণ: সচ্চিদানন্দ বিগ্রহঃ।
অনাদিরাদির্গোবিন্দঃ সর্বকারণকারণম্" [৩]।।

অর্থাৎ সেই পরম পুরুষ শ্রীকৃষ্ণই হলেন আনন্দঘন আদি পুরুষ এবং তিনিই সর্ব কারণের কারণ স্বরূপ। ভগবান্ শ্রীকৃষ্ণের প্রতি অহৈতুকী ভক্তি উদিত হয় এই ভাগবত শ্রবণের ফলে এবং জীবের যাবতীয় শোক, মোহ, ভয় দূরীভূত হয়।

"যস্যাং বৈ শ্রূয়মানায়াং কৃষ্ণে পরমপুরুষে।
ভক্তিরুৎপদ্যতে পুংসঃ শোক-মোহ-ভয়াপহা" [৪]।।

সুতরাং আমরা যদি সেই আদিপুরুষ গোবিন্দের ভজনা করি তাহলে আমাদের চিন্তার কিছু থাকবে না। এখন প্রশ্ন হল আমরা ভগবানের আরাধনা কেন করব? কারণ ভগবান হল আমাদের সচেয়ে বড় নিঃস্বার্থ বান্ধব। তিনি অন্তর্যামীরূপে প্রত্যেকটি জীব হৃদয়েই বাস করেন। তবে সকলেই যে তার আরাধনা করবে এমন নয় কারণ প্রত্যেকটি মানুষের চিওবৃত্তি ভিন্ন ভিন্ন। কিন্তু ত্রিতাপ জ্বালা থেকে মুক্তিলাভের এবং প্রকৃত সুখলাভ ভগবানের আরাধনা ব্যতীত অন্য কোন পথ নেই।

একদা সূতমুনি শৌণকাদি ঋষিগণের অনুরোধে জীবের প্রকৃত মঙ্গল কিসে হবে তর উত্তরে বললেন — এই কলিকালে সকল মানুষই প্রায় আসুরী স্বভাব সম্পন্ন, কলহপরায়ন, নিরন্তর রোগব্যাধিতে জর্জরিত। তাই তাদের মুক্তিলাভ একমাত্র ভগবান্ শ্রীকৃষ্ণের প্রতি একান্ত ভক্তি লাভেই সম্পন্ন হবে।

"স বৈ পুংসাং পরো ধর্মো যতো ভক্তিরধোক্ষজে।
অহৈতুক্যপ্রতিহতা যয়াৎত্মা সম্প্রসীদতি" [৫]।।

ISSN-[illegible]

[illegible] ভগবানের [illegible] অবতীর্ণ [illegible]

[illegible] নাস্তিকতার প্রভাবে পৃথিবী ভারাক্রান্ত হয়, ধর্মের গ্লানি হয় তখনই ভগবান স্বয়ং অবতীর্ণ হয়ে ধর্ম স্থাপন করেন এবং সাধুগণকে রক্ষা করেন।

"যদা যদা হি ধর্মস্য গ্লানির্ভবতি ভারত।
অভ্যুত্থানমধর্মস্য তদাত্মানং সৃজাম্যহম্ ॥
পরিত্রাণায় সাধূনাং বিনাশায় চ দুষ্কৃতাম্।
ধর্মসংস্থাপনার্থায় সম্ভবামি যুগে যুগে" ॥

এই জীবনের উদ্দেশ্য কেবলমাত্র অন্ন ইন্দ্রিয় ভোগ সুখ নয়। তা আপাত সুখকর হলেও পরিণামে তা দুঃখদায়ক। তাই এই জীবনের উদ্দেশ্য হল পরমতত্ত্ব বিষয়ে জিজ্ঞাসা এবং তার অনুসন্ধান করা। ভাগবতে ভগবান শ্রীকৃষ্ণ মানব কল্যাণে তিনটি যোগের কথা বলেছেন যথা কর্মযোগ, জ্ঞানযোগ ও ভক্তিযোগ।

"যোগাস্ত্রয়ো ময়া প্রোক্তা নৃণাং শ্রেয়োবিধিৎসয়া।
জ্ঞানং কর্ম চ ভক্তিশ্চ নোপায়োঽন্যোঽস্তি কুত্রচিৎ" ॥

এই তিনটি যোগের দ্বারাই মানুষ নিজ কল্যাণ সাধন করতে পারে। সুতরাং এই দুর্লভ মানব জন্মে ইন্দ্রিয় সুখ ভোগে মত্ত না হয়ে, বৃথা সময় নষ্ট না করে ভগবানের ভজনা করে চিন্ময় ধামে ফিরে যাওয়াই বুদ্ধিমানের পরিচয়। সত্য, ত্রেতা, দ্বাপর, কলি এই চারটি যুগের পৃথক পৃথক যুগধর্ম আছে। সেই ধর্মের সাধনের দ্বারা ভগবানকে প্রাপ্ত করা যায়। কলিযুগের যুগধর্ম হল হরিনাম সংকীর্তন। এই কলিতেই ভগবান শ্রীকৃষ্ণ স্বয়ং শ্রীচৈতন্য মহাপ্রভুরূপে অবতীর্ণ হয়ে এই হরিনাম সংকীর্তনের মহিমা প্রচার করেছিলেন।

"কৃষ্ণবর্ণং ত্বিষাকৃষ্ণং সাঙ্গোপাঙ্গাস্ত্রপার্ষদম্।
যজ্ঞৈঃ সঙ্কীর্তনপ্রায়ৈর্যজন্তি হি সুমেধসঃ" ॥

শ্রীচৈতন্য মহাপ্রভু প্রবর্তিত এই দিব্যনামের মহিমা অপার। এই রূপ মঙ্গল লাভের সহজতম পন্থা অন্য কোন যুগে প্রাপ্ত হয় নাই। তাই দেবতারা পর্যন্ত এই ভারতভূমিতে জন্মগ্রহণ করতে ইচ্ছা প্রকাশ করেন। ভাগবতে বলা হয়েছে –

যদ্যত্র নঃ স্বর্গসুখাবশেষিতং
স্বিষ্টস্য সূক্তস্য কৃতস্য শোভনম্।
তেনাজনাভে স্মৃতিমজ্জন্ম নঃ স্যাদ্
বর্ষে হরির্যদ্ভজতাং শং তনোতি" ॥

ভারতে মনুষ্যজন্ম লাভ করে আমরা কতই না ভাগ্যবান। তাই মহাপ্রভু প্রবর্তিত হরিনাম সংকীর্তনের মাধ্যমেই আমরা আমাদের সর্বাঙ্গীন মঙ্গল লাভের জন্য যত্নশীল হব। শ্রীচৈতন্য মহাপ্রভু ভারতবাসীর কর্তব্য সম্বন্ধে বলেছেন –

"ভারতভূমিতে হৈল মনুষ্যজন্ম যার।
জন্ম সার্থক করি কর পর উপকার" ॥

ISSN-2454-4884

এই দিব্যবাণী যদি আমরা নিজ জীবনে পালন করতে পারি তাহলে ধন্য হয়ে যাব। পাশ্চাত্যের ধনীদেশগুলি থেকেও মানুষ আজ ভারতবর্ষে এসে এই ভাগবত ধর্ম গ্রহণে ব্রতী হয়েছে। মহাপ্রভুর অনুগামী গৌড়ীয় বৈষ্ণব সম্প্রদায়ের সাধু ও সজ্জনগণ ব্যাপক ভাবে দেশে ও বিদেশে দিব্য হরিনাম প্রচার ও প্রসারে রত হয়েছেন শত বাধা অতিক্রম করে। তাই আমরা যারা নিজ মঙ্গলকামী তারা এই ভাগবদ্ ধর্মগ্রহণ ব্রতী হব। নিজেদের দেশের ও দশের কল্যাণে আমরা আন্তরিকভাবে প্রচেষ্টা করব, ঈশ্বরের কৃপায় সকলই সম্ভব।

তথ্যসূত্র

১) ভাঃ ১/১/১
২) ভঃগীঃ ১০/৮
৩) ব্রহ্মঃসঃ ৫/১
৪) ভাঃ ১/৭/৭
৫) ভাঃ ১/২/৬
৬) গীতা ৪/৭
৭) গীতা ৪/৮
৮) ভাঃ ১১/২০/৬
৯) ভাঃ ১১/৫/৩২
১০) ভাঃ ৫/১৯/২৮
১১) চৈঃ চঃ আদি ৯/৪১)

গ্রন্থপঞ্জী

১) ব্যাসদেব, শ্রীমদ্ভাগবত, গীতাপ্রেস গোরখপুর, ২০৪৩ বৈক্রমাব্দ।
২) দীন ভক্তদাস, ভাগবত কথামৃত, অক্ষয় লাইব্রেরী, মাঘ ১৪২৫ সন, ইং- (ফেব্রুয়ারী ২০১৯)
৩) বন্দ্যোপাধ্যায় ধীরেন্দ্রনাথ, সংস্কৃত সাহিত্যের ইতিহাস, পশ্চিমবঙ্গ রাজ্যপুস্তক পর্ষৎ ১৯৮৮
৪) গোস্বামী শ্রী শ্রী জীব, ভক্তিসন্দর্ভ, কলকাতা বিশ্ববিদ্যালয় ১৯৬২।
৫) নাথ রাধাগোবিন্দ, চৈতন্যচরিতামৃতের ভূমিকা, ভক্তিগ্রন্থপ্রচার ভান্ডার, বালিগঞ্জ, কলকাতা, ১৩৫৫ বঙ্গাব্দ।
৬) দাস রাধেশ্যাম, ভগবদ্গীতার সারতত্ত্ব, ইসকন্, শ্রীমায়াপুর নদীয়া, ভক্তিবেদান্ত গীতা অ্যাকাডেমী, প্রথম সংস্করন ২০০৫।

.....

গবেষিকা সিকম্ স্কিলস্ ইউনিভার্সিটি , বোলপুর

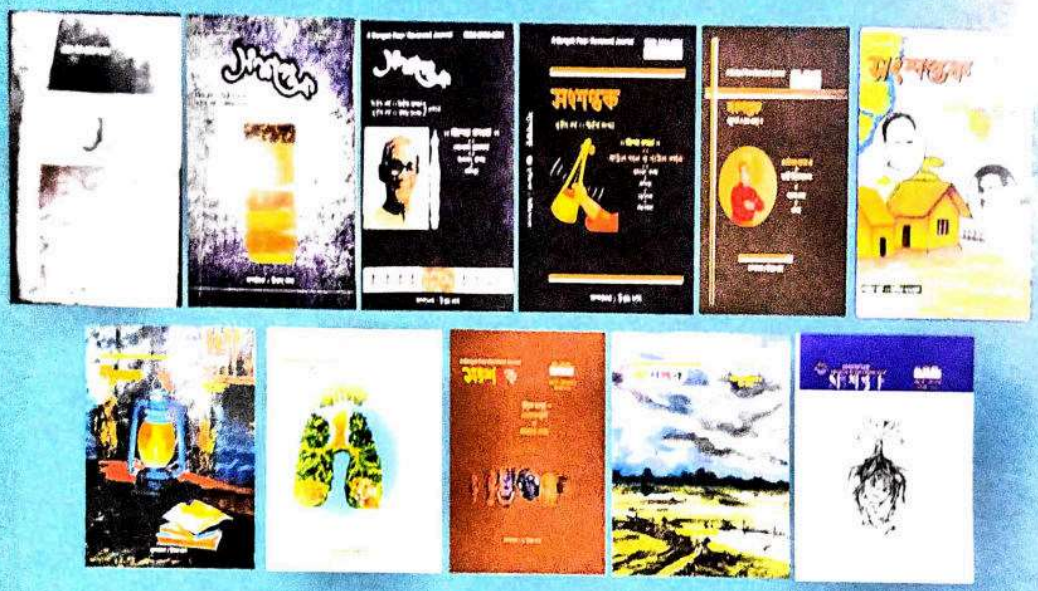
SAMSAPTAK

A bi annual journal based on research social, Literary and cultural discourse

অষ্টম বর্ষ ।। দ্বিতীয় সংখ্যা ।।

Vol. 8, Issue - 2

June - 2023



Price : Rs. 440/-

মূল্য - ৪৪০ টাকা

e-mail :

samsaptakuk12@ gmail.com

Web site : www.samsaptaksig.wordpress.com