A knowledge based volume on

Environmental Issues: Approaches and Practices

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SYAMAPRASAD COLLEGE

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Environmental Issues: Approaches and Practices

Syamaprasad College
Kolkata, 2019

First Published: 2019

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Visit our world wide web at: www.syamaprasadcollege.in
ISBN for E-Book: 978-81-939266-1-1
ISBN for paper-back: 978-81-939266-0-4

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Acknowledgments

We are enormously grateful to the *reviewers* who agreed to contribute to this book with their time and suggestions; their comments and ideas have improved the quality and scope of the book.

We are gratified to *Dr. Susmita Mukherjee*, the Vice Principal of Syamaprasad College, who accepted our initial idea about the need of this book. Moreover her conviction and eagerness has motivated us to navigate the different steps to complete this project. We are appreciative of the teachers of Syamaprasad College for their unconditional inspiration which accelerated our concern for cognizance of and research on environmental facets.

We also thank *Dr. Rahi Soren* of Jadavpur University and *Mr. Shantanu Majee* of Jogmaya Devi College for helping us to advance the preparation and production of this book. We are also thankful to *Dr. Somnath Mazumder* of National Institute of Biomedical Genomics for his meticulous editorial assistance and expertise. We thank *Mr. Supratim Laha* of University of Calcutta for his valuable creative ideas to design the cover of the current book.

If this ambitious effort has been successful, it is because of the exceptional quality of the *invited* and *in-house authors* who have commendably presented their exploration and understanding in the articles which have opened new arenas in different environmental aspects. Any opinions, findings, and conclusions or recommendations expressed in this book are those of the authors.

Board of Editors

Sarmistha Saha

Tilottama Mukherjee

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Preface

This brief introduction describes the organization and contents of our book. This volume is an effort to present, in one readable collection, the diversity of environmental issues. Researchers from different fields of subject like Political Science, Environmental Science, Economics, Geography, Pollination Biology, History, English, Earth Sciences and Zoology are addressing these environmental issues through their findings independently. Diverse approaches toward the environmental concerns can open great array of opportunity for possible solutions to the real time environmental problems. The publication committee of Syamaprasad College so decided to put together a selection of papers from various subjects, concentrating on environment that will inform, stimulate and provoke thoughts of the environmental concerns among their students as well as the readers worldwide with their first publication of an e-book entitled "Environmental Issues: Approaches and Practices".

The book is being made available at the Syamaprasad College website. Open access to the e-book and the published articles will certainly attract global audience with the prevalent response. This book will incite, instruct, inspire and inform both the lay readers and specialists. Students will surely enjoy the well-expressed articles from diverse fields of study published in this knowledge based volume as there are invited research papers from well-known national and international research labs. Anyone keen to know more about the 'What', 'How' and 'Why' from different viewpoints toward environmental issues will find this e-book, a precious knowledge resource.

The book consists of nine chapters discussing the theoretical background of several environmental intimidations, from basic to the applied methods and real-time practices in addressing those concerns and also considering our great resource of age-old anthropogenic knowledge which edify the approaches of ecosystem preservation and protection. Climate change is an important concern in current time. Many of the chapters in this book have discussed different aspects of this environmental perturbation.

In order to reduce the effects of climate change, the relationship between renewable energy consumption, economic growth and its impact on total carbon dioxide emissions need to be analyzed. Chapter 1 gives an understanding of the drivers of CO_2 production in India and role of country's emission reduction efforts.

Chapter 2 unfolds the way to reduce the water pollution from domestic sewage while boosting local economy by wastewater reuse. Here the author has discussed the sewage management procedure in the fisheries of East Kolkata Wetlands, the largest wastewater-fed aquaculture system in the world.

Global food crops which comprise a large fraction of global food demand, partially depend on pollination by insects. Prevalent deteriorations in pollinator diversity have led to worry about a

global “pollination crisis” not only to sustain food security but preserve biodiversity of plant population too. In chapter 3, the author has discussed numerous concerns which act synergistically to affect honey bee populations worldwide to help alleviating the effects of those environmental stresses successfully.

Latest developments in atmospheric science have revealed that due to human activity the chemical composition consisting of the climate forcing agents of the whole atmosphere of the planet has been changed. The heat balance of the planet which are driven by local discrepancies in energy equilibrium, had changed subsequently. To understand this multifaceted subject systematically, the authors have measured climate forcing agents and analyzed their effect in a rural location in West Bengal in chapter 4.

Chapter 5 accentuate the highest emphasis on current international political arguments on climate change and how India has developed its foreign policy over time to meet the present challenges.

Environmental destruction has put our planet in severe danger. To sustain life on earth we need to preserve what we have in hand and escalate these acts as wisdom into our children. Chapter 6 emphasizes on the depiction of the environment in the fable of the Pañcatantra and what children can acquire from them.

To conserve the nature and natural resources many environmental movements took place in India which inspire environmentalists worldwide even today. In chapter 7, the author has given a historical account of the famous Chipko movement - a Gandhian practice of nonviolent protests on the human rights to protect and utilize the forests.

Air pollution in India is a serious issue. Respiratory and cardiovascular diseases induced by air pollution globally account for approximately 45% of deaths in the advanced countries. Chapter 8 addresses a vast evaluation on the role of air pollution in the growth of respiratory diseases like pulmonary fibrosis. This chapter interprets the future perceptions in pulmonary fibrosis research and remark on the monitoring approaches to regulate air pollution.

The book ends with Chapter 9 which shows the potentials of the folkloric beliefs practices to preserve nature, established on the close proximity amidst environment and human existences.

I hope the interdisciplinary approach of this book will help to widen awareness of the reader about the environmental perspectives.

Sarmistha Saha
Subject Editor

Environmental Issues: Approaches and Practices (2019), 1:10-19
ISBN: 978-81-939266-1-1

Sewage Management to Fish Culture - An Age Old Eco-practice at East Kolkata Wetlands

Sarmistha Saha

Abstract Understanding the comprehensive mechanism of sewage decontamination process of East Kolkata Wetlands (EKW) used for the commercial fish production, sustainable development of the area, conservation of local biodiversity and its relation to ecosystem services, needs in-depth research. Sewage-fed aquaculture can contribute to the preservation of high-diversity systems, which may deliver vital ecosystem services such as decreasing environmental pollution, carbon sequestration in the wetlands and keeping balance in different bio-geo-chemical cycles. Scientific knowledge of nutrient recovery from waste, considering relative importance of eco-friendly waste management processes and traditional fish culture methods by reusing sewage might make EKW a replicable model worldwide.

Keywords Carbon cycle, East Kolkata Wetlands, fisheries management, plankton, sewage purification

INTRODUCTION

Controlling urban domestic wastes is a key concern throughout the world, mostly in large emerging nations due to its fast development in these countries (Bassi et al. 2014). In South Asian region like Nepal, Bangladesh and India, surface water pollution has become extensive and life-threatening because of high loads of waste disposal into the river stretches and large water bodies (Karn and Harada 2001; Saha et al. 2016). Sustainable waste management skills are consequently the main focus at this point of time. Reflecting on this global need, the waste-use practices established by the fishermen community in East Kolkata Wetlands (EKW) can be observed as natural and eco-friendly solution for waste treatment and reuse of both sewage and solid waste (Furedy and Ghosh 1984; Mukherjee 1996).

EAST KOLKATA WETLANDS AND ITS UNIQUENESS

EKW is located in the eastern peripheries of metropolitan city of Kolkata, stretching nearly between latitude 22°25′N to 22°40′N and longitude 88°22′E and 88°55′E (Kundu et al. 2008). EKW was nominated as a Ramsar site - a wetland of international importance in 2002 as per the Ramsar convention because of its important role in minimizing load of city sewage along with producing fish out of it (Ghosh 1993). Predominantly it functions as flood control plain along with providing environmental

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profits over value $38.54 million which causes the maintenance of the employment of approximately 1.5 lakh residents directly for last ninety years (Bhattacharyya et al. 2008).

Some occurrences of transforming waste to usable resource by using solid waste in agriculture can be found in various countries including China, Sweden, Hungary and Munich. In China this practice is performed since 1960s (Yan and Zhang 1994), in Sweden sewage-fed aquaculture was experimentally tried out in 1992 as a greenhouse mesocosm in a northern climate (Guterstam 1996), in Hungary (Olah et al. 2003) and secondary sewage for fish culture in Munich (Jena et al. 2010).

Paralleled to these efforts, East Kolkata Wetland (EKW) of India is worlds' oldest and largest multi-functional resource retrieval model system which is active since 1930 (Ghosh 1999; Raychaudhuri et al. 2008). EKW expands about 12,700 hectares area (Maiti et al. 2012), among which approximately 5,800 hectares of water area (including 3,798 hectares of fisheries area) commercially produce 30,000 metric tons of fish per year (Saha et al. 2014). City sewage is used to produce planktons that act as the main food resource in fish cultivation. The waste to wealth transformation in EKW has made this fisheries a unique aquaculture culture system (Ghosh 2005).

SEWAGE MANAGEMENT TO FISH CULTURE: ENVIRONMENTAL-SOCIO-ECONOMIC IMPACT OF EKW

Since last ninety years, local fishermen, farmers, scavengers and other groups have been generating their livelihood from this area (Edwards and Pullin 1990). Ponds and sewage carrying canals are instrumental in the traditionally developed waste water treatment process in EKW. Approximately 30% of the domestic city sewage of Kolkata is stored in these fishery ponds. The main component of the sewage is organic matter. Microbial population actively take part in degradation of the organic substance of sewage within favorable environmental condition (Sarkar et al. 2009). Thus microbes play significant role in the natural treatment and recycling of wastewater (Sarkar et al. 2014). Within one month of receiving the sewage waste these ponds become ready for fish cultivation. Pond preparation is a crucial step in this water purification process. During pond preparation phase, pond is dried during the period between winters to pre-monsoon seasons (middle of December to early of May). Afterwards, the bottom mud of the pond is ploughed, treated with lime and left for about a month (Sarkar et al. 2011). Subsequently, the raw sewage is let into the pond through the sewage carrying channels (Basu et al. 2016). Sewage is allowed to fill up to a depth of about 60 to 90 cm of the lime treated pond. At the time of sewage entry, the color of the sewage water is deep black and within 3 to 4 days, the water color changes to green due to algal growth. At this time, due to eutrophication, phytoplankton growth reaches its highest and algal bloom takes place. In next 2 to 3 days the algal mat is sieved away by fishermen turning the water crystal clear (Gupta et al. 2016). After netting the algal bloom, the pond with clear water is left for 25 to 30 days before using it for fish cultivation. At the end of the tenure of 30 to

40 days of natural purification process (Saha et al. 2017) through biological oxidation the pond becomes ready for fish cultivation. The water of the pond at this point of time also become usable for irrigation of the agricultural lands or safely discharged into the surrounding areas (Sarkar et al. 2009; Saha et al. 2014).

The sewage quality can be predictably determined by measuring some key physico-chemical parameters like DO and BOD. However, all the biotic and physico-chemical factors undergo composite and cumulative interactions towards developing an ecosystem (Wetzel 2001). In conventional sewage management, three different pools e.g., sedimentation or anaerobic, facultative and maturation pond are employed consecutively (Sarkar et al. 2009). Each pond has precise activities to add in the purification course. The exclusive feature of this system is that here only one pond is used instead of three sequential ponds, where all the physicochemical activities needed for the purification process, take place (Sarkar et al. 2017; Sarkar et al. 2009).

In the last 25 years numerous studies have been made on the sewage water purification process at EKW ponds. Some studies throw light on the metabolic status and functional diversity of microbial community that is involved in sewage purification process of sewage fed fisheries (Sarkar et al. 2017) and provided an idea about the nature of gradual changes of the physicochemical components during the treatment process (Sarkar et al. 2009). Some of the studies were intended to explore the quality of water after the treatment and the products which were acquired from the treated effluent (Saha and Ghosh 2003; Roy Choudhuri et al. 2007).

Study by Kundu et al. in 2008 put emphasis on the management plans for conservation of the sewage-fed fisheries system as to maintain the livelihood of the local stakeholders as EKW nurtures world's largest wastewater aquaculture system with 30,000 tons of fish produce each year.

DIVERSITY AND OTHER ECOSYSTEM FUNCTIONS PROVIDED BY EKW

Species diversity help to decrease temporal variability in ecosystem processes in changing environments (Loreau et al. 2001). Anthropogenic impacts on the environment cause general decline in diversity for which many ecosystem functions can be disrupted (Grime et al. 2000) thus detail study of species community diversity is important. Several studies have been carried out on the biodiversity focusing trees, plants, herbs, shrubs, land and aquatic insects, birds, mammals and fishes of EKW (Kundu et al. 2008, Bhattacharyya et al. 2008, ,Maiti et al. 2012; Saha et al. 2014). Our previous research concerned the effect of the seasonality on the zooplankton and macroinvertebrate community in the intensive 'sewage-fed' fish culture systems and comparing them with control non-fishery ponds showing different trends in their species abundance (Saha et al. 2017). Other than serving as food source for cultivated fish, both plankton and aquatic macroinvertebrate act as indicator of the water quality conditions like pollution or degradation because of their natural ability to

counter to such changes (Saha 2018; Maiti et al. 2014; Khan and Ghosh 2001). Diversity of plankton is of great concern in the city sewage carrying canals to the Bay of Bengal (Maiti et al. 2013) and during high and low tide at different points over the stretch of river Bidyadhari where the major sewage carrying canals discharge the naturally treated effluent (Sen et al. 2015 (*a & b*); Maiti et al. 2012). Studies showed the large size wetlands are important for wetland dependent birds and held diverse migratory birds during winter in EKW (Saha et al. 2014). Destruction in the wetland habitat by human activities were indicated by the change in bird diversity and abundance at different habitat patches within these sewage-fed fisheries were observed (Bhattacharyya et al. 2008). Research on the microbial diversity at EKW demonstrate involvement of diverse microbial communities in the sewage purification revealing a significant variation in their metabolic spectrum (Sarkar et al. 2017) and their role as indicator of heavy metal pollution (Sarkar et al. 2011).

THIRST AREAS FOR RESEARCH ON SEWAGE-FED FISHERIES SYSTEM

Since 1930 EKW is functioning as the kidney of the Kolkata metropolis along with generating economy for the local inhabitants but the fruits of research are yet to reach the global scale. Based on the review of research articles and Government reports on EKW, it is felt that the following concepts must be prioritized for future investigation to evolve a wholesome understanding about the dynamics system:

A. Index of biological integrity (IBI) is associated with anthropogenic influences on a water body and is an essential tool to map the integrity of a perturbed aquatic system (Hawkins 2006; Mack 2007). IBI can be formulated using data developed from bio-surveys (Kerans et al. 1992). Biological integrity study of polluted system like the sewage-fed fisheries might reveal the impact of human activities on the biological functions played by the biotic communities within these water-bodies.
B. Since sewage consist mostly of organic matter, the transformation of the nutrient particles present in this organic matter is mainly done by the planktons which are the key driving force in nutrient release and recycling of wastewater (Mukherjee et al. 2012). To unravel the underlying mechanism of wastewater purification at this unique and largest sewage fed fisheries system of EKW, it would be important to know the interactions among the various physicochemical parameters and plankton. The time dependent changes in the plankton community structure parallel to the changes in different physicochemical components of wastewater during the purification regime also need to be evaluated.
C. Plankton are the live food organisms that are foraged by fishes in commercial fisheries (David 2003). In open waters, phytoplankton are the main producer and form the basis of

the food chain (Falkowski 1980). Zooplankton constitutes a major part of the diet for fish larvae in the natural food webs (Das et al. 2012). Investigating the significance of plankton community interplay in relation to physicochemical changes during the pond preparation for fish culture in sewage-fed fisheries might serve as a stepping-stone for future study to reveal the exact mechanism of the waste purification process. This will possibly help the underlying mechanism that can be replicated elsewhere for purifying waste water and reuse it for profitable aquaculture.

D. Recycling of energy-matter or nutrients are fundamental processes which occur in every ecosystem as a buffering mechanism allowing ecosystems to face shortage of nutrient inflows (Allesina and Ulanowicz 2004). Energy cycling through ecological networks acts as homeostatic response to stress (Tollner and Kazanci 2007). To estimate the integrity of the ecosystem, nutrient flow cycle of the system is important to be known. Study should be done to analyze nutrient cycles or bio-geo-chemical cycles like carbon, nitrogen and phosphorus in these fisheries.

E. Research on conceptual and mathematical modeling of the basic nutrients – carbon, nitrogen, phosphorus etc in sewage-fed system will offer vital information leading to enormous understanding of the ecosystem functioning and maintaining ecosystem structure in a sustainable manner. Only a single work was done on phosphorus dynamics (Mandal et al. 2015) on EKW fisheries, while in our previous research, the conceptual model on carbon cycle were proposed and regulatory chemical parameters were identified (Basu et al. 2016; Saha et al. 2016). Such comprehensive study might help to formulate rational and important management approaches that can be included in the conservation strategies of the world's largest waste to wealth transforming Ramsar site.

SUSTAINABILITY OF THE EAST KOLKATA WETLANDS

In developing countries, waste management focuses mostly on chemical treatment (Nasr et al. 2007), yet the potential biological processes of sewage purification and many services which wastes can provide in eco-friendly ways are ignored. EKW is the unique system in the world where both effluent management by the process of biological purification, sewage utilization as fish feed and large scale economy generation through fish cultivation are being taken care of.

Sustainable development emphasize on the balance between three parameters - environment, society and economy (Clune and Zehnder 2018). In sewage-fed fisheries of EKW all these parameters are fulfilled naturally as here the load of city sewage of Kolkata is decreased to one third per day by channelizing it to the surrounding fisheries

(Sen et al. 2015 *(a)*; Bhattacharyya et al. 2008) which plays an important role in sewage purification thus balancing environmental wellbeing of the area. Providing employment to the local fishermen by the commercial production of huge amount of fish (Sen et al. 2015 *(b)*; Ghosh 2005) and using domestic sewage as nutrients for fish help the practitioners to cut their expenses for externally added marketed fish-feed. Thus accomplish the economic upliftment through sustainability. Fish of EKW serves as an important animal protein resource to the local people and thus might add to the societal health benefit (Hussan 2016; Edwards 2008).

CONCLUSION

Wastewater aquaculture can be a foremost driver of global change and make significant influences in the conservation of the wetlands, while earning benefits from the sustainable management of biodiversity and ecosystem services. These applied potentials of sewage-fed fishery system support the conventional knowledge of biodiversity-driven aquatic ecosystem functioning. More in-depth research addressing both biological and geo-chemical aspects are needed to improve and upscale the view of such eco-practice globally.

Acknowledgments
Author is thankful to the anonymous referees for their constructive comments.

Compliance with Ethical Standards

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Environmental Issues: Approaches and Practices (2019), 1:10-19
ISBN: 978-81-939266-1-1

Sewage Management to Fish Culture - An Age Old Eco-practice at East Kolkata Wetlands

Sarmistha Saha

Abstract Understanding the comprehensive mechanism of sewage decontamination process of East Kolkata Wetlands (EKW) used for the commercial fish production, sustainable development of the area, conservation of local biodiversity and its relation to ecosystem services, needs in-depth research. Sewage-fed aquaculture can contribute to the preservation of high-diversity systems, which may deliver vital ecosystem services such as decreasing environmental pollution, carbon sequestration in the wetlands and keeping balance in different bio-geo-chemical cycles. Scientific knowledge of nutrient recovery from waste, considering relative importance of eco-friendly waste management processes and traditional fish culture methods by reusing sewage might make EKW a replicable model worldwide.

Keywords Carbon cycle, East Kolkata Wetlands, fisheries management, plankton, sewage purification

INTRODUCTION

Controlling urban domestic wastes is a key concern throughout the world, mostly in large emerging nations due to its fast development in these countries (Bassi et al. 2014). In South Asian region like Nepal, Bangladesh and India, surface water pollution has become extensive and life-threatening because of high loads of waste disposal into the river stretches and large water bodies (Karn and Harada 2001; Saha et al. 2016). Sustainable waste management skills are consequently the main focus at this point of time. Reflecting on this global need, the waste-use practices established by the fishermen community in East Kolkata Wetlands (EKW) can be observed as natural and eco-friendly solution for waste treatment and reuse of both sewage and solid waste (Furedy and Ghosh 1984; Mukherjee 1996).

EAST KOLKATA WETLANDS AND ITS UNIQUENESS

EKW is located in the eastern peripheries of metropolitan city of Kolkata, stretching nearly between latitude 22°25′N to 22°40′N and longitude 88°22′E and 88°55′E (Kundu et al. 2008). EKW was nominated as a Ramsar site - a wetland of international importance in 2002 as per the Ramsar convention because of its important role in minimizing load of city sewage along with producing fish out of it (Ghosh 1993). Predominantly it functions as flood control plain along with providing environmental

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profits over value $38.54 million which causes the maintenance of the employment of approximately 1.5 lakh residents directly for last ninety years (Bhattacharyya et al. 2008).

Some occurrences of transforming waste to usable resource by using solid waste in agriculture can be found in various countries including China, Sweden, Hungary and Munich. In China this practice is performed since 1960s (Yan and Zhang 1994), in Sweden sewage-fed aquaculture was experimentally tried out in 1992 as a greenhouse mesocosm in a northern climate (Guterstam 1996), in Hungary (Olah et al. 2003) and secondary sewage for fish culture in Munich (Jena et al. 2010).

Paralleled to these efforts, East Kolkata Wetland (EKW) of India is worlds' oldest and largest multi-functional resource retrieval model system which is active since 1930 (Ghosh 1999; Raychaudhuri et al. 2008). EKW expands about 12,700 hectares area (Maiti et al. 2012), among which approximately 5,800 hectares of water area (including 3,798 hectares of fisheries area) commercially produce 30,000 metric tons of fish per year (Saha et al. 2014). City sewage is used to produce planktons that act as the main food resource in fish cultivation. The waste to wealth transformation in EKW has made this fisheries a unique aquaculture culture system (Ghosh 2005).

SEWAGE MANAGEMENT TO FISH CULTURE: ENVIRONMENTAL-SOCIO-ECONOMIC IMPACT OF EKW

Since last ninety years, local fishermen, farmers, scavengers and other groups have been generating their livelihood from this area (Edwards and Pullin 1990). Ponds and sewage carrying canals are instrumental in the traditionally developed waste water treatment process in EKW. Approximately 30% of the domestic city sewage of Kolkata is stored in these fishery ponds. The main component of the sewage is organic matter. Microbial population actively take part in degradation of the organic substance of sewage within favorable environmental condition (Sarkar et al. 2009). Thus microbes play significant role in the natural treatment and recycling of wastewater (Sarkar et al. 2014). Within one month of receiving the sewage waste these ponds become ready for fish cultivation. Pond preparation is a crucial step in this water purification process. During pond preparation phase, pond is dried during the period between winters to pre-monsoon seasons (middle of December to early of May). Afterwards, the bottom mud of the pond is ploughed, treated with lime and left for about a month (Sarkar et al. 2011). Subsequently, the raw sewage is let into the pond through the sewage carrying channels (Basu et al. 2016). Sewage is allowed to fill up to a depth of about 60 to 90 cm of the lime treated pond. At the time of sewage entry, the color of the sewage water is deep black and within 3 to 4 days, the water color changes to green due to algal growth. At this time, due to eutrophication, phytoplankton growth reaches its highest and algal bloom takes place. In next 2 to 3 days the algal mat is sieved away by fishermen turning the water crystal clear (Gupta et al. 2016). After netting the algal bloom, the pond with clear water is left for 25 to 30 days before using it for fish cultivation. At the end of the tenure of 30 to

40 days of natural purification process (Saha et al. 2017) through biological oxidation the pond becomes ready for fish cultivation. The water of the pond at this point of time also become usable for irrigation of the agricultural lands or safely discharged into the surrounding areas (Sarkar et al. 2009; Saha et al. 2014).

The sewage quality can be predictably determined by measuring some key physico-chemical parameters like DO and BOD. However, all the biotic and physico-chemical factors undergo composite and cumulative interactions towards developing an ecosystem (Wetzel 2001). In conventional sewage management, three different pools e.g., sedimentation or anaerobic, facultative and maturation pond are employed consecutively (Sarkar et al. 2009). Each pond has precise activities to add in the purification course. The exclusive feature of this system is that here only one pond is used instead of three sequential ponds, where all the physicochemical activities needed for the purification process, take place (Sarkar et al. 2017; Sarkar et al. 2009).

In the last 25 years numerous studies have been made on the sewage water purification process at EKW ponds. Some studies throw light on the metabolic status and functional diversity of microbial community that is involved in sewage purification process of sewage fed fisheries (Sarkar et al. 2017) and provided an idea about the nature of gradual changes of the physicochemical components during the treatment process (Sarkar et al. 2009). Some of the studies were intended to explore the quality of water after the treatment and the products which were acquired from the treated effluent (Saha and Ghosh 2003; Roy Choudhuri et al. 2007).

Study by Kundu et al. in 2008 put emphasis on the management plans for conservation of the sewage-fed fisheries system as to maintain the livelihood of the local stakeholders as EKW nurtures world's largest wastewater aquaculture system with 30,000 tons of fish produce each year.

DIVERSITY AND OTHER ECOSYSTEM FUNCTIONS PROVIDED BY EKW

Species diversity help to decrease temporal variability in ecosystem processes in changing environments (Loreau et al. 2001). Anthropogenic impacts on the environment cause general decline in diversity for which many ecosystem functions can be disrupted (Grime et al. 2000) thus detail study of species community diversity is important. Several studies have been carried out on the biodiversity focusing trees, plants, herbs, shrubs, land and aquatic insects, birds, mammals and fishes of EKW (Kundu et al. 2008, Bhattacharyya et al. 2008, ,Maiti et al. 2012; Saha et al. 2014). Our previous research concerned the effect of the seasonality on the zooplankton and macroinvertebrate community in the intensive 'sewage-fed' fish culture systems and comparing them with control non-fishery ponds showing different trends in their species abundance (Saha et al. 2017). Other than serving as food source for cultivated fish, both plankton and aquatic macroinvertebrate act as indicator of the water quality conditions like pollution or degradation because of their natural ability to

counter to such changes (Saha 2018; Maiti et al. 2014; Khan and Ghosh 2001). Diversity of plankton is of great concern in the city sewage carrying canals to the Bay of Bengal (Maiti et al. 2013) and during high and low tide at different points over the stretch of river Bidyadhari where the major sewage carrying canals discharge the naturally treated effluent (Sen et al. 2015 (*a & b*); Maiti et al. 2012). Studies showed the large size wetlands are important for wetland dependent birds and held diverse migratory birds during winter in EKW (Saha et al. 2014). Destruction in the wetland habitat by human activities were indicated by the change in bird diversity and abundance at different habitat patches within these sewage-fed fisheries were observed (Bhattacharyya et al. 2008). Research on the microbial diversity at EKW demonstrate involvement of diverse microbial communities in the sewage purification revealing a significant variation in their metabolic spectrum (Sarkar et al. 2017) and their role as indicator of heavy metal pollution (Sarkar et al. 2011).

THIRST AREAS FOR RESEARCH ON SEWAGE-FED FISHERIES SYSTEM

Since 1930 EKW is functioning as the kidney of the Kolkata metropolis along with generating economy for the local inhabitants but the fruits of research are yet to reach the global scale. Based on the review of research articles and Government reports on EKW, it is felt that the following concepts must be prioritized for future investigation to evolve a wholesome understanding about the dynamics system:

A. Index of biological integrity (IBI) is associated with anthropogenic influences on a water body and is an essential tool to map the integrity of a perturbed aquatic system (Hawkins 2006; Mack 2007). IBI can be formulated using data developed from bio-surveys (Kerans et al. 1992). Biological integrity study of polluted system like the sewage-fed fisheries might reveal the impact of human activities on the biological functions played by the biotic communities within these water-bodies.
B. Since sewage consist mostly of organic matter, the transformation of the nutrient particles present in this organic matter is mainly done by the planktons which are the key driving force in nutrient release and recycling of wastewater (Mukherjee et al. 2012). To unravel the underlying mechanism of wastewater purification at this unique and largest sewage fed fisheries system of EKW, it would be important to know the interactions among the various physicochemical parameters and plankton. The time dependent changes in the plankton community structure parallel to the changes in different physicochemical components of wastewater during the purification regime also need to be evaluated.
C. Plankton are the live food organisms that are foraged by fishes in commercial fisheries (David 2003). In open waters, phytoplankton are the main producer and form the basis of

the food chain (Falkowski 1980). Zooplankton constitutes a major part of the diet for fish larvae in the natural food webs (Das et al. 2012). Investigating the significance of plankton community interplay in relation to physicochemical changes during the pond preparation for fish culture in sewage-fed fisheries might serve as a stepping-stone for future study to reveal the exact mechanism of the waste purification process. This will possibly help the underlying mechanism that can be replicated elsewhere for purifying waste water and reuse it for profitable aquaculture.

D. Recycling of energy-matter or nutrients are fundamental processes which occur in every ecosystem as a buffering mechanism allowing ecosystems to face shortage of nutrient inflows (Allesina and Ulanowicz 2004). Energy cycling through ecological networks acts as homeostatic response to stress (Tollner and Kazanci 2007). To estimate the integrity of the ecosystem, nutrient flow cycle of the system is important to be known. Study should be done to analyze nutrient cycles or bio-geo-chemical cycles like carbon, nitrogen and phosphorus in these fisheries.

E. Research on conceptual and mathematical modeling of the basic nutrients – carbon, nitrogen, phosphorus etc in sewage-fed system will offer vital information leading to enormous understanding of the ecosystem functioning and maintaining ecosystem structure in a sustainable manner. Only a single work was done on phosphorus dynamics (Mandal et al. 2015) on EKW fisheries, while in our previous research, the conceptual model on carbon cycle were proposed and regulatory chemical parameters were identified (Basu et al. 2016; Saha et al. 2016). Such comprehensive study might help to formulate rational and important management approaches that can be included in the conservation strategies of the world's largest waste to wealth transforming Ramsar site.

SUSTAINABILITY OF THE EAST KOLKATA WETLANDS

In developing countries, waste management focuses mostly on chemical treatment (Nasr et al. 2007), yet the potential biological processes of sewage purification and many services which wastes can provide in eco-friendly ways are ignored. EKW is the unique system in the world where both effluent management by the process of biological purification, sewage utilization as fish feed and large scale economy generation through fish cultivation are being taken care of.

Sustainable development emphasize on the balance between three parameters - environment, society and economy (Clune and Zehnder 2018). In sewage-fed fisheries of EKW all these parameters are fulfilled naturally as here the load of city sewage of Kolkata is decreased to one third per day by channelizing it to the surrounding fisheries

(Sen et al. 2015 *(a)*; Bhattacharyya et al. 2008) which plays an important role in sewage purification thus balancing environmental wellbeing of the area. Providing employment to the local fishermen by the commercial production of huge amount of fish (Sen et al. 2015 *(b)*; Ghosh 2005) and using domestic sewage as nutrients for fish help the practitioners to cut their expenses for externally added marketed fish-feed. Thus accomplish the economic upliftment through sustainability. Fish of EKW serves as an important animal protein resource to the local people and thus might add to the societal health benefit (Hussan 2016; Edwards 2008).

CONCLUSION

Wastewater aquaculture can be a foremost driver of global change and make significant influences in the conservation of the wetlands, while earning benefits from the sustainable management of biodiversity and ecosystem services. These applied potentials of sewage-fed fishery system support the conventional knowledge of biodiversity-driven aquatic ecosystem functioning. More in-depth research addressing both biological and geo-chemical aspects are needed to improve and upscale the view of such eco-practice globally.

Acknowledgments
Author is thankful to the anonymous referees for their constructive comments.

Compliance with Ethical Standards

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Environmental Issues: Approaches and Practices (2019), 1:20-31
ISBN: 978-81-939266-1-1

Multifactorial Declines in Global Insect Pollinator Populations – Case Studies in Honey Bees

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Abstract Global decline in insect pollinator populations, especially honey bees, is a cause of serious concern. Pollination not only ensures food security, but also maintains biodiversity of the vast floral resources across the world. Various abiotic and biotic stressors have been attributed to the detrimental impacts on bee pollinator populations. This short review will emphasize on the various multifactorial concerns affecting honey bee populations worldwide ranging from pests, pathogens, diseases, pesticides and malnutrition. These elements are often synergistic, causing reduced longevity, suppressed immune systems and increased oxidative stress in worker honey bees, to name a few instances. Malnutrition further increases honey bee susceptibility to pathogens and diseases. It is important to understand the dynamics and impacts of these environmental stressors on important pollinator populations to be able to mitigate their effects efficiently.

Keywords Pollinators, Pesticides, Nutrition, *Varroa*, *Nosema*

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INTRODUCTION

Pollinators provide a vital ecosystem service to both wild and cultivated plants, ensuring production of food crops, floral biodiversity and maintenance of insect-pollination dependent plants. Crops like strawberry, apple, almond and melons are heavily dependent on pollination for production of seed sets and approximately 70% of the 124 major food crops are dependent on pollinators (Klein et al. 2007; Gallai et al. 2009). Insect pollination ensures maintenance of the genetic diversity in wild plants (Williams and Carreck 1994). A wide variety of plant species may also provide food sources for many mammals and birds. Thus, the economic and environmental costs of global decline in insect pollinators are profound (Vanbergen et al. 2013).

Honey bees are perhaps the best studied among insect pollinators (Basu and Chakrabarti 2015). They are essential components of agriculture and many crops are completely dependent on them for pollination (Free 1993). Honey bee colonies are also a good source of revenue generation for commercial beekeepers. For example, the value of crop pollination in the United States by honey bees is estimated to be more than $17 billion (Calderone 2012). There has been a sharp decline of 61% in honey bee populations

reported between 1947 and 2008 (Ellis et al. 2010; vanEngelsdorp and Meixner 2010). This is alarming to both beekeepers and growers, whose economic viabilities are interdependent.

Multiple factors are responsible for the collapse of entire honey bee colonies, as well as a significant reduction in native bee populations. This short review will focus on honey bees as the pivotal insect pollinators and will emphasize some of the important biotic (viruses, pests, pathogens etc.) and abiotic (pesticides, malnutrition etc.) stressors, which are currently held responsible for global declines in insect pollinator populations.

PESTS, PARASITES, PATHOGENS AND DISEASES

Insect pollinators, especially honey bees, are bombarded with innumerable viruses, bacteria, fungi and parasites which threaten their populations. *Ascosphaera apis* and *Aspergillus flavus* cause chalkbrood disease and aspergillosis respectively in honey bees. It has been reported that environmental variances (*viz.* rain, humidity, temperature variations etc.) accentuate these fungal infections (Mehr et al. 1978; Aronstein and Murray 2010). *A. apis* spores may contaminate foundation wax and this in turn may be the source of the infection in healthy colonies (Flores et al. 2005).

Bacterial pathogens infecting honey bee colonies are primarily *Paenibacillus larvae* and *Melissococcus pluton* which result in American foulbrood and European foulbrood infections, although, honey bees have been reported to progressively develop resistance to *P. larvae infection* as they age (Brødsgaard et al. 1998). Lesser-researched diseases include honeybee spiroplasmosis, septicemia, and paratyphoid disease caused by *Spiroplasma melliferum*, *Pseudomonas* sp. and *Salmonella paratyphi A* respectively (Morse and Nowogrodzki 1978; Mouches et al 1983; Clark et al. 1985; Evans and Schwarz 2011).

Varroa destructor mite is the primary vector for the viral infections in honey bee colonies. Viruses cause damage to the honey bee colony by affecting bee physiology, morphology and other functions (Chen et al. 2005; Maori et al. 2007; Runckel et al. 2011). There have been reports of numerous viruses (more than 20) infecting honey bee colonies (Bailey 1981; Ellis and Munn 2005; Zhang et al. 2012; Li et al. 2014), of which, the three major viral infections are: 1) The deformed wing viral infection causes morphological aberrations including deformed wings in adult honey bees (Bailey and Ball 1991). Even though this virus does not usually harm pupae, it reduces adult longevity by its independent and cumulative effects with *Varroa* mites (Dainat et al. 2012). 2) The Chinese sacbrood virus is another important viral pathogen and is reported to cause sacbrood disease in *Apis cerana* (Gong et al. 2016). This disease inhibits larval development and thereby subsequent pupation (Aronstein and Murray 2010; Han et al. 2013). 3) The Israeli acute paralysis virus is often considered

responsible for colony collapse in the United States (Cox-Foster et al. 2007) and this has been supported by other recent studies which report similarities in colony malfunctions between Israeli acute paralysis viral infection and colony collapse symptoms (Hou et al. 2014).

Nosema ceranae and *Varroa* mites are the most commonly reported honey bee parasites producing microsporidiosis and acarine diseases respectively (Martin 2001; Sak et al. 2004). *N. ceranae* was first identified in *Apis cerana* (Asian honey bee) and was later found to expand its host range to *Apis mellifera* (Western honey bee / European honey bee). Numerous reports have attributed honey bee gut epithelial degeneration, tissue impairments, reduced longevity, increased oxidative and energetic stress in honey bees to *Nosema* infection (Antunez et al. 2009; Mayack and Naug 2009; Dussaubat et al. 2012; Wolf et al. 2014; Mayack et al. 2015). *Varroa* mites, on the other hand, feed on honey bee hemolymph causing physiological injury, suppressed immunity and malnutrition (Degrandi-Hoffman and Chen 2015). Some recent studies are also exploring fat ingestion by *Varroa* mites and the risk they pose to honey bees as a result of fat body consumption (Ramsey et al. 2019).

PESTICIDE AS A MAJOR CAUSE FOR POLLINATOR DECLINE

Even though agricultural intensification has significantly contributed to the increased food production over the past 50 years (Matson et al. 1997), land use intensification has also reduced species richness and ecosystem functioning (Flynn et al. 2009). Intensification of the land essentially indicates increased use of not only fertilizers but also various pesticides and insecticides. Even though targeted towards pests, pesticides have often been reported to impose detrimental effects on non-target beneficial insect pollinators (Desneux et al. 2007). Previous studies have attributed agricultural intensification and habitat loss, due to increased agricultural expansion, as drivers for loss in pollinator richness and abundance (Ricketts et al. 2008; Winfree et al. 2009; Potts et al. 2010). Like honey bees, crop pollination by native bees has also been reported to be on the decline due to agricultural intensification (Kremen et al. 2002). Pesticide use has often been cited as a major driver of global pollinator decline (Whitehorn et al. 2012; Chakrabarti et al. 2015 a). Exposure to pesticides can occur through multiple routes – mostly when foraging bees are exposed while pollinating agricultural fields or when contaminated nectar and pollen are brought back to the hive. Honey bee hive matrices like pollen and wax have been shown to contain significant pesticide residues (Mullin et al. 2010; Pettis et al. 2013) and chronic sublethal exposures may bring about adverse detrimental effects on the whole hive.

Many pesticides, *viz.* organochlorines and carbamates, have been reported to cause significant oxidative stress (Qiao et al. 2005; Chakrabarti et al. 2015 a). Increased antioxidant enzyme activities have been reported in honey bees in pesticide laden environments (Chakrabarti et al. 2015 a)

and are often considered as potential biomarkers for oxidative stress (Badiou-Beneteau et al. 2012). An elevated oxidative stress may also be observed in honey bees when environmental exposures are coupled with migratory hive managements (Simone-Finstrom et al. 2016). Among other oxidative stress enzymes, xanthine oxidase has also been reported to increase under pesticide exposure (Chakrabarti et al. 2015 a). Unlike other insects, honey bees lack certain detoxification enzymes to counteract the detrimental effects of pesticides (Claudianos et al. 2006) and hence, pesticide toxicity is one of the major concerns for global bee declines. Commonly used miticides, *viz*. formic acid, have been reported to reduce brood survival and honey bee longevity (Fries 1991; Underwood and Currie 2003; Di et al. 2013). Indeed, regulation of acaricide treatment in honey bees has been reported to be influenced by numerous immunity-related genes (Boncristiani et al. 2012).

New studies reveal more information on the effects of sublethal pesticide toxicity on honey bees – ranging from impaired olfaction, learning, social immunity, reduced life span, foraging and hygienic behavior in honey bee workers, decreased egg laying by queens and precocious foraging in workers (Schneider et al. 2012; Henry et al. 2012; Chakrabarti et al. 2015 b; Tsvetkov et al. 2017). Behavior (avoidance and repellence) and morphology (*viz.* thickened cuticle acting as a natural barrier) may provide the first route of resistance to pesticides (Smirle 1988). However, when insect behavior and morphology are altered due to pesticides, bees are more susceptible to further toxic exposures. Honey bees, like other insects, are constantly exposed to numerous random odor stimuli which they use to synthesize substantial information. Proboscis extension response/reflex (PER) studies have been a common tool in understanding the effects of pesticides on honey bee olfaction (Han et al. 2010; Chakrabarti et al. 2015 b). Odor detection is assisted by help of olfactory receptor neurons (ORNs) called sensilla (Sandoz 2012), which are located on the antennae. A recent study has helped identify the morphological aberrations of sensilla and significant reductions in their numbers in pesticide-exposed honey bee populations by help of Scanning Electron Microscopy (Chakrabarti et al. 2015 b). Ion channel activity has a pivotal role to play in olfactory pathway in the honey bee brain (Grunewald 2003). Calcium, being the preliminary trigger for long term olfactory development (Perisse 2009), has often been studied. Pesticides have been recently reported to impede honey bee olfaction by reducing biologically active free Ca^{2+} in the two major olfactory regions of the honey bee brain – mushroom body and antennal lobe regions (Chakrabarti et al. 2015 b).

Even though in declining numbers, honey bee colonies do survive in the intensive agricultural field sites. Perhaps through developing genetic heterozygosity, these hives are able to cope with the environmental stress. In fact, metals and other pollutants, like pesticides, are reported to be absorbed by the cellular

components of the physiological processes, leading to various changes including alterations of the genetic system leading to the inhibition or alteration of enzyme alleles (Dix 1981). A recent study reported that honey bee (*A. cerana*) populations exposed to pesticides over a prolonged period exhibited increased genetic diversity at both protein and DNA levels (Chakrabarti et al. 2018). The repertoire of various studies help shed light on the impacts of pesticides on honey bee populations, thereby having a far reaching effect in understanding the responses in other insect pollinator species.

NUTRITIONAL STRESS IMPACTING INSECT POLLINATORS

Poor nutrition is recently being recognized as one of the important causes for bee declines. Malnutrition in honey bees may result from a combination of factors ranging from loss in habitat, monocultures and alterations in floral phenology (Kremen et al. 2002; Naug 2009; Vanbergen et al. 2013, Otto et al. 2016). In fact, sufficient nutrition is attributed to stronger colonies with better immunity – well-nourished bees are less susceptible to *Nosema ceranae*, have lower pathogen loads, overwinter more successfully and are better able to cope with parasites, diseases and insecticides (Eischen and Graham 2008; Di Pasquale et al. 2013; DeGrandi-Hoffman et al. 2016; Jack et al. 2016, Glavinic et al. 2017; Brodschneider and Crailsheim 2010; Mao et al. 2013; Schmehl et al. 2014). Insufficient nutrition in colonies leads to physiological anomalies in emergent spring workers (Mattila and Otis 2006) and in larval stages, results in formation of ineffective foragers and selection of fewer queens in the colony (Scofield and Mattila 2015; Sagili et al. 2018). Habitat imposed nutritional stress is one of the important drivers of the recent honey bee declines (Naug 2009; Archer et al. 2013). Optimal nutrition is hence often considered the primary defense in honey bee colonies against both abiotic and biotic stressors and is crucial in maintaining healthy pollinator populations, especially in an adverse environment (Brodschneider and Crailsheim 2010).

CONCLUSIONS

With increasing decline in the abundance and diversity of bee forage, increasing exposure to agrochemicals and cumulative pressures from pests and pathogens, bees are on a steady global decline (Goulson et al. 2015). It is important to note that stressors do not act in isolation and their cumulative effects are perturbing. For instance, malnutrition increases pollinator vulnerability to parasites, pathogens and diseases. This in turn weakens them and renders them susceptible to pesticide exposures. Chronic exposures to multifactorial stressors seem to drive global bee population decline – for both managed and wild bees (Goulson et al. 2015). Incorporating flower- rich habitats into farmlands to reduce nutritional stress on bees, reducing pesticide exposures of insect pollinators through adopting sustainable farming methods and implementing effective quarantine actions

on infected managed colonies are all practical measures that may be adopted (Chakrabarti et al. 2015 a; Goulson et al. 2015). Pollination is one of the most crucial ecosystem services of global benefit, and measures must be taken to ensure a sustainable future. Further research on the various biophysical pathways, gene expressions, habitat studies, pesticide toxicity assays and exposure mechanisms in insect pollinators can hold the key to understand methods required to offset the various biotic and abiotic stressors.

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Environmental Issues: Approaches and Practices (2019), 1:32-39
ISBN: 978-81-939266-1-1

First Measurements of Aerosol Climate Forcing Agents in Rural West Bengal

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Abstract This study reports the first measurements of aerosol climate forcing agents (black and brown carbon; BC and BrC) from a rural location in West Bengal. To this end, time-resolved measurements of aerosol optical properties were carried out at Mohanpur, West Bengal using a 7-wavelength Aethalometer during summer 2018. These were supplemented by time-integrated fine-mode aerosol ($PM_{2.5}$) samples, and analysis of optical properties of their aqueous and organic extracts. The daily averaged BC varied from 0.9-7.5 μg m^{-3} (mean: 3.6±2.0 μg m^{-3}), and its diurnal profile exhibited early morning (0700-0800 h) peaks characterized by high fossil fuel BC, and late evening (1900-2100 h) peaks from residential fuel use reflected by enhanced biomass burning (BB-BC). The contribution of BB-BC to BC_{total} was 17% for the study period. The diurnal profile of BrC absorption ($b_{abs(BrC)}$) tracked the BC-BB fraction with a concurrent peak during 1900-2100 h, suggesting co-emission. Overall, BrC contributed 15% and 18%, respectively, to total and BC-associated light absorption at 370 nm. Aqueous and organic extracts of summertime aerosol showed strong wavelength-dependence with averaged BrC_{AE} values of 7.2 and 6.2, respectively, confirming a substantial presence of both aqueous- and organic-soluble BrC chromophores. Fluorescence spectra for aqueous extracts showed a strong peak at ~420 nm, possibly indicating the presence of poly-conjugated humic-like substances (HULIS), while that for organic extracts exhibited a broader and more intense peak suggesting water-insoluble BrC chromophores. Overall, this study established for the first time that BrC is a significant component of light absorbing aerosol in rural West Bengal.

Keywords Angstrom exponent, Carbonaceous aerosols, Concentration-weighted trajectory (CWT), India, Optical properties

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INTRODUCTION

Among aerosol chemical constituents, black carbon (BC) is the most potent climate forcing agent (radiative forcing estimate: +1.1 W m^{-2}; Bond et al., 2013) with pronounced effects on atmospheric stability, large scale circulation, monsoon patterns and snow albedo (Tiwari et al., 2013 and references therein). In India, large internal heterogeneities exist for BC

emission inventories, which translate into uncertainties in model-predicted atmospheric BC concentrations and corresponding climate effects on regional scales. Field-based measurements of BC aerosol concentrations, diurnal and seasonal variations, sources, and optical properties are therefore vital to constrain regional model predictions. Another fraction of carbonaceous aerosols, termed brown carbon (BrC), has emerged recently as a possibly significant contributor to aerosol climate forcing. BrC refers to the light-absorbing fraction of atmospheric organic carbon (OC), and is associated with both primary (biomass/bio-fuel combustion) and secondary (atmospheric photooxidation) sources, with effects on the surface UV budget and tropospheric chemistry (Mok et al., 2016). However, field studies on BrC optical properties and sources are highly scattered globally and are rare in India, which demands concerted efforts in this direction.

The Indo-Gangetic Plain (IGP) is considered to be the predominant area source of BC in India and recent estimates show that West Bengal, located in the eastern IGP, is the second largest BC emitter nationally (Paliwal et al., 2016). Increased emission from this region is possibly from the use of biomass fuels and kerosene lamps for domestic energy production in rural areas, open crop residue burning, and outflows from the megacity Kolkata and population centers in the central and northwestern IGP. Despite such high emissions, field-based studies investigating BC distribution, sources and optical properties in this region are rare while those on BrC are non-existent. This limits our understanding of the impact of regionally transported (and photochemically aged) emissions on aerosol optical properties in rural West Bengal. This lack of surface measurement data also signifies that regional model estimates of BC cannot be validated for this region. In view of the above, we present here the first measurements of summertime BC and BrC, corresponding light absorption parameters, and potential source sectors at a rural site affected by regional emissions in West Bengal.

METHODS

Study area

The study was carried out at Mohanpur (22º96'N, 88º56'E), a rural area in Nadia district, West Bengal, characterized by agricultural fields and village settlements, with reduced vehicular traffic. The nearest town is Kalyani (population: 0.1 million) around 10 km to the W and the megacity Kolkata (population: 4.9 million) lies ~50 km to the S-SW. A cluster of small- and medium-scale industrial units are located ~10 km to the W, and the 450 MW Bandel coal-fired power station is situated ~15 km to the NW of the site. On a regional scale, clusters of large thermal power plants and steel industrial complexes in West Bengal, Odisha, Bihar, Jharkhand and Chhattisgarh are located within 500 km of the study area.

SAMPLING AND ANALYSIS

1) Time-resolved measurements of BC and BrC

A 7-wavelength (370-950 nm) Aethalometer (AE-33, Magee Scientific) was employed during late summer (May-July) 2018 to collect BC concentration and aerosol light

absorption data at a time resolution of 1 min. Aerosol light absorption coefficients (b_{abs}) were determined from wavelength-dependent BC mass absorption efficiencies (MAE) and BC mass density data. Assuming a BC Angstrom exponent (AE) of 1, a power law equation was used to estimate BC absorption across the entire wavelength range, followed by the determination of residual absorption by BrC ($b_{abs(BrC)}$). Subsequently, the wavelength dependence of BrC light absorption (AE_{BrC}) was calculated from a fit of $b_{abs(BrC)}$ vs wavelength. Diurnal variations of BC, b_{abs}, $b_{abs(BrC)}$ and AE_{BrC} were also studied. Finally, a two-component mixing model was employed for a preliminary assessment of fossil fuel vs biomass burning sources of BC.

2) Time-integrated optical measurements of Aerosol Aqueous and Organic Extracts

A low-volume $PM_{2.5}$ sampler (APM550 MFC, Envirotech) was deployed to collect 24 h $PM_{2.5}$ during April-July 2018 (n=29) using pre-combusted 47 mm quartz filters (QMA, Whatman). $PM_{2.5}$ loads were determined using a microbalance (Mettler-Toldeo, sensitivity: 0.01 mg) after conditioning in a constant temperature and RH chamber. A fraction of these samples (n=5) were extracted separately with 20 ml ultrapure water and 10 ml methanol for 30 min in an ultrasonicator to get water- and organic-extractable fractions of $PM_{2.5}$, respectively. The extracts were filtered through 0.22 µm PVDF syringe filters (Rankem), and were analyzed for optical characteristics of organic aerosol chromophores using UV-Vis (Evolution 201, Thermo-Fisher) and fluorescence (FluoroMax-3, Horiba) spectrometers. Corresponding b_{abs} were calculated and were used to estimate AE values of water- and organic-extractable fractions (Hecobian et al., 2010), and to comment on potential BrC sources.

3) Air mass trajectory clusters and Concentration Weighted Trajectories (CWTS)

To identify aerosol transport pathways and potential source sectors over this region, we calculated daily wind backward trajectories using GDAS meteorological data and the HYSPLIT transport and dispersion model (https://www.ready.noaa.gov/HYSPLIT.php). HYSPLIT was run for 96 hours backward at a starting height of 100 m to calculate daily trajectories followed by clustering based on standard protocol. Subsequently, BC, b_{abs}, $b_{abs(BrC)}$ and AE_{BrC} values were apportioned to each cluster. Directional gradients of source contributions were established by calculating concentration weighted trajectories (CWTs) for BC, b_{abs}, $b_{abs(BrC)}$ and AE_{BrC} (TrajStat; http://www.meteothinker.com/).

RESULTS AND DISCUSSIONS

1) Diurnal variations of BC and relative contributions of Fossil Fuel vs Biomass burning

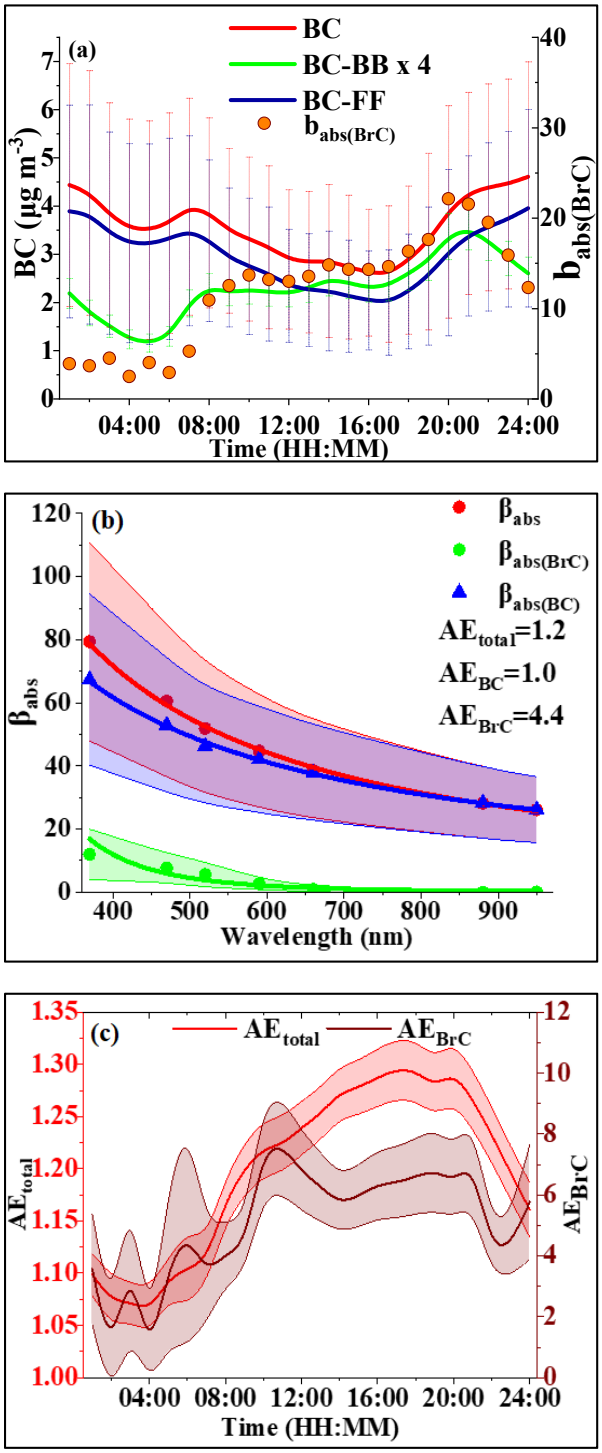
Daily averaged BC concentration for the study period varied from 0.9-7.5 µg m^{-3}, with an overall mean of 3.6 ± 2.0 µg m^{-3}. BC levels were significantly higher (p<0.01) during nighttime (mean: 4.1 ± 1.9 µg m^{-3}) compared to daytime (mean: 3.1 ± 1.3 µg m^{-3}), possibly due to increased residential fuel use emissions, and accumulation resulting from lower nocturnal mixing depths. The diurnal

profile of BC (Fig. 1a) shows an increasing trend after 1700 h lasting till 0200 h, and a secondary peak at 0700-0800 h. Based on results of the two-component mixing model, fossil fuel use is responsible for the overwhelming majority (83%) of the observed BC levels, and this component (BC-FF) tracks the total BC profile very well. It therefore appears that the secondary BC peak at 0700-0800 h is related to morning traffic even though the site is well away from major roads. The post-evening increasing trend of BC is also reproduced by the BC-FF component, possible due to increased nighttime movement of diesel trucks on the National Highway around 1.5 km away. The biomass burning component (BC-BB), on the other hand, contributes 17% to total BC, and shows a distinctly different diurnal profile. There is a notable rise in BC-BB during 0600-0800 h, possible from morning cooking activities, and a much larger peak at 2100 h followed by a decline, suggesting enhanced residential fuel use during the evening.

2) Time-resolved BrC light absorption characteristics

The overall aerosol b_{abs} shows a similar wavelength dependence (AE =1.2, Fig. 1b) as pure BC (AE = 1). Extrapolating b_{abs} for BC to lower wavelengths gives an estimate of BrC absorption in the UV-Vis region. The $b_{abs(BrC)}$ at 370 nm is used as a proxy of total BrC absorption, and its diurnal variation is shown in Fig. 1a. It is clear that $b_{abs(BrC)}$ follows a similar hourly profile as BC-BB, suggesting co-emission. The high overall mean AE_{BrC} (4.4, Fig. 1b) with notable peaks (AE_{BrC} = 4-6.5) during 0600 and 2100 h (Fig. 1c) also strongly support a biomass burning

Figure 1: Diurnal variation of BC, fossil-fuel and biomass burning (×4) BC, and babs(BrC) (a); wavelength dependence of total, BC and BrC absorption (b); total and BrC AE (AEtotal, AEBrC) (c).

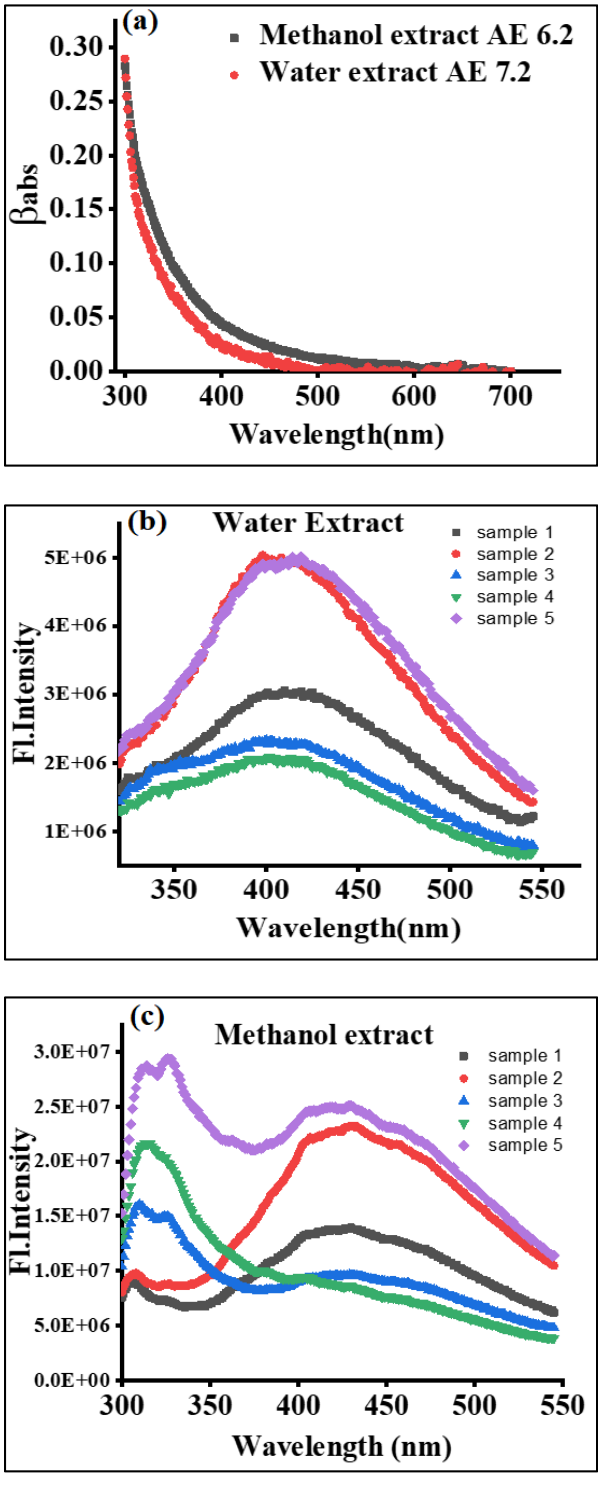


source (Hecobian et al., 2010). This might indicate that smoldering combustion of biofuels in the residential sector produce substantial amounts of BrC chromophores along with BC. Interestingly, the hourly $b_{abs(BrC)}$ profile shows a slowly increasing trend during afternoon hours, which is mirrored by a AE_{BrC} peak of ~7.5 at 1100-1200 h. This possibly suggests secondary BrC formation from atmospheric processes in the afternoon as a consequence of increased emissions of biogenic volatile organic compounds in response to heat stress followed by photochemical oxidation in the presence of oxidants (OH, O_3, etc.). Overall, the relative contributions of BrC to total and BC-associated light absorption were considerable (15% and 18%, respectively, at 370 nm), which establishes that BrC is a significant component of light absorbing aerosol in the eastern IGP.

3) Optical properties of aerosol extracts

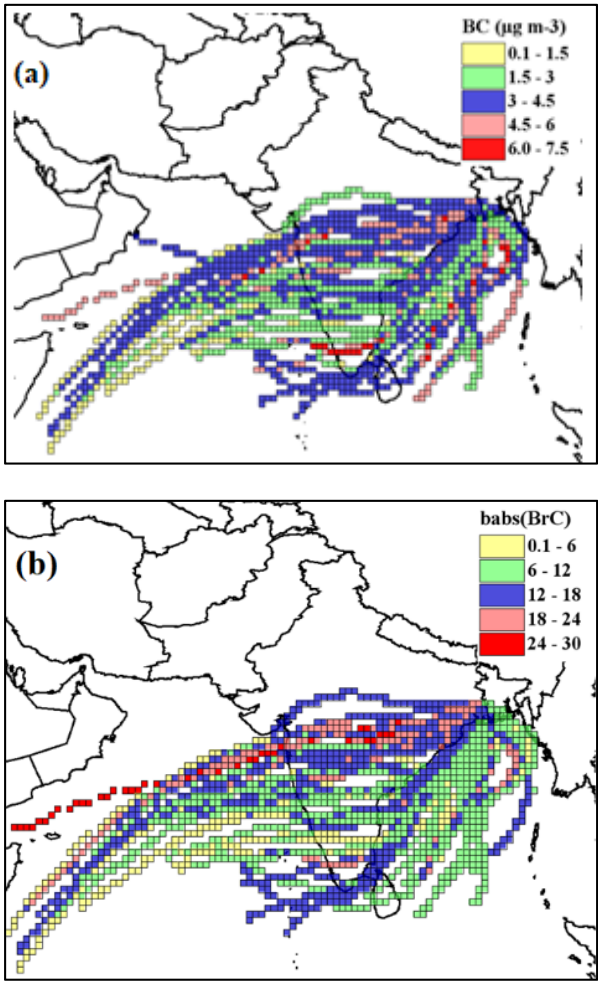
UV-Vis absorption for water and organic extracts were converted to corresponding b_{abs}, and were used to estimate corresponding AE (Fig. 2a). The averaged AE for the water extracts was 7.2, which confirms the presence of water soluble BrC chromophores. Previous studies have reported AE values of ~7 for aqueous extracts of water-soluble humic like substances (HULIS) from biomass burning plumes and fresh secondary organic aerosol (SOA) (Hecobian et al., 2010 and references therein). In comparison, methanol extracts showed an averaged AE of 6.2. Fluorescence spectra for the aqueous extracts (Fig. 2b) showed a strong peak at ~420 nm, similar to that observed for aqueous extracts of HULIS with poly-conjugated structures (Varga et al.,

Figure 2: Optical characteristics of aqueous and organic extracts of PM2.5: a) babs-λ relationship for UV-Vis; b) fluorescence spectra of water extract; c) fluorescence spectra of methanol extract.



2001). For organic extracts (Fig. 2c), the fluorescence intensity was elevated and the peak at ~420 nm was broader, suggesting that a substantial fraction of aerosol chromophores are water-insoluble. Overall, this chemical-optical characterization of aerosol liquid extracts confirm a substantial presence of organic chromophores, and supports the conclusions from *in situ* optical measurements presented in the previous section.

Figure 3: CWT plots of BC (a) and babs(BrC) (b) for the study period.



4) Potential source sectors and aerosol age

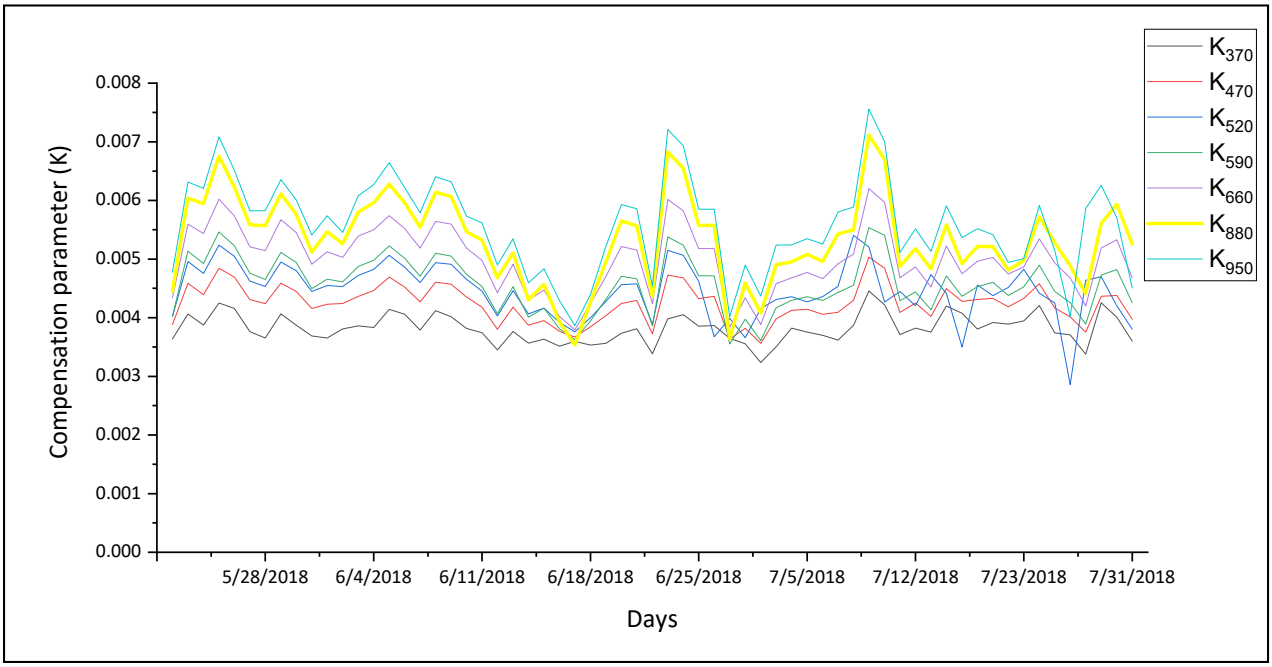
The majority of air masses arrived from the SW during the study period, and two trajectory clusters were identified: i) originating over Bay of Bengal; ii) originating over the Arabian Sea and travelling over central and peninsular India. A CWT plot of BC concentration (Fig. 3a) shows that small amounts of BC were transported across central India and the eastern coast to the study site, with scattered high values potentially associated with power plant clusters in Odisha and Chhattisgarh, industrial centers in peninsular India, and ship tracks over Bay of Bengal. On the other hand, $b_{abs(BrC)}$ showed relatively higher values associated with air mass transport over central India compared to other pathways. Summertime forest fires over central India (especially, Chhattisgarh and coastal Odisha) could potentially be responsible for the high $b_{abs(BrC)}$ (along with BC) observed here (Venkataraman et al., 2006).

An independent estimate of aerosol aging is provided by the real-time calculation of the compensation parameter (k) in the AE-33 Aethalometer. A time series of k for the 7 seven selected wavelengths is presented in Fig. 4. The value of k at 880 nm (k_{880}) varies from 0.004 to 0.007 for summer 2018 in rural West Bengal, indicating an overall predominance of relatively fresh aerosols (Drinovec et al., 2016). This shows that although air masses arrived at the study location via long-range transport (thousands of km), BC aerosols were most likely sourced from the regional vicinity of the study site during summer.

CONCLUSIONS

This pilot study on summertime aerosol optical characteristics in rural West Bengal

Figure 4: Time series of the compensation parameter (k) for the study period.



found that BC in this region has a strong fossil-fuel derived signature mixed with a residential fuel use derived component. Aerosol BrC, predominantly sourced from smoldering biofuel combustion and secondary processes, makes a non-trivial contribution to total aerosol light extinction. Aqueous and organic aerosol extracts show a strong wavelength dependence of UV-Vis absorption, consistent with the presence of polyconjugated HULIS chromophores, in addition to broad fluorescence signatures. There also appears to be a small contribution from regional atmospheric transport to aerosol BC and BrC in rural West Bengal.

ACKNOWLEDGEMENT

Archita Rana and Sayantan Sarkar acknowledge IISER-Kolkata for provision of Integrated Ph.D. fellowship and Start-up Grant, respectively, for the duration of this work.

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Environmental Issues: Approaches and Practices (2019), 1:40-46
ISBN: 978-81-939266-1-1

Climate Change and India's Foreign Policy

Tilottama Mukherjee

Abstract Concerns over climate change and approaches to mitigate its adverse impact have emerged as a major issue in international arena in the 21st Century. Developing world led by India and China, both economic giants, is continuously negotiating with the mighty West to secure and safeguard its interests while building consensus over safeguards and various action and measures to stave off Climate Change. The 'Climate Diplomacy' of India and China, along with the support of other countries of the 'third world', has provided them an opportunity to strengthen their bilateral and regional cooperation on this issue. This paper aims to highlight the chief focus of today's global political debate on climate change and how India has evolved its foreign policy over the years to meet the present challenges.

Keywords China, India, Paris Accords, United States, common but differentiated responsibilities

CLIMATE CHANGE: GENERAL TRENDS IN INDIAN FOREIGN POLICY

India, presently the fourth largest carbon emitter in the world (after China, the United States and the European Union) has often been pulled up by the Western world as a not-so-responsible energy user. India, along with China and other countries of the developing world has been very vocal in propagating the principle of "common but differentiated responsibilities" in matters of environmental protection and policies on climate change. This principle refers to the belief in international environmental law which establishes that all States are responsible for addressing climate change and environmental destruction; however, not all States are equally responsible. This means that it is totally justified that all States should actively participate in mitigating global environmental problems yet not all are equally capable in terms of their levels of economic development to equally contribute towards meeting the challenge. In such a situation it is the moral responsibility of the developed countries to support the developing countries in their efforts toward addressing the environmental problems, by providing them with adequate financial support and facilitating technology transfers to help them move towards clean energy.

This notion has been intensively propagated by India and China in last few decades so that they can continue on their path of development without cutting their carbon emission to an unfeasible level, yet at the same time using the non- renewable sources of energy judiciously. India's foreign policy regarding climate change,

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under successive governments, has always been emphasizing the fact that climate change that has occurred is the result of accumulated greenhouse gas emissions over past centuries. Historically, the West is the major culprit. Therefore, the developing world with India and China as its vanguard, refuse to accept such a distorted global model of fighting climate change which seeks to put the common responsibility on every country to fight the scourge of climate change, without paying any heed to the development needs of the third world countries. Western countries' arguments also do not take into cognizance the fact that most of these countries are still reeling under disappointing levels of poverty and low Gross Domestic Product (GDP) in their own countries which makes them incapable to use the latest high- cost technologies to cut carbon emission. Moreover, India has been arguing in various United Nations Climate Change Conferences that in such a scenario, the West should bear the cost of funding necessary technologies and must facilitate technology transfers to less developed countries.

Such an argument, however, is not new in the domain of India's foreign policy. In fact, way back in 1972, India's Prime Minister Mrs Indira Gandhi had remarked in the UN Stockholm Conference:

> "Many of the advanced countries of today have reached their present affluence by their domination over other races and countries, the exploitation of their own natural resources. They got a head- start through sheer ruthlessness, undisturbed by feelings of compassion or by abstract theories of freedom, equality or justice…We do not wish to impoverish the environment any further yet we cannot for a moment forget the grim poverty of large numbers of people. Are not poverty and need the greatest polluters?"

Therefore, since the time of the Rio Earth Summit in 1992, India has always been hammering the issue of historical responsibility of the developed countries and thus, India along with China spearheaded the movement for establishing the principle of "common but differentiated responsibilities". They achieved success when Article 3 of the Rio Climate Accords at the conclusion of the Rio Earth Summit adopted the principle of "common but differentiated responsibilities", despite immense pressure from a section of the Western world. The Rio Earth Summit of 1992 remains a very significant event till date as it agreed on some very important measures to combat climate change. For instance, it led to the establishment of the United Nations Framework Conventions on Climate Change (UNFCCC), and the establishment of the United Nations Commission on Sustainable Development.

Furthermore, when during the Kyoto Climate Conference of 1997, the developed Western countries were pressurizing the developing world to shoulder greater responsibilities to fight climate change, deft diplomacy on the part of leaders of India and China could successfully offset such an effort and the Kyoto Protocol not only re- iterated the principle of "common but differentiated responsibilities", it also refrained from levying on the developing world, any other additional commitments or any time- frame to cut carbon emissions. Moreover, India could succeed in forming a 'Green Group' comprising seventy two developing countries with the purpose of showing unity and solidarity on the global platform to thwart any undue pressure from the West in the name of cutting carbon emissions. However, after the Kyoto Summit, a new line of argument was put forward by the West that not all developing countries stand on the same platform. They highlighted the role of Brazil, South Africa, India and China (BASIC), the most emerging economies, as the most important polluters in the developing world. Therefore, since the Bali United Nations Conference in 2007, India's foreign policy towards climate change got modified a bit and it started accepting voluntary carbon use mitigation efforts, on the premise that the Western world would be more generous in coming forward to provide greater financial support and genuine help in technology transfers to the developing world. India, more particularly after the Bali Summit of 2007, reshaped its foreign policy in this regard and pledged to reduce carbon emission by 20-25 per cent by 2020 as against 2005. This was a major shift from the stance that India adopted during the 1972 Stockholm Conference and the 1992 Rio Earth Summit, much of which is because of increasing international pressure on India, China and other fast growing economies to conform to the global environmental principles.

Table 1: Top Ten Polluting Countries (The Hindustan Times, 3rd October, 2016)

Country	**Total carbon dioxide emission from the consumption of energy (in million metric tons)**
China	8715.31
U.s	5490.63
Russia	1788.14
India	1725.76
Japan	1180.62
Germany	748.49
Iran	624.86
South Korea	610.95

THE PARIS CLIMATE ACCORDS: INDIA'S PERCEPTION

The most recent climate accord that has been reached upon by consensus on 12 December 2015 within the fold of United Nations Framework Convention on Climate Change (UNFCCC) is the Paris Climate Accords. The Paris Agreement stipulates the contracting members to put in their highest efforts through 'nationally determined contributors' (NDCs) and to strengthen these efforts in the years ahead.

This includes requirements that all parties report regularly on their emissions and on their implementation efforts. There will also be a global stock- take after every five years to assess the collective progress. Interestingly enough, Articles 9, 10 and 11 stipulate the developed countries to support the efforts of the developing countries to build clean, climate- resilient futures, encouraging voluntary contributions("What is the Paris Agreement?: UNFCCC").

India extending its support to the Paris Climate Agreement ratified the treaty on 2 October, 2016. According to the Paris Accords, each member country must make binding national commitments to restrict Carbon Dioxide emission to keep global average temperatures from rising above 1.5 degree Celsius as compared to pre-industrial years. India, which is an active party to the Accords, has made known its plans to reduce its Carbon Dioxide emissions (emission per unit of GDP) by 33-35 percent by 2030 and increasing its dependence on non- fossil fuels, that is, renewable energy sources and India has pledged to increase its forest cover by 5 million hectares by 2030(Adoption of the Paris Agreement 2015).

However, in a very surprising move, the United States pulled out of the Paris Agreement in June 2017. Amidst the whole raising hue and cry on this issue, President Donald Trump has justified his decision by arguing that such an agreement would have been disastrous for his country and has blatantly charged India and China as the most significant beneficiaries of this agreement. He is particularly against Articles 9, 10 and 11 which instruct the developed countries to support the developing countries in the transitional phase of combating climate changes. To quote Trump:

> "…we have massive energy reserves. We have coal. We have so much…And basically, they were saying, 'Don't use it. You can't use it.' So what it does is it makes us uncompetitive with other countries." He further remarks, "Other countries, big countries- India and others- we had to pay, because they considered them a growing country…They were a growing country. I said, what are we? Are we allowed to grow, too? Ok? No…They call India a developing nation. They call China a developing nation. But the US? We are developed. We can pay."("Trump blames India, China for his decision to withdraw from Paris climate deal" 2018).

Thus, when the Western world is pointing fingers at India and China for the initial setback of the Paris Agreement, India's the then Minister of Power remarked in the Documentary entitled "An Inconvenient Sequel: Truth to Power":

> "I will do the same thing after hundred and fifty years, after I have used my coal, after I have got my people jobs, after I have created my infrastructure, highways and roads, when I have technology, when my people earn 57,000 per capita income, using low cost fossil fuel- based energy, the way the US did for hundred and fifty years. It is very easy to say now 'oh, we are not using coal' but what about the past. So, I am only asking for the carbon

> space that you utilized for hundred and fifty years" ("Inconvenient truth for India in Al Gore's documentary?" 2017).

Thus, we see, India stuck in the quagmire of duality of presently being a major emitter of greenhouse gases and at the same time historically not responsible for the present scenario of climate change. Despite India's phenomenal economic growth in last few decades, it still has a whopping twenty one percentage of population languishing below the poverty line. Therefore, after the withdrawal of the US from the Paris Accord, India and China have great opportunities to emerge as global leaders in combating climate change. The Prime Minister of India, Narendra Modi has described the agreement as part of "our duty to protect Mother Earth" and has promised to go even "beyond" the Paris Accords in this respect. ("Trump climate deal: Modi vows to go beyond Paris accord" 2017).

Therefore, till the very recently concluded Paris Climate Agreement, India, along with the help of mighty China, have been successful in thwarting the pressures from a section of the Western world to do away with the principles of "common but differentiated responsibilities" and obligation to provide financial and technical support to the developing countries by the developed ones. The US- led section of the Western world argues if China and India can at all be put in the same bracket with other developing countries in the 21st Century. With the tremendous economic growth of both China and India, both the countries realize that the Paris Agreement was a 'very hard fought one' (Elliott et al. 2017). It is heartening that India is promising to "go beyond" the Paris Accords and contribute significantly to the global fight against climate change, yet its high percentage of citizens reeling below poverty line, domestic economic challenges and lack of sufficient modern technologies at its disposal, are the major roadblocks in the way of India's making major strides in fighting climate change.

COMBATING CLIMATE CHANGE: EMERGENCE OF SINO- INDIAN LEADERSHIP IN THE 21ST CENTURY

Realizing fully well that their unity and mutual collaboration is the bulwark against Western pressures, India and China are increasingly cooperating on the issue of Climate Change. This is despite the fact that both these countries have considerable political and strategic differences for decades. Some years back, in October 2009, India and China reached a bilateral "Agreement on Cooperation on Addressing Climate Change". It reiterated the friendship of both these countries on the issue of tackling climate change and at the same time, reaffirmed the principle of "common but differentiated responsibilities". In this Agreement, the two sides pledged to hold ministerial consultations to deepen mutual understanding, strengthen coordination and to foster regular exchange of views. Furthermore, both these countries agreed to establish an India- China Working Group on Climate Change, which will be responsible to hold annual meetings alternately in China and India to exchange views on important issues concerning international negotiation on climate

change, respective domestic policies and measures and the implementation of related cooperative projects. As areas of mutual collaboration, the two sides identified the following areas: (a) joint research and development activities, including commercially viable research and development; 5 (b) demonstrations of technologies and application development; (c) organization of scientific seminars, symposia, conferences and workshops as well as participation of experts in those activities; (d) Public Private Partnerships (PPP); (e) Any other mode of activity jointly agreed in writing by The Two Sides. This agreement remains an exemplary one till date as a model of cooperation between two Asian giants on the issue of climate change, leaving their differences of opinion on other issues aside ("Agreement on Cooperation on Addressing Climate Change…."2009).

With the exit of the United States from the Paris Climate Accords, India and China have a huge opportunity to play the leadership role in climate negotiations and proactively commit to fulfill exemplary responsibilities in combating Climate Change even while balancing their respective national developmental needs. Moreover, India has prioritized her ties with the BRICS (which India has formed with Brazil, Russia, China, South Africa) and the BASIC countries (a bloc of four large newly industrialized countries, Brazil, South Africa, China along with India) and there is an increasing pressure from the Western nations on these countries to conform to the global environmental norms, standards and principles. This necessitates these countries to collectively voice their concerns and make them heard on the international podium. This would require united strength and deft diplomacy. It is hoped that they would measure up to the challenges ahead.

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Environmental Issues: Approaches and Practices (2019), 1:47-51
ISBN: 978-81-939266-1-1

Environmental Consciousness in Indian Fables: How and What the Pañcatantra can Teach Our Children

Nivedita Bhattacharya

Abstract Environmental crisis and destruction of environment is perhaps the single gravest danger that the earth faces today. Children are observant and learn easily. They observe events in their immediate surroundings. In order to ensure that our children preserve what is rightfully theirs, i.e. an earth which will hold them securely, their love for and consciousness of the environment should be instilled in them from a very early age. Literature can help in achieving this goal; and children's literature is where one should begin. In order to develop this awareness in children it is imperative to develop an environmentally conscious reading of literature more appropriately called green reading or eco-centric reading of texts. Eco-criticism is defined as the relationship between nature and literature and how nature is represented in a text. Fables, myths and folklore are an important part of children's literature. Some of the oldest fables in the world originate in India. The Indian fables have been in circulation for many centuries and were finally collected under the guidance of sage Vishnushama and titled Pañcatantra meaning the five tantras or books on policies or nitis. This paper deals with the representation of the environment in the fable of the Pañcatantra. An eco-centric reading of the Pañcatantra can reveal how children can have informative reading about nature, how nature functions and the positive effect of nature on living beings.

Keywords Green reading, Eco-centric reading, Pañcatantra, fables, children's literature

INTRODUCTION

Environmental crisis is one of the greatest dangers that our children will face in the future. Air and water pollution, disappearance of forests and water bodies, global warming and acid rains can lead to extreme hardships and perhaps even extinction of our race. Thus creating environmental awareness and love for environment in our children has become important. This is what brings us to the green reading of texts, or an ecocentric reading of texts particularly of children's literature of which fables form an inherent part.

If we want to develop environmental awareness through text reading it is imperative that one understands the concept of ecocriticism. Ecocriticism is defined by Cheryll Glotfelty as follows:

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Environmental Issues: Approaches and Practices (2019), 1:47-51
ISBN: 978-81-939266-1-1

"...study of the relationship between literature and the physical environment....ecocriticism takes an earth-centred approach to literary studies. Ecocritics and theorists ask questions like: How is nature represented in this sonnet? ..." (Glotfelty, Introduction xviii, 1996). Ecocriticism and green reading of texts is literature's answer to the challenges of environmental concerns in today's world.

> We are facing a global crisis today, not because of how ecosystems function but rather because of how our ethical systems function. Getting through the crisis requires understanding our impact on nature as precisely as possible, but even more, it requires understanding those ethical systems and using that understanding to reform them. Historians, along with literary scholars, anthropologists, and philosophers, cannot do the reforming, of course, but they can help with the understanding (Donald, 27:1994).

Children are the most sensitive to their environment and observant. This makes them good learners and easiest to mould. They are curious and observant. So an environmentally interpretative reading of a literature catering to the imaginations of children can mould them to develop an eco-sensitivity that they will carry into adulthood. Fables and folklores have been an important part of children's literature. Fables have been used all over the world as tools for moral, social and political instruction. They have used their allegorical and anthropomorphic forms to entertain and instruct children, the method of instruction being so subtle that children internalise them without realising. Thus fables form an important part of children's literature.

This article shows how there can be an alternative way of reading the *Pañcatantra* (the celebrated collection of Indian fables) as opposed to reading it only for reasons of teaching moral value and political and social systems-asking Glotfelty's question of how nature is represented in the text as also how such a reading can create environmental awareness in children.

ENVIRONMENTAL CONSCIOUSNESS IN THE PAÑCATANTRA

In India the fables of the *Pañcatantra* is a collection of fables known to be one of the most ancient in the world. They have been widely translated and have travelled the world to be integrated and absorbed in other countries and cultures, whether manifestly or covertly.

> Even to this day, there are at least a few stories from the *Pañcatantra* which are incorporated in literature books in the curriculum of most schools, at the junior level. Thus the fables of the *Pañcatantra* have a positive formative effect on children even though the *Pañcatantra* was probably originally conceived to serve as instruction for the art of politics. Since fables primarily use anthropomorphic forms, primarily in the form of speaking animals and trees, by their very nature fables create awareness about the environment:

Environmental Issues: Approaches and Practices (2019), 1:47-51
ISBN: 978-81-939266-1-1

animals, trees, water bodies and other natural habitats of animals.

For the purpose of this article the translation of Arthur Ryder of the *Pañcatantra* will be treated as the primary source as in this translation, Ryder not only remains completely faithful to the form of the text (translating prose to prose and verse to verse) but also avoids any analysis or critical comments in the main body of the text. The *Pañcatantra* is divided into five books or tantras (meaning *nitis*), with an introduction which gives a description of the ignorant sons of the king of Mahilaropya who had three sons who were stupid and uneducated. Desperate to make his sons worthy of being princes the king seeks the help of the Brahmin Vishnusarma who uses fables to impart education to the princes. The stories he narrates have been organised into five texts: Mitrabheda (Loss of Friends), Mitralabha (Acquisition of friends), Kakulokiya (the war of crows and owls), Labdhapranasha (loss of gains) and Aparikshitakarak (ill considered action). Talking of environmental consciousness in the *Pañcatantra* and other Indian folklores and folktales Aditya Narayan Dhairyasheel Haksar says, "... I would describe them as folklores with a strong environmental sense. They cover different aspects of nature but are not confined to that. Underlying these tales is the belief that unity encompasses human as well as non-human forms. These stories display a fairly exact knowledge and understanding of environmental phenomena, of seasons, of climatic changes, of birds, beasts and vegetation. While describing animals and plants, the writers of these anthologies show a great sympathy towards them."('Ancient Indian literature … phenomena' 2018)

How does the *Pañcatantra* create awareness about the environment? To begin with, the *Pañcatatra* has far more stories situated in milieus that are away from urban areas rather than in cities and towns. The very first Book or Tantra (Mitrabheda) begins with the story of a merchant from the city. Having given a description of city of Mahilaropya in details and in all its splendour the scene very quickly shifts to that of a forest which has to be traversed by the merchant Vardhamana with his two bulls, Nandaka and Sanjivaka. The first tantra gives a beautiful description of the forest with detailed information on its trees and animals. The forest was dense with trees like acacias, sals and dhaks and animals like elephants, tigers, boars, deers and wild oxens. The water was pure and plentiful and there were caves (Ryder, 21:1925). The description is so picturesque that it is very easy for a child to transport himself in his mind to these natural surroundings, far away from the populous environment of a city or a town. The child reading it gets a lot of information on the fauna and flora of an Indian forest. If this is combined with a nature trip to identify some of the trees cited, the child's awareness about the preservation or the loss of such flora or fauna is heightened.

The frame fable touches with its story of how Sanjivika is abandoned by his owner as he gets injured. No thought is spared for his survival as the merchant and his companion decide to move on with their business. However, Sanjivika soon recovers on feeding upon the fresh green grass of the forest. This is the first indication of the importance given to environmental factor. The freshness of the environment helps an animal to survive.

On the other hand the final demise of Sanjivika in the hand of Pingalaka due to the intrigue of the jackals (Karataka and Damanaka) is a demonstration of the functioning of the food chain. The bull is the natural food of the Lion and the jackals who contrive to get Sanjivika killed by the lion are scavengers feeding off the flesh of a dead animal. The child unconsciously internalises this arrangement of nature. The same frame story talks about the principal characteristics of some animals when they exist in their natural surroundings. This is done in a beautiful manner: in verse form. "The lion scorns the jackal..." (Ryder 1925) and "Dogs wag their tails and fawn and roll..." (Ryder 1925).

There are stories like the "Blue Jackal" which teaches about the pack behaviour of jackals. The jackal gets caught because he cannot resist responding to the call of other jackals. The entire third book deals with crows and owls. We come to know about the nocturnal nature of owls. We know that they are flesh eaters. On the other hand man is criticised as being greedy. This has an underlying implication: that man can cause destruction to his surroundings. "Since cattle draw the plough/Through rough and level soil" (Ryder, 28:1925) teaches the child that cattle are used for ploughing and farming. The fable "Monkey and the Crocodile" (Ryder 1925) underlines the repercussions of the change of habitat of animals. The monkey who is a land animal loses his survival instinct when he is taken into the water by his crocodile friend. At the same time the crocodile (the amphibian) has no idea about the ways of a land animal underlined by the fact that he believes the monkey when he says that he has kept his heart on a tree.

CONCLUSION

S K Mishra (2016) rightly observes that "Indian philosophy is rich in ecological thought since Veda which paid equal importance to all organisms. India is also a land of rich biodiversity. From the Himalayas of North to Kanyakumari of South, from the Bay of Bengal off east to the Arabian Sea on the west, the country has versatile physical surroundings leaving a deep impact on human beings. Literature is not apart from that. A good number of writers deal with ecocritical texts" (Mishra, 169: 2016). Thus it is little wonder that *Pañcatantra* represents nature at its purest. It depends on the teacher or the parent to put emphasis on this aspect to create environmental awareness in the child. Makwanya and Dick (2014) in their analysis of the role of children's poem in creating environmental awareness concluded that "children's literature promotes

environmental consciousness, appreciation, knowledge, and stewardship of the children. In addition, in order to inculcate long lasting impression on environmental stewardship, it has been concluded that catching them young is the best method (Makwanyna and Dick, 15: 2014).

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Environmental Issues: Approaches and Practices (2019), 1:52-59
ISBN: 978-81-939266-1-1

Hugging the Trees: Chipko Movement (1973 - 1981)

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Abstract Chipko movement was an ecological and social movement concerned with the preservation of forests and thereby with the maintenance of the traditional ecological balance in the Sub-Himalayan region. It started in 1973 in the Garhwal Himalayas under the leadership of men like C. P. Bhatt and Sunderlal Bahuguna. It was a wide spread movement that resisted excessive cutting of the trees and destruction of forests by outsiders by hugging the trees. Local men and women also played an important role in the movement. Gandhian techniques of nonviolent protests were used in this movement. Chipko movement continues to inspire environmental movements in India and globally even today.

Keywords Gandhi, Women, Chipko Movement, Himalayas, Sarvodaya

INTRODUCTION

As late as 1980, Lester Thurow the noted MIT economist wrote that countries interested in environmental issues or individuals supporting it are generally from upper middle class. 'Poor countries and poor individuals simply aren't interested' (Guha 2016). But poorer countries have seen considerable rise in movements relating to gender, ethnic and environmental issues. Seven years before Lester Thurow's statement Chipko movement in India had decisively demonstrated the involvement of the poor into the domain of environmentalism. The Chipko movement was an ecological and social movement concerned with the preservation of forests and thereby with the maintenance of the traditional ecological balance in the Sub-Himalayan region. Here people share a natural and spiritual bond with nature and for them forest preservation or river preservation becomes synonymous with a movement for protecting their own local and marginal identity against outside encroachments. The hill people traditionally maintain a positive relationship with nature and a strong veneration for environment. H. Rangan suggests that Chipko movement had taken on an iconic status and is certainly seen by many as an inspiring example of local action against the alienating and destructive incursions of modern development state (Rangan 1996; Escobar 1995; Bandyopadhyay 1992; Ekins 1992; Redclift 1987).

In the recent times Chipko movement have been analysed from different dimensions. Ramchandra Guha has viewed Chipko in terms of the changing relationship between the state and peasantry. He also emphasised the social changes that created a 'money- -order' economy and an asymmetrical

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demographic profile in the villages of Uttarakhand. According to Guha it can be understood as a response to the fragmentation of village community in recent times. It was an organised and sustained social movement which embraced other social issues and sought alternative strategies of resource use and social development. Women participation was also an important aspect of this movement (Guha 1989*a*). Vandana Shiva employs an eco-feminist perspective to assert that Chipko struggle was "explicitly an ecological and feminist movement" (Shiva 1988). Tom Brass has however, argued against these perspectives. According to Brass the new social movements in India, such as the farmer's and environmental movements are mainly neo-populist and middle class in nature trying to uphold structures of power and privilege to their own benefits rather than transforming them to the advantage of the oppressed communities (Rangan 2000*a*). Gail Omvedt argues somewhat differently when she pulls up the Marxists of big Communist Parties for characterising the ecology movements as 'petty bourgeois' rather than delving into the social base of the peasant of farming community and tribal people (Rangan 2000*b*).

CHIPKO MOVEMENT – ROLE OF CHANDI PRASAD BHATT

The Chipko movement was initiated by a group of Sarvodaya workers (followers of Gandhi's disciple Binobha Bhave). It officially began on April 24, 1973 at Mandal, Chamoli district of Garhwal Himalayas. Inspired by Gandhian ideals Sunderlal Bahuguna and Chandi Prasad Bhatt played a very vital role by involving the poor people into the domain of environmentalism (Guha 2016). In 1956 Bhatt heard a speech by the Gandhian leader Jayprakash Narayan and adopted the Sarvodaya movement and the Gandhian campaigns of Bhoodan and Gramdan.

Sarvodaya members led by C.P. Bhatt became active in the field of social reconstruction. While many young men had left the Garhwal Himalayas in search of new employment, Bhatt stayed back to deal with the growing social problems. He decided to accept the challenge of community building. He wanted to find alternative source of employment for the younger generations so that they live a dignified life in their own homeland (Mishra and Tripathi 1978).

In 1960 the Sarvodaya workers established workers' co-operative which organised unskilled and semiskilled construction workers. The group established Dasholi Gram Swarajya Sangh (Dasholi Village Self- Reliance Cooperative) in 1964 with the aim of starting village industries based on the natural resources of forest. He believed in development without destruction and creating a right atmosphere of work. The cooperative entered the market by buying forest rights though auctions to supply its small workshops manufacturing farm tools for local use. The scale of production in these units was not only relatively low but also dependent to a large extent at the mercy of the forest Departments production and management policies. However, after initial success they were being out manoeuvred by wealthy contractors.

Meanwhile DGSS started a project of collecting roots and herbs from the forest and in their endeavour they gave employment to 1000 villagers amid 1969 to 1971. In 1971 it opened a small processing plant in Gopeshwar, which manufactured turpentine and resin from pine sap. The government was not co-operative enough and did not allot adequate supplies of pine sap even when the price paid for it was higher than that paid by a partly state owned producer in the plains. For eight the plant had to be closed because of the paucity of raw material. The plant was operational for only four months. On 22 October 1971, the Sangha workers held a demonstration in Gopeshwar against government forest policy. In the meantime the Forest Department turned down the Sangha's annual request for ten ash trees for its farm tool workshop and instead handed over a contract for three hundred trees to Symond Company, a sporting goods manufacturer from the Allahabad to make tennis racquet. In March 1973, the agents from the Symond Company arrived at Gopeshwar to supervise the cutting of trees. On March 27 1973, at a meeting at Gopeshwar local people decided not to allow a single tree to be felled by the Symond agency. A month later on 24 April the DGSM workers marched from Gopeshwar to Mandal, beating drums and singing traditional songs. A compromise was struck whereby the government would allot DGSM ash trees on condition that the goods firm could take its quota. But the stiff resistance of the Sangh workers could not be broken and the Symonds Company was forced to turn away (Guha 1989*b*).

In June a new set of ash trees was allotted to Symonds Company near the village of Phata, in the Mandakini valley, en route to Kedarnath 80 kilometres from Gopeshwar. When the DGSS workers came to know of it they contacted late Kedar Singh Rawat, a prominent social worker of the region. On June 24, 1973 despite heavy rainfall the Sarvodaya workers organised a Chipko demonstration in Phata. The Company's agents returned to Gopeshwar and complained at the forest office that despite depositing the guarantee money they were unable to fell trees assigned to them (Guha 1989*c*).

The government however, did not heed these early protests and continued with the yearly auction of forests in November, 1973. One of the plots earmarked was the Reni forest, located near Joshimath in the Alakananda Valley. The area was already affected by floods in the recent past. It was inhabited by the Bhotiya community who had opted for settled agriculture instead of nomadic pastoralism. When the news was disclosed the DGSS workers contacted Govind Singh Rawat of the CPI party and found that 2000 trees had been earmarked for felling. Meetings were organised and C.P. Bhatt suggested the adoption of Chipko technique (hugging of trees).

The felling were scheduled to be held at the last week of March 1974. On March 25 a massive demonstration was organised in Joshimath where college students threatened to begin a Chipko movement unless the felling procedures were called off. Sensing trouble the forest department took to deception. On March 26 the men of Reni and neighbouring villages were

called to Chamoli to receive the compensation for lands appropriated by the Indian army after the Chinese invasion of 1962. Taking advantage of this situation the lumbermen proceeded to the forests. But in Reni the faced stiff opposition from the women who refused to bow down .The lumbermen had no option but to retire (Guha 1989*d*).

The movement in Reni will be remembered in the annals of the history of Chipko movement. Firstly women participation took place in a major way and secondly government could no longer dismiss it as a reaction 'of the motivated local industry deprived of raw material.' (Guha 1989*d*). It was hailed as a peasant movement in defence of traditional forest rights. The Chief Minister of U.P. H.N. Bahuguna agreed to set up a committee to look into the incident. Commercial felling procedures were banned for a decade in the upper catchment of Alakananda River and its tributaries. C.P. Bhatt and his followers continued the mode of reconstruction through afforestation camps, installation of bio-gas plants and other low cost energy saving devices. The rate of survival of saplings by afforestation camp was 65 to 80 percent in comparison to government which was 10 to 15 percent (Guha 1989*e*). DGSS workers claimed that it was done through the participation of local people. The Chipko movement spread to different parts of Himalayas namely the Tehri, Kumaon, Chamoli and Badyagarh. The success of the movements here depended to a great extent on the role of Sunderlal Bahuguna.

SUNDERLAL BAHUGUNA: THE DEFENDER OF HIMALAYAS

Sunderlal Bahuguna played a very important role in the preservation of the forests. He joined the Indian politics in 1947 and was elected as the general secretary of Tehri Garhwal branch of the Congress party. He moved away from formal politics and set up an ashram on Gandhian principle. Initially he followed the policy of Bhatt and DGSS in organising forest labourers in the fight for economic independence from big forest contractors. But very soon Bahuguna witnessed that forest contractors were replaced by forest corporations and growth of forest based industries. He now realised that all industries based on felling of tress was harmful. Bahuguna wanted all commercial green felling to be stopped and no new contracts to be entered with industrialists to supply raw materials. Here Bahuguna deviates from Bhatt who believed in fostering local industries based on conservation and sustainable use of forest wealth for local benefit. Bahuguna thought of Chipko movement as a humble effort to materialise the messages of Indian culture as revived by Gandhi. The tactics involved in the movement were nonviolent strategies like Satyagraha, fasts, rallies of protest and persuasion. Bahuguna organised several Chipko protests and gave wider publicity to Chipko cause by his foot marches, fasts, writings and lecture tours. He used popular idioms and Gandhian aphorisms in all his narratives and public meeting. Bahuguna very skilfully blended Gandhian maxims, environmental doom sayings, and populist critiques of western models of development and asserted the

spiritual relationship between humans and nature (Rangan 2000*b*).

During 1975 he spent most of the year on padayatras or hiking, interacting with the villagers and witnessing the destruction of nature with his own eyes. He believed that the trees must be availed by the local people for meeting their needs of fuel, fodder and wood but the trees could not be felled for commercial purposes by any one. According to Bahuguna ecological crisis had taken a great proportion.

In the middle of 1977 Bahuguna and his followers met at Dharam Ghar and demanded the stoppage of the commercial exploitation of green trees in the Himalayas for a decade (Weber 1987*a*). In 1979, before the cutting of trees in the Malgudi forest, sarvodaya workers, trusted lieutenants of Bahuguna came to Badiyargarg to find out the grievances of the people. They travelled through villages informing the people about the proposed felling of trees and its detrimental consequences. The movement started on December 25 1978 but reached great proportion when Bahuguna went on a hunger strike from January 9, 1979 (Guha 1989*f*). In the words of Bahuguna, 'when all our proposals, requests and people's representation failed to persuade the UP State government to stop green felling in the hills and felling of trees started in full strength in the sensitive catchment of the Alakananda in spite of people's protests ...I have started this self-imposed penance to awaken the sleeping spirit of the conservatives to save Himalayas and ultimately the flood devastated country.' (Weber 1987*a*). Bahuguna was taken away by the police and lodged in Tehri jail. The fellers met with stiff resistance from the villagers in spite of the arrest of their leader had to abandon their plan of felling trees and conceded defeat. On January 31 the cancellation of felling of trees at Amarsar and Badiyargarh was ordered and two days later a blanket moratorium was announced (Weber 1987*b*). This government order did not go down well with Chipko leaders including Chandi Prasad Bhatt who stated his opposition to the abridgement of any of the people's right and quoted a sarvodaya worker that 'no environmental policy can succeed if it ignores the people in that environment, who are as much a part of it as the trees, rivers and mountains' (Weber 1987*c*).

Bahuguna did not perceive Chipko as a movement merely to protect trees. For him it was a movement to re-establish a harmonious relationship between man and nature. He felt economic crisis in the hills could be solved by addressing ecological crisis. In 1981 he went on an indefinite fast urging a total ban on green felling in the Himalaya above an altitude of 1000 mts. In response to this government recommended an eight member expert committee to report on Himalayan forest policy. The government allowed a fifteen year moratorium on commercial felling in the Himalayas. It was a victory for Bahuguna because he held commercial forestry and the close links that exist between contractors and forest officials responsible for the deteriorating Himalayan environment. Ramchandra Guha states that the fifteen year moratorium marked the end of an epoch for the people and landscape of the Indian Himalayas (Guha 1989*g*).

Bahuguna directed his appeal to the national government and succeeded in getting the attention of the politicians in New Delhi. He presented tree protection as the conduit through which Himalayan nature and culture as well as India's integrity and cultural heritage could be defended. Following Gandhian model he criticised modern science and technology which led to unbridled exploitation of nature. He believed in spiritually infused science and technology which can enable all living beings to use the fruit of nature like food, fodder, fuel, fertilisers and fibre trees (Rangan 2000*c*). Sunderlal Bahuguna preferred to connect Himalayan deforestation with national and global environmental concerns rather than limiting it to local issues.

ROLE OF WOMEN IN THE CHIPKO MOVEMENT

In the words of Ramchandra Guha a unique characteristic of hill agriculture throughout India is the prevalence of women and the important role assigned to them. Joint participation of men and women are extremely important in the difficult terrain to sustain a family. Hence women of the house become equal partners in the struggle to attain economic security. Except ploughing, women helps in all other work like working in the field with men, domesticating animals, household and husband and child care. In the Chipko movement the women also played an important role (Guha 1989*h*).

In Reni village Gauda Devi a young child widow played an important role in warding off labourers who had come to cut trees. The forest officials in a planned manner had asked the menfolk to come to Chamoli on March 26, 1973 and collect their compensation cheque for the land that had been appropriated during Chinese war. While men from Malari, Reni and Lata villages were absent the axemen moved in. Gauda Devi rushed to the spot with twenty seven women and young girls to combat the men who were rude and even brandishing a gun to frighten them. Gauda Devi moved to the front and challenged the gunman. She compared the forest to her mother's home and persuaded them not to cut the trees. The women guarded the pathway to the forest whole night. The axemen returned the next morning. Four days the villagers guarded the forest. The trees of the Reni forest were thus saved by the bravery of the hill women (Weber 1987*d*). However, this unforeseen release of women power was frowned upon by their male counterparts who wanted final control of policy making and planning (Weber 1987*e*). Yet their bravery and strength cannot be undermined.

CONCLUSION

The uniqueness of Chipko movement lay in the fact that instead of being led by professional leaders it was guided by common rural population. Chandi Prasad Bhatt and Sunderlal Bahuguna were the two important leaders of the movement. Both wanted to protect nature but their views were different. The movement has also been generated a lot of debate and has been analysed by environmental historians from different angles. Irrespective of Chipko's grassroot achievements, it has accomplished a lot in the national and international domain. Chipko had put

forests on the political agenda of our country. The Forest Conservation Act of 1980 and the creation of Environmental Ministry was possible because of the movement. Yet it may be said that Chipko movement had the potential to be a radically political movement for self-determination and self-management of the resources yet it remained a purely conservationist one.

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Environmental Issues: Approaches and Practices (2019), 1:60-84
ISBN: 978-81-939266-1-1

Air Pollution and Pulmonary Fibrosis: A Mechanistic Perspective

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Abstract Fibrosis is a major global problem accounting to ≈45% of deaths in the developed countries. Fibrosis-associated extensive tissue remodeling, organ failure and consequent mortality is evident in diverse diseases including liver cirrhosis, systemic sclerosis, cardiovascular fibrosis, nephritis and most notably pulmonary fibrosis (PF). PF is characterized by thickening and scarring of lung tissue with reduced vital capacity which interferes with the ability to breathe. According to the World Health Organization, deaths due to lung diseases in India were on the rise accounting for 11% of the total deaths, thereby ranking India 1st in lung disease-associated deaths. PF comprises 15% of the pulmonary physician's practice and interestingly, the Indian Council of Medical Research has estimated the incidence of Chronic Obstructive Pulmonary Disease as 5% in Indian men. In fact, PF is among the most severe complications of interstitial lung disease (ILD), which are heterogeneous admixture of acute to chronic inflammatory and fibrotic lung pathologies characterized by proliferated and thickened pulmonary interstitium. With the advancement in the understanding of PF pathogenesis, it is becoming further clear that air pollution (AP) is a major etiological contributor. A recent report projects AP to be the third highest cause of deaths in India. The problem is more significant in developed/developing cities where industrial and automobile exhausts largely contribute to the deteriorating environmental health. The present review precisely discusses the role of AP in the development of PF along with comments on the future perspectives in PF-research as well as regulatory strategies to control AP.

Keywords Air pollution, pulmonary fibrosis, myofibroblasts, TGF-β1, cigarette smoke, particulate matter

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INTRODUCTION

Fibrosis is a severe clinical complication characterized by scarring and hardening of the affected tissue due to exaggerated deposition of extracellular matrix (ECM) components including collagen and fibronectin (Wynn 2008). The process initiates as a normal wound healing response where fibroblasts participate to repair the injury by producing ECM. But owing to the loss of control in the repair process, due to unregulated fibroblast activation under the

influence of various proinflammatory cytokines and chemokines (predominantly transforming growth factor-β1, TGF-β1), the parenchyma hardens resulting in organ damage. Fibrosis is progressive, irreversible and debilitating. It affects multiple organs including liver, heart, kidney, lungs, skin and intestine. Multiple causes including genetic and epigenetic factors contribute to the pathogenesis. Chronic inflammatory conditions often end up with fibrotic organ failure. Pulmonary fibrosis (PF) is a very common complication where the lungs stiffen resulting in breathing trouble in patients. The histological appearance (upon surgical lung biopsies) largely resembles typical features of usual interstitial pneumonia (UIP). In the lungs, type I alveolar epithelial cells (AECs I) predominate the alveolar surface mediating gaseous exchange besides controlling AEC-II-dependent surfactant secretion for lubrication. In response to pulmonary injuries, AECs-I die and AECs-II initially grows in order to cover the injured surfaces. These hyperplastic AECs-II later die after the wound is repaired and the remaining cells differentiate into AEC-I. However, chronic cycles of injury-repair accompanied by faulty restoration process and alveolar epithelial-mesenchymal crosstalk defects result in pre-mature death of even AECs-II along with accumulation of resident fibroblasts in these foci leading to fibrogenesis (Hosseinzadeh et al. 2018). Diverse molecular pathways activate pro-fibrotic signaling. Wingless/Int (WNT)-β-catenin pathway, TGF-β1-SMAD pathway and recently YAP/TAZ-Hippo pathway have been extensively explored in regards to establishing anti-fibrotic targets. Most of these pathways converge at some points and signaling cross-talks occur for maintaining myoFB phenotype and nuclear translocation of transcriptional up regulators for pro-fibrotic gene expression (Piersma et al. 2015). Fibrosis initiates as a typical inflammatory process with complex interplay of $T_{cytotoxic}$ and T_{helper} cells. Th1-derived cytokines initiate the proinflammatory signaling in response to injury which later shifts towards the Th2 arm to allow a chronic inflammatory and fibrogenic state (Wick et al. 2010). Among T_{helper} cells, Th2-derived cytokines (including IL-4, IL-5, IL-10 and IL-13) have been found to especially contribute to fibroblast activation and matrix development (Keane 2008). Of the various pro-inflammatory cytokines (including IFN-γ, IL-12, IL-18, TNF-α, IL-1β, IL-4, IL-5 and IL-10) and chemokines (including CXCL2 and CXCL3), that have been evidently linked with fibrosis, TGF-β1 is the foremost critical mediator of fibroblast activation that triggers their transformation into myofibroblasts (myoFBs), which attain hyper contractile properties owing to the over expression of specialized proteins including α-smooth muscle actin (α-SMA) (Kolahian et al. 2016). In the lungs, TGF-β1 is produced by alveolar macrophages, activated AECs, neutrophils, platelets, fibroblasts and myoFBs. In fact α-SMA-induced contractile force generated from the activated myoFBs has been found to activate latent TGF-β1 from the ECM which in turn triggers more fibroblast trans-differentiation to myoFBs in a perpetuating positive feed-back loop (Zhao et al. 2018). Moreover, α-

SMA is also directly implicated in wound contraction by ECM remodelling and has been documented in stress fibers (Shinde et al. 2017). These myoFBs are highly efficient in ECM deposition and maintain a dynamic relation with their microenvironment during tissue repair, with reciprocal actions leading to cell differentiation, angiogenesis, proliferation, quiescence, and apoptosis. During normal wound healing, α-SMA-dependent myoFB contraction plays crucial role in maintaining tissue architecture and wound closure via contraction of the granulation tissue. After sufficient collagen deposition and resolution of wound, the activated fibroblasts die. However, the reciprocal interaction between myoFBs and various cellular/acellular components in their microenvironment gets altered during chronic inflammation, fibrosis and aging (Darby et al. 2014) and the myoFBs become resistant to apoptosis. A detailed discussion on fibrosis-associated changes in myoFB life span and metabolism has been extensively explained (Kis et al. 2011). This results in the loss of metabolic homeostasis and persistence of hyper-contractile myoFBs in the pulmonary interstitium, at the cost of epithelial cells, causing detrimental ECM remodelling (Yazdani et al. 2017), parenchymal retraction and alveolar collapse which ultimately ends up into typical honeycombing of the pulmonary parenchyma, which is a signature of PF (Aburto et al. 2018). Environmental and occupational exposure to pulmonary irritants, smoking, gastroesophageal reflux disease, certain drugs (chemotherapeutic drugs like bleomycin, methotrexate and cyclophosphamide, cardioprotective drugs like amiodarone, antibiotics like nitrofurantoin and ethambutol and anti-inflammatory drugs like rituximab and sulfasalazine), infectious agents, metabolic diseases including diabetes mellitus, systemic lupus erythematosus, sarcoidosis, pulmonary hypertension, lung cancer, radiation therapies and even inherent genetic factors are some of the established risk factors of PF. MyoFB accumulation may be traced back to 4 independent sources including activation and trans-differentiation of the resident fibroblasts in response to lung injuries (Phan 2002), transition of the pulmonary AECs into mesenchymal state by EMT (Kim et al. 2006), origination from pericytes of the pulmonary interstitium and finally differentiation of the bone marrow-derived circulating mesenchymal fibrocytes into fibroblasts (Moeller et al. 2009). In addition to aforesaid determined factors that facilitate fibrogenesis, PF has been often diagnosed with no conclusive underlying cause. These cases with unknown etiological factors are referred to as idiopathic pulmonary fibrosis (IPF) that mostly affects middle-aged and older adults (mostly above 50 years of age) with no cure (Pardo and Selman 2016). In fact, IPF is clinically most challenging among pulmonary complications owing to the dart of non-invasive therapeutic options, progressive nature, complex molecular etiology and an average median lifespan of $\leq$ 3 year in patients post diagnosis (Vancheri et al. 2010). IPF is diagnosed by physical examination, clinical data and high resolution CT images of the chest and histopathological examination of lung biopsies (Lynch et al. 2018). Cigarette

smoking (Baumgartner et al. 1997), air pollutants, microbes (Han et al. 2014; Lawson et al. 2008; Molyneaux et al. 2013; Stewart et al. 1999; Tang et al. 2003), gastroesophageal reflux (Lee et al. 2011; Tobin et al. 1998), genetic predisposition (Allen et al. 2017; Noth et al. 2013) due to mutations (Armanios et al. 2007; Kropski et al. 2015; Stuart et al. 2015; Thomas et al. 2002; van Moorsel et al. 2010) and telomere dysfunction (Alder et al. 2008; Naikawadi et al. 2016; Stuart et al. 2015) are potential risk factors for IPF. Lung transplantation seems the only option in the end stage respiratory anomalies. Hence precise understanding of underlying factors triggering the pathogenesis is essential. Owing to the alarming and concerted increase of air pollution (AP) and pulmonary complications, the present review highlights the unequivocal association of AP and PF along with emphasis on environmental contribution and occupational risk factors, contributing to the pathogenesis. It also highlights some clinical case reports and therapeutic research for identifying potential anti-fibrotic compounds/drugs. Finally, a future perspective in anti-fibrotic research is presented along with suggestion on designing rational preventive measures as an effort to fight this seemingly un-opposable progressive fatal disease.

AIR POLLUTION AND LUNG FIBROSIS

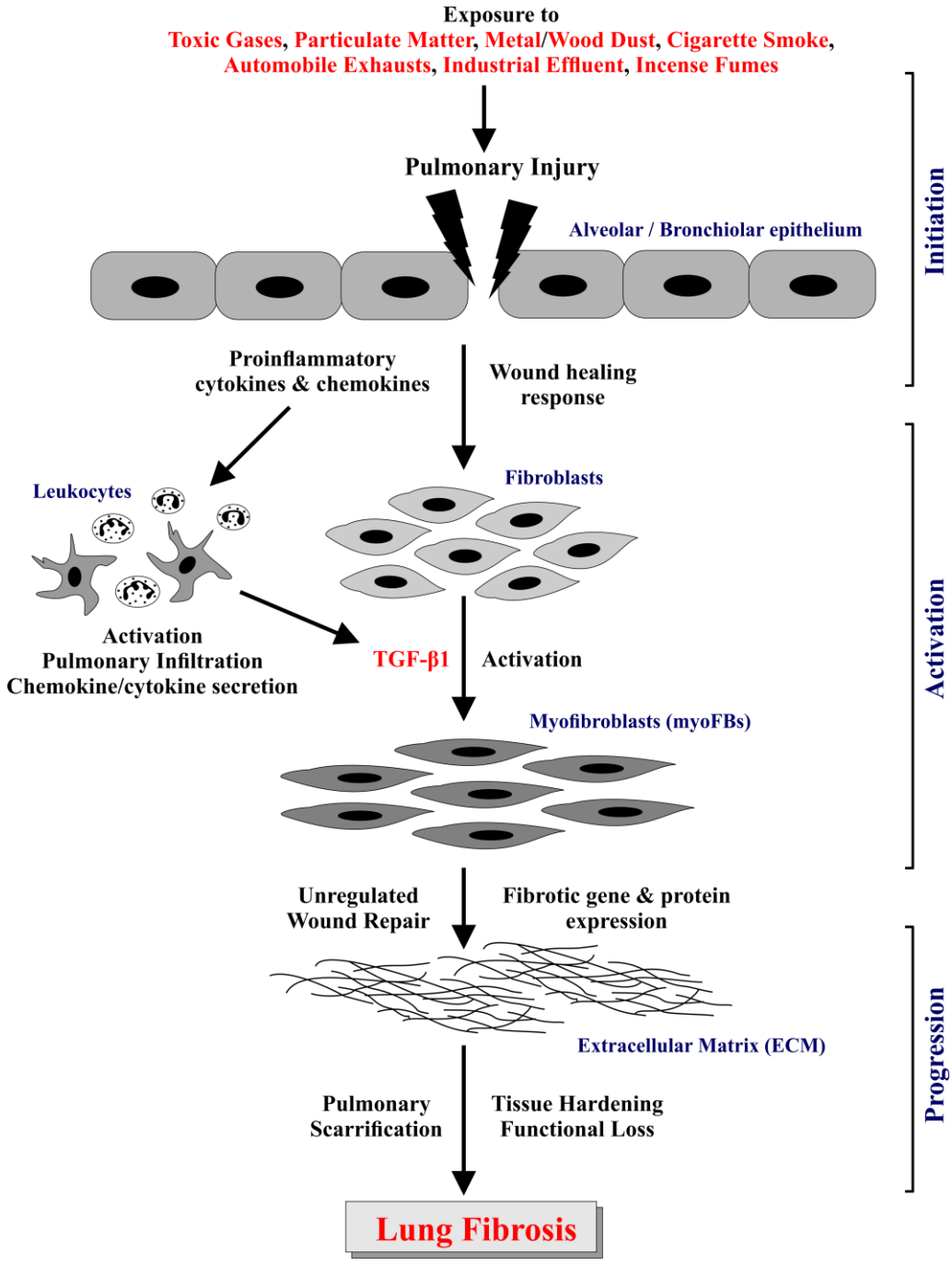
The relation of “bad air” and human ailments stemmed out much earlier (much of 19th century and some quarters of 20th century) when the physicians extravagantly condemned polluted air as the causative factor for seemingly all kinds of diseases. According to the “miasmatic theory”, several diseases like cholera, Chlamydia and plague were caused by “miasma” (μίασμα, ancient Greek: "pollution"), which referred to “pollution” or “bad air” (Halliday 2001). Although this is an obsolete medical theory displaced by the discovery of germs in 19th century, still a number of epidemiological data have correlated AP with the occurrence of IPF, chronic obstructive pulmonary disease (COPD), asthma and even lung cancer. AP is an established risk factor behind multiple respiratory complications with polluted air initiating, accelerating and exacerbating various forms of ILDs through pulmonary and systemic inflammation (Johannson et al. 2015). Occupational and environmental exposure to aluminium, silicon, carbon black, silicon oxide, titanium dioxide, asbestos, ozone [O_3] and nitrogen dioxide cause epithelial cell damage, inflammatory response and oxidative stress which further triggers fibrogenesis characterized by elevated expression of fibrotic markers including hydroxyproline, TGF-β1, MMP-9, TIMP and consequent deposition of collagen fibers in the lung tissue. The influence of polluted air on the natural history of the incidence of PF (Sese et al. 2018b) and functional decline especially in IPF has been extensively studied (Winterbottom et al., 2018). The United States Environmental Protection Agency has classified 6 air pollutants as nitrogen dioxide [NO_2], particulate matter [PM], sulphur dioxide, O_3, carbon monoxide and lead; of which PM, NO_2 and ground-level O_3 are most prominently implicated in respiratory pathologies (Johannson et al.

2015). The quality of ambient PM is a strong determinant of the associated ILD in the people living in that particular area. PM is a heterogeneous admixture comprising of solid particles, liquid droplets and gaseous components from diverse geological sources, metals and end products of fossil fuel combustion like carbon and diesel exhaust-particles. Studies have revealed a significant association of exposure to PM with an aerodynamic diameter ≤ 10 μm (PM_{10}) and IPF progression although little or no link was found with $PM_{2.5}$; although prolonged exposure to air with $PM_{2.5}$ demanded greater oxygen consumption in 6 min. walk-test (Sese et al. 2018a).In fact pollutants like O_3 and NO_2 synergistically contributes to PM toxicity. The potential of air quality as a determinant of ILDs and specifically IPF stems from the fact that PM directly deposits in the respiratory tract epithelia upon long term exposure thereby causing oxidative stress and inflammation along with telomeric distortions in the air way cells (Grahame and Schlesinger 2012). The pro-inflammatory stimuli initiated in the lungs further spread systemically to potentiate the damage. The major contributors of reactive oxygen species (ROS)-induced pulmonary damage are superoxide anions and hydroxide radicals. Endogenous glutathiones counteract these cyto-damaging entities; however, overwhelming accumulation due to acute and persistent pollution overpowers the inherent ability of the lungs to cope up with the insult leading to IPF (Grahame and Schlesinger 2012). The loss of lung function is prominently evident from reduced forced vital capacity (FVC) as monitored by spirometry. These responses eventually turn into systemic complications owing to the development of a perpetual inflammatory state that worsens the prognosis (Sese et al. 2018a). Cigarette smoke (CM) is a significant contributor of AP and risk factor of IPF (Baumgartner et al. 1997; Ye et al. 2014) and smokers are at 60% higher risk of developing and/or exacerbating ILDs (Baumgartner et al. 1997). CM essentially subjects the lungs to encounter volatile organic compounds and PMs of various sizes which often results in aberrant, hyper activated immune response leading to persistent inflammation, airway epithelial injury and consequent fibrosis as a gradual response. In addition to CM, another prominent domestic risk factor significantly contributing to AP and pulmonary complications is incense smoke. In Asian countries, including India, incense sticks are regularly burned as a religious practice. Interestingly, incense smoke contains most of the characterized air pollutants including toxic gases, volatile organic compounds and PM and that too more compared to CM thereby qualifying as an even worse risk factor for various pulmonary diseases including neoplasms (Lin et al. 2008).

Daily exposure to incense fumes is strikingly associated with compromised lung functions as evident from a study in adolescent students (Chen et al. 2017). Prolonged exposure to toxic gases like O_3 and NO_2 also inherently increases the risk of IPF exacerbations. The most significant, but controllable, sources of NO_2 and O_3 in the industrialized portions of the world are emissions from the motor-driven vehicles. Tropospheric O_3 (formed as a result of

Environmental Issues: Approaches and Practices (2019), 1:60-84
ISBN: 978-81-939266-1-1

Figure 1. Air pollutants, pulmonary injury and fibrosis. Exposure of bronchiolar and alveolar epithelial cells to different pollutants result in the activation and transformation of fibroblast to myofibroblast under the direct influence of cytokines secreted from damaged epithelial cells and/or resident as well as infiltrated leucocytes. The process primarily starts as a normal wound healing response. Persistent insult disrupts the immunoregulatory homeostasis leading to progression of fibrosis under the major influence of TGF-β1 through overwhelming deposition of extracellular matrix components that ultimately causes pulmonary thickening, hardening, scarring and functional failure.



miscellaneous chemical reactions between NO_2, volatile organic compounds in presence of sunlight) triggers inflammation-associated hyper-reactions, elevated mucus secretion and altered expression of various immunoregulatory proteins in the airway epithelia (Alexis et al. 2010; Larsen et al. 2010). In addition to IPF, while O_3 is mostly associated with exacerbation-risks of asthma and cystic fibrosis, NO_2 has been implicated in COPD, asthma, traffic-associated pollution exposure and consequent increased risk of post lung transplant bronchiolitis obliterans syndrome (Johannson et al. 2014). A direct association of O_3 exposure and irreversible elevation in interstitial collagen deposition (Reiser et al. 1987) as well as epithelial lesions is also documented (Adamson et al. 1999). NO_2 and other nitrogen oxides often combine with NH_3 and moisture to form pulmonary penetrable end products which initiate pronounced bronchial inflammatory response associated with altered distribution of leukocytes in circulation as well as bronchoalveolar fluid (Ayyagari et al. 2004). Notably, in regard to occupational and environmental risk factors of IPF, it has been found that there is a pronounced male predominance of the disease owing to the skewed sex distribution in professions involving exposure to metal and wood-dust in industries. Although there is an appreciable diversity of pollutants contributing to respiratory symptoms in IPF, oxidative stress plays the major role in triggering as well as perpetuating the detrimental immunomodulatory and tissue remodeling responses with TGF-β1 acting as the central player in most fibrogenic signaling cascades. Telomere shortening and elevated expression of epithelial to mesenchymal (EMT) transition proteins have been largely documented in IPF associated with hyper-activated TGF-β1 signaling (Armand et al. 2013; Chen et al. 2013). Hence the relationship of AP and PF stands undoubtedly clear and warrants for serious consideration from the research as well as regulatory perspectives.

CLINICAL CASE REPORTS

Although the cause of IPF is unknown, several reports suggest a role of polluted environment and occupational exposure in the etiology especially as "risk factors" rather than direct "cause" (Garantziotis and Schwartz 2006; Miyake et al. 2005; Taskar and Coultas 2006). Metallic dust exposure is very hazardous and found to be associated with PF (Koo et al. 2017). Occupational and environmental exposure of metals like arsenic, copper, cadmium, nickel, molybdenum, uranium, tungsten, cobalt, vanadium (Assad et al. 2018) and aerosol containing Indium tin oxide (InSnO) (Homma et al. 2005) are also positively correlated with PF. Workers in the aluminium, asbestos, silica industries, coal mines and those exposed to organic dusts, wood dusts and PM are particularly susceptible.

Aluminium in different forms is used in cosmetics, ceramics, boat-construction industries and fireworks factories. The first case of PF in aluminium-industry worker was reported from Great Britain (Mitchell 1959). Recently, a study on geographically diverse, large population revealed pulmonary deposition of aluminium trihydroxide and silicon in IPF patients

(Raghu et al. 2014). Bauxite produces dust and fumes when processed at high temperature. An autopsy-based study revealed that workers exposed to these dusts and fumes and other aluminium oxides were at high risk of PF (Bellot et al. 1984; Jederlinic et al. 1990).

In addition to aluminium, workers from asbestos industry are also at risk of PF. The first case of death due to PF on account of extensive asbestos exposure was reported in 1899 which is now known as the "Montague Murray Case" after British physician Dr. Montague Murray. Radiographic screening of workers below 70 years of age and at least with 1 year of working experience in asbestos industry showed consistent interstitial PF (Koskinen et al. 1998). Several radiological studies relating PF to asbestos-exposed industry workers (Kang et al. 2018; Kim, 2009; Koskinen et al. 1996) along with smoking history have identified a positive correlation of smoking and asbestosis in PF (Lilis et al. 1986; Roggli et al. 1986) although certain instances of cigarette smoking-independent PF was also evident (Johannson et al. 2014). In fact asbestos-exposed workers show characteristics of IPF which is classified as "atypical" asbestosis (Attanoos et al. 2016). It is worth mentioning that owing to the similar histological and radiographic manifestations, it is difficult to differentiate IPF from asbestos/silica exposure based on CT scan images in spite of differences in coarseness of fibrosis (Gotway et al. 2007; Wells et al. 2003), bronchiolar obstruction (Akira et al. 2003), opacity, emphysema and traction bronchiectasis (Arakawa et al. 2007). Several other industrial pollutants have been implicated in PF pathogenesis. In metallurgical industries, quartz (crystalline silica) is heated above the boiling point to produce vapors of amorphous silica which is then cooled and condensed to fine powder. Quartz is widely correlated with the pathogenesis of PF (Martin et al. 1972); even chronic exposure to amorphous chemically inert silica with diameter < 1 μm and regular surface appears to cause nodular PF (Vitums et al. 1977). Risk factors of IPF also involve lead, brass, steel (Hubbard et al. 1996), fabricated metal products (Pinheiro et al. 2008). In fact male workers (in chemical, petrochemical industries, carpentry, those exposed to wood dusts and wood preservatives) and female workers (involved in farming, bird raising and those with occupational exposure to dusts, pesticides, animal feeds) are at increased risk of occupational IPF (Awadalla et al. 2012; Taskar and Coultas 2006). A recent study in southern Europe showed higher incidence of IPF among farmers, veterinarians, gardeners, metallurgical and steel industry workers (Paolocci et al. 2018) wherein metal dust, fumes and organic dust were found to be the major risk factors positively associated with the extent of occupational exposure.

In addition to the aforesaid pollutants, CM demands especial mention as potential risk factor for IPF. Both familial and sporadic IPF have been linked with smoking (Steele et al. 2005; Taskar and Coultas 2006).

CM has been found to induce changes in the methylation pattern of genes, including WNT7A, involved in IPF pathogenesis (Tennis et al. 2012). Reports also exist about differential survival extents of smoker *vs*.

Table 1: *In vitro* Studies on Pulmonary Fibrosis due to Air Pollution

Nature of pollutant/s	Source of pollutant/s	Affected cells	Cellular effect/s	Reference
Vanadium pentoxide (V_2O_5)	Fumes from oil burning furnaces which use V_2O_5-containing fuels	Lung fibroblasts	Increased proliferation and elevated collagen deposition through stimulation of other pulmonary cells	(Cooper, 2007; Fortoul et al., 2014; Hoppe et al., 1991)
		Macrophage	Enhanced IL-1β release and activation of PDGF-α receptor in rat lung myoFBs	(Bonner et al., 1998a)
		Lung fibroblasts and bronchial epithelial cells	HB-EGF and CTGF expression	(Ingram et al., 2007; Ingram et al., 2003; Zhang et al., 2001)
		Rat myoFBs	Elevated ERK-MAPK activation	(Wang and Bonner, 2000)
Uranium	Nuclear industrial effluents and military munitions industries	NR8383 macrophages	TNF-α secretion through JNK and p38 MAPK activation	(Gazin et al., 2004)
Chrysotile asbestos, residual oil fly ash and titanium dioxide	Contaminated air and industrial effluents	Lung fibroblasts	Upregulation of PDGF receptor-α and IL-1β expression	(Lindroos et al., 1997)
SiO_2, Al_2O_3, Fe_2O_3, and TiO_2	Asian dust particles containing PM_{10}	Bronchial cells	Upregulation of TGF-β and fibronectin along with ROS production	(Kyung et al., 2012)
PM_{10}	Dust from southern, northern and central Mexico	Human airway epithelial cells	Up regulation of PDGF receptor expression	(Bonner et al., 1998b)
	Urban commercial and industrial zone		Enhanced MMP-2 and MMP-9 expression	(Morales-Barcenas et al., 2015)

Table 1: *In vitro* Studies on Pulmonary Fibrosis due to Air Pollution (continued)

Nature of pollutant/s	Source of pollutant/s	Affected cells	Cellular effect/s	Reference
$PM_{2.5}$	Polluted air	Bronchial epithelial cells, pulmonary fibroblast and macrophage	Epithelial to mesenchymal transition Fibroblast activation and TGF-β/Smad dependent-macrophage activation	(Xu et al., 2019)
	Air from cache valley (Northern Utah)	Bronchial epithelial cell	Elevation of IL-1, IL-6 and STAT 3 and IL-6/GP130/STAT3-associated fibrotic signaling	(Watterson et al., 2007)
	Polluted air, motor vehicle exhaust	Human Airway Epithelial Cells	HMGB1-RAGE-dependent fibrotic signaling through elevated TGF-β1, PDGF-AB, and PDGF-BB expression	(Zou et al., 2018)
Crystalline silica, zinc and iron salts, 1-nitropyrene and lipopolysaccharide	PM containing dust	Human bronchial epithelial cells	CXCL8 elevation in a TACE/TGF-α/EGFR-regulated pathway	(Keane et al., 1997; Ovrevik et al., 2009; Ovrevik et al., 2011)
$PM_{2.5}$	Diesel exhaust	A549 and NCI-H292 cells	Increased MMP-1 expression via ERK 1/2 pathway mediated by NOX4	(Amara et al., 2007; Kagawa, 2002)
Ligands of aryl hydrocarbon receptor (AhR) like benzopyrene, nitrated polyaromatic hydrocarbon and polychlorinated biphenyls and 2,3,7,8-tetrachlordibenzo-p-dioxin	Urban polluted air	NCI-H441 cells	Elevated MMPs, IL-1β and TNF-α expression	(Wong et al., 2010)
Single walled and multi walled carbon nano tubes	Polluted air borne of carbon nano tube manufacturing industries	Fibroblasts and macro-phages	Elevated TGF-β1 and PDGF production to induce fibroblast to myoFB transformation	(Azad et al., 2013; Chen et al., 1977; He et al., 2011; Wang et al., 2010)

Table 2: *In vivo* Studies on Pulmonary Fibrosis due to Air Pollution

Nature of pollutant/s	Source of pollutant/s	Affected species and route of administration	Cellular effect/s	Reference
Copper oxide nano particles	Effluent of electronic industries	Mice (intranasal delivery)	Pulmonary inflammation and myoFB activation via α-SMA expression	(Lai et al., 2018)
Titanium dioxide (TiO_2)	Nano particles in air	Rats (intra-tracheal instillation) and human lung fibroblasts	Transient inflammation. Fibrogenic effect through MMP-1 induction via IL-1β-dependent pathways	(Armand et al., 2013; Oyabu et al., 2013; Yoshiura et al., 2015)
		Mice and rats (intra-tracheal instillation or intravenous administration)	Increased expression of pro-inflammatory cytokines; response is specific to pollutant nature. Highly toxic in intravenous treatment and at higher dose	(Halappanavar et al., 2015; Morimoto et al., 2011; Rahman et al., 2017; Xu et al., 2013)
Nickel Dioxide (NiO_2) and Nickel (II) oxide (NiO)	Nano particles in air	Rats (intra-tracheal instillation and inhalation)	Moderate inflammation through neutrophil infiltration and pro-inflammatory cytokine production in bronchoalveolar lavage (BAL) fluid; Persistent inflammation by NiO	(Morimoto et al., 2016)
Indium oxide (In_2O_3), sintered indium tin oxide (SITO),indium oxide (IO) and indium tin oxide (ITO)	Ventilation dust and aerosol	Rats and mice (inhalation)	Pulmonary fibrosis	(Badding et al., 2016)

Table 2: *In vivo* Studies on Pulmonary Fibrosis due to Air Pollution (continued)

Nature of pollutant/s	Source of pollutant/s	Affected species and route of administration	Cellular effect/s	Reference
Pure alpha-alumina	Foundry dust	Rats (intra-tracheal instillation)	Increased collagen, elastase fibre deposition. MMP2 and MMP9 elevation in lungs, irritation and inflammation in lungs	(Halatek et al., 2005)
V_2O_5 and Uranium	Polluted air from industries	Rats and mice (intra-tracheal instillation or inhalation)	Non neoplastic lesions, increased collagen deposition, inflammation and oxidative stress leading to PF progression	(Bonner et al., 2000; Monleau et al., 2006; Ress et al., 2003; Walters et al., 2014)
Diesel exhaust	Polluted air	Mice (Bleomycin pre-treated mice exposed to diesel exhaust)	NF-E2-related factor 2 (Nrf2)-regulated lung fibrosis	(Li et al., 2017)
PM_5, titanium, iron, silicon, calcium, aluminium, magnesium	Iraq dust	Army men samples, A549 cell line treatment and exposure of mice to dust challenges	IL-2 upregulation and depletion of T_{reg} cells to induce PF	(Harrington et al., 2017; Szema et al., 2014)

non-smoker IPF patients (Antoniou et al. 2008). Ambient AP is another crucial risk factor of IPF wherein NO_2, O_3 and PM were differentially implicated in the development and exacerbation of IPF as evident from the diverse reports (Conti et al. 2018; Johannson et al. 2014; Johansson et al. 1987; Sese et al. 2018b; Winterbottom et al. 2018).

A recent study performed in a slum area in New Delhi, India showed that both ambient and household AP affects lung function among adult women (Arora et al. 2018). Although there is much debate regarding the specific contribution of different toxic gases and particulate components, due to differences in region and context-specific observations, the involvement of AP in the pathogenesis of PF is unambiguous and alarming. Recently a number of *in vitro* and *in vivo* studies have established the association of air pollutants with the occurrence of IPF. A detailed mention about

these findings is presented in table 1 and table 2.

THERAPEUTIC RESEARCH

PF is progressive and fatal with limited therapeutic options and that too mostly depending on anti-inflammatory agents and immunosuppressive agents that only prevent disease progression (Rafii et al. 2013; Woodcock and Maher 2014). Lung transplantation is the last resort (Gross and Hunninghake 2001; Macagno et al. 2017). Corticosteroids have proven slightly helpful owing to their immunosuppressive action that can deter persistent inflammation and pulmonary scarring (Rafii et al. 2013). Nintedanib (receptor tyrosine kinase inhibitor in the form of humanized monoclonal antibody) and pirfenidone (a drug that down regulates growth factor and pro-collagen production) are the two currently used FDA–approved (King et al. 2014; Noble et al. 2011; Richeldi et al. 2011; Richeldi et al. 2014) drugs against PF. In addition, Lebrikizumab, STX and doxycycline have proven highly promising and are under clinical trials (Mishra et al. 2011; Woodcock and Maher 2014). However, due to the various side effects of the available drugs and poor efficacy in completely subduing the disease (Hughes et al. 2016; Zeskind 2011), alternative strategies for identifying potential anti-fibrotic remedies (mostly relying on herbal medicines) are always in demand. Traditional medicinal plant-based research for IPF treatment has shown marked increase in recent times owing to the reduced toxicity of the herbal formulations. Owing to the constraint in scope and space, these studies are not discussed in the current review. However, extensive information about herbal extracts and their efficacy in combating PF may be found in the literature (Bahri et al. 2017; Hosseini et al. 2018; Mojiri-Forushani et al. 2017).

CONCLUSION AND FUTURE PERSPECTIVE

The role of AP in causing pulmonary damage, especially IPF, is unambiguous. Although definitive evidences regarding the role of air pollutants as initiators of injury or exacerbators of existing pulmonary complications (leading to fibrosis) stand elusive, longitudinal epidemiological and translational studies clearly warrant the need for reframing the regulatory guidelines for monitoring as well as controlling AP with an aim to counter ILDs. Clearly defining the “exposome” in the air-pollution-associated pulmonary complications will help to design rational monitoring and regulatory strategies catering to public health. Identifying potential environmental contributors to IPF, either directly or through posing epigenetic regulation by gene-environment crosstalk, will help in better understanding of the complex molecular etiology. Existing studies have already characterized certain biomarkers of exposure to air pollutants (Berhane et al. 2014; Fry et al. 2014; Neophytou et al. 2013). Further explorative studies to identify novel non-invasive biomarkers predicting early stages of PF in pollutant-exposed population from highly industrialized area are essentially required. In this regard, profiling of respiratory tract microbiome as biomarker of pollution might prove instrumental in characterizing stage-

specific changes in the microflora as a potential indicator of respiratory microenvironmental alteration. Moreover plausible changes in BAL fluid pH might also help to address the changing physicochemical parameters in the respiratory tract. These studies will be challenging due to the difficulties in precisely defining the exposome in PF patients (compared to normal individuals) owing to the requirement for repeated measurements of the diverse biomarkers of exposure and that too in a longitudinal manner in sufficiently large cohorts; however, the end result will be highly rewarding. Government bodies should strictly monitor the quality of ambient air in the cities with stern measures to reduce pollution. At a personalized level, awareness and avoidance of exposure to potential household pollutants like incense smoke, CM and occupational as well as traffic-associated pollutants are highly desired in order to invite a better tomorrow with a pollution free atmosphere and people with healthy lungs.

Acknowledgments

This study was supported by research grants from Higher Education, Science & Technology and Biotechnology, Dept. of Science and Technology, Govt. of West Bengal (Grant Number: 291(Sanc.)/ST/P/S&T/9G-35/2017) and Early Career Research Award, Science and Engineering Research Board (SERB), Department of Science and Technology, Govt. of India (File Number: ECR/2017/002573). The authors also thank Dr. Somnath Mazumder for thoroughly editing the manuscript.

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Environmental Issues: Approaches and Practices (2019), 1:85-93
ISBN: 978-81-939266-1-1

Conservation of Environment through Folkloric Beliefs and Practices

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Abstract In the modern age of scientific development and technological sophistication, environment or ecology is a much discussed issue. Specifically, in the twenty-first century the environment is being continually polluted as a result of global warming, greenhouse gas effects, population explosion, contamination of water, air and soil pollution, extensive misuse of natural resources, nuclear radiation, etc. Such ecological deprivations ultimately bring about the loss of ecological balance and environmental equilibrium. The human activities triggered by swiftly varying socio-economic patterns due to technological development are predominantly responsible for deterioration of the world's environment. As human beings and their natural environment are integrally related to each other, the existence of human life is not possible without the natural environment. Thus, the growing ecological troubles and their upshot exhibit a serious threat to both mankind and the environment. Under such circumstances, the need for the conservation of environment and the necessity for the restitution of ecological balance are strongly felt throughout the world. Literature plays a vital role in this reinstallation of environmental equilibrium. Ecocriticism explains this interconnection between literature and environment. Folklore as part of literature, particularly of oral literature can play an important role in a further susceptible discernment of ecosystem and thereby may perform a significant function in the conservation of environment. This paper attempts to explore the possibilities of environmental conservation practices through the explication of the intimate connection between ecology and the folkloric beliefs and practices of human beings.

Keywords Ecocriticism, ecology, environment, folklore, Traditional Ecological Knowledge (TEK)

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INTRODUCTION

Man is an unbreakable part of nature. Nature creates and molds man and in turn is also shaped by man: "human culture is connected to the physical world, affecting it and affected by it" (Glotfelty 1996). Thus, in the modern era of technological advancement, rapid industrialization has caused utter destruction to the natural environment leading to the loss of ecological balance: "deep ecologists, ecofeminists and Heideggerian ecocritics identify the scientific revolution as an ecological disaster in and through which a primal authenticity was lost" (Garrard 2007).

The current distressing ecological circumstances like Tsunami, earthquakes, floods, deforestation, desertification, seasonal disorder, melting of polar ice, loss of biodiversity, sanitation problems, loss of soil and soil fertility, water shortage and contamination, ozone depletion, population explosion, inadequate health care, "lead and asbestos poisoning, toxic waste contamination, extinction of species at an unprecedented rate", (Glotfelty 1996) all creating environmental deprivation oblige us to think in a bio-centric way as Jonathan Bate maintains, "It is profoundly unhelpful to say 'There is no nature' at a time when our most urgent need is to address and redress the consequences of human civilization's insatiable desire to consume the products of the earth" (Bate 1991).

In such a critical situation, human beings must perform a prominent role in the maintenance of the ecological balance. It is a fundamental duty of all people to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures. Not only scientists, politicians and social workers but also literary personalities should play a vital role in this important task of maintaining environmental equilibrium. Literature has a significant part to accomplish in this restoration of ecological balance. Such interrelationship between literature and environment is studied by the ecocritics. Folklore as part of literature (especially oral literature) plays a substantial role in environmental concerns and attitudes and thereby has an outstanding function in ecological conservation practices.

For many years, environmental communicators have acknowledged the importance and supremacy of using folklore and conventional belief, like songs, tales, drama, puppetry, proverbs etc. to communicate environmental messages to the people at large. Despite technologically advanced forms of mass media, countless populace even today recount more eagerly and easily to traditional media, which are nearer to their local cultures, and are very often more interactive and participatory than the standard forms of mass media. This paper attempts to highlight on this prominent role of folkloric beliefs and practices in the conservation of environment through explaining the interrelation between folkloric beliefs and ecology from an ecocritical point of view.

ENVIRONMENT/ ECOLOGY

The term environment may be explained in a very wide sense taking into account of all those factors which straight forwardly or obliquely have a bearing upon the natural surroundings of human beings. And the term ecology, coined by the German zoologist Ernst Haeckel, signifies the association of the living and non-living to their environment. "Eco" comes from the Greek root oikos etymologically meaning household or earth and "logy" is derived from logos which implies logical discourse. Jointly they indicate "analysis of the house, of the surroundings as revealed in literary text" (Selim 2018). There are two shades of ecology — shallow ecology and deep ecology. Deep Ecologist Arne Naess opines that every existing entity contains an inherent merit and nobody is the master of anyone. Each individual life form must therefore,

learn to enjoy its benefits by forming a part of the system in close relation with other species. Such an attitude ensures equal rights to every living being and thereby maintains ecological balance.

ECOCRITICISM

Cheryll Glotfelty defines ecocriticism as the study of literature and environment: "Simply put, ecocriticism is the study of the relationship between literature and the physical environment" (Glotfelty 1996). Ecocriticism evaluates literature from the perspective of ecology. Ecocritics examine literary texts from the point of view of their environmentally harmful or helpful effect. Though the word eco-criticism was first coined by William Rueckert in *Literature and Ecology: An Experiment in Ecocriticism*, in 1978, ecocriticism, as a movement or school of criticism developed in 1990s. Among the renowned ecocritics one may mention the names of Cheryll Glotfelty, Harold Fromm, Lawrence Buell, Jonathan Bate, Greg Garrard and William Rueckert.

FOLKLORE: DEFINITION

Since the middle of the nineteenth century, "folklore" refers to the collective name used for the traditional "verbal compositions, and social rituals that have been handed down solely, or at least primarily, by word of mouth and example rather than in written form" (Abrams 2015). As Abrams points out, folklore comprises of legends, music, oral history, ballads, folksongs, tales, superstitions, proverbs, riddles, popular beliefs, fairy tales, magic spells, sayings about the seasons, marriage and funeral rituals and "traditional dances" and dramatic forms performed on holidays or at collective assemblage (Abrams 2015). However, in the Introduction to *The Meaning of Folklore The Analytical Essays of Alan Dundes*, Simon J. Bronner remarks that Dundes did not think "traditions" to be artifact "of the past", and repeatedly tried to demonstrate that folklore was remarkably a constituent of the "modern technological world" (Bronner 2007). Dundes regarded folklore to be '"something alive and dynamic" rather than "dead and static"' (Bronner 2007). In a broad sense, a folk group was, according to Dundes "any group of people whatsoever who share at least one common factor"' (Bronner 2007).

FOLKLORE AS LITERATURE

Folklore and literature are interrelated. As Vladimir Propp maintains, there is intrinsic relationship between folklore and literature, between the "science of folklore and literary criticism". "In its descriptive elements the study of folklore is the study of literature. The connections between these disciplines is so close that folklore and literature are often equated" (Propp 1997). Though it is usually acknowledged that "literature is transmitted through writing and folklore by word of mouth" (Propp 1997), Dundes, argued that "an orally transmitted item may be folklore", but '"by itself [oral transmission] is not sufficient to distinguish folklore from non-folklore"' (Bronner 2007). Thus folklore is embodied in both oral and written literature.

RELATION BETWEEN FOLKLORE AND ENVIRONMENT

Folklore and environment are integrally

related. "The folkloric tales, legends, myths, sayings, songs, ballads, dances, music and poetry can significantly illuminate on the man-nature relationship" (Selim 2018). Folktales are instructional, not only about specific environmental knowledge and for the purpose of understanding the religious perspective of the environment; these two features of the folktales are deeply interrelated. As Vellerman maintains, "A story does more than recount events; it recounts events in a way that renders them intelligible, thus conveying not just information but understanding" (Vellerman 1979).

Frequently, countless fundamental scientific concepts and policies about nature are derived from folklore and legends. There is a wide spread agreement that miscellaneous important lessons can be obtained from the cognitive and experiential dimension of folkloric tradition for the conservation of natural resources to make sure sustainable development of the communities in specific and mankind in general. One of the most fruitful means to inculcate ecological values and ethics is to tell tales that convey pro-environmental emotions. The ethical foundation of numerous resource utilization and conservation strategies adopted by the primitive people can simply be communicated putting emphasis on the necessity of revitalizing those values in current situation with the help of these oral traditions. Folktales from indigenous communities may serve this function of tale telling by creating a sense of care and concern for the non-human world living in their surrounding environment.

INTERCONNECTION BETWEEN FOLKLORE AND TRADITIONAL ECOLOGICAL KNOWLEDGE (T E K)

There exists intrinsic relationship between folklore and Traditional Ecological Knowledge (TEK). Also considered as element of cultural folklore, Traditional Ecological Knowledge (TEK) can be described as a "cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 1999). As a recent popular discussion indicates, folklore and traditional ecological knowledge (T E K) of indigenous people, particularly having partnership features, can put forth constructive impact on the conservation of environment.

ENVIRONMENTAL CONSERVATION THROUGH FOLKLORIC BELIEFS: SEVERAL EXAMPLES

One of the foremost established means of environmental conservation through folkloric beliefs appears to be the application of taboos. For the purpose of preserving rare plants and trees and endangered animals some beliefs are popularized among people. Thus folkloric beliefs consider several plants and animals as embodiment of gods and, therefore, ought not to be incapacitated or disturbed. Hence such flora and fauna are never touched or hunted by people or are even badly spoken of. Similar folk-beliefs are relevant to forests, woodlands, and water along with other natural resources. For

instance, in India, the people of Meghalaya believe that their jungles are the abode of several deities. Therefore, cutting of plants, harvest of fruits or plucking of flowers would cause offense to the divinities and consequently bring about catastrophe in their residence (Jeeva et al. 2006). This sense of veneration may stimulate a sensation of protecting these natural resources for the benefit of their future generation and accordingly helping in maintaining environmental balance.

Similarly, diverse tribal people of Arunachal Pradesh cherish varying beliefs and attitudes towards their neighboring plants and animals. Nevertheless, under each legend prevails the subsistence of goddesses or dominant celestial powers embodied in the shapes of flora and fauna. In Hill Miri, particular areas containing specific trees are preserved ardently. Spitting, urinating or throwing stones in the region are prohibited as a means of showing respect or reverence to the sacred plant goddesses. In the same way, the Aka of West Kameng have the belief that the destruction of certain ponds and lakes will cause devastation of life. In addition to this, drawing out some resources from the revered hill, Woke, is not allowed as this will lead to oral and nasal hemorrhage, eventually causing death (Saikia 2008).

Similarly, killing of tiger is tabooed among the Mishmis and Galos. Even specific seasonal birds are not hunted because such birds are considered to be sacred and also supposed as the agents of new season and symbol of good productivity (Riba 2003). Thus a variety of beliefs and taboos of Arunachal tribes concerning animal world subsidize a roundabout form of conservation of varied animal species. Such folk-beliefs have environmental implication which if used appropriately will serve as emblematic instances of conveying the message of animal preservation and thus maintaining ecological balance.

Similar folk-beliefs can be traced among the inhabitants of Sundarbans who believe in the story of Ma Bon-Bibi, a traditional mythological folk drama of Sundarbans which tells the tale of how the forest queen Bon-Bibi makes a balance between Dakshin Rai, the demon king and the foresters who enter into the forest in search of food, firewood and honey: “Thus order was brought to the land of eighteen tides, with its two halves, the wild and the sown, being held in careful balance” (Ghosh 2004). The Bon Bibi myth applies the power of folklore to draw an association between mankind and the natural environment. All these examples indicate the connection between ecology and folk belief systems customarily fulfilling the purpose of resource conservation either directly or indirectly.

Such folk-beliefs can be traced not only in India but also in other countries of the world. Thus, in Sulawesi of Indonesia ancestral spirits taking the shapes of different plants or animals are considered to be deities. Despite constant pillaging of crops as well as groves, people never hunt, kill or even speak badly of the macaques, and their occupied jungles are never entered into in order not to disturb the monkeys (Riley and Priston 2010). From the above examples it becomes quite evident that in the world of folklore, plants and trees, birds and fishes, ponds and rivers, animals and humans all live with cordial relation. These tales, if narrated with the purpose of

communicating the message of preserving the endangered species, will help in conserving biodiversity. This diversity is believed to be derived inevitably from ecology, as Ynestra King maintains: "A healthy, balanced ecosystem, including human and nonhuman inhabitants, must maintain diversity…." (King 1989). Nurturing an outlook of close connection with all other entities in the course of experience and veneration recurrently lead to positive as well as harmonious consequences. On the contrary, fostering an attitude representing all other entities to be isolated from one another, usually results in anarchism and uncertainty.

FOLKLORIC BELIEF IN SACRED GROVES

A significant ecological component helping in environmental conservation is tree. Plants and trees are always believed as the first home of the deities, and "sacred groves" are considered to be their earliest place of worship, thus both were held in utmost reverence in ancient times (Pliny 1945; Quantz 1898; Porteous 1928). As can be found in Celtic mythology, the Celts used hallowed gardens, entitled nemeton in Gaulish to perform spiritual rituals. In India, "sacred groves" are scattered all over the country enjoying the benefit of conservation. It is also believed that Malay folklore narrates that plants whisper hymns to God in absolution of the precedent transgression of the soil's previously human population. Likewise in Nigerian mythology The Osun-Osogbo Sacred Grove is dedicated to the deity of fruitfulness in Yoruba legends, and is spotted with temples along with incarnations (Selim 2018). It is now an acknowledged fact that plants are not venerated for themselves, people respect them for what is personified in them, for what is embodied and symbolized by them (Eliade 1958; Zahan 1979), and, chiefly, for various divinities attributed to them (Hamilton 2002).

In the same way, in British folklore, Ash tree is credited with a range of protective and therapeutic purposes frequently related to children's wellbeing. Ash trees grow up at the vicinity of Irish holy wells, and on the Isle of Man people believed ash trees to be able to protect the transparency of fountains. Similarly, in the British Isles the rowan tree has an elongated and still popular folkloric history to be a tree defending against witchcraft and enchantment. When people become conscious of the benefits of such locally obtainable herbs and other natural resources, they begin preserving these as precious possessions. If certain values are attributed to these folk-beliefs, conservation, rather than demolition of ecology will be started. Equally, conventional Asian cultures think about bamboo as one of the most propitious rudiments. It stands for stability, harmony, industriousness, and flexibility. The overwhelmingly apprehended and ubiquitous belief that any harm done to a sacred tree will instantaneously cause divine vengeance confers some fortification. Such systems of punishment are acknowledged as the means of protection of the woodland resources from over-exploitation.

FOLK-BELIEF IN HOLY WATER

Another vital ecological ingredient, water plays a prominent role in folklore, fairy tales, myths and legends throughout the world. The

primitive people had a high regard for this water resource and they created many myths and legends connected with the water spirit. This folk-belief in the holiness of water of holy well can also be traced in written literature. For instance, apart from the physical reality of the sea water in J. M. Synge's play *Riders to the Sea*, we also find the mythological property of water by considering it as "holy" (Synge 1969). Water also plays an important part in Synge's other play, *The Well of the Saints* in which the eye-sight of an old blind beggar, Martin Doul and his blind wife, Mary Doul is restored with the application of the holy water drawn from a certain well under the supervision of a holy saint: "There is a green ferny well, I'm told, behind of that place, and if you put a drop of the water out of it, on the eyes of a blind man, you'll make him see as well as any person is walking the world" (Synge 1969). There is a profound environmental implication behind this folk-belief of people in regarding water as holy. "Water", as indispensable component for the nourishment of life on the world must be given due importance and measures ought to be adopted to protect this important natural element from pollution. The primitive Irish people portrayed in Synge's plays might not be well aware of this scientific fact; but their folkloric belief about defending the purity of water in a roundabout way shows their deep environmental consciousness.

CONCLUSION

The modern man must re-establish the lost connection between human life and the natural environment. Folklore can help in examining the inherent relationship of human and natural world and by exploring the interaction between human culture and nature in the conventional folklore, one can build up a nature consciousness and carry out a sense of accountability towards mother earth. Thus folklore plays a vital role in transforming people's attitude from anthropocentric to eco or bio centric one and thus storytelling may initiate environment education with a new and positive approach. Through an ecocritical analysis of folkloric beliefs and practices this paper thus explains how folklore as part of either oral or written literature coveys an important message of environmental conservation as the ultimate venture of ecocritics is to defend nature and build up a harmonious balance between mankind and the physical environment.

Acknowledgments

I would like to express my deep gratitude to my supervisor Professor Amzed Hossein for proper guidance and valuable suggestions. He suggested and helped me with huge resources of folklore and its interconnection with ecology. I am extremely indebted to the staff of Syamaprasad College Library, British Council Library, Kolkata and National Library, Kolkata who extended their helping hands to carry on my research work.

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