



Knowledge  
Based Volume 1

आत्मदीपो भव

# Environment

## A Multidisciplinary Approach



Research Committee

**Jogamaya Devi College**  
**Kolkata, India**

# **Environment**

## **– A Multidisciplinary Approach**

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## Foreword

This Knowledge-based volume is a maiden attempt of the Principal and Faculty of Jogamaya Devi College, Kolkata, to open a small window that will allow the world to have a glimpse of their research work. The contents are marked for their heterogeneity. They span over a wide spectrum of subjects – from Sanskrit Literature to Zoology. In the first issue, the topics orbit around a central theme, that is, the Environment.

The endeavour serves the immediate purpose of giving an opportunity to the faculty members to publish their work in a recognized forum. Since the publication is being made accessible through the Internet, the published articles will surely get a global readership and the widest publicity.

One may question the utility of an academic publication on such varied areas of knowledge, due to an apprehension that an article might be of little interest to scholars working in other areas. This point has not escaped the attention of the authors or of the Editorial Board. The published articles are sufficiently explanatory, so that they can be read and appreciated not only by readers specializing on the subject, but also by the ‘intelligent layman’. Wherein the main body of an article demands familiarity of the subject that the layman is not expected to have, an explanatory note has been appended that conveys the essential points to any reader. In a way, this feature brings about some amount of porosity in the barriers that compartmentalize different branches of knowledge.

The volume is being published primarily in the e-mode, which has an additional advantage of its own. It will encourage the readers to send their comments by either adding to the information or providing constructive criticism. It is but certain that in either ways, the volume will be enriched.

Success of this publication, thus, depends not only on the quality of the articles received but also on the cooperation of the readers, which we seek wholeheartedly.

*Pratip Kumar Chaudhuri*  
*Chief Editor*

## From Principal's Desk

Nature and environment are complementary rather synonymous for their co-existence dating from the creation of this earth. Nature gets nurtured congenially through upkeep of healthy and habitable environment amiable for all the living and non-living beings.

Today both Nature and environment encounter a great challenge for existence with their congenital originality with peace and tranquillity. Fast moving world with recklessness pays very little or no heed towards wellness of the surroundings and thus the very matrix of the universe is at peril. Obviously the moment has come to have a little space to stand and look at our wellbeing and wellbeing of nature and environment for the present and the days to come. We should be religiously alert with parental love and care in our mind to make our environment healthy and habitable and leave no stone unturned to let our beloved nature remain undisturbed in its own vast empire.

With an aim towards such an adorable and result oriented positive atmosphere of beautiful environment for all of us living today and also for the future generations who are supposed to dwell in this beautiful world one day, we, the pioneers of Jogamaya Devi College, Kolkata, took vow with all pains and pleasures to bring out this maiden edition of e-journal for awareness of the mass with our determined endeavour. Obviously, this publication will become periodical in the coming days with the spontaneous patronage of like-minded people.

We firmly believe our noble approach and indomitable spirit would undoubtedly bring about efficacious result to make the world really a comfortable place to live in.

We are looking forward to the esteemed readers' suggestions and their all-out participation to enrich our righteous path.

With thanks,

*Dr. Srabani Sarkar*  
*Principal*



## From the Editors' Desk

It is universally acknowledged that the extent of problems related to the environment has grown substantially in the past decades and will continue to expand and diversify more in the future. There is no escape from the fact that no generation has ever faced a more daunting agenda. No one discipline can encompass the depths of the environment we live in. To focus on the vastly interdisciplinary perspective of our environment, this Knowledge Based Volume is an initiative endorsed by the Research Committee of Jogamaya Devi College in the hope to accommodate the varied approaches under an umbrella. This volume not only explores the wonders of Nature, current threats and concurrent methods in addressing several conflicting environmental issues but also looks into the methods of preservation and protection.

This publication begins by revisiting the Indian epics, mainly the classical Sanskrit literature – the Ramayana and the Mahabharata. Though the epics have been subjected to varied studies; it had not been much studied through the spectrum of environmental awareness. The paper by Dr. Sushree Chakraborty discusses the relevance of these classics with innumerable philosophical thoughts as well as ecological and environmental awareness. Such an approach is not only valuable but also relates to our own hard times. Panchali Mukherjee's article treads on similar path. She leads us through the ancient *vratas* for achieving the goal of conservation of natural environments and wild taxa so as to be able to live in perfect harmony with nature. Though *vratas* had a direct religious context, the author shows us the immense religious sentiments with regard to development of reverence and gratitude towards biotic resources that provides for human existence. A relatively new line of literary theory, the idea of eco-feminism has been explored in the works of the marginal poet Mamang Dai. Soma Mandal (Halder) visits her 'River Poems', and discusses how nature can emerge as a living source of sustenance for people whose tradition is not recorded in the written history. The poem voices the urge to restore nature as it faces the ordeal under the pressure of development. These articles look into the idea of environmentalism/ environmental awareness through literature across a wide spectrum from the classical ages to the contemporary times. Shantanu Majee attempts to stride through yet another little known territory of research in humanities. His article evinces on digital humanities which is an emerging discipline in the contemporary academic discourse. His article discusses archives of natural sound and comments on the importance of preservation of such natural registers through the intervention of technology.

This volume also strives to look into biotic entities such as the ghost crabs, macroinvertebrates as well as spiders. It is very interesting to note how our little friends contribute to sustain planet earth for themselves as well as for us, humans. While Dr. Ranu Naskar introduces us to the potential of shore crabs to alter the physical and chemical characteristics of the Indian coast line, Pushan Chakraborty and Dr. Poulami Adhikary lead up to the fascinating cogwheels of nature. Both the articles show us the

marvels of co-evolution, how different species reciprocally affect each other's evolution.

We also get a glimpse of the bio-indicators, how the changing environment can be detected by locating changes in the biology of different species, the ones we share our planet with. Dr. Sarmistha Saha enlightens us about aquatic macroinvertebrates as potential bio-indicator species. She discusses how they react swiftly to the fluctuations in the water quality, triggered by pollution and degradation. The issue of intensive pesticide usage was addressed by Dr. Rahi Soren. The use of pesticide has not only affected the ecological balance but also adversely affected human health. In this scenario, her paper attempts to explore the potential of spiders as a biological pest control agent, in the hope to curb the indiscriminate use of pesticides.

Further, the present scenario of environmental pollution and its probable mitigation is suggested in the articles of Aditya Haldar, Amrita Mukherjee and Arghya Choudhury. These papers make us aware of anthropogenic potential to degrade the ecosystem and rob it of its sustainability and resilience. They provide us with a concise overview of the current global scenario of e-waste. They also confer the health and environmental impacts of e-waste, current disposal and recycling mechanisms practiced in our country. Dr. Prasenjit Ghosh's article examines the impact of economic growth on the environmental quality in India. He suggests that the role of economic growth is not satisfactory to improve the quality of environment similar to developed countries. In India, air pollution remains a major challenge, and to overcome the problems, Environmental Fiscal Instrument (EFI) may play a significant role. Proper and adequate use of natural resources and environmental management are essential not only for our survival but also for attaining and sustaining economic growth and development.

As stated earlier, the approach has been interdisciplinary, in its true sense. It is just a snapshot of nature presented to the readers. However, much is yet to be addressed to fulfil the unquenching thirst for knowledge. The Editorial team sincerely hopes to add a drop in the vast ocean of knowledge.

*Board of Editors*

# Environmental Awareness in the ‘Ārṣa Mahākāvya’

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*Abstract: Ecology and environment are closely related to each other. The former denotes the study of the relationships between living organisms and their environment, while the latter denotes the maintenance of ecological balance and the conservation of the ambience free from pollutions. The world today is confronted with the severe problem of maintaining ecology and environment. Promoting a delicate balance among the human beings, the flora and the fauna has been the need of the hour. In order to execute the same, searching the ancient Indian stock of knowledge has been proved really imperative from every aspect.*

*The Rāmāyaṇa and the Mahābhārata, the pillars of Indian culture, are replete with innumerable philosophical thoughts as well as ecological and environmental awareness. The preamble of Rāmāyaṇa, the hunting of the ‘Krauñca’ bird, ending with the curse of sage Vālmīki to the hunter, prove the disapproval to the destruction of wildlife. The unnecessary killing of wild animals has been prohibited through the dialogues of various characters. The name of the chapter ‘Aranyakāṇḍa’ itself denotes the importance of the wild forestation of that period. The usage of ‘Viśalyakaraṇī’, ‘Sañjīvaī’ etc. proves the well-known curative value of these herbs. The Mahābhārata proclaims the equal right of all the organisms to live on this beautiful and bountiful earth. The realization that plants do have life is evidently revealed in the Śāntiparva. Tree plantation has been promoted several times. Limited usage of natural resources is suggested repeatedly. Killing domestic animals attracted different types of atonements.*

**Keywords: flora, fauna, Mahābhārata, Rāmāyaṇa**

Ecology and environment are closely related to each other. The former denotes the study of the relationships between living organisms and their environment, while the latter denotes the maintenance of ecological balance and the conservation of the ambience free from pollutions. The world today is confronted with the severe problem of maintaining ecology and environment. Promoting a delicate balance among the human beings, the flora and the fauna has been the need of the hour. In order to execute the same, searching the ancient Indian stock of knowledge has been proved really imperative from every aspect. The Vedic Saṃhitās contain a genuine sense of awareness of maintaining a pollution-free environment. The scriptures like *Manusāṃhitā*, *Yājñavalkyaśāṃhitā* etc. have numerous regulations to protect the environment and the eco-system in one form or another and violating those rules used to attract punishments according to the severity. Sanskrit Epics, also, do have an immense intellectual contribution towards the nurture and the conservation of Nature.

The *Rāmāyaṇa* and the *Mahābhārata*, these two Epics are categorized as *Ārṣa Mahākāvya*s. These two canonical works are the pillars of Indian culture and these are replete with innumerable philosophical thoughts as well as ecological and environmental awareness. The *Rāmāyaṇa* is distinguished by the unity of treatment and elegant style; whereas the *Mahābhārata* is enriched with the diversified content

and didactic materials. Along with that, the old-age phenomenon of human ties with Nature and the idea of ecological balance are traceable in abundance in both these works. We have to keep in our mind a fact that the state of the people of this Epical era was not identical with the people of the Vedic era. The latter used to be abashed worshipper of Nature, whereas secured and settled Epical people observed Nature from an ontological and philosophical perspective. Therefore, the environmental cognition suggested in the *Rāmāyaṇa* and the *Mahābhārata* is not that inextricably direct and personal compared to the depiction found in the Vedic literature.

### ENVIROMENTAL AWARENESS REFLECTED IN THE RĀMĀYAṆA

The bond between human beings and nature is evident from the very onset of the *Rāmāyaṇa*. In the preamble, the incident which formed the source of the Epic is the episode of *Vālmiki* cursing the hunter who shot down the *Krauñca* bird, when it was in union with its female counterpart. This agonizing rumpus made the verse burst out from the heart of the sage, which is revered as the ‘first poem’ composed in Indian literary history –

*mā niṣāda pratiṣṭhām tvamagamaḥ śāśvatīḥ samāḥ l*

*yat krauñcamithunadekamavadhīḥ kāmamohitam ll (Bālakāṇḍa – 2/15)<sup>[1]</sup>*

[Meaning—“O hunter! You will never achieve success in life since you have killed the male one out of the pair of Heron birds when it was making love.”]

This suggests the importance attached to the preservation of animal life in forest. An environmentalist can very well resemble this curse with the ‘Wild Bird Protection Act’, 1887 which is the first codified law on preservation of birds in Indian wood; ‘The Wild Birds and Animals Protection Act’, 1912 and ‘The Wildlife (Protection) Act’, 1972. Not only *Krauñca*, another bird, named *Jatāyu*, the atypical bird with humongous size and gigantic strength, was killed by *Rāvaṇa*. *Rāvaṇa* would have been convicted for killing a bird of endangered species by the stringent law of ‘Endangered Species Act’ (ESA), if this incident had taken place in modern days.<sup>[2]</sup>

Not only birds, killing any kind of living beings in the vicinity of the penance groves or even in the forests unless it was absolutely necessary, was never approved in the *Rāmāyaṇa*. We find *Sītā* warning *Rāma* about the redundant massacre of the *Rākṣasa*-s dwelling in *Daṇḍakāraṇya* –

*trīṇyaṃ yadidaṃ raudraṃ paraprāṇābhīḥsanam l*

*nirvairam kriyate mohāttacca te samupasthitam ll...*

*aparādham vinā hantum lokān vīra na kāmaye l (Aranyakāṇḍa – 9/9, 25)<sup>[3]</sup>*

We find *Rāma* intending not to stay in the hermitage of sage *Sutīkṣṇa* for long because of the thought that in case he unnecessarily kills the deer grazing over there –

*tānaḥ sumahābhāga mṛgasaṅghān samāgatān ll*

*hanyām niśitadhāreṇa śareṇānataparvaṇā l...*

*etasminnāśrame vāsaṃ ciraṃ tu na samarthaye l (Aranyakāṇḍa – 7/20-22)<sup>[4]</sup>*

The congenial relationship between human and animals is demonstrated in every possible occurrence in the *Rāmāyaṇa*. In *Bālakāṇḍa*, when *Rāma* and *Lakṣmaṇa*, guided by sage *Viśvāmitra*, were leaving the hermitage of sage *Vāmana*, all the deer and the birds were coming after them along with all the ascetics—

*mṛgapakṣigaṇāścaiva siddhāśramanivāsinaḥ l*  
*anujagmurmahātmānaṃ viśvāmitraṃ mahāmuniṃ ll (Bālakāṇḍa— 31/18)<sup>[5]</sup>*

In *Aranyakāṇḍa*, we find a delicate description of the overwhelming grief of both the plants and the animals of *Pañcavaṭī* forest on hearing the mourning of *Sītā* during her abduction by *Rāvaṇa*. In this *kāṇḍa*, we find *Kavandha* briefing *Rāma* and *Lakṣmaṇa* about various birds and amphibians, on the bank of the river *Pampā*, who were aweless of human presence –

*tatra haṃsāḥ plavāḥ krauñcāḥ kurarāścaiva rāghava ll*  
*balgusvanā nikūjanti pampāsaliḥlagocarāḥ l*  
*nodvijante narān dṛṣtvā vadhasyākovidāḥ purā ll (Aranyakāṇḍa— 73/12-13)<sup>[6]</sup>*

Here we may mention an incident which apparently seems contrary to this harmonious relationship. In *Aranyakāṇḍa*, we find *Kavandha* suggesting *Rāma* and *Lakṣmaṇa* to hunt the huge birds on the bank and the various fishes in the water of the river *Pampā* –

*ghṛtapiṇḍopamān sthūlāṃstān dvijān bhakṣayiṣyathaḥ l*  
*rohitān vakratuṇḍāṃśca naḍamīnāṃśca rāghava ll*  
*pampāyāmiṣubhirmatsyān... (Aranyakāṇḍa— 73/14-15)<sup>[7]</sup>*

This hunting is nothing but an example of the relation between food and the consumer, which ultimately preserves the ecosystem and the food-chain balance and therefore, is not at all in contradiction to the amiable affiliation between man and Nature evoked in this epic.

Demolition of natural resources is severely prohibited in the *Rāmāyaṇa*. In *Aranyakāṇḍa*, after the abduction of *Sītā*, grievous *Rāma* asked the river *Godāvarī* and the mountain *Prasravaṇa* about the whereabouts of *Sītā*; and failing to get any answer, enraged *Rāma* was about to destroy both of them. *Lakṣmaṇa* arrested the misdeed and reminded *Rāma* that, it is unjust to destroy nature to protest against some human felony – *ekasya nāparādhena lokān hantum tvamarhasi (Aranyakāṇḍa – 65/6).<sup>[8]</sup>*

*Rāma* was about to disturb the natural stability on another occasion. In *Yuddhakāṇḍa*, to build the bridge on the sea *Rāma* was worshipping the Sea-God; and when he didn't show up, *Rāma* became furious and got ready to parch the sea. Then the Sea-God appeared and uttered the eternal mandate of Nature that the five elements of nature, *ḥṣiti* (earth), *ap* (water), *tejas* (fire), *marut* (air) and *vyoman* (space), always comport according to the cosmic laws and they will always be like that. This is the reason that the Sea-God will never refrain his water from flowing and will remain the same keeping the aquatic life unruffled –

*prthivī vāyurākāśamāpo jyotiśca rāghava l*  
*svabhābe saumya tiṣṭhanti śāśvataṃ mārgamāśritāḥ ll*  
*tatsvabhābo mamāpyeṣa yadagādho'hamaplavaḥ l*  
*vikārastu bhabedgādha etatte vedayāmyaham ll*  
*na kāmānna ca lobhādvā na bhayāt pārthivātmaja l*  
*grāhanakrākulaṃ jalaṃ stambhayeyaṃ kathañcana ll (Yuddhakāṇḍa— 22/26-28)<sup>[9]</sup>*

These cautions from *Lakṣmaṇa* and the Sea-God are the reminders of the interminable fact that going against the Nature is always unethical and consequently disastrous.

Alongside some hostilities against nature, the *Rāmāyaṇa* figuratively expressed some human cooperation towards the development of nature also. In *Bālakāṇḍa*, we find the story of a severe drought caused by the immoral and abominable practices of King *Romapāda*, which was finally controlled and eradicated by the sage *Ṛṣyaśṛṅga*, the worthy son of sage *Bibhāṇḍaka*.<sup>[10]</sup>

Immediately after the aforementioned *Rāma-Samudra* episode, we find an incident where *Rāma*, on the request of *Samudra*, shot his fierce and infallible arrows and parched the impure waterbodies of a place, which had been mentioned as *marukāntāra* thereafter –

*ābhīrapramukhāḥ pāpāḥ pibanti salilaṃ mama ll*  
*amoghaḥ kriyatām rāma ayaṃ tatra śarottamaḥ ll*  
*tasya tadvacanāṃ śrutvā sāgarasya mahātmanaḥ l*  
*mumoca taṃ śaraṃ dīptaṃ paraṃ sāgaradarśanāt ll*  
*tena tanmarukāntāraṃ pṛthibyaṃ kila viśrutam l* (Yuddhakāṇḍa—22/33-36)<sup>[11]</sup>

Not only this, *Rāma* provided a huge source of fresh water there, which was as big as a sea. Using this pure water, that barren land became fertile and enriched with various flora and fauna –

*pāśabyaścālparogaśca phala-mūla-rasāyutaḥ l*  
*bahusneho bahukṣīraḥ sugandhivividhauṣadhiḥ ll*  
*evametaiśca saṃyukto bahubhiḥ saṃyuto maruḥ l*  
*rāmasya varadānācca śivaḥ panthābabhūba ha ll* (Yuddhakāṇḍa—22/42-43)<sup>[12]</sup>

In shroud of allegory, these incidents are evidences of the synergy between Nature and human beings, which is really required for the environmental prosperity.

Forests have a very prominent associative role in the *Rāmāyaṇa*. This epic throws light on three major ecosystems of Tropical Deciduous forest, Alpine Region semi-forest and the Evergreen Tropical forest of *Laṅkā* with details of geographical descriptions along with the rivers and the mountains therein. To suggest the significance of the forests and the incidents that took place there, the third chapter of this epic is named as *Aranyakāṇḍa*. Forests likewise were of two types – forest and the sub-forest. *Daṇḍakāraṇya* was the biggest among the forests and was mentioned as *Mahāraṇya* – *praviśya tu mahāraṇyaṃ daṇḍakāraṇyamātmavān* (*Aranyakāṇḍa* – 1/1)<sup>[13]</sup>. *Pañcavaṭī*, *Mātaṅga* etc. were smaller in size and belonged to the sub-forest category.

The diversity of the plants enlisted in the *Rāmāyaṇa* really incites our wonder. *Aṅkola*, *Cūrṇaka*, *Pāribhadraka*, *Tiniśa*, *Cūta*, *Aśoka*, *Ketaka*, *Kobidāra*, *Syandana*, *Candana*, *Mucakunda*, *Dhava*, *Aśvakarṇa*, *Śirīṣa*, *Naktamāla*, *Kimśuka*, *Pāṭala* etc.- hundreds of names, both familiar and unfamiliar, produce the strong evidence of the preservation of these plants and the consequent environmental balance of the forests<sup>[14]</sup>. Not only plants, these dense forests were the suitable abode of various species of carnivores, herbivores, birds, amphibians and reptiles also. In *Aranyakāṇḍa*, we find a vivid description of *Mataṅgavana*, which was famous for its animal resource; elephants, bear, deer, snakes etc. are some of them to name –

*tatrāpi śīsunāgānāmākrandah śrūyate mahān l*



*krīdatām rāma pampāyaṃ mataṅgāśramavāsinaḥ ll*  
*saktā rudhiradhārābhiḥ saṃhatya paramadvipāḥ l*  
*pracaranti prthakkīrṇā meghavarṇāstarasvinaḥ ll*  
*ṛkṣāmśca dīpinaścaiva nīlakomalakaprabhān l*  
*rurūnapetanajayān dr̥ṣṭvā śokaṃ prahāsyasi ll* (Araṇyakāṇḍa— 73/35-36,38-39)<sup>[15]</sup>

Some parts of these forests, having water bodies in vicinity, provided habitable environment primarily to the local tribals and secondarily to the persons in the *Vānaprastha* stage of life and the ascetics for their scholastic and spiritual activities. The forests of the *Rāmāyaṇa* was described as ‘*Śānta*’ (tranquil), ‘*Madhura*’ (sweet), ‘*Raudra*’ (fury) and ‘*Bībhatsa*’ (terror). These categories suggest the four ‘*Rasa*’s or sentiments predominant in forest environment. The first two represent the serene atmosphere of the penance groves and the latter is associated with the wilderness of the forests.

The mountain-born forests of medicinal plants are one of the most significant facets of the woodland resources depicted in the *Rāmāyaṇa*. The forest-clad mountain of medicinal plants is stated to have been located between two mountains, ‘*R̥ṣabha*’ and ‘*Kailāsa*’, and stretched to a long area of over thousand ‘*Yojana*’s –

*himavantam nagaśreṣṭham hanuman gantumarhasi ll*  
*tataḥ kāñcanamatyuccamṛṣabham parvatottamam l*  
*kailāsaśikharāñcātra drakṣyasyariniśūdana ll*  
*tayoḥ śikharayormadhye pradīptamatulaprabham l*  
*sarvaśādhīyutam vīra drakṣyasyoṣadhiparvatam ll* (Yuddhakāṇḍa— 74/29-31)<sup>[16]</sup>

The southern peak of this Himalayan semi-forest was famous for four highly potential drug plants named after their particular curative properties. These are –

*mṛtasañjīvanīñcaiva viśalyakaraṇīmapi l*  
*suvarṇakaraṇīñcaiva sandhānīñca mahauśadhīm ll* (Yuddhakāṇḍa – 74/33)<sup>[17]</sup>

*Mṛtasañjīvanī* or *Sañjīvanakaraṇī*—plant which revives the dead with life-principles  
*Viśalyakaraṇī*—plant which removes dirt from body  
*Suvarṇakaraṇī*—plant which gives a glowing complexion – *suvarṇakaraṇīm*  
*svarṇasamānavarṇasya dehādeḥ karaṇīm*<sup>[18]</sup>

*Sandhānakaraṇī*—plant used for the healing of fractures— *sandhānīm chinnaśiraḥkavandhayorapi*  
*yathāpūrvam nāḍīsandhānam*<sup>[19]</sup>

According to the description of the *Rāmāyaṇa*, all these plants were glowing – *drakṣyasyoṣadhayo dīptā dīpayantīrdiśo daśa* (Yuddhakāṇḍa – 74/32)<sup>[20]</sup>. The mountain was named *Gandhamādana* after the aromatic property of these plants.

## ENVIROMENTAL AWARENESS REFLECTED IN THE *MAHĀBHĀRATA*

In the ‘*Sarpayajña*’ offered by *Janmejaya*, *Vaiśampāyana*, the dear disciple of *Kṛṣṇadvaipāyana Vedavyāsa*, narrated the chronicle of the *Candra* dynasty from their origin to the *Mahāprasthāna* and *Svargārohaṇa* of the *Pāṇḍava*-s. This discourse is entitled as *Mahābharata*. The story of this epic mainly revolves around the strife and the conflicts between *Pāṇḍavas* and *Kauravas* and therefore any

straightaway directive regarding environmental awareness is not traceable herein. But, this huge epic, consisting of eighteen parvas, fondly mentioned as '*Pañcama Veda*' for its vast range of topics, certainly represents the environmental and ecological perception of the then people and society through its embedded narratives making the comment *paraṃ na lekhaḥ kaścidetasya bhubi vidyate* (*Ādiparva* – 1/70) <sup>[21]</sup> [Meaning: There can be no better literary creation than this book on Earth], gratified.

In *Śāntiparva* of *Mahābhārata*, it is stated that the *Paramabrahma*, desirous of creating, first created a divine lotus and from that lotus Lord *Brahmā* was manifested. The latter then brought into existence the entire animal world of different varieties like *jarāyuja* (the viviparous), *aṇḍaja* (the birds), *udbhijja* (the sprouting) etc., and the mountains, the rivers, the celestial bodies like the Sun and the Moon and *Pañcamahābhūta*, the basic five elements. <sup>[22]</sup>

This epic has given paramount importance to *Pañcamahābhūta*. The eternal axiom, that the *kṣiti* – the solidified, the *ap* – the liquid, the *tejas* – the heat, the *marut* – the air in motion and the *vyoman* – the ether infinite – these five elements have formed the entire universe, is evoked and established in this epic –

*ceṣṭā vāyuh khamākāśamuṣmāgniḥ salilaṃ dravaḥ l*  
*pr̥thivī cātra saṅghātaḥ śarīraṃ pāñcabhautikam ll*  
*ityetaiḥ pāñcabhirbhūtairiyuktaṃ sthāvara-jaṅgamam l* (*Śāntiparva* – 184/4-5) <sup>[23]</sup>

In the *Mahābhārata*, emphasis has been laid on water as the origin of the universe. In *Śāntiparva*, to answer the queries on the creation of the world, *Yudhiṣṭhira* quoted the '*Bṛgu-Bharadvāja Saṃvāda*', where the role of all the five elements and specially the crucial role of water in the formation of the universe are stated with a quite scientific approach. According to this narrative, there was only the infinite space that existed in the very first stage of the creation. Then water from the Ether and air from the water were manifested. Then due to the friction of air and water, heat was generated. The air and the water evaporated due to the heat, condensed in the space and the precipitated residual molecules formed the *kṣiti* (the Earth), which is the place of origin of the basic five senses and all the living and non-living beings –

*pura stimitamākāśamanantamacalopamam l*  
*naṣṭacandrārkapavanam prasuptamiva sambabhau ll*  
*tataḥ salilamutpannam tamasīvāparam tamaḥ l*  
*tasmācca salilotpīḍādudatiṣṭhata mārutaḥ ll...*  
*tathā salilasamruddhe nabhaso'nte nirantare l*  
*bhittvārṇavatalam vāyuh samutpatati ghoṣavān ll*  
*tasmin vāyvambusaṅgharṣe dīptatejā mahābalaḥ l*  
*prādurabhūdūrdhaśikhaḥ kṛtvānistimiraṃ nabhaḥ ll*  
*tasyākāśe nipatitaḥ snehastiṣṭhati yo'paraḥ l*  
*sa saṅghātatvamāpanno bhūmitvamanugacchaati ll*  
*rasānām sarvagandhānām snehānām prāṇinām tathā l*  
*bhūmiryoniriha jñeyā yasyām sarvaṃ prasūyate ll* (*Śāntiparva* – 183/9-10,12,14,16-17) <sup>[24]</sup>

In the Mahābhārata, verdurous kingdom has been given the optimal importance in order to keep the environmental stability and the ecological balance. To our sheer astonishment we find that the claim of plants having life, which is accepted by all the scientific communities in the modern world, was proclaimed in the epic five thousand years ago.

In *Bhṛgu-Bharadvāja Saṃvāda*, comprised in the *Śāntiparva*, the sage Bhṛgu presented a logical and rational argument in favour of not only life, but also deliberation, emotion and perception in plants. He stated that, the leaves, the fruits, the flowers and the bark of a plant get withered and wizened when they come in contact with heat; therefore, plants can perceive touch. The blaring sound of air, fire and thunder make the plants pale and shrivelled; therefore, plants can perceive sound. The creepers proceed and then surround the trees for their existence and extension; therefore, plants can perceive sight. Plants stay well and flourish better in the auspicious aroma of incense; therefore, plants can perceive smell. Plants are capable of absorbing water from the soil with the help of their roots; therefore, plants can perceive taste. The torn and split parts of a plant sprout and grow again. The shiny, full-blossomed state and the pale, lacklustre states of the plants suggest their happiness and sorrow respectively. Therefore, this is validated with a lot of evidence that plants *do* have life –

*uṣmato mlāyate paṇaṃ tvak phalaṃ puṣpameva ca l*  
*mlāyate śīryate cāpi sparśastenātra vidyate ll*  
*vāyvagnyaśaninirghoṣaiḥ phalaṃ puṣpaṃ viśīryate l*  
*srotreṇa gṛhyante śabdastasmācchṛṇvanti pādapāḥ ll*  
*vallī veṣṭayate vṛkṣaṃ sarvataścaiva gacchati l*  
*na hyadrṣṭeśca mārgo'sti tasmāt paśyanti pādapāḥ ll*  
*puṇyāpuṇyaistathā gandhairdhūpaiśca vividhairapi l*  
*arogāḥ puṣpitāḥ santi tasmājjighranti pādapāḥ ll*  
*pādaiḥ salilapānācca vyādhīnām cāpi darśanāt l*  
*vyādhīpratikriyatvācca vidyate rasanāṃ drume ll...*  
*sukha-duḥkhaśca grahaṇācchinnasya ca virohaṇāt l*  
*jīvaṃ paśyāmi vṛkṣāṇāmacaitanyaṃ na vidyate ll (Śāntiparva – 184/11-15,17) [25]*

We can find plants being compared to human beings in Vedic Literature. But the scientific approach on the issue of the presence of life-principles in plants was first established in the *Mahābhārata*. And it will not be out of content to mention that, the theory of Sir Acharya Jagdish Chandra Bose to ascertain the paranormal emotion and perception in plants, presented at Royal Society of London in the year 1910, is quite similar to this rationale presented in the Mahabharata.

The process of food preparation of the plants as described in the *Mahābhārata* is undoubtedly pioneering to the 'Photosynthesis' theory of modern science. In *Śāntiparva*, it is stated that, as the water can be sucked by mouth through the stalk of a lotus plant, in the same way, plants absorb water through their roots. That absorbed water is used by the plant with the help of heat from sunlight. This assimilation provides nutrients for the nourishment of the plants –

*vaktreṇotpalanālena yathordhaṃ jalamādadet l*  
*tathā pavanasaṃyuktaḥ pādaiḥ pivati pādapaḥ ll*  
*tena tajjalamādattaṃ jarayatyagni-mārutau l*

*āhārapariṇāmācca sneho vṛddhiśca jāyate ||(Śāntiparva – 184/16,18) [26]*

The knowledge of the food-processing mechanism of plants, as depicted in the *Mahābhārata*, certainly proves the environmental awareness of the-then human society.

The narrator of the *Mahābhārata* not only established the consciousness in plants, but also enormously encouraged the plantation. In *Anuśāsanaparva*, we find *Yudhiṣṭhira* classifying the immobile world (*sthāvara*) into six categories – *Vṛkṣa* (tree), *Gulma* (thicket), *Latā* (*durvā*), *Vallī* (creeper), *Tvaksāra* (bamboo) and *Trṇa* (grass) and announcing the virtue acquired by planting them –

*sthāvarāṇāṃ tu bhūtānāṃ jātayaḥ ṣaṭ prakīrtitāḥ |*  
*vṛkṣa-gulma-latā-vallyastvaksāra-trṇa-virudhaḥ ||*  
*etā jātyastu vṛkṣāṇāmeṣāṃ ropaguṇāstvime | (Anuśāsanaparva – 96/17-18) [27]*

The *Mahābhārata* considers these plants as the offspring of the planter – *tasya putrā bhavantiye pādapā nātra saṁśayaḥ* (*Anuśāsanaparva* – 96/22) [28]. The sprouted plants must be reared with the same affection and attention deserved by the children of the planter – *putravat paripālyāśca putrāste dharmataḥ smṛtāḥ* (*Anuśāsanaparva* – 96/27) [29]. These plants satisfy human needs by offering fruits and flowers in this world and emancipate his soul in the world beyond death –

*puṣpitāḥ phalavantaśca tarpayantīha mānavān ||*  
*vṛkṣadān putravat vṛkṣāḥ tārayanti paratra ca | (Anuśāsanaparva – 96/25-26) [30]*

Unnecessary ruining of plants is strictly forbidden in the *Mahābhārata*. If some ignorant one destroys a tree, even severs a single leaf on a new moon, he will implicate himself with the sin of slaying of a *Brāhmaṇa*. Considering the demolition of a plant as a sin itself institutes the importance of the flora in the environmental system.

The incident of setting *Khāṇḍavavana* on fire may seem contradictory to the ecological awareness proclaimed in the *Mahābhārata*. But we have to keep in mind that, it was a decision of Lord *Kṛṣṇa* in order to sort some political conflicts and to situate and develop an affluent human habitation; the destruction of Nature was not at all the primary reason of this. Eminent author Mr. Buddhadeb Basu explained this incident altogether from a different and ecology-related approach. The story told that, the *Khāṇḍavavana* was set on fire seven times and each time the fire was extinguished by Indra, the God of Rain. Ultimately on the eighth time, Indra got debilitated and Lord *Kṛṣṇa* got the chance to succeed in his plans. Mr. Basu explained this incident with an example. The relation of a tiger and a deer, the predator and the prey, is full of rivalry to be alive but this food-consumer inimical relation, this food chain, ultimately provides the support to keep the balance of the eco-system. So is in Nature. The internal innate contradiction of fire and water becomes complementary when they work in co-operation to sustain the ecological stability and to transform a fierce forest into a habitable abode. [31]

The ‘Kingdom Animalia’, the fauna, is another important component of the environment. The *Mahābhārata* is enriched with mentions of a good number of various animals, birds, reptiles, etc. all through the book. The cows were the most important animal in terms of utility. Cattle wealth was

considered to be signature of the affluent class of society. King *Duryodhana* and the King of *Virāṭa* were famous for their cattle wealth. *Sahadeva*, the youngest of the *Pāṇḍavas*, was skilled in cattle management –

*kṣipraṇca gābo bahulā bhabanti*  
*na tāsū rogo bhabatīha kaścana l*  
*taistairupāyairviditaṃ mamaita-*  
*detāni śilpāni mayi sthitāni ll (Virāṭaparva – 10/13)<sup>[32]</sup>*

Offering of cows was considered as one of the best charities –

*prāṇā vai prāṇināmete procyante bharatarṣabha l*  
*tasmād dadāti yo dhenuṃ prāṇāneṣa prayacchati ll (Anuśāsanaparva – 66/49)<sup>[33]</sup>*

Atrocity with cows or assassination was contemplated as a criminal offence –

*vikrayārthaṃ hi yo hiṃsyād bhakṣayed vā niraṅkuśaḥ l*  
*ghātayānaṃ hi puruṣaṃ ye’numanyeyurarthinaḥ ll (Anuśāsanaparva – 74/3)<sup>[34]</sup>*

Consuming beef was prohibited too –

*ghātakaḥ khādako vāpi tathā yaścānumanyate l*  
*yāvanti tasya romāṇi tāvad varṣāṇi majjati ll (Anuśāsanaparva – 74/4)<sup>[35]</sup>*

Not only the cattle, killing any kind of animal was a punishable offence and it attracted atonements of different degrees according to the severity of the crime –

*śva-varāha-kharān hatvā śaudrameva vrataṃ caret l*  
*māṛjāra-cāṣa- maṇḍūkān kākāṃ byālañca mūṣikam ll*  
*uktaḥ paśusamo doṣo rājan prāṇinipātanāt l...*  
*alpe vāpyatha śoceta prthak saṃvatsaraṃ caret l (Śāntiparva – 165/58-60)<sup>[36]</sup>*

The meaning of the verdict is-- the slayer of dogs, boars and donkeys have to observe the rites reserved for the *Śūdra*-s. Slayers of cats, birds, frogs, snakes and rats had the same punishment; sincere repentance was the atonement for killing small animals and killing a lot of them attracted a year-long penance.

The *Mahābhārata* held some directions for a King to rule over and to protect the subjects properly. In *Śāntiparva*, *Bhīṣma* has been seen counselling Yudhiṣṭhira that as the person, who severs the udder of a cow, cannot get the milk, and who takes care and serves the cow with proper food and water, can get plenty of milk, in the same way, the King who administrates his kingdom by protecting the subjects, justifies the designation of ‘*Rājā*’ and prospers every single day –

*ūdhaśchindyāt tu yo dhenvāḥ kṣīrārthī na labhet payaḥ l*  
*evaṃ rāṣṭramayogena bhuñjāno labhate phalam ll*  
*yo hi dogdhrīmupāste ca sa nityaṃ vindate payaḥ l*  
*evaṃ rāṣṭramupāyena bhuñjāno labhate phalam ll (Śāntiparva – 71/16-17)<sup>[37]</sup>*

*Bhīṣma* suggests *Yudhiṣṭhira* to be like a florist or a gardener, who not only collects flowers from the plants, but rears them with affection and takes good care of them, and not to be like a coalman, who only sets the trees on flames to get the coal and never serves or nurses the plants –

*mālākāropamo rājan bhaba māṅgārikopamaḥ l*  
*tathā yuktaściraṃ rājyaṃ bhoktuṃ śakṣyasi pālayan ll (Śāntiparva – 71/20) [38]*

In *Udyogaparva*, we see *Vidura* advising almost the same preaching to *Dhṛtarāṣṭra* that, as the honey-bee sucks nectar from the flower but never causes harm to the flowers, in the same way, a king should impose tax on his subjects but should never oppress them with over-taxation –

*yathā madhu samādatte rakṣaṇaṃ puṣpāni śatpadaḥ l*  
*tadvadarthān manuṣyebhya ādadyādabhiṃsayā ll (Udyogaparva – 34/17) [39]*

In all these examples, the message of the protection and preservation of Nature in the shroud of preaching and sermons, is clearly suggested.

The *Mahābhārata* reminds us of the fundamental truth that, all the living beings are created by the *Ekamevādviṭīyam* Supreme Animator; therefore, all of them *do* have equal right to live in this beautiful world according to their own way of living and no one is sanctioned to do any harm to anybody. This great epic, though revolving around the story of a blood-soaked battle between good and bad, justice and injustice, morality and immorality, beautifully depicts the undercurrent of the eternal message of non-violence and passivity in apparent contradiction –

*ahiṃsā sarvabhūtebhyo dharmebhyo jyāyasī matā (Śāntiparva – 265/6) [40]*  
*ahiṃsā sakalo dharmo hiṃsādharmastathāhitāḥ (Śāntiparva – 272/20) [41]*  
*ahiṃsā paramo dharmo ahiṃsā paramaṃ sukham l*  
*ahiṃsā dharmasāstreṣu sarveṣu paramaṃ padam ll (Anuśāsanaparva – 245/2) [42]*

The corporal side of non-violence, the philanthropic approach towards all the living beings, *Sarvabhūtahita*, is sermonised many times in the *Mahābhārata* –

*ātmabhūtaḥ sadā loka cared bhūtānyahiṃsayā (Śāntiparva – 294/30) [43]*  
*bhūtānāṃ hi yathā dharmo rakṣaṇaṃ paramā dayā (Śāntiparva – 71/26) [44]*  
*adroheṇaiva bhūtānāṃ yo dharmāḥ sa satām mataḥ (Śāntiparva – 21/11) [45]*

The concept of *Ahiṃsā* and *Sarvabhūtahita* adopted together, is the only way to build a healthy environment; both internally and externally. The words uttered by *Pāṇḍu* in *Ādiparva*, may be quoted in this context –

*prasannavadano nityaṃ sarvabhūtahite rataḥ l*  
*jaṅgamajāṅgamaṃ sarvamahiṃsaṃścaturvidham ll (Ādiparva – 118/11) [46]*

In the light of the foregoing discussion, it is evident that the people of ancient India were fully conscious of their surroundings in which they lived and at the same time they developed a keen sense of awareness in maintaining a pure and pollution-free environment. These two epics approach to humanity to foster an intimate relation between human-beings and nature, to maintain ecological



balance and to develop a spirit of tolerance and trust to make the life all the more pleasant and peaceful on Earth.

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# Women Rites and Conservation of Plants in Traditional Societies: *The Vrata*

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**Abstract:** *Vrata*, in the Vedas, has been stated as a divine ordinance in the form of a prayer while in the Dharmaśāstras, the lawgivers dealt with observation of several scriptures in the form of *prāyaścitta* and dictated *vratas* to be obligatory in different stages of life (*Brahmaçarya*, *Gārhastya*, *Vānaprastha* and *Sannyāsa*). Apart from these, certain *vratas* were considered voluntary or *kāmya* in nature whereas others were obligatory. The present topic deals with *vratas* of *kāmya* or voluntary type or self-imposed for achieving the goal of conservation of natural environment and wild taxa to be able to live in perfect harmony with nature. The *vratas* in the Purāṇas, which were ritual observances as *niyama* performed by all classes of people, particularly women, for fulfillment of desired reality will be discussed in this presentation. According to the Purāṇas, *vratas* could be performed by one and all irrespective of caste, creed, community, religion and sect independently and without the guidance of a priest or other *dharmagurus*. Some of the *vratas* are being followed religiously in different parts of the country. To mention a few – *Tulasī Vrata*, *Vaṭa-Sāvitṛī Vrata*, *Aśokāṣṭamī Vrata*, *Āmalakī-Dvādaśī Vrata* and so on. Through the performance of *vratas* a kind of strong bonding with nature develops, leading to a life to be lived together with full breath; this also involves religious sentiments with regard to development of reverence and gratitude towards such biotic resources that serve humanity enormously in solving bio-resource conservation crisis, oxygen protection, cleaner environment and production of food and fodder, thus salvaging our plant genetic heritage. Although the major objective of *vrata* is *bahujanahitāya bahujanasukhāya ça* with particular emphasis on conservation-development, the *Vratacārī*, in turn, is privileged in terms of his/her soul purification along with eternal peace and happiness showered on him/her.

**Keywords:** Conservation, Plants, *Vrata*, Women.

The fact that relationship between man and the environment is necessarily symbiotic, is known from time immemorial. Man's existence is dependent upon a neat balance among the various elements on earth. The environment performs three basic functions in relation to man: (i) it provides living space and other amenities that make life qualitatively rich for man; (ii) it is the source of agricultural, mineral and other resources, which are consumed directly or indirectly; and (iii) it is a sink, where all the wastes generated are assimilated.

It is essential that capacity of the environment to perform these functions remains unimpaired. Our authors of Sanskrit literature were deeply concerned about ecology and the environment. They felt a strong need to maintain a balance among the various ecological components through such means, which would be well accepted by the common people. After all, their basic aim was to achieve ecological qualities within acceptable levels mainly through the conservation of various plants around us. A section of our population was already aware of the ecological implications, and they also knew that natural environment could no longer survive without positive action by man to conserve it.

Majority of population, however, requires ecological awareness in order to make conservation truly effective.

Plants and trees are well known ecological components. These were considered as valuable resources in rural and urban life of ancient Indians. Trees were used by them not only for fuel and construction of house but also for maintaining ecological balance. Authors of ancient Indian literature were well aware of this fact. Arthaśāstra of Kauṭilya gave immense importance to plantation of trees, which were useful resources, though his main concern was the well-being of royal treasury which was to a large extent dependent on the forest produce. Whatever be the reason behind his prescriptions for creating and preserving forests, these recommendations ensured that vast forest resources were not used up jeopardizing the ecosystem. It may be pointed out that those violating the rule and destroying forests were liable to punishment implying thereby the presence of elements who did not follow the norms—  
*kupyādhyakṣo dravyavanapālaiḥ kupyamānayet. dravyavanakarmāntāmśca prayojayet. dravyavanaccchidāṃ ca deyamatyayaṃ ca sthāpayedanyatrāpadbhyaḥ* (Kauṭīlyam Arthaśāstram2/17/1).<sup>[1]</sup>

Plantation of trees was also encouraged in the Purāṇas; and variety of rewards were suggested for Vṛkṣotsava in the Matsyapurāṇa—

*yaścaikamapi rājendra vṛkṣaṃ saṃsthāpayennarḥ|  
so'pi swarge vasedrājan yāvadindrāyutatrayaṃ||  
bhutānbhavyāmśca manujāmstārayeddrumasammitān|  
paramāṃ siddhimapnoti punarāvṛttirdurlabhāṃ||  
ya idam śṛṇuyannityaṃ śrāvayedvāpi mānavāḥ|  
so'pi sampūjito devairvrahmaloke mahītale||* (Matsyapurāṇam:Adhyāya-59)<sup>[2]</sup>

At the very dawn of Aryan civilization, during the Vedic period, there was consciousness about ecology. Vedic gods like Sūrya, Indra, Agni, Varuṇa, Vāyu, Maruts, Āpaḥ, Uṣas and Prithvī, were nothing but personifications of natural phenomena. Sūrya is the blazing sun, Agni is fire, Maruts are storms, Vāyu is wind, Āpaḥ water, Uṣas dawn and Prithvī Mother Earth.<sup>[3]</sup> These natural forces maintain ecological balance of the world. There was consciousness to protect the ecology in thoughts and ideas of the śāstrakāras. But all these were restricted to the intellectual society beyond the reaches of common people and especially women – the mother and non-formal teacher of the future generations. An attempt to make them conscious about ecology was found in the Purāṇas through depiction of *vratas*. There was no prohibition for women and śūdras in reading or listening to the Purāṇas. It is probable that the wise men of the society thought that ecological consciousness could properly be inculcated and would have due relevance if these concepts were accepted and practised by the womenfolk. With a view to materializing this thought the Purāṇas introduced several *vratas* of which some important ones were related to several of our immensely useful plants. The main purpose was to arouse widespread awareness in respect of conservation of such plants for human welfare; and make them acquainted with several fruits, flowers and trees around us, the knowledge of which could be transmitted to future generations by non-formal education at home.

Before discussing in some detail, let us narrate the meaning of *Vrata* and its relationship with ecology.

In the earliest literature, the *R̥gveda*, the word *Vrata* meant divine ordinance or ethical pattern of conduct. In the *R̥gveda* 8.II.1, the word *Vrata* occurs in a prayer to Agni who is described as protector of ordinances among gods and men – *tvamagne vratapā asi deva ā martyeṣvā|tvam yajñeṣvīdyah* (*R̥gveda* 8.II.1).<sup>[4]</sup> Sāyaṇācārya described the word ‘*vratapā*’ as – *devānām vratapāḥ karmaṇo rakṣakah* (*R̥gveda* 8.II.1).<sup>[5]</sup> Yāskācārya in his *Nirukta* explained the word ‘*vrata*’ in the following way – *Vratamiti karma nāma| nivṛttikarmavārayatīti sataḥ| idamapītaradvratam etasmādeva vṛṇotīti sataḥ| annamapi vratamucyate| yadāvṛṇoti śarīram |(Nirukta, Naighaṇṭukakāṇḍam-2.14).<sup>[6]</sup> It means a religious vow observed with of some restrictions of daily habits, especially regarding consumption of food when a person undergoes such vow.*

In the *Dharmaśāstras*, *Manu*, *Yājñavalkya* and many other *śāstrakāras* dealt with the observance of several strict rules as *vratas*, known as *prāyaścitta*; and they also discussed *vratas* of *brahmachārī*, *snātaka* and *gṛhastha* or the householder. But *vratas*, belonging to the category of *prāyaścitta* are not my subject of discussion. The *vratas* of *brahmachārī* (religious student) or *snātaka* (an initiated householder), which are obligatory or *nitya*, are not being dealt with now. I wish to restrict my topic to the *vratas*, which are *kāmya* or voluntary and self-imposed for securing some specific ends; and try to find out their relation to ecology. *Amarakośa* declared - *niyamo vratamastrī taccopavāvasādi puṇyakam* (*Amarakośa. Brahmanavarga-93*).<sup>[7]</sup>

According to this, *vrata* and *niyama* are synonymous. In the *Agnipurāṇa* *vrata* is *niyama* declared by the *śāstras* which is equivalent of *tapas* as it restrains senses from their enjoyment and imposes hardship on the performer in different ways–

*śāsroditō hi niyamo vrataṃ taṇṇa tapo matam|*  
*niyamāstu viśeṣāstu vrataṣyaiva damādayaḥ||*  
*vrataṃ hi karṭṛsantāpāttapa ityabhidhīyate|*  
*indriyagrāmanīyamānnīyamaścābhidhīyate|| (Agnipurāṇa 175.2-3 )*<sup>[8]</sup>

This paper will discuss about the *vratas* found in the *Purāṇas* which are ritual observances as *niyama*, performed by all classes of people, including women for fulfillment of desire.

In *lokāyata* tradition i.e., beliefs and ideas of the common people, these *vratas* are performed with the objective of achieving the earthly objects eg. wealth, healthy offspring, good harvest, good luck, longevity and so on and so forth. These *vratas* could be performed by all, including *śūdras*, maidens, widows and even by *yavanas*. The *Bhaviṣya Purāṇa* states that –

*haihayaistālajāṅghaiśca turaṣkairiyavanaiḥ śakaiḥ|*  
*upoṣitā ihātraiva vrāhmaṇatvamabhīpsubhiḥ|*  
*ityeṣā paramā puṇyā śivā pāpaharā tathā|| (Bhaviṣyapurāṇa, Brahmaparva-16.61-62) |*<sup>[9]</sup>

Some such *vratas* are being narrated in this context. The first one to be discussed is the *Dūrvāṣṭamī vrata* which is obligatory for women. According to *Purāṇic* tradition the *dūrvā* plant having been generated from the body of *Viṣṇu*, is associated with him–

*kṣīrodasāgare pūrvam mathyamāne ’mṛtārthinā|*  
*viṣṇunā vāhujāṅghābhyām vidhṛtomandārogirih||*  
*tena vegena lomāni gharṣitāni patanti ca|*

*tānyetāni jalormibhirutkṣiptāni taṭe'rṇavāt||*  
*ajāyata śubhā dūrvā ramyā hariatsādvalā|*  
*evameṣā samutpannā dūrvāviṣṇutanuruhā| (Skandapurāṇam, Viṣṇukhaṇḍa)<sup>[10]</sup>*

*Dūrvā* by means of proliferation of its branches holds the soil in such a way that it prevents soil erosion to keep the soil fertility intact for the growth of food crops like rice, sesame etc. In the worship of *dūrvā*, prayer mantra is chanted by *vratin* in this way –

*tvam dūrve'mṛtanāmāsi vanditāsi surāsuraiḥ|*  
*soubhāgyasantatīrdattvā sarvakāryakarī bhava||*  
*yathā śākhāpraśākhābhīrvistṛtāsi mahītale|*  
*tathā māmapi santānaṃ dehi tvamajarāmaram|| (Skandapurāṇam, Viṣṇukhaṇḍa)<sup>[11]</sup>*

– ‘O *Durvā* ! you are immortal, honoured by gods and asuras, give me *saubhāgya*, progeny and all happiness (*Bhaviṣyottarapurāṇa*:56).<sup>[12]</sup>

The mantra itself is self-explanatory, emphasizing the role of *dūrvā* on this earth, whose spread keeps the soil fertility intact for creating convenient environment for future generation, maintaining the progeny (*santati*) vis-à-vis the production of important food crops (*saubhāgya*) for growth and sustenance of human being. This might teach people to treat *dūrvā* as a beneficial plant species enabling the vigorous growth of food crops and not to treat it as weed of little or no value.

Another example of a sacred plant is *tulasī*, which is worshipped in *Tulasī Vrata*, and which has a great utilitarian role in rural and urban life. Great stress was given on plantation of this plant in the *vratakathā* of *Tulasī Vrata*. *Tulasī* plant was equated with the abode of Lord *Viṣṇu*, and great reward was pronounced for plantation of *tulasī* –

*ropitā tulasī yāvat kurute mūlavistaram|*  
*tāvad yugasahasrāṇi brahamaloke mahīyate||*  
*tulasīpatrasaṃyuktajale snānaṃ çared yadi|*  
*sarvāpāvinirmukto modate viṣṇumandire||*  
*vrindāvanañça kurute ropañārthaṃ mahāmune|*  
*tāvataiva vimuktāgho brahmabhuyāya kalpate||*  
*tulasīkānaṃ brahman grhe yasyāvatiṣṭhate|*  
*tadgrhaṃ tīrthabhūtaṃ tu na yānti yamakimkarāḥ||*  
*sarvāpāharam puṇyaṃ kāmadaṃ tulasīvanam|*  
*ropayanti narāḥ śreṣṭhāste na paśyanti bhāskarim||*  
*tulasīśākāsaṃyutaṃ gandhaṃ yo dhārayennaraḥ|*  
*taddehaṃ na sprśet pāpaṃ kriyamāṇaṃ tathaiva ca|| (Skandapurāṇam, Viṣṇukhaṇḍa)<sup>[13]</sup>*

*Tulasī* is a medicinal plant of multiple use; and each part of the plant is known to be useful for cure of some ailment or other and it is said that leaves of *tulasī* release more oxygen than other commonly known plants, making the household atmosphere more purified. Its great utility was realized; and its plantation was suggested in every household premise for better health and hygiene. Another sacred tree worshipped in *Vaṭasāvitṛī Vrata* is *vaṭa* or banyan tree. This *vrata* is observed on the fifteenth day of the darkhalf of the month of *Jyaiṣṭha*. While performing this *vrata* the legend of *Satyavān* and *Sāvitṛī* is



narrated under this tree. Under this tree Sāvitrī wrested back the lost life of her husband from Yama. The *Agnipurāṇa* briefly describes a *vrata* which is same as *Vaṭa Sāvitrīvrata* –

*pañcadaśyaṃ vratī jyeṣṭhye vatamūle mahāsatīm|*  
*trirātropayoṣitā nārī saptadhānaiḥ prapūjayet||*  
*prarūdhaiḥ kaṇṭhasūtaiśca rajanyāṃ kuṃkumādibhiḥ|*  
*vaṭāvalamvanam kṛtvā nṛtyagītaiḥ prabhātake||*  
*namah sāvitrīyai satyavatena naivedyaṃ cāpayeddvijah|*  
*veśma gatvā dvijān bhojya svayaṃ bhuktvā visarjayet||*  
*sāvitrī prīyatām devī saubhāgyādikamāpnuyat| (Agnipurāṇa-194.5)<sup>[14]</sup>*

The worship of the banyan tree is associated with the *Vaṭa-Sāvitrī Vrata*, because this tree serves the role of a ‘wish tree’ which fulfils the desires of the worshippers. It is described in the *Skanda Purāṇa* that at the time of *pralaya*, the only tree to be spared is *vaṭa* and the sanctity of this tree was glorified as an eternal one and a symbol of God –

*vāribhiḥ śīryayate naitat dahyate kālavahninā|*  
*samvartakādibhirnaitat śoṣyate na vicālyate||*  
*ekārṇave mahāghore nouriva kṣetramīkṣyate|*  
*yatrāyaṃ yūpasadrśo nyagrodhastiṣṭhate mahān||*  
*abiruddham kṣetramidam nyagrodha īśitustanuḥ|*  
*mahāpralayavātena śākhā nāsya hi kampate||*  
.....  
*nyagrodha hara me pāpaṃ viṣṇurūpa namo’stute|*  
*namo’sṭtvāvyaktarūpāya mahāpralayasthāyine||*  
*ekāśrayāya jagatām kalpavṛkṣaya te namaḥ| (Skandapurāṇam, Viṣṇukhaṇḍa)<sup>[15]</sup>*

*Vaṭa* is a medicinal plant, and it has fertility power. Perhaps for this power, it is accepted as a symbol of *Śaṣṭhī*, the goddess of fertility in *Aranya Śaṣṭhī Vrata*. Because of its sacred nature and medicinal value, it has been preserved from time immemorial, which is an example of preservation of tree cult through ages.

It is known from the *Purāṇas* that Pārvatī betrayed by Śaṅkara, went to practise penance under the *Aśoka* tree. Under this tree her sorrow was banished; she was freed from grief forever, and thus, the plant became known as *Aśoka*, meaning ‘free from grief’. *Aśokāṣṭamī Vrata* is celebrated on *Śuklāṣṭamī* of the month of *Çaitra*. In this *vrata*, worship of *Durgā* with *aśoka* flowers is prescribed. It has also been recommended that one should drink water mixed with eight *aśoka* buds with the *mantra* –

*tvaṃ-aśoka harābhīṣṭam madhumāsa-samudbhavam|*  
*pivāmi śokasantapto māmśokaṃ sadā kuru|| (Kālaviveka-422)<sup>[16]</sup>*

A great importance was attached to *Aśoka* tree as a token of regard and respect. All of us want to get rid of miseries and agonies of life. Through drinking water with *aśoka* buds, a *vratī* faces life’s agony with triumphant faith. It was an attempt to draw reverence and respect for tree.

Trees were accepted as symbols of different gods and goddesses. Different gods became associated with the trees of certain varieties; and were imagined to dwell in particular trees, which became sacred and symbolical to them. Such an example is seen in *Āmalaki Dvādaśī Vrata*. In this *vrata*, *Dhātrī* (*Āmalakī*) fruit and tree were given much importance and were eulogised. Perhaps, utility of this beneficial tree was appropriately realized by ancient sages. *Dhātrī* means earth or mother. Just as a mother nourishes and takes care of her offspring *Dhātrī* provides mankind with immense benefit through abundant provision of its nutrient-laden juicy fruit or the *āmlā* –

*ato dhātrī mahābhāgā pabitrā pāpanāśinī*  
*dhātrī caiva nṛṇāṃ dhātrī dhātrīvat kurute kriyām*|| (*Skandapurāṇam, Viṣṇukhaṇḍa*)<sup>[17]</sup>

An attempt to popularize its plantation was seen in *Vratakathā* of *Āmalaki Dvādaśī Vrata* in the *Brahmapurāṇa* –

*yaḥ karoti mahārāja dhātrīvrkṣasya ropanam*  
*sa yāti śivasānnidhyaṃ mānavo nātra saṃśayaḥ*||  
*dvādaśyāṃ durlabhā dhātrī snānāñcaiva viśeṣataḥ*  
*yatraiva vidyate dhātrī tatra tiṣṭhati śankaraḥ*||  
*dhātrīphalaṃ rakṣayed yo gehe bhaktisamanvitaḥ*  
*yāvanti puṇyatīrthāni tatra nityaṃ vāsanti vai*||  
*śivaliṅgaṃ sakṛd bhaktyā dhātrīpatraiḥ prapūjayet*  
*vimuktaḥ sarvapāpebhyo nātra kāryā viçaraṇā*|| (*Brihat Purohit Darpan*)<sup>[18]</sup>

In this context we must not forget or ignore a very important fact. The offence in the form of destruction of forests is not committed for the first time by modern world people. Deforestation has always been essential for the growth of human civilization everywhere. Forests which are nature's protective shields were affected by urbanization, a direct effect of expansion of territory by the kings. Apart from natural calamity there were ideas of settling villages (*janapadaniveśaḥ*) which was not possible without deforestation in most cases. *Janapada* or countryside was a major component of *Saptaprakṛti Rājya*. To expand the populated land area a *vijigīṣu* (a king bent on conquest, obviously of unconquered territories) would even rehabilitate his own subjects in a newly conquered land (just as did Aśoka, known from his Major Rock Edict XIII). The king also tried to maintain balance of population by forcing migration of excess masses of a particular locality to uninhabited or sparsely populated places. This was essential for political and economic growth of a monarchy. It is not difficult to visualize the adverse effect which must have been produced through this process of continuous deforestation. Common people do not generally bother about the ecosystem or the damage done to the environment by their destructive activities. They can be controlled to a certain extent by proper awareness programmes or strict implementation of prohibitive laws. Just as in modern world the people responsible for the welfare of the land, the kings and the thinkers of ancient India became worried about the future of the land and prescribed various measures to protect Mother Earth. These included planting trees along with creating and preserving other natural resources. Kauṭilya's prescription in the chapter called *Janapadaniveśaḥ* of the *Arthaśāstra* is a clear pointer to this fact –

*bhūtapūrvamabhūtapūrvam vā janapadaṃ paradeśāpavāhanena swadeśābhiṣyandavamanena*  
*vā niveśayet*  
*nadī-śaila-vana-grṣṭi-darī-setubandha-śālmālī-śamī-kṣīravṛkṣānanteṣu sīmnāṃ sthāpayet*

(*Kauṭīlīyam Arthaśāstram 2.1.1*).<sup>[19]</sup>

*Vratas*, which are *kāmya* or self-imposed, are performed mostly by women. The rationale behind it is that women want to fulfil their urge to take part in rituals through observance of *vratas*. It may be the impact of mother cult which existed in prehistoric times. Mother Goddess seems to have occupied an honourable position in the Indus Valley Civilization. A remark of A.L Basham is worth quoting in this respect – “Certain trees were sacred, as they are in Hinduism today, notably the *Pipal*, which is specially honoured by Buddhists as the species under which the Buddha found enlightenment. One very interesting seal depicts an horned Goddess in a *pipal* tree, worshipped by a figure also wearing horns, with a human-headed goat watching the ceremony and a row of seven pig tailed women, probably priestesses in attendance.”<sup>[20]</sup>

It may be the symbol of Mother Earth, who makes all nature ready to yield. Women took part in ritualistic observance as priestesses in this civilization. Mother Goddess gradually evolved into *Śakti* or *Caṇḍī* or *Annadā*, *Annapūrṇā*, *Śākambharī* in the *Mārkaṇḍeya Purāṇa*. In the patriarchal vedic society, the Ṛgvedic idea of wife as *patnī* capacity wife as a co-participator of sacrifice with the husband (vide *Pāṇini's sūtra*—‘*patyurnoyajñasaṃyoge* – ‘*Aṣṭādhyāyī 4.1.33*’)<sup>[21]</sup> faded away in course of time. The concept of wife as *bhāryā* and *jāyā* became prominent in the later vedic age. Women lost their importance regarding religious practices (though in the royal families we come across queens performing sacrifices with husbands and giving away gifts and sacrificial fees to Brahmins). In the age of *Dharmaśāstra*, the dictates of the Vedas were considered by the authors of *Sūtra* and *Dharmaśāstra* literature as the root of every code of conduct or *dharma - vedo dharmamūlam* (*Goutamasṃṛtiḥ: Smṛti Sandarbha*).<sup>[22]</sup> Manu ordained that, women have no right to take part in the vedic rituals for they have no knowledge of *mantras*; and therefore, her ritualistic activities are futile –

*nāsti strīṇāṃ kriyā mantrairiti dharme vyāvasthitā|*  
*nirindriyā hyamantrāśca striyo'nṛtamitistitiḥ||* (*Manusmṛtiḥ 9/18*)<sup>[23]</sup>

The position of women faced a disastrous change for the presence of *śūdra* women (non-Aryan) in Aryan social set up. *Dharmaśāstrakāra-s* recognized marriage outside the caste as lawful. But an apprehension that non-Aryan wife might take part in ritual observance provoked the orthodox *Śāstrakāra-s* to prevent them from actively participating in such religious performance. The black non-Aryan wife may remain his associate in sensual enjoyments, but not in religious activities –

*dvijasya bhāryā śūdrā tu dharmārthaṃ na bhavetkwaçid|*  
*ratyarthameva sā tasya rāgāndhasya prakīrtitā||* (*Viṣṇusmṛtiḥ 26|5*)<sup>[24]</sup>

In this social context, depiction of *vratas* may be conceived as an attempt to remove the barrenness of ritual activities in the life of women at that age, to engage them in activities which were beneficial for the family and the society and also to add some colour to their otherwise wan life and lend a sense of self esteem for themselves. *Vratas* acted as a medium for arousing awareness among the masses, including women, of the environment in which they lived. By the performance of *vratas*, they could at least promote consciousness about trees, plants and herbs. Apart from that an attempt to make people rever and care for plants may have culminated in the prescriptions of performing certain *vratas*. This was informal education, which began at home; and through which people looked at trees and plants

with religious sentiments, and believed some plants as abode of gods and goddesses, which enhanced reverence and gratitude towards plants and trees, the integral components of ecology. Dr. P. V. Kane mentioned, “*Matsyapurāṇa* 154.512 states that a son is equal to ten deep reservoirs of water and a tree planted is equal to ten sons. It is said by *Varāṇhapurāṇa* (172.36-37) that just as a good son saves his family, so a tree, laden with flowers and fruits, saves its owner from falling into hell and that one who plants five mango trees does not go to Hell ; *Viṣṇudharmottarapurāṇa* (III.297.13) remarks about trees ‘a single tree nurtured by a man performs what a son would do, in that it gratifies gods with its flowers, travelers with its shade, men with its fruits ; there is no fall in hell for the planter of a tree’.”<sup>[25]</sup>

Man has been constantly striving to reach the goal of spirituality through the lower form of worship, through worship of plants and trees in *vratas*. Man’s material thoughts could rise to spirituality; and this could be achieved by non-formal worship or by *vratas*, aimed at generous outlook of welfare of mankind. Plants, which have great importance in keeping ecological balance in earth, are revered in *vratas*; and their plantations become a *vrata* that means a vow or *niyamas* in *vratas*.

According to the Purāṇas, *vrata*-s could be performed by one and all, irrespective of caste, creed, community, religion and sect independently and without the guidance of priests or other *dharmagurus*/religious preachers. Some of the *vratas* are being followed religiously in different parts of the country. Through the performance of *vratas*, a kind of strong bonding with nature develops leading to a life to be lived together with full breath. This also involves religious sentiments with regard to development of reverence and gratitude towards such biotic resources that serve humanity enormously towards solving bio-resource conservation crisis, oxygen protection, cleaner environment and production of food and fodder, thus salvaging our plant genetic heritage. Although the major objective of *vrata* is *bahujanahitāya bahujanasukhāya ça* with particular emphasis on conservation-development, the *vrataçārīṇī* woman, in turn, is privileged in terms of her soul purification along with eternal peace and happiness, showered on her.

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# *River Poems:* **Interweaving Nature and People**

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*Abstract: Mamang Dai's 'River Poems' is a conglomeration of places and people. It is indeed a saga of land shaping the life of its people. The poems record, in an unmistakable way, how nature can emerge as a living source of sustenance for people whose tradition is not recorded in written history. They can also be explored from the perspective of critical discourse such as ecocriticism as they interweave ecology and literature. They voice the urge to restore nature as it faces the ordeal under the pressure of development. Written in lyrical verses so characteristic of Dai, 'River Poems' has an enduring appeal to preserve the pristine nature that reflects the tradition of her land. A reading of the poems gives a scope to celebrate nature that emerges to be the repository of culture. The paper reads her poems and tries to focus into the interrelationship between nature and people so uniquely portrayed by Dai.*

**Keywords: Adis, Ecocriticism, River Poems**

## **INTRODUCTION**

In an attempt to connect ecology and literature, Glotfelty has commented that 'literature does not float above the material world in some aesthetic ether, but rather, plays a part in an immensely complex global system, in which energy, matter, and ideas interact'<sup>[1]</sup>. This observation attains a poignancy in the poetic creation of Mamang Dai (1957-), a poet from Arunachal Pradesh. Her collection of poetry, entitled 'River Poems', interweaves land and her people. In the words of eminent critic Nigamananda Das, 'In her poetry, life in Arunachal Pradesh, peoples' faiths and her own, agriculture, mountains, streams, rivers and stones, myths, and nature's magic, reveal the myriad world of Arunachal's ecology and mysterious and glorious heritage.'<sup>[2]</sup> Thus her book resonates with voices of nature.

## **ECOCRITICISM**

Ecocriticism is a branch of study which studies relationships between human culture and the physical world. The term "Ecocriticism", coined in 1978 by William Rueckert in his essay *Literature and Ecology: An Experiment in Ecocriticism* is derived from the Greek 'oikos' and 'kritis'. The Greek word 'oikos', meaning 'home', incorporates within it the animate as well as the inanimate world in a larger perspective and 'kritis' stands for judge. By the term Rueckert meant "the application of ecology and ecological concepts to the study of literature".<sup>[3]</sup> The conceptualisation of nature as an abstract entity demands, therefore, a reinvestigation and scholars throughout the humanities endeavour to address the global crisis. In 1990, the University of Nevada, Reno, created the first

academic position in Literature and the Environment. A new 'Association for the Study of Literature and Environment' (ASLE) was formed in 1992 in order "to promote the exchange of ideas and information pertaining to literature that considers the relationship between human beings and the natural world." The establishment of ISLE (Interdisciplinary Studies in Literature and Environment) by Patrick Murphy in 1993 was an endeavour to "provide a forum for critical studies of the literary and performing arts proceeding from or addressing environmental considerations. These would include ecological theory, environmentalism, conceptions of nature and their depictions, the human/nature dichotomy and related concerns." In India, OSLE (Organisation for Studies in Literature and Environment) was established in order to provide a forum for promoting ecocriticism. Dr. Nirmal Selvamony (Founder President of OSLE-India) first introduced the ecoliterature course in the Department of English, Madras Christian College. The fundamental premise in ecological criticism is the interconnection between human culture and physical world; therefore to study the relationship between literature and physical environment is its primary concern. For the ecocritic, nature is not a concept, it is actually present as an entity which affects us and which we can affect, if we mistreat it. While in other critical approaches the social sphere assumes the most important place, in ecological criticism the notion of the world is expanded and includes the entire ecosphere. The common motivation shared by all ecological work is that the environmental degradation is largely our own making - it is a 'by-product of culture'. Ecocriticism provides the scope 'to analyse critically the tropes brought into play in environmental debate, and more tentatively, to predict which will have a desired effect on a specific audience at a given historical juncture.'<sup>[4]</sup> Therefore, instead of being confined in a fragmented way of knowing the world through merely values, traditions, point of view and language, literary scholars endeavour to educate themselves in the interdisciplinary courses so that a holistic world-view can be achieved for the restoration of the environment.

### **MAMANG DAI AND HER POETIC OEUVRE**

Located in the northeast frontier of India, Arunachal Pradesh is a land of profound scenic beauty. Earlier known as NEFA (North East Frontier Agency), the land got its name as Arunachal Pradesh meaning the land of 'rising sun' in 1972.<sup>[5]</sup> Inhabited by some twenty five major and many sub-tribes, the land is a treasure trove for ethnographic study as it preserves their customs and tradition. The custom, rituals and culture of the tribes reflect their inextricable relation with nature; and languages spoken by the tribes are varied and without any written script. However, the writers of the land have attempted to reflect the life of the people in their works in myriad ways. The folklore, myth, legends of the land reflect the intimate relationship of nature and people.

Born on February 23, 1957 at Pasighat to an Adi community, East Siang District, in Arunachal Pradesh, Mamang Dai has depicted the beautiful world of Arunachal Pradesh in her fictions, poems and other literary works. Dai left the prestigious profession of an IAS officer to pursue a career as a journalist and a writer. Recipient of State Verrier Elwin Award in 2003 and Padmasree in 2011, Dai articulates in her writing the primordial beliefs and cultures of her land. She has been a member of many societies and committees such as the Arunachal Pradesh Literary Society, the North East Writers' Forum, and Arunachal Pradesh Public Service Commission. She was a programme officer with World Wide Fund for Nature(WWF). She has also worked with the Bio-diversity Hotspots Conservation programme of the eastern Himalayas. Her poetical works include 'River Poems', 'Midsummer Survival Poems' and a bilingual work 'The Balm of Time'. In an essay entitled

“Contemporary Literary Scenario in the Northeast States,” she talks about “an inviolate space,” “a mysterious landscape,” which is likened to a “person’s secret garden.” “It is here,” she writes, “that the aesthetic fact resides.” In her words ‘What is true, what is sacred, what is imagined – it is still a mysterious landscape to me too, even though I was born here. I know not everyone will feel the same way about land and landscapes. I am very attuned to spirit of place and the natural world, wherever it may be. This is my response. To me it is a living presence.’<sup>[6]</sup> The concept of nature as a living presence is the recurrent theme of her poems and this she owes to the tradition of her land. When asked to comment on the theme of the union of nature and man in her poetry she has opined that ‘The traditional belief of the Adi community to which I belong is full of this union. Everything has life -- rocks, stones, trees, rivers, hills, and all life is sacred. This is called Donyi- Polo, literally meaning Donyi- Sun, and Polo- moon as the physical manifestation of a supreme deity, or what I like to interpret as ‘world spirit.’<sup>[7]</sup> Thus the interrelation of nature and people constitutes the very bedrock of her poetic oeuvre.

### ‘RIVER POEMS’

Dai’s portrayal of her land in ‘River Poems’ offers a unique view of Northeast ecology. As Agarwal has observed that “the Mingling of realism and imagination in the presentation of nature exhibits Dai’s extreme devotion to her art. Her picture of nature appears to be complete and it does not smack of any false sentimentalism or illusory romanticization of the subject.”<sup>[8]</sup> The book opens with ‘The Missing Link’ -

“There are no records./ The river was the green and white vein of our lives/ linking new terrain,”<sup>[9]</sup>

One notes how nature has provided the language which is now being recorded in poetry. The state of Arunachal Pradesh houses six rivers- Subansiri, Lohit, Dikrong, Dirang, Kameng and Siang. Both Siang and Lohit flow down to merge with the mighty river Brahmaputra in Assam. According to the Survey of India the Siang river of Arunachal Pradesh was referred to as ‘the missing link’ before it was established that the Siang is the connecting channel that links the Tsanpo river of Tibet with the river Brahmaputra of Assam. Dai attributes a new note to the river as it becomes the very soul of the people of her land. Doley observes that ‘As the river is an essential element in the lives of these people, the poet uses it as a symbol while expressing the life and times of the land, along with the symbol of mountain and forests, quite extensively to express the pain of the lost past.’<sup>[10]</sup> The poem also becomes relevant from the contemporary perspective keeping in view the recent controversies regarding dams and development in the state. The proposed project for the Siang valley may have promises to usher in new development but it has the potential to alter the river that has played the role of ‘missing link’. The poem thus becomes poignant as one recalls Dai’s comment on how she envisages ‘development’, which becomes almost like ‘invasion’ if not considered from an inclusive point of view.<sup>[11]</sup> The river thus becomes the symbol of resistance as well as the repository of culture.

In ‘River Poem’ we are introduced to the magical land –

“Without speech/we practised a craft,/leaving imprints on sky walls/ linking the seasons/coding the trailing mist,/ in silent messages/ across the vast landscape.”<sup>[12]</sup>

The introductory phrase ‘Without speech’ reflects the unheard communion between her land and its people. In animistic culture such as practised by the Adis, one observes how the inanimate entities can interact with people. As Christopher Manes puts it ‘In addition to human language, there is also the language of birds, the wind, earthworms, wolves, and waterfalls - a world of autonomous



speakers whose intents (especially for hunter-gatherer peoples) one ignore at one's peril.'<sup>[13]</sup> The 'silent messages' across the vast landscape, therefore, become vocal enough to initiate a new mode of communication. Environment is not only a sphere that sustains us that but also can emerge as a living entity, shaping and recording the tradition of people.

Cultural memory is an integral part of Dai's work. Without any written script, nature preserves the memory. In 'River Poems' Dai records how the land itself emerges as a living historian:

"Full of memories the land rises/ to meet us at dawn./ Still hiding the beloved features/ the mountain shaped with horns/ guards the iron gate/ where we clamoured,"<sup>[14]</sup>

Nature not only preserves the memories but can be identical with beloved.

"I see your mould, steadfast / in the outline of the hills ...In these hills,/ the centre of being,/ one by one / voices are extinguished."<sup>[15]</sup>

Rituals and customs of Arunachal Pradesh have their roots in the heart of nature - Adis believe in animism which primarily concerns the elements of nature. The poem written in reference to the ritual Ponung dance of the Adis record how the ritual is performed in the heart of nature:

"The cloud is in love with the mountain./ The blue crest wrapped in stillness /bears this addiction of air and water, / the mark of rain on the steep jungle/ the mysteries of the path in her valleys,/ and the silent space of her memories."<sup>[16]</sup>

Another dance is Tapu, which is performed by men during the time of community-fencing. It is also viewed as a war dance to exorcise malevolent spirits, but once there was a belief that women who had borne no sons could put on male attire and join the dancers in the hope of conceiving a son.

"In this diagram/ looking through the sun's face, / peeping through the moon, the meaning of life is contained in fulfilling obligation."<sup>[17]</sup>

Many Arunachal communities believe that man and tiger were born brothers. The killing of a tiger is considered as equivalent to the killing of a man and rigorous rituals are associated with it. Dai's poem 'Man and Tiger' reflect such interrelationship and record the rituals that are performed -

"The tiger runs swiftly from my father's house/ calling my name. / Brother! Man brother! / Have mercy for our destiny!"<sup>[18]</sup>

One major aspect of Northeast poetry is its preoccupation with political movements. 'River Poems' is not an exception to it. One marks how nature remains an active agent in moments of turmoil-

"This summer it rains more than ever. / The footfall of soldiers is drowned and scattered./ In the hidden exchange of news we hear/ that weapons are multiplying in the forest."<sup>[19]</sup>

'River Poems' also reflects some of Dai's personal emotions that are expressed in terms of nature imageries. In 'Spirit Sun' for instance:

"In my mind / I turn you into the land,/...and I link you with all the seasons."<sup>[20]</sup> or the lines from 'Small Towns and the River': "Small towns always remind me of death./ My home town lies calmly amidst the trees,"<sup>[21]</sup> are reminiscent of her loving relation with her land.

One can mark a romantic poet's adoration and passionate evocation of nature in her poems such as in the lines "Now, when it rains/ I equate the white magnolia with perfect joy"<sup>[22]</sup> or "One morning, flowering peonies / swelled my heart with regret."<sup>[23]</sup> Nature is not only the backdrop or place being out there – it has a voice of its own- the voice that becomes vocal in her poetry- "In the sound of the rain/ is contained/ all the spirit of the jungle."<sup>[24]</sup>

## CONCLUSION

In spite of having a heterogeneous identity, poetry of the Northeast has shown considerable preoccupation with ecology. Dai's poetry evokes with passionate poignancy the tradition and the identity of her land in a way that makes her one of the remarkable writers of the Northeast. She has observed that the survival of a man in her land becomes possible not by conquering nature but by establishing for him a way of life that is in harmony with the environment that surrounds him.<sup>[25]</sup> 'River Poems' celebrates nature and focuses on this spirit of harmonious existence between man and nature.

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## উন্নয়ন ও বিশ্বায়নের প্রেক্ষিতে ভারতীয় অরণ্য (১৮৬৪-১৯৮৫)

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পরিবেশের উপর বিশ্বায়নের প্রভাব নতুন নয়। পরিবেশসচেতনতা নিয়ে সমগ্র বিশ্বে একাধিক ধারণা তৈরী হয়েছে। প্রত্যেকটি ধারণা নিজস্ব নীতিতে এগিয়ে চলেছে। আবার কোথাও একটি ধারণার সঙ্গে অপর ধারণার যোগসূত্র তৈরী হয়েছে। ভারতীয় উপমহাদেশের উপরও পরিবেশ ধবংসের ব্যাপক প্রতিক্রিয়া লক্ষ্য করা যায়। ঔপনিবেশিক সরকার ভারতীয় উপমহাদেশে কতগুলো আইন তৈরী করে পরিবেশকে নিয়ন্ত্রণ করেছিল। তেমনি ভারত স্বাধীন হওয়ার পরেও ঔপনিবেশিক আইনের সেই কাঠামোটিই সম্পূর্ণ থেকে যায়। ভারত সরকার যে সমস্ত পরিবেশবিষয়ক আইন তৈরী করে তাতে পরিবেশ দূষণকে তেমন একটা নিয়ন্ত্রণ করা যায়নি। অরণ্য সংরক্ষণের নামে ব্রিটিশ সরকার যে আইন তৈরী করেছিল, তার লক্ষ্য ছিল অরণ্যের সম্পদকে নিজেদের স্বার্থে ব্যবহার করা। ব্রিটিশদের রেলপথ উন্নয়ন এবং জাহাজশিল্পের উন্নয়নই ছিল তাদের লক্ষ্য। এর ফলে ভারতীয় অরণ্য আস্তে আস্তে ধবংসের সম্মুখীন হয়ে পড়েছিল।

পরিবেশ, প্রতিবেশ নিয়ে গত দু'দশক ধরে চারদিকে বহু আলোচনা শোনা যাচ্ছে। এর সঙ্গে জুড়ে গেছে 'উন্নয়ন'-এর প্রশ্নটিও। ফলে নানান তর্ক-বিতর্ক - প্রকৃতি না পরিবেশ, প্রকৃতি বনাম পরিবেশ, প্রকৃতি ও পরিবেশ ইত্যাদির সৃষ্টি হয়েছে। সাহেবদের কৃষ্টিতে লালিত-পালিত তৃতীয় বিশ্বের বুদ্ধিজীবীকুলও এহেন বিতর্কে শুধুই শ্রোতা থাকবেন এমনটা ভাবা ভুল। বিশ্বের কথা ভুলে নিজের দেশের দিকে তাকালেই চলতি বিতর্কের মূল বিষয়গুলোর হদিশ মিলবে ; এদেশেও এই সংক্রান্ত যাবতীয় বিতর্ক চলছে এবং তা অবশ্যই প্রতিনিধিত্বমূলক। এই লেখার মাধ্যমে উন্নয়ন ও বিশ্বায়নের জন্য ভারতীয় অরণ্যে উপর যে প্রভাব পড়েছে তার আলোচনা করাই মূল উদ্দেশ্য। ১৮০৬ সালের 'মালাবার রাজ্য সংক্রান্ত' আইনকে ভারতীয় অরণ্য নিয়ন্ত্রণের প্রথম পদক্ষেপ রূপে ধরা হয়। ১৮৫০ সালের পর থেকে ভারতীয় অরণ্যকে রেলের উন্নয়নের কাজে লাগানো হতে থাকে। ১৮৬৫ সালে প্রথম অরণ্য আইন তৈরী করা হয় এবং ১৮৭৮ সালে আবার এই অরণ্য আইনকে সংশোধিত করে নতুন অরণ্য আইন তৈরী হয়। আর এই আইনের মাধ্যমে ১৮৯০ সালের মধ্যে ভারতীয় অরণ্যের এক-পঞ্চমাংশ ব্রিটিশদের অধীনে চলে যায়।

আমাদের দেশে পরিবেশসচেতনতা বা পরিবেশ আন্দোলন নিয়ে বিভিন্ন মতামতের সহাবস্থান লক্ষ্য করা যায়। 'আমাদের প্রকৃতি-পরিবেশ সচেতনতা পশ্চিমী দুনিয়া থেকে ধার করা, দেশীয় বাস্তবতার সঙ্গে এর কোনো যোগাযোগ নেই। ফলে এই প্রকৃতি পরিবেশ সচেতনতা ভারতের বেশীরভাগ মানুষের সমস্যা আশা-আকাঙ্ক্ষার যথার্থ প্রতিফলন নয়; ফলতঃ সাহেবী শিক্ষায় শিক্ষিত, সাহেবী ধ্যানধারণায় সম্পৃক্ত দেশের মাটিতে শিকড়হীন এক মুষ্টিমেয় গোষ্ঠীর চর্চাতেই এটা সীমাবদ্ধ'।<sup>১</sup> আমাদের প্রকৃতি-সচেতনতা আসলে এসেছে আমাদের পশ্চাৎপদতা থেকে। আজকের দুনিয়ার প্রযুক্তি এবং এগিয়ে থাকা ধারণার সামনে অসহায় বোধ করে একদল লোক। তাদের পশ্চাৎমুখী জীবনযাপন প্রণালী এবং দর্শনকে কেন্দ্র করে প্রকৃতি-পরিবেশ সংক্রান্ত যে অতি-আধুনিক ভাবাদর্শগত বিতর্ক গড়ে উঠেছে, সেই মোড়কে মুড়ে গ্রহণযোগ্য করে তুলতে নতুন আন্দোলন তৈরী করছে তারা। এতে হয়ত বহু ভারতবাসী সামিল, কিন্তু ভাবাদর্শ হিসেবে এটি ক্ষতিকর, অতএব এটি বর্জনীয়। এছাড়া প্রকৃতি-পরিবেশ সমস্যাকে আর্থ-সামাজিক সমস্যার অঙ্গ হিসেবেও দেখা হয়। আজকের দুনিয়া অনেক

জটিল এবং মানবজাতির জ্ঞান গত এক শতকে অনেক বেড়েছে। জ্ঞানের পরিধি বাড়ার সঙ্গে সঙ্গে অনেক ধরনের নতুন প্রশ্ন উঠে এসেছে, পীড়িত করেছে বিভিন্ন প্রজন্মের মানুষদের। জ্ঞানতত্ত্বের ইতিহাসে এটা আজকে মোটামুটি মেনে নেওয়া হচ্ছে যে, সম্পূর্ণ বিপরীতধর্মী সমাধান আসলে আংশিক জ্ঞান দেয়। সাদা- কালোর মাঝে এক বিস্তীর্ণ ধূসর এলাকায় কোথাও সত্য লুকিয়ে রয়েছে। প্রথম ভাবাদর্শটি বস্তুত: দেশীয় সব ঐতিহ্যকে নাকচ করে দেয় এবং এটি পরিপ্রেক্ষিতহীন ভাবাদর্শ আমদানির প্রবল সমর্থক। এই ধারার মূল উদগাতা আমাদের কেন্দ্রীয় ও রাজ্য সরকারগুলো। এরা নির্বাহীর ভূমিকা গ্রহণ করে এবং এদের পেছনে তাত্ত্বিক নেতৃত্ব দিতে এগিয়ে আসে সাহেবী চিন্তায় উদ্বুদ্ধ, আত্মমর্যাদাহীন, আত্মবিস্মৃত একদল প্রতিষ্ঠানপ্রেমী বুদ্ধিব্যবসায়ী আর তাদের সঙ্গ দেয় সাহেবী মদতপুষ্ট সুবিধাভোগী আমলাকুল। বিশ্বব্যাঙ্ক, আন্তর্জাতিক অর্থভান্ডার, ভূবনায়ন, বেসরকারীকরণ, অরণ্যধ্বংস, জৈবসম্পদ লোপাট ইত্যাদি যাবতীয় শ্বেতাঙ্গ কুকর্মের একদল গৌড়া সমর্থক দেশে দেশে বিদ্যমান। মেকলে সাহেবের এদেশে খ্রিস্টান শিক্ষাপ্রসারের যে দার্শনিক ভিত্তি, তা আজও শ্বেতাঙ্গ লুটতরাজের সাহায্যে আসছে। ‘কেন্দ্রীভূত পরিকল্পনার নামে অরণ্যের অভ্যন্তর থেকে উচ্ছেদ করা হচ্ছে আদিবাসীদের। হাত বদল হয়ে এই অরণ্য সম্পদ যাচ্ছে অরণ্য উন্নয়ন পর্যদের কাছে’।<sup>[২]</sup> পরিকল্পিত উপায়ে ঠিকাদারদের মাধ্যমে বিশ্বব্যাঙ্ক প্রচারিত ‘খোলা বাজার’-এ বিকোচ্ছে এই অরণ্যসম্পদ বিরাট মুনাফার বিনিময়ে। তবে অরণ্যের অধিকার নিয়ে যে আন্দোলন তৈরী হয়নি, তা নয়। ১৯৭৩ সালের উত্তরাখণ্ডের গারোয়াল হিমালয়ে গৌরা দেবী, বাচনী দেবী, সুন্দরলাল বহুগুণা প্রমুখের নেতৃত্বে চিপকো আন্দোলন, ১৯৬৪ সালে শ্রী চন্ডীপ্রসাদ ভাট-এর নেতৃত্বে দাসোলি গ্রাম স্বরাজ্য মণ্ডল আন্দোলন, সাইলেন্ট ভ্যালি আন্দোলন এবং অমৃতাদেবী বিশনোই আন্দোলন উল্লেখযোগ্য। আর এই আন্দোলনের ফলে কিছুটা হলেও কেন্দ্রীভূত পরিকল্পনায় পরিবর্তন করা হয়। দ্বিতীয় ভাবাদর্শটি প্রথমটির থেকে একটু আলাদা। যে কোনো সমাজে ভাবাদর্শের সংঘাত থাকে। সময়ের পরিবর্তনের সঙ্গে সমাজের পরিবর্তন সমাজের সব অংশের এক সঙ্গে ঘটে না। সমাজে অর্থনৈতিক স্বার্থের সংঘাত সমাজের বিভিন্ন অংশকে বিভিন্নভাবে মেজাজ বদলাতে সাহায্য করে। অর্থনৈতিক স্বার্থের সংঘাত ভাবাদর্শের সংঘাতের রূপ নেয়। অশ্রারুঢ় যাযাবর আর্থজাতি নগর সভ্যতার সামনে এসে তাদের ভাবাদর্শের শূন্যতা উপলব্ধি করেছে, দুই মতাদর্শ সংঘাতে লিপ্ত হয়েছে। মহেঞ্জোদারো, হরপ্পা, ইনকা আর মায়া সভ্যতার ধ্বংসের অন্যতম কারণ হিসেবে এই মতাদর্শকে মনে করা হয়। এছাড়া আরো একটি সুপ্রাচীন দর্শন নজরে আসে। যেমন: যাহাই নবীন তাহাই আধুনিক, যাহাই প্রাচীন তাহাই পশ্চাৎপদ। এই মূল্যবোধ আরোপের মূল উদগাতা যে পশ্চিম ইউরোপ এবং ইঙ্গ-মার্কিন দেশের দার্শনিককুল, তাতে সন্দেহ কি? নিজেদের অসংযত ঐতিহ্য এবং হিংসা-দ্রোহ-রিরংসা কটকিত, কলঙ্কময় অতীতকে অস্বীকার না করতে পারলে তারা কোনো গুরুত্ব পাবে না। তবে এই ধারাটি পরিবেশ-সমস্যা সমাধানের জন্য চলতি সমাজ-আর্থনীতিক নিয়মের বাইরে গিয়ে অনুসন্ধান করতে হবে। এই ধারার নির্ঘাস হল যে, চলতি ব্যবস্থার বিপরীতে একটি বিকল্প ব্যবস্থা খাড়া করতে হবে। তবেই সমাজ-আর্থনীতিক-রাজনৈতিক-কৃষ্টিক সমস্যার পাশাপাশি পরিবেশ-সমস্যার সুষ্ঠু সমাধান সম্ভব। সমাজবিজ্ঞানীরা বলেন যে, ভাবাদর্শগত বিতর্ক ও মতবাদগত প্রয়াসে অংশগ্রহণকারীদের বক্তব্যে আপনা-আপনিই সমাজে তাদের অর্থনৈতিক অবস্থানের প্রতিফলন ঘটে। অর্থাৎ এখানে ভাবাদর্শ ও মতবাদগত প্রয়াস ‘পক্ষপাতদুষ্ট’। সে যাহোক, ধারাগুলোর বিষয়ে বৃহত্তর আলোচনায় না গিয়ে এবারে উন্নয়নের ধারণা সম্পর্কে একটু আলোকপাত করা যাক।

আজকের পরিবেশ-আন্দোলনের কর্মীদের আর একটি বিতর্কের সামনে পড়তে হয় ‘উন্নয়নের’ ধারণা নিয়ে। বিশ্বব্যাঙ্ক প্রভৃতি অর্থনৈতিক দিক থেকে সুগঠিত বিশ্বব্যাপী সংগঠনগুলো অক্লান্তভাবে প্রতিবছর বিভিন্ন ধরনের উন্নয়নের সূচক বের করছে। কখনো তা মৃত্যুহার, কখনো গড় পরমায়ু, কখনো তা জনপ্রতি বিদ্যুৎ-ব্যবহার। উন্নয়নের ধারণাটি বহুলাংশে পক্ষপাতদুষ্ট। বাজারে চালু সূচকগুলো আমাদের কাছে তেমন গ্রহণযোগ্য নয়। আমরা নিজেরা নতুন সূচক বের করতে পারি। যেমন গ্রামে পুকুরের সংখ্যা কমছে কিনা, গ্রামের জঙ্গলে ফুল বেশী বেশী ফুটছে কিনা, চাষীর জমি চাষ করার সুযোগ বাড়ছে কিনা, দেশের খাদ্যভান্ডারে খাদ্যের পরিমাণ বাড়ার সঙ্গে সঙ্গে গ্রামে-গ্রামে অনাহার বাড়ছে কিনা ইত্যাদি। এর বদলে আমরা যদি দেশে জনপিছু বিদ্যুৎ-ব্যবহারকে সূচক হিসেবে ধরি এবং বলি যে বিদ্যুৎ-ব্যবহার বাড়ছে মানে দেশের শিক্ষা বাড়ছে, দেশ সমৃদ্ধ হচ্ছে এবং লোকে বিদ্যুৎ-চালিত পরিষেবা উপভোগ করছে, তবে তা নিতান্তই একটি সাহেবী ধারণা হবে। অন্যদিক

থেকে এই ব্যাপারটিকে আমরা দেখতে পারি। যেমন - বিদ্যুৎ-ব্যবহার বাড়তে পারে শীততাপ যন্ত্র চালানোর জন্য। অর্থাৎ অল্প লোক প্রচুর বিদ্যুৎ ব্যবহার করতে পারেন, তার ফলে গড় ব্যবহার বাড়বে। শীতল পানীয় প্রস্তুতের জন্য বিভিন্ন কোম্পানীগুলো যথেষ্ট পরিমাণে বিদ্যুৎশক্তি ব্যবহার করে। এর ফলে প্রচুর পরিমাণে বিদ্যুৎ-শক্তির ঘাটতি দেখা দেয়। সাহেবরা অন্যদেশ লুণ্ঠন করে সেই অর্থ নিজের দেশে ব্যবহার করে; কিন্তু সেই কদর্য অপকর্মটি উন্নয়নের নামে আমাদের করতে হবে কেন? আমরা বলি, আগে বিদ্যুৎতের চাহিদার হিসেব হোক অগ্রাধিকারের ভিত্তিতে - যাতে জনপ্রতি বিদ্যুৎ-ব্যবহার বাড়বে এবং অন্যদিকে অপচয় কমবে। উন্নয়নের ধারণায় ‘অগ্রাধিকার’ কথাটি ব্রাত্য হয়ে উঠেছে ক্রমশঃ। মার্কিনীদের বিশ্বনিয়েন্ত্রক মনোভাবের জন্য জীবাশ্ম জ্বালানীর প্রয়োজন, কেননা তাদের যুদ্ধ বিমান এবং যুদ্ধ জাহাজ সারা পৃথিবী টহল দিয়ে নজরদারী করবে। অতএব তারা এই অমূল্য জ্বালানী অপচয় করবে এবং জ্বালানীর বেশী বেশী ব্যবহার যে উন্নতির সূচক তা প্রচার করবে তার অপকর্মের সাফাই হিসেবে। তবে উন্নয়নশীল দেশের সূচক কখনো উন্নত দেশের সূচকের সমপর্যায়ভুক্ত হতে পারেনা। কেননা তাদের বিভিন্ন পরিকাঠামোর অভাব রয়েছে।

পরিবেশ আজ বিপন্ন। তবে এই বিপন্নতার সঙ্গে বিশ্বায়নের সম্পর্ক রয়েছে। বিশ্বায়ন সম্পর্কে পশ্চিমী বিশ্ব তাদের নিজস্ব মনগড়া মতবাদ জাহির করেছেন। ‘মার্কসবাদী দৃষ্টিতে আর্থনীতিক বিশ্লেষণ করে এগোলে প্রকৃত স্বরূপ উদ্ঘাটন করা সম্ভব হয়। পশ্চিমী বিশ্ব এক ধরনের আধিপত্যধীন অর্থব্যবস্থার সর্বজনীন বিস্তার ও ক্রিয়াশীলতাকে বিশ্বায়ন বলে চালাচ্ছে’।<sup>[৩]</sup> সত্তরের দশকে ‘কাঠামোগত বিস্তার পুনর্গঠন কর্মসূচী’ দিয়ে এর শুরু এবং বর্তমানে নতুন ‘গ্যাট’ চুক্তিতে তার পরিণতি। বিশ্বজনীন অর্থ ব্যবস্থার ভিত্তি হল মুক্ত বা স্বাধীন বাণিজ্য এবং সব দেশ যদি স্বাধীন বাণিজ্যক্রিয়ায় অংশ নেয় তাহলে আন্তর্জাতিক বাণিজ্যের তাগিদেই জাতীয় স্তরের বিভিন্ন উৎপাদনক্রিয়া ও পণ্যের বিভাগ গুলি নিজেদের মধ্যে মানিয়ে নিয়ে পারস্পরিক পরিপূরক প্রক্রিয়ার একটি ছকে পূর্ণগঠিত হয়ে যাবে। অর্থাৎ আন্তর্জাতিক বাণিজ্যক্রিয়ার অনড় শর্তের চাপে জাতীয় উৎপাদনের ছক পাল্টে যাবে যাতে আন্তর্জাতিক প্রয়োজন মেটে। নতুন গ্যাট চুক্তির মাধ্যমে আন্তর্জাতিক বাণিজ্যের শর্তগুলি সবার ঘাড়ে চাপানো হয়েছে, চাপিয়েছে জি-৭ দেশগুলি।

এই বিশ্বায়ন কি কোনো অভিনব বা অভূতপূর্ব ঘটনা? একে কি বিশ্বায়ন বলা যায়? পারস্পরিক অবাধ বিনিময়ব্যবস্থায় সমৃদ্ধ এক বাণিজ্যক্রিয়ার মাধ্যমে সংঘবদ্ধ এক বিশ্বজনীন অর্থব্যবস্থাকে ‘বিশ্বায়ন’ বলা যেতে পারে। বর্তমান বিশ্বায়নের প্রক্রিয়া ও কাঠামো অনেকদিন আগে থেকেই চেনা। তখন অবশ্য তার নাম বিশ্বায়ন ছিল না, ছিল সাম্রাজ্যবাদ বা ঔপনিবেশিকতাবাদ। তখন বিশ্বের সমগ্র ভূখন্ড পশ্চিম ইউরোপের অ্যাংলো-স্যাক্সন, নর্ডিক, গলিক, রোমান, স্লাভ প্রভৃতি উপজাতির অধীনে উপনিবেশ বা আধা-উপনিবেশে পর্যবসিত হয়েছিল। অধীন দেশগুলির উৎপাদনক্রিয়া, পণ্যবিভাগ, বাণিজ্য ক্রিয়া প্রভৃতি নিয়ন্ত্রন হত লুণ্ঠনকারী প্রভুদেশগুলির কর্তাদের নির্দেশে। অর্থাৎ প্রায় সমগ্র বিশ্ব জুড়ে এক আধিপত্যধীন আন্তর্জাতিক বাণিজ্যব্যবস্থা ও উৎপাদনক্রিয়া এক ধরনের বিশ্বায়নের ছত্রছায়ায় ছিল। বিংশ শতাব্দীতে পুরনো বিশ্বায়নের বাঁধন শিথিল হতে থাকে কমিউনিস্ট সোভিয়েত রাশিয়ার আর্বিভাব, আরো কমিউনিস্ট রাষ্ট্র জুড়ে কমিউনিস্ট শিবির গঠন, উপনিবেশগুলির স্বাধীনতা অর্জন প্রভৃতি ঘটনার ফলশ্রুতিতে। এই সব দেশের উৎপাদন ও বাণিজ্য ক্রিয়ার পুরোটা বা একাংশ সাম্রাজ্যবাদী বিশ্বায়নের গন্ডীর বাইরে চলে আসে। ফলে বিশ্বায়ন ছত্রভঙ্গ হওয়ার উপক্রম হয়। কারণ ঐ বিশ্বায়নের মূল উদ্দেশ্য ও প্রতিক্রিয়া ছিল - (১) উপনিবেশ থেকে প্রভুদেশগুলিতে নিয়মিতভাবে সম্পদ প্রবাহ বজায় রাখা। (২) উপনিবেশের বাজারে একচেটিয়া দামে প্রভু দেশের পণ্য বিক্রি। (৩) উপনিবেশের জৈব সম্পদ ভাঙ্গিয়ে একচেটিয়া বাণিজ্যক্রিয়া। এই প্রক্রিয়ার ভাঙ্গন ধরার ফলে জি-৭ শিবিরের অর্থ ব্যবস্থায় সংকট দেখা দেয়। তাই নতুন বিশ্বায়ন এর উদ্যোগ ও অবতারণা। এই নতুন বিশ্বায়নকে নয়া সাম্রাজ্যবাদ বলা হয়।

‘পরিবেশ বলতে মানুষের আশেপাশের প্রাকৃতিক পরিবেশকে বোঝানো হয়। যার মধ্যে পড়ে ধরিত্রী দেহ, বায়ুমণ্ডল, অরণ্য, সমুদ্র ও জীবজগত’।<sup>[৪]</sup> পরিবেশ থেকে মানব প্রজাতির উদ্ভব হয়েছে এবং পরিবেশ থেকেই নানা অফুরন্ত রসদ সংগ্রহ

করে মানুষ জীবন ধারণ করে, ভোগ করে, ফুটি করে। এই রসদ নিষ্কাশনের পরিমাণ ও গতি এত বেড়েছে, ভোগের প্রক্রিয়া এত উচ্ছৃঙ্খল হয়েছে যে প্রাকৃতিক পরিবেশ ক্ষয় পাচ্ছে ও দূষিত হচ্ছে। পরিবেশের ক্ষয়-দূষণ এমন সংকটময় স্তরে পৌঁছেছে যে, যদি এভাবেই চলে, যদি বর্তমান জীবনযাত্রা ও মনুষ্যক্রিয়া সংশোধন করে পরিবেশ সংরক্ষণের কর্মসূচী গ্রহণ না করা হয় তাহলে প্রকৃতির ভবিষ্যৎ অন্ধকার। বাস্তবতায় বিষয়ে অভিজ্ঞতাসম্পন্ন মানুষের ধারণা অন্য। প্রকৃতিকে ধ্বংস করার মতো যথেষ্ট ক্ষমতা মানুষের হাতে নেই। আঘাত সহ্য করা, ক্ষয় মেরামত ও ক্ষতি পুনরুদ্ধার করার সামর্থ্য তার এমনই অগাধ যে, এর আগে যে পৃথিবীর অনেক পরিবর্তন ঘটেছে তা প্রকৃতি সামলে নিয়েছে। যদিও তাতে ৬৫% প্রজাতি ধ্বংস হয়ে গিয়েছিল। ‘মনুষ্যক্রিয়ার ফলে পরিবেশের বড় জোর এমন পরিবর্তন ঘটতে পারে যাতে মনুষ্য প্রজাতির জীবন যাত্রা একটু সমস্যা সংকুল হয়ে পড়বে এবং সেই সঙ্গে অন্যান্য প্রজাতিও প্রতিকূলতার কবলে পড়বে কিন্তু প্রকৃতি প্রকৃতিতেই থাকবে’।<sup>[৫]</sup> একথা সত্যি যে, ধরিত্রীর জীবনযাত্রায় ন্যূনতম ক্ষতি করার ক্ষমতাও মানুষের হাতে নেই। সাড়ে ছয় কোটি বছর আগে যে ১০ কিলোমিটার আয়তনের উপগ্রহখন্ডের আঘাত ডাইনোসর জাতীয় প্রাণীকুলের অবলুপ্তির কারণ হিসেবে ধরা হয়, আমাদের এখনকার জমানো সব পারমাণবিক বোমার সম্মিলিত আঘাতও সেই আঘাতের .০০০১ ভাগেরও কম। কিন্তু উপগ্রহখন্ডের আঘাতের পরেও ধরিত্রী অক্ষত রয়েছে তাই নয়, মানবপ্রজাতির জন্মও দিয়েছে। অর্থাৎ চূড়ান্ত পারমাণবিক যুদ্ধও পরিবেশকে ধ্বংস করতে পারবেনা। হয়তো অধিকাংশ মানুষ ও অনেক অন্যান্য প্রজাতি মরে যাবে, কিন্তু লক্ষ লক্ষ অনুজীব ও অন্যান্য প্রজাতি বেঁচে থাকবে এবং ভূতাত্ত্বিক সময়ের প্রেক্ষিতে ধরিত্রী আবার মানুষ-প্রাণী ধন-ধান্যে পুষ্পে-ভরে উঠবে। কিন্তু পরিবেশবাদীর মাথাব্যথা মানব সময়ের প্রেক্ষিতে নিজেদের নিয়ে, পরবর্তী প্রজন্ম নিয়ে। আমরা মরে যাওয়ার কয়েক লক্ষ বছর পরে আবার মানব সমাজ গড়ে উঠবে, তা জেনে আমাদের কোনো লাভ নেই; জানার ইচ্ছেও নেই। বর্তমান ও পরবর্তী প্রজন্মের স্বার্থের প্রেক্ষিতে পরিবেশ বিপন্ন কিনা সেটাই প্রাসঙ্গিক। পৃথিবীর  $\frac{1}{3}$  থেকে  $\frac{1}{2}$  ভাগ জমি ও অর্ধেকের বেশী জল সম্পদ মানুষের ভোগের শিকার হয়ে পড়েছে, জীবজগতের মধ্যে মনুষ্যপ্রজাতিই বায়ুমণ্ডল থেকে সবচেয়ে বেশী নাইট্রোজেন টেনে নিয়ে খরচ করছে, সামুদ্রিক মৎস্যসম্পদের ২২% আহরণের সীমা ছাড়িয়ে গেছে এবং ৪৪% এর ক্ষেত্রে সীমা স্পর্শ করেছে; ব্যাং ১৫ থেকে ২০ কোটি বছর ধরনীতে বহাল তব্বিতে থাকার পরে এখন ক্রমশ অদৃশ্য হয়ে আসছে। মানব, প্রাণী ও উদ্ভিদের দেহ রাসায়নিক দ্বারা আক্রান্ত ও দূষিত হয়ে পড়েছে। যদিও বিবর্তন-সৃষ্টি নয়, মনুষ্যক্রিয়ায় উদ্ভূত ৭০ হাজার রাসায়নিক উপাদান বাস্তবতায় প্রক্রিয়ায় ও জীবদেহে কী কী বিপর্যয় বা অসুখ ঘটতে পারে তা এখনো জানা যায়নি। অর্থাৎ পরিবেশ যে বিপন্ন এবং সেই বিপন্নতা যে প্রাসঙ্গিক তা নিয়ে আর প্রশ্ন বা সন্দেহের অবকাশ নেই।

পরিবেশবাদীরা কেউ কেউ অস্তিত্বমান উন্নয়নক্রিয়া বন্ধ করে দিয়ে, শহরে শিল্প-নির্ভর সভ্যতার পাট তুলে দিয়ে ছোট ছোট গ্রামীণ সমাজ গড়ে তুলে সাদৃশ্য জীবনযাপনের সুপারিশ করেছেন। কেউ কেউ পরিবেশ সংরক্ষণকারী বিকল্প প্রযুক্তি উদ্ভাবন করে কাজে লাগিয়ে শিল্প-কৃষির চরিত্র পরিবর্তনের কর্মসূচী হাজির করেছেন। বাস্তু-নারীবাদ তত্ত্ব হাজির করে কিছু নারীবাদীর বক্তব্য, মেয়েরাই চিরকাল পরিবেশের লালন পালন করে এসেছে, মেয়েদের হাতে কর্তৃত্ব ছেড়ে দিলে পরিবেশের অধঃপতন রোখা সম্ভব হবে। ‘স্ব-নির্ভর অর্থনীতির’ ধারণায় ইউরোপের সবুজ আন্দোলনের রেশ প্রবলভাবে দেখা যায়। এ নিয়ে সব দেশে ছোটখাটো পরীক্ষা-নিরীক্ষাও হয়েছে। কিন্তু বাস্তবে পুঁজিবাদী কাঠামোর মধ্যে থেকে কিভাবে তা গড়ে তোলা সম্ভব এ নিয়ে এবং তারও আগে এর আদৌ দরকার রয়েছে কিনা তার বিচার হওয়া দরকার। বহুজনই বহু প্রেসক্রিপশন দিয়েছেন বা দিচ্ছেন, কিন্তু বাস্তবে কোনোটাই ধোপে টেকেনি। ভারতবর্ষের এক-এক অঞ্চলে আলাদা আলাদাভাবে অর্থনৈতিক স্বয়ংসম্পূর্ণ জনগোষ্ঠী বাস করবে - এটা কল্পনা করা সোজা, কিন্তু বাস্তবে কতটা সম্ভব? ‘বর্তমানে জঙ্গলের তুচ্ছ পাতা থেকে সুরু করে যে কোনো প্রাকৃতিক সম্পদই আজ বাজারভিত্তিক অর্থনীতির সঙ্গে আট্টেপৃষ্ঠে বাঁধা। সুদূর গ্রামাঞ্চলের এক কোনে পড়ে থাকা যৎসামান্য সম্পদও প্রত্যক্ষ বা পরোক্ষভাবে বিশ্ব পুঁজিবাদের সঙ্গে সংযুক্ত’।<sup>[৬]</sup> অন্যদিকে এই সব বিভিন্ন জনগোষ্ঠীর চাহিদাও তৈরী হয়েছে বা তৈরী করা হয়েছে সেই একই কায়দায়। ফলে প্লাস্টিক থেকে পেপসিকোলা, লিপস্টিক থেকে টনিক আজ এদের জীবনযাত্রার অবিচ্ছেদ্য অঙ্গ চাহিদার অন্যতম উপাদান। চরকায় সুতো কেটে কাপড় বুনলেও

গ্রামের সেই মেয়েটির কাছে সিস্টেটিক শাড়ির আকর্ষণ, দুবেলা রুটি না জুটলেও বাহারী শ্যাম্পু কিংবা ম্যাগী, নুডলস এর হাতছানি থেমে থাকে না। সার্বভৌম রাষ্ট্রের স্বয়ংসম্পূর্ণ অর্থনীতির ধ্যান ধারণা তথা পরীক্ষা-নিরীক্ষার ফলাফলও জানা হয়ে গেছে। অতএব, এটাই ঘটনা হিসেবে প্রতিষ্ঠিত যে, দেশের অর্থনীতি চাঙ্গা করার জন্য আরো বেশি বেশি বিদেশী মুদ্রা অর্জন করতে হবে। ফলে রপ্তানি বৃদ্ধির প্রয়োজন এবং সেই অনুযায়ী উৎপাদন চালিয়ে যেতে হবে। এতে প্রয়োজনে উর্বর শস্যক্ষেত্র গোচারণভূমিতে পরিণত হবে, সমুদ্রের ইকলজি নষ্ট করে সমুদ্রসম্পদ আহরিত হবে, অরণ্য ধ্বংস করে মাটির নিচ থেকে তোলা হবে রপ্তানীযোগ্য আকর, শিল্প স্থাপন করে অর্থোক্তিক ও অপয়োজনীয় সব পণ্য উৎপাদন করতে হবে, দূষিত হবে পরিবেশ, বিনষ্ট হবে প্রাকৃতিক সম্পদ। এই যেখানে চিত্র, সেখানে পাশাপাশি সেই দেশের কোনো একটিমাত্র গ্রামে স্বয়ংসম্পূর্ণ অর্থনীতি হয়তো গড়ে তোলা যায়, কিন্তু তা সারা দেশের সব গ্রামের ক্ষেত্রে সাধারণভাবে যে প্রযোজ্য হবে না, এটা বোঝা খুব একটা কঠিন কাজ নয়।

পরিবেশ আন্দোলনের ঢেউ যত বেশি বিস্তৃত হয়েছে, রাষ্ট্রের তরফে তাকে অঙ্গীভূত করার প্রয়াসও তীব্রতর হচ্ছে। ভারতরাষ্ট্রেও তার ব্যতিক্রম ঘটেনি। নানান র‍্যাডিক্যাল বক্তব্যের আড়ালে এরা মূলত যে দিক নির্দেশগুলি দেন তাতে রাষ্ট্রযন্ত্রকে আরো শক্তিশালী এবং চূড়ান্ত নিয়ন্ত্রকের ভূমিকায় যেতে সহায়তা করে মাত্র। এককথায় এদেরকে পরিবেশ-ম্যানেজমেন্টপন্থী বলা যেতে পারে। মূল দৃষ্টিভঙ্গির জায়গায় এরা স্বনির্ভর অর্থনীতি, স্থিতিশীল অর্থনীতি ইত্যাদির কথা বলে থাকেন। উন্নতি-প্রগতির প্রচলিত মাপ কাঠি, মূল্য-বোধ, দৃষ্টিভঙ্গির উপর নির্ভর করে ‘ইকোলজি’ বা পরিবেশ রক্ষা করা তথা উন্নয়ন বজায় রাখার কিছু পদ্ধতি প্রকরণের সুপারিশ করেন, এরা পাশাপাশি আবার রাষ্ট্রনায়কদের মতোই ‘শক্তিশালী’ ‘স্বনির্ভর’ ভারতবর্ষের ছবি ঝঁকে থাকেন। উন্নয়নের জন্য বিশ্বব্যাপ্ত, আই.এম.এফ ইত্যাদির কাছে ঋণ নিতে খুব একটা আপত্তি না থাকলেও যখন এই সব সুদখোর কসাইরা উন্নতদেশের পরিবেশ আন্দোলনের চাপে পড়ে ঋণের চুক্তিতে পরিবেশ সংক্রান্ত শর্ত আরোপ করেন তখন এরা উদ্ভা প্রকাশ করেন। ‘উন্নতদেশের খবরদারি’, দেশের সার্বভৌমত্বে হস্তক্ষেপ ইত্যাদি যুক্তির আড়ালে এরা মূলত পুঁজিবাদী কাঠামোর বিকাশের ধারাকেই অব্যাহত রাখতে চান। এরা বলেন, তৃতীয় বিশ্বের পরিবেশ আন্দোলনে আলাদা একটি চরিত্র রয়েছে কারণ এখানে দারিদ্র্য ভয়ংকরভাবে উপস্থিত। বন্যতার জন্য বনসংরক্ষণ নয়। এ দেশের সাধারণ মানুষের রুটিরুজির সংস্থান বহাল রাখতে বনের যৌক্তিক ব্যবহারের কথা বলে থাকেন, এতে আপত্তি করার কিছুই নেই। এ দেশের বহু উন্নয়ন প্রকল্পের কারণে মানুষ স্থানচ্যুত হয়, কর্মহীন হয়ে পড়ে, বহু মানুষের রুটিরুজির রাস্তা বন্ধ হয়ে যায়। কিন্তু এ জায়গায় থেকে তারা বলার চেষ্টা করেন যে, এ দেশের পরিবেশ আন্দোলনের আলাদা একটি চরিত্র রয়েছে, মৌলিক কিছু তফাৎ রয়েছে, তাই নতুন কায়দায় ‘ভারতীয় ছাঁচের পরিবেশ আন্দোলন’ গড়ে তুলতে হবে।

এটা ঠিকই যে, উন্নয়ন প্রকল্পসংক্রান্ত এই বিষয়গুলি এ দেশের পরিবেশ-আন্দোলন গড়ে তোলার প্রাথমিক ক্ষেত্রটি প্রস্তুত করেছে এবং আগামীদিনেও এ দেশের যে কোনো পরিবেশ সংক্রান্ত আন্দোলন বড়ো একটা যুক্তি হিসেবেও প্রতিপন্ন হবে। কিন্তু এই জায়গা থেকে তৃতীয় বিশ্বের পরিবেশ-আন্দোলনকে মূলগতভাবে ভিন্ন চরিত্রের ভাবলে ভুল হবে। উন্নয়ন-প্রকল্পের দরুন ছিন্নমূল হওয়া বা রুটিরুজি হারানোর সমস্যা এই আন্দোলনে একটা মাত্রা যোগ করেছে কারণ - (১) এদেশে রাষ্ট্রের তরফে ন্যূনতম সামাজিক নিরাপত্তাসংক্রান্ত আইন এবং পরিষেবা অনুপস্থিত (২) এ দেশে পরিকল্পনাবিদ ও আমলারা তুলনায় অল্প, অপটু এবং অসচেতন। তত্ত্বগত ভাবে এটা হয়ত ঠিক যে, আধুনিক যন্ত্র কিংবা শিল্পবিকাশ নয়, পুঁজিবাদী কাঠামোয় শিল্পবিকাশের ধারা ও তার চরিত্রের কারণে পরিবেশ ও জনস্বাস্থ্য বিপর্যস্ত হয়, ইকোলজির উপর আঘাত আসে। কিন্তু বাস্তব ঘটনা হলো - সমাজতান্ত্রিক শিল্পবিকাশ বলে আলাদা কোনো ধারা নেই, পুঁজিবাদী এবং সমাজতন্ত্রী রাষ্ট্রের মধ্যে তুলনা টানলে দেখা যাবে শিল্পবিকাশের রূপ এবং তার গুণগত চরিত্রের মধ্যে সামান্যতম কোনো পার্থক্য নেই। কৃষি উন্নয়নের ধারাপ্রকৃতিতে কোনো মৌলিক তফাৎ খুঁজে পাওয়া যাবে না। মানবজীবনের তথা রাষ্ট্রের পরিপ্রেক্ষিতে উন্নতি বা প্রগতির মাপকাঠি পুঁজিবাদী দেশেও যা, সমাজতন্ত্রী দেশের ক্ষেত্রেও তাই। পণ্যসর্বস্ব জীবনযাত্রা ও পণ্যনির্ভর মূল্যবোধ - যা পুঁজিবাদী সমাজে ব্যক্তি তথা সমাজ-জীবনকে চালিত করে, তার কোনো ব্যতিক্রম সমাজতান্ত্রিক দেশগুলোর ক্ষেত্রে ঘটেনি।



এবারে আসা যাক ভারতীয় অরণ্যের সামাজিক ইতিহাস প্রসঙ্গে। ক্রান্তীয় অরণ্যের ভবিষ্যৎ সম্প্রতি পাশ্চাত্যে বেশ আলোড়ন তুলেছে। অর্থনীতিবিদরা মনে করেন যে, যখন কোনো সম্পদ তুলনায় পর্যাপ্ত, তখন তা সাধারণের অধিকারে অর্ন্তভুক্ত থাকে। উপনিবেশপূর্ব ভারতে বিভিন্ন ধরনের সামাজিক গোষ্ঠী - যথা শিকারী-সংগ্রহকারী, ঝুমচাষী, লাঙ্গল দিয়ে চাষ করা কৃষক, পশুপালক, হস্তশিল্পী এবং নগরাঞ্চলের জনগণ বিভিন্ন অঞ্চলের অরণ্যসম্পদের উপর তাদের অধিকার প্রতিষ্ঠিত করেছিল। অরণ্যসম্পদ যখন পর্যাপ্ত ছিল, তখন একটি পরিবারের পক্ষে এককভাবে নিয়ন্ত্রণ করার তুলনায় তা ছিল যথেষ্ট বেশী। ইতিহাসের যে বিক্ষিপ্ত-বিচ্ছিন্ন সাক্ষ্য পাওয়া যায়, তাতেই বোঝা যায় যে ভারতের বিভিন্ন অংশে গ্রাম্য জনগোষ্ঠী বিভিন্ন ধরনের সামাজিক বিন্যাসের মাধ্যমে অরণ্যকে নিয়ন্ত্রিত করতো -

(১) ধর্মীয় পদ্ধতি: ভারতের বিভিন্ন অংশে, বনের মধ্যে এক-একটি অঞ্চলকে পবিত্র বলে মনে করা হতো এবং সেখানে কেউ কোনোভাবে গাছপালার কোনো ক্ষতি করতে পারতো না। সমস্ত উপমহাদেশে এই রকম পবিত্র বনাঞ্চল ছড়িয়ে ছিটিয়ে ছিল - আয়তনে কয়েক হেক্টর থেকে কয়েকশ বর্গমিটার ব্যাপ্ত। মন্দিরের চারদিকে বাগানগুলির ক্ষেত্রে ধর্মীয় আচারের সঙ্গে এদের সম্পর্ক খুবই স্পষ্ট। ভারতের প্রথম অরণ্য-পরিদর্শন অধিকর্তা ডায়োট্রিশ ব্র্যাডিস একেই বলেছেন - ‘ভারতের অরণ্য সংরক্ষণের প্রাচীন পদ্ধতি’।

(২) ধর্মীয় বিধি নিষেধ আরোপ: কয়েকটি বৃক্ষকুঞ্জকে পবিত্র বলে ঘোষণা করে সেখানে প্রবেশ নিষেধ করার সঙ্গে সঙ্গে বনাঞ্চলের পরিচালনার ভার ঘুরিয়ে-ফিরিয়ে বিভিন্ন গোষ্ঠীর কাছে যাবে, এ ব্যবস্থাও গ্রামের জনগোষ্ঠীরা করেছিল। বহুগ্রামে এই কৌম বনাঞ্চলগুলি সামাজিকভাবে গৃহীত কিছু নিয়ম এবং নিষেধ দিয়ে নিয়ন্ত্রণ করা হতো, তার মধ্যে ছিল প্রতিটি পরিবার কতটা জ্বালানী, পশুখাদ্য এবং ছোটো কাঠের টুকরো পাবে তার নিয়ন্ত্রণ। কোনো ধর্মীয় উৎসবে বা বিদ্যালয় নির্মাণের মতো কৌম প্রয়োজনে এই নিয়ম শিথিল করা হতো। বিধিভঙ্গকারীকে শাস্তি হিসাবে জরিমানা দিতে হতো অথবা একঘরে হয়ে যেতে হতো। ঔপনিবেশিক কর্মকর্তাদের লেখায় দেখা যায় যে, বিধিবদ্ধভাবে রাষ্ট্রীয় নিয়ন্ত্রণ কায়েম হবার আগে পশুপালনের চারণক্ষেত্র এবং জ্বালানীর জন্য বনাঞ্চলে নানা ধরনের কৌম নিয়ন্ত্রণে ছিল। যে সমস্ত অঞ্চলে বাণিজ্যের প্রবেশ এখনো ঘটেনি, সেখানে এখনো এ ধরনের কৌম নিয়ন্ত্রণ দেখা যায়।

(৩) ভৌগোলিক বিভাজন: দেশজ প্রকৃতি সংরক্ষণের তৃতীয় গুরুত্বপূর্ণ রূপ হলো বিভিন্ন সামাজিক গোষ্ঠীর মধ্যে আঞ্চলিক এবং ঋতুগত বিভাজন। এ ধরনের বিভাজনের উদাহরণ হলো - (১) প্রতিবেশী গ্রামগুলির কোনো বনাঞ্চলকে সমবায় ভিত্তিতে নিয়ন্ত্রণ, (২) সম্পদের ঋতুগত নিয়ন্ত্রণ, বিশেষত স্থায়ী কৃষকদের এবং যাযাবর পশুপালকদের মধ্যে - যাযাবর পশুপালকরা শীতকালে বনাঞ্চল ও চারণক্ষেত্র ব্যবহার এবং প্রবেশের অধিকার পাবে, বিনিময়ে তারা পশুর মল এবং অন্যান্য পরিষেবা প্রদান করবে, (৩) বিভিন্ন শিকারী জনজাতির মধ্যে বন্যপ্রাণীর বিশেষ বিশেষ প্রজাতিকে শিকার করার অধিকার প্রদান ইত্যাদি। ‘এই সামাজিক প্রক্রিয়াগুলি থেকে বোঝা যায় কেন ভারতীয় বন ব্যবস্থা পরিবেশে নিজেকে মানিয়ে নেবার তাগিদেই জন্ম নিয়েছিল এবং আজো চলে আসছে আর এইভাবে বিভিন্ন বর্ণের মধ্যে প্রতিযোগিতা কমিয়ে সম্পদের অতি ব্যবহার বন্ধ করতে চেয়েছে’।<sup>[৭]</sup>

(৪) বৃক্ষরোপণ: সবশেষে ভবিষ্যতের ব্যবহারের জন্য বৃক্ষরোপণ। কুমায়ুন হিমালয়ে বহু অঞ্চলে বহু বনাঞ্চল প্রাকৃতিক নয় এবং তা পাহাড়ী মানুষের বাগিচা বানানো এবং বন সংরক্ষণের সচেতনতারই একটি প্রকাশ। সত্যিই-‘পর্বত শ্রেণীর মধ্যে এবং পাহাড়ের ঢালে বিস্তৃত বনরাশি প্রজন্মের পর প্রজন্ম কুমায়ুনীরা কিভাবে গাছের যত্ন নিয়েছে তারই প্রমাণ দেয়। সুবর্ণসিড়ি উপত্যকার আপাতানি কৃষকরাও এইভাবে শুধু কেবলমাত্র ভবিষ্যৎ প্রজন্মের প্রতি দায়বদ্ধতার থেকে এমন গাছ রোপণ করছে, যেগুলি বড়ো হতে একটি পূর্ণ মানব-জীবনের থেকেও বেশী সময় নেয়।

যৌথসম্পদ এবং তার ব্যবহারকে নিয়ন্ত্রণকারী সামাজিক বিধি-নিষেধের ব্যবস্থা এই সময় চালু থাকার অন্যতম কারণ হলো যে, উপনিবেশপূর্ব সময়ে রাষ্ট্র এগুলিকে নিয়ন্ত্রণ করা বা এদের বাণিজ্যিক স্বার্থে ব্যবহারের ব্যাপারে কোনো আগ্রহ প্রকাশ করেনি। শিকার কিংবা যুদ্ধের স্বার্থে হাতির প্রয়োজন হলেই একমাত্র ব্যতিক্রম ঘটেছে। ‘কিন্তু এ ধরনের রাষ্ট্রের তরফে সচেতন হস্তক্ষেপের ব্যাপার খুবই কম ঘটত। সাধারণভাবে ব্রিটিশ রাজ্যের আগে যে সমস্ত ছোটো রাজ্যগুলি ছিল, সেখানে যে কেউ বিনা বাধায় অরণ্য থেকে প্রয়োজনীয় দ্রব্য সংগ্রহ করা, যত্রতত্র পশুচারণ এবং জঙ্গল কাটার ক্ষমতার অধিকারী ছিল’।<sup>[৮]</sup> ব্রিটিশরাজ কায়ম হবার পরে, বিশেষ করে ১৮৫৭ সালের মহাবিদ্রোহের পরে, রেলপথ বিস্তারের কর্মসূচীতে অরণ্যের ভূমিকা ছিল সবচেয়ে বেশি। ‘বৈজ্ঞানিকভাবে’ সংরক্ষণের কোনো নিজস্ব ঐতিহ্য না থাকায় ব্রিটিশরা জার্মানদের ডাকল ভারতীয় বনবিভাগের পত্তন ঘটাতে। এই নতুন বিভাগটি বনাঞ্চলের উপর রাষ্ট্রের একচেটিয়া অধিকার কায়ম এবং কাঠের উৎপাদন অব্যাহত রাখতে বিস্তারিতভাবে আইন প্রণয়ন করল। ঔপনিবেশিক অরণ্যনীতির মূল বোঁক ছিল অরণ্যকে বাণিজ্যিক ব্যবহারের প্রতি। সাম্রাজ্যবাদী যুদ্ধের প্রয়োজনে অর্থাৎ মূলত রেলপথ এবং দুটি বিশ্বযুদ্ধের জন্য বনাঞ্চলকে ব্যবহার করা হয়েছে। ঔপনিবেশিক অরণ্য কর্মসূচীর লক্ষ্য ছিল মিশ্র বনাঞ্চলগুলিকে কেবলমাত্র বাজারদাম আছে, এরকম গাছের একক বনাঞ্চলে পরিণত করা। বনাঞ্চল থেকে সরকারের আর্থিক আয় বাড়ানোর উপর জোর দেওয়া হয়। আর্থিক আয়ের উপর এই জোর দেবার ফলেই বনাঞ্চলের উপর গ্রামের লোকদের অধিকার অবহেলিত হয়ে পড়ে। ১৮৯৩ সালে একজন ব্রিটিশ রসায়নবিদ মন্তব্য করেন যে নতুন বিভাগগুলি - ‘কোনো অর্থেই কৃষি সংক্রান্ত নয়, তাদের সাফল্য মূলত আর্থিক মানদণ্ডে বিচার করা হয়; বিভাগটিকে আয় অর্জনকারী হতে হবে। সত্যিকথা বলতে কি, আমরা এতটাই বলতে পারি যে, এর উদ্দেশ্য কৃষির বিরোধী, আর কৃষিকে এই বিভাগের প্রাপ্ত সুফলগুলির অংশীদার করা থেকে বঞ্চিত করাতেই উৎসাহ বেশী’।<sup>[৯]</sup> এই নতুন পরিচালনব্যবস্থায় গ্রামবাসীদের আক্ষরিক এবং সামাজিক অর্থে কোনো প্রবেশাধিকার দেওয়া হয়নি। অরণ্য-আইনের বিভিন্ন শাস্তিমূলক ব্যবস্থার মাধ্যমে তাদের প্রবেশাধিকার আক্ষরিক অর্থে বন্ধ করে দেওয়া হল।

‘স্বাধীন ভারতের সরকার আরো বহু কিছুর সঙ্গে ঔপনিবেশিক অরণ্যনীতিও উত্তরাধিকার সূত্রে পায়। ১৮৯৪ সালের অরণ্যনীতির মূল ভিত্তিগুলিকে গ্রহণ করে ১৯৫২ সালের জাতীয় অরণ্যনীতি ঘোষণা করা হয়। রাষ্ট্রের মালিকানা এবং নিয়ন্ত্রণ, বনের নিকটস্থ গ্রামবাসীদের তুলনায় ‘জাতীয় প্রয়োজনে’র অগ্রাধিকার দেওয়া হলো’।<sup>[১০]</sup> সাম্রাজ্যবাদের প্রয়োজনের পর এখন অরণ্যনীতির মূল ভিত্তি হলো শিল্প ও বাণিজ্যের প্রয়োজন মেটানো। ঔপনিবেশিক এবং উপনিবেশোত্তর অরণ্যনীতির আইনী এবং প্রশাসনিক ব্যবস্থায় একটা ধারাবাহিকতা লক্ষ্য করা যায় - অরণ্যের উপর রাষ্ট্রের একচেটিয়া মালিকানা এবং নিয়ন্ত্রণ, এর বাণিজ্যিক মনোভাব এবং বনাঞ্চলে রক্ষীবাহিনী রেখে দরিদ্র জনগনকে এর থেকে দূরে সরিয়ে রাখার মধ্যে ঔপনিবেশিক বনসংরক্ষণের নীতিকে গ্রহণ করা হয়েছে। সম্প্রতিক কালে সবুজায়নের যে সমস্ত প্রয়াস সরকার গ্রহণ করছে, তাতে সামাজিক সাম্য এবং পরিবেশ ভারসাম্য মাথায় না রেখে বাণিজ্যকেই মূল লক্ষ্য করা হয়েছে। এই দেশের স্থানে স্থানে সবুজায়নের প্রয়াস এবং স্থানে স্থানে জঙ্গল ধ্বংস করে দেওয়া - দুই-ই দরিদ্র জনগনের স্বার্থের পরিপন্থী। এক কথায় সরকার অরণ্যের মাধ্যমে দেশের কুড়ি শতাংশ জমি অধিগ্রহণ করেছে। এতে ভারতের অধিকাংশ জনসাধারণের ব্যাপক অসন্তোষের সৃষ্টি হয়েছে। বিশেষত গ্রামাঞ্চলে নিম্নশ্রেণীর লোক, যারা বেঁচে থাকার জন্য সরাসরি অরণ্যের উপর নির্ভরশীল, তাদের কাছে অরণ্যের উপর গোষ্ঠীগত অধিকার থেকে রাষ্ট্রীয় মালিকানায় পরিবর্তন হয়েছে ব্যাপক এবং অত্যন্ত দ্রুতভাবে। পূর্ববর্তী গোষ্ঠীগত মালিকানার প্রথা বনাঞ্চলের ব্যবহারের ক্ষেত্রে কয়েকটি আভ্যন্তরীণ বিধি নিষেধ চাপাত। তুলনায়, নতুন ব্যবস্থাটি নির্ভর করছে এবং করেও কয়েকটি বাহ্যিক বিধিনিষেধের উপর। এই বিধিনিষেধের মূল ভিত্তি জনসাধারণের উপর এক পুলিশী ব্যবস্থা আরোপ। যার ফলে অরণ্যের অধিকার খর্ব হওয়ার ফলে অরণ্য নিয়ে একাধিক আন্দোলন ভারতবর্ষে হয়েছে।

গত একশো পঁচিশ বছরে সঞ্চিত তথ্য থেকে এটা স্পষ্ট যে, এই রাষ্ট্রীয় অরণ্য সামাজিক এবং পরিবেশগত উভয়দিক দিয়ে প্রচণ্ডভাবে ক্ষতি করেছে। বন ধ্বংস এবং তার ফলাফল বর্তমানে ভারতের সবচেয়ে বড় পরিবেশগত সমস্যা হয়ে দাঁড়িয়েছে।

এর ফলশ্রুতি হল বন্যার তীব্রতা বৃদ্ধি, সেচ প্রণালী এবং জলাধারগুলির দ্রুত মজে যাওয়া এবং জলের উৎসগুলি শুকিয়ে যাওয়া। বনাঞ্চলের ক্রমাগত হ্রাস পাওয়ার সামাজিক প্রতিক্রিয়াও কম গুরুত্বপূর্ণ নয়। এর ফলে বিভিন্ন ব্যবহারকারীরা বনজ উৎপাদনের তীব্র অভাব অনুভব করছেন; বড়ো শিল্প এবং ছোটো কাঠের অভাব, পশুপালনকারীদের পশুখাদ্য এবং চারণক্ষেত্রের অভাব, কুমচাষী এবং শিকারী-সংগ্রহকারীদের জমির অভাব। এই অভাবে সবচেয়ে বড় প্রভাব পড়েছে মেয়েদের স্বাস্থ্য এবং সামাজিক ভূমিকার উপর, কারণ শুধুমাত্র তারাই বহু পরিবারে পশুখাদ্য এবং জ্বালানী সংগ্রহের দায়িত্বে থাকে। বনজদ্রব্যের পরিমাণ ক্রমাগত কমে যাওয়ার ফলে বনজ দ্রব্যের দাবীদার বিভিন্ন গোষ্ঠীর মধ্যে সংঘাত বৃদ্ধি পেয়েছে।

পরিশেষে এটা বলা যায় যে, উন্নয়নের গোলকধাঁধায় ভারতীয় সামাজিক প্রতিষ্ঠানের উপর যেমন প্রভাব পড়েছে, তেমনি পরিবেশের উপরও এর প্রভাব ভীষণভাবে পড়েছে। যার ফলে ভারতীয় অরণ্যও বাজারজাত হয়ে পড়েছে। উন্নয়নের নামে অরণ্য অঞ্চলে পর্যটন ব্যবস্থাকে উন্নত করতে গিয়ে পরিবেশের সামাজিক ভারসাম্যকে হারাতে হচ্ছে। তাহলে বিশ্বায়ন ও উন্নয়নের নমুনাই কি পরিবেশের ভারসাম্য নষ্ট করছে? অদূর ভবিষ্যতে এর ফলাফল আরও মারাত্মক আকার ধারণ করবে।

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# **“Still wouldst thou sing, and I have ears in vain”: Archive of Bird Sound and Preserving Acoustic Memories**

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*Abstract: Bird Sound Archives have revolutionised the taxonomic study of birds. Apart from locating new species, they contribute in preserving a specific legacy of natural soundscape. This article discusses such initiatives in home and abroad.*

**Keywords: Bird Sound Archives, Archive of Natural Sound, Archiving, Database**

The earth maintains an archive of its own. In affirmation of the Blakean vision “To see a world in a grain of sand/ And a heaven in a wild flower”<sup>[1]</sup>, every transformation in this planet leaves a trace of its own. It needs the eye of a palaeontologist to excavate such wonders of the world, the talent of a visionary to look through the evolutionary design of such scheme. The 90s kids may surely remember the most intriguing testimony to alike thought from a science-fiction film. Near the beginning of Steven Spielberg’s classic *Jurassic Park* (1993), scientists reveal how they have collected the DNA of dinosaurs from mosquitoes trapped in amber more than 65 million years ago. These insects had previously fed on dinosaurs’ blood and by extracting these blood cells, and removing their DNA, entrepreneur John Hammond recreates genomes of velociraptors, triceratops, and other dinosaurs. From these genomes, he clones the terrifying creatures that go on to terrorize the film’s characters.

How befitting of such representations to glorify the ‘clockwork’ model of Newtonian universe wherein from the cosmically vast to the infinitesimally small, every aspect of the universe is meticulously arranged as a perfect machine. Every rock has a story to tell if you know how to read it. Within the unique composition and arrangement of materials that compose different rocks, one can find patterns that are evidence of the processes that formed them – processes that represent chapters in Earth’s dynamic history. Appropriating such frame of reference thereafter, it becomes obvious processes may be explained in the world of nature in terms of ‘design’ and ‘mechanism’. Obvious list of examples will surely contain those who had championed the gradualist approach of geological transformation, namely the Scottish naturalist James Hutton known for his *Theory of the Earth* (1795), and Sir Charles Lyell with his *Principles of Geology* (1830 – 1833), who popularized

uniformitarianism among the common public. Such unifying concepts in geosciences solidified the assumption that the same natural laws and processes that operate in the universe now have always operated in the universe in the past and apply everywhere. The ramifications of these assertions are to echo in the work of fellow evolutionists. For instance, Robert Chambers in his *Vestiges of the Natural History of Creation* (1844) puts forward a cosmic theory of transmutation which suggests that everything currently in existence has developed from earlier forms. Not to forget of Charles Darwin and *On the Origin of Species* (1859), whose body of work remains synonymous with the concept of 'evolution', to the persistent assumption that the process must necessarily involve some kind of progress or development from the simple to the complex.

In tracing such development of nineteenth-century science, an important factor, unprecedented until now, seems to make its presence felt: a certain sense of 'history' that ushers in an important break with earlier scientific paradigms. This idea emphasizes how necessary it is to have a sense of causality in understanding natural processes. In the natural world, this important status accorded to history connects one process with another, where the first is partly responsible for the second, and the second is partly dependent on the first. The doctrine of causation accentuates the value of history in building theories of man's interaction with nature. A layout of that kind eventually brings us back to our preliminary observation then – to look at earth as a physical place that holds an accumulation of historical records which brings forth its own account of gradual development.

Though the thrust of this article does not lie on laying bare the earth's archives and rather seeks to explore the intervention of human technology in preserving records of the environment and nature that surrounds us, the stratagem behind establishing such a collection is in agreement with traversing nature's diversity, the taxonomic history of which lays preserved in archival catalogues.

I am chiefly interested to discuss archives of bird sound in the scope of this article and how such natural soundscape recordings persist in our own understanding as acoustic memories. Sound has been long established as an essential component of biodiversity and acoustics of landscapes, which is our prime contention, and is constituted of not only animal sounds, collectively known as biophony, but also the geophonic intervention of the elements and obviously by human agents too, the anthropophony. In the light of such realisation, it is but obvious that the information about organisms, their activities, and the environment in general captured in soundscapes can be useful in understanding patterns and tendencies of biodiversity as well as individual species behaviour or evolution.

A suitable example to understand how sound may be useful in reading certain trends in the animal world may be sought in the works of the American zoologist Richard Lynch Garner, who was particularly interested in the language of the monkeys. His ingenious enquiries into the language of the apes made him use Edison's phonograph to read what he claimed to be a 'Simian Tongue':

In the room where the monkeys were kept by a dealer in Washington, there was a cage which contained a young white-faced Cebus of rather more than average intelligence. He was a quiet, sedate, and thoughtful little monkey, whose gray hair and beard gave

him quite a venerable aspect, and for this reason I called him Darwin. From some cause unknown to me he was afraid of me, and I showed him but little attention. On the same shelf and in an adjacent cage lived the little Capuchin, Puck. The cages were only separated by an open wire partition through which they could easily see and hear each other. For some weeks I visited Puck almost daily, and in response to his sound for food I always supplied him with some nuts, banana, or other food. I never gave him any of these things to eat unless he would ask me for them in his own speech. On one of my visits my attention was attracted by little Darwin, who was uttering a strange sound which I had never before heard one of his species utter. I did not recognize the sound at first, but very soon discovered that it was intended to imitate the sound of the Capuchin, in response to which I always gave Puck some nice morsel of food. Darwin had undoubtedly observed that this sound made by Puck was always rewarded with something good to eat, and his evident motive was to secure a like reward. After this I always gave him some food in acknowledgment of his efforts, and I observed, from day to day, that he improved in making this sound until at last it could scarcely be detected from the sound made by Puck.<sup>[2]</sup>

In case of birds, voice is the most noticeable form of communication. Birds use their voices to make sounds for all sorts of reasons. Birders who are familiar with the different sounds birds make can use those sounds for auditory identification. But as far as bird sound recordings are concerned, they are much more than an important indicator for speciation. There is no denial to the fact that it safeguards our scientific legacy. However, in times when a photograph is just a mobile click away, there are individual species among our feathered friends which are morphologically similar but differ in the virtue of distinct vocalization.<sup>[3]</sup> Scientists have been successful in locating new species of birds at times by solely scrutinising their distinct vocalisations. Some of these species might escape attention as they are highly secretive and difficult to see. In such circumstances, the sound of a bird becomes the sole marker of identity.

Differences in acoustic signals among birds may have even wider reach in certain cases. Popularised by the well-known example of Darwin's finches, also known as the Galápagos finches, allopatric speciation is a globally accepted concept now. Such phenomenon occurs when a species separates into two separate groups and are isolated from one another chiefly by a physical barrier, which makes it impossible for them to breed with one another. Each species develops differently based on the demands of its unique habitat or the genetic characteristics of the group that are passed on to the offspring. Often such variations are specified by the difference in bird sounds, thereby emphasising the importance of vocalisations in the assessment of taxonomic rank.

An example of topical relevance in this case might be that of the Bengal Bushlark, commonly known as *jhaarbharat*, and bearing uncanny resemblance with the House Sparrow, *chorui*. The Bengal Bushlark was previously treated as a polytypic species ranging from India to Sri Lanka and Vietnam. However, pronounced differences in songs, calls and song-flights, as well as morphological variations, have confirmed their claim to be treated from four allopatric taxa to separate species. Similarly, Old World Warblers are renowned for being morphologically poorly differentiated, although the species usually differ more clearly by their songs.

These instances then corroborate the fact that modern studies on bird vocalisations would not have been possible without a collection of sound recordings, which is, in comparison to collection of 'physical' specimens, a relatively new practice. It has been widely accepted that the recording of animal sounds stretches back over 125 years, beginning in 1889 with the recording on an Edison wax cylinder by Ludwig Koch in Germany of a captive Indian white-rumped Shama. The first wild bird sound recordings were probably those of a song thrush and a nightingale made by Cherry Kearton, also on wax cylinder, in England in 1900. In the Australasian region, the first recordings of wild birds were those of a Superb Lyrebird, recorded and published on a 78 rpm disc in 1931. In the Antarctic, recordings date from 1934 with the braying of an Emperor Penguin. In the Oriental region, the Carpenter expedition of 1937 made recordings of Hornbills, while in the Neotropics, recordings made on Barro Colorado Island in Panama was conducted thereafter. However, the systematic recording of animal sounds was not to appear before 1930s when Dr. Arthur 'Doc' Allen and his graduate student Peter Paul Kellogg were to develop techniques for recording birds as a corollary to demonstrate a new technology – motion-picture film with synchronized sound.<sup>[4]</sup>

Initiatives which have had such humble beginnings were solidified with later development. At the twentieth session of the International Ornithological Congress in December 1990, a round table discussion was held on standards of documentation for archived bird recordings. Participating discussants unanimously agreed on a list of essential data items required to document sound recordings, wherein there is scope of incorporating technical information like instrument of recording with necessary specifications; geographical markers like location, climatic zone and habitat; temporal data like temperature and weather as well as specific zoological facts like class of the animal whose sound is being recorded, order, family, etc.

In most cases, such initiatives have begun as personal collectives only to be acquired by larger institutions later. Allen and Kellogg's recording activities, a collection of bird and some other animal sound recordings at Cornell University was to become the Library of Natural Sounds at the Laboratory of Ornithology there. The Cornell Lab of Ornithology today is the world's premier scientific archive of natural history audio, video, and photographs. Although the archive's history is rooted in birds, the collection also preserves recordings of other species' behaviour and natural history. Endearingly known as the Macaulay Library now, it is named in honour of Linda and William (Bill) Macaulay, avid birders whose generous donation was instrumental in creating the Macaulay Library's outstanding new home at Sapsucker Woods, Ithaca, New York. The contributions of the Macaulays extend far beyond financial support. With nearly 6,000 individual birdsong recordings of over 2,600 species, Linda Macaulay has been one of the most productive and talented contributors to the library's sound archive.

The fruits of their labour entirely available at <https://www.macaulaylibrary.org/>, when you enter a species name in the search box, this website gives you a total count of audio, video and image specimens available on the basis of your input. If you are interested in bird sound recordings, you simply choose the audio search results on which you will be led to explore individual sound files, tagged with necessary documentation details on date, venue and contributor of specific recording.

The audio sample is also visually represented on a graph for better understanding of minute details. However, this is only one among quite a few institutionalized natural sound archives to provide a centralised collection which can be drawn upon by any person or organisation with a serious use for such recordings.

**TABLE I**  
**Major natural sound archives (adapted from Alström and Ranft 2003)**

Sound library	year established	number of recordings
Macaulay Library of Natural Sounds, Ithaca, USA	1956	150,000
The British Library Sound Archive, London, UK	1969	140,000
Tierstimmenarchiv, Berlin, Germany	1952	100,000
Fitzpatrick Bird Communication Library, Pretoria, South Africa	1979	30,000
Australian National Wildlife Collection, Lynham, Australia	1961	25,000
Arquivo Sonoro Neotropical, São Paulo, Brazil	1978	25,000
Borror Laboratory of Bioacoustics, Ohio, USA	1945	24,000
Florida Museum of Natural History, Florida, USA	1973	15,000

Table 1<sup>[5]</sup>

However, things are not adequately promising down at home. We have had American experts on South Asian birds such as Pamela Cecile Rasmussen, who is also the author of the landmark publication *Birds of South Asia: The Ripley Guide*, published in 2005. This book claims to include several taxa newly recorded for the region of species whose voice was previously unknown to the West. An information worth mentioning in this respect concerns description of recordings related to bird vocalisation in this book that is supported with over a thousand of sonograms. Besides that, apart from individual contribution made by prolific contributors of sound records such as Namassivayan Lakshmanan, our hope rests on online databases and associated communities like eBird India (<http://ebird.org/content/india/>), created in the model of international online platforms dedicated to sharing of bird sounds, such as xeno-canto (<http://www.xeno-canto.org/>), which is presently the largest online database of bird sound recordings. Web spaces as these are making archives come alive as collaborative projects where there is an emergence of like-minded communities who hold a high opinion on discussion and feedback within such active spaces. This is possible as such web platforms ensure repeated exposure to archival samples that enhances the process of remembering and comprehending, so necessary to unravel new possibilities of expansion. The eBird India portal itself is managed by Bird Count India, which is a partnership of a large number of organizations and groups working to increase the collective understanding of the distribution, abundance, and population trends of Indian birds.

Most online sound archives now contain tips to record bird sounds with smartphones. Though a smartphone may never function as a replacement for a dedicated sound device, it can make decent documentation recording with a proper recording app that allows one to create uncompressed WAV files and provides increased control for making recordings in the field. Such suggestions, accentuating the extent to which technology has shaped our lives, are not merely to relish the aural



delights of the natural world, but to make us aware of our natural legacy, ignorance to which is to aggravate our cataclysm in this era of ensuing derangement.

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# **Conflict between Economic Growth and Environmental Quality in India - A Role of Environmental Fiscal Instrument**

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*Abstract: Economic growth has been associated with exploitation of natural resources and environmental degradation. India has been experiencing an upward trend of economic growth, and will, therefore, need to use available natural resources for the production of goods and services. But excess exploitation of resources may reduce the level of available energy for productive activities. The scarcity of factors of production may hamper the sustainable productive activities of the economy. The present study intends to examine the impact of economic growth on the environmental quality in India. The study is based on the “Environmental Kuznets Curve (EKC)” hypothesis. This hypothesis postulates the impact of economic growth on environmental quality and according to this hypothesis environmental degradation such as air pollution, water pollution increases up to a certain level as Gross Domestic Product (GDP) increases and after that environmental quality increases. On the basis of available data on carbon dioxide and nitrogen dioxide, the study concludes that the relation between economic growth and environmental degradation in India does not follow “Environmental Kuznets Curve (EKC)” hypothesis, rather the relation shows an upward linear relation. The role of economic growth is not satisfactory to improve the quality of environment similar to developed countries. In India pollution, particularly air remains a major challenge and to overcome the problems, Environmental Fiscal Instrument (EFI) may play a significant role.*

**Keywords: Economic Growth, Environmental Degradation, GDP, Environmental Fiscal Instrument**

## **I. INTRODUCTION**

The economic progress of a country is indicated by upward trend of per capita Gross Domestic Product (GDP). India, a developing country, has been experiencing an increasing level of GDP, i.e. a higher level of production, which is associated with excessive exploitation of natural resources. Excessive use of available resources threatens the sustainable growth of the economy, and hampers the economic and productive activities. The natural environment has certain level of capacity to resist degradation created by excessive use of non-renewable factors, but the environmental quality starts deteriorating when it exceeds that capacity level. The degraded environment reduces the fruitful side of growth as this situation imposes direct costs on the health and badly influences the longevity and living standard of people.

In India one of the crucial environmental problems is the of air pollution occurred due to the combustion of fossil fuels. The polluted air caused serious health problems to the people, particularly urban people; and with the rapid expansion of industrial production and urbanisation in the economy, these impacts have become a matter of concern. But economic growth is very imperative for overall development; and policymakers are concerned with how to reduce the volume of pollutants, or to protect environment from different types of pollution considerably. In this regard, Environmental Fiscal Instruments (EFI) - an instrument of taxation and pricing- may play a crucial role in reducing environmental degradation. This fiscal instruments help to reduce the excessive use of natural resources and at the same time generate revenues which can be used for maintaining sustainable economic activities and the use of natural resources. It also imposes taxes on the use of non-renewable productive factors and which in turn discourage the production processes, responsible for environmental degradation and at the same time, restrict the use of limited natural resources.

The present study intends to investigate the relationship between economic growth and environmental degradation in India and examines whether Kuznets' hypothesis<sup>[1]</sup> is applicable in India. The study also explores the role of Environmental Fiscal Instruments (EFIs) for improving environmental quality in Indian economy.

The paper is organized into seven sections. Section 2 provides a review of previous studies relevant to the relationship between economic growth and environmental degradation. Kuznets' hypothesis has been discussed in section 3. Data source and methodology are described in section 4. Section 5 describes the conflicting relation between economic growth and environmental quality in India. The role of Environmental Fiscal Instruments (EFIs) for improving environmental quality is presented and discussed in section 6. Conclusions are drawn in section 7.

## II. LITERATURE REVIEW

The present study considers a number of studies relevant to the relationship of economic growth with environmental degradation to make the analysis an effective one.

Eric Neumayer<sup>[2]</sup> examines the relation between economic growth and the environment in his study and also explains the environmental optimism and environmental pessimism. After analysing available relevant data, author concludes that the empirical analysis does not follow any general conclusions about the impacts of economic growth on the environmental quality, like Environmental Kuznets Curve (EKC).

Katar Singh<sup>[3]</sup> focuses on the impact of various types of pollution on human health and longevity. For attaining and sustaining economic development, author classifies the mitigation and restrictive measures

for the problems of environmental degradation into four categories, namely, institutional changes, direct controls, economic or market-based instruments, and technological measures.

Ashish Chaturvedi, Manjeet S. Saluja, Abhijit Banerjee, Rachna Arora<sup>[4]</sup> in their paper presents the concepts of instruments of environmental fiscal reforms (EFR) and finds the impact of EFRs on environmental quality in India. According to their empirical study, EFR may improve environmental quality more efficiently and cost-effectively than traditional restrictive measures. They also mentioned various obstacles in the way of EFR implementation in India, including inadequate policy framework and institutional capacity; as well as conflict between political support and poverty alleviation.

Sumana Mukherjee<sup>[5]</sup> in her study makes an attempt to examine the relationship between economic growth and environmental degradation. According to the author, productive and consumption activities are important for achieving targeted level of economic development but these activities lead to a significant level of environmental degradation. This type of growth-oriented development is not compatible with long-term socio-economic sustainability. India has also experienced the same pattern of development; and the author suggests some protective and preservative measures to improve environmental quality in India.

Ahuti Singh<sup>[6]</sup> in his study identifies the impact of environmental hazards on human health, caused by the use of machinery and factories after the Industrial Revolution during 1700s. According to author, due to the Industrial Revolution, the exploitation of natural resources, emissions of the carbon, various pollutants and human health problems may have a disastrous impact on the world environment. The author also recommends some restrictive measures for improvement of the world environment, including the use of clean technologies and environmental friendly production techniques.

Grossman and Krueger<sup>[7]</sup> examine the relationship between economic growth and environmental performance on the economy-wide level and they mention that environmental quality determined by the level of urban air pollution and contamination of river basins with heavy metals. They find that the level of environmental quality depends upon the level of per capita income, where income is an indicator of economic growth. In their study authors observed that in the initial phase of development, environmental degradation increases and reach highest level and eventually start to decrease following the rise in per capita income. And the pattern of relation appears as inverse-U-shaped curve.

### III. RELATION BETWEEN ECONOMIC GROWTH AND ENVIRONMENTAL QUALITY – KUZNETS' HYPOTHESIS

Simon Kuznets conducted a study to determine the nature of the relationship between environmental degradation and per capita GDP. According to his study, in the initial stages of economic growth environmental degradation increases, but beyond some level of per capita GDP the trend reverses; so high level of economic growth leads to environmental improvement. As a result, the relationship between the environmental degradation and per capita GDP indicates an inverted U-shaped curve. An explanation for the inverted U-shaped relation, given by Kuznets, is that in the initial stage of growth, people mainly focus on the expansion of production and consumption to achieve a targeted level of growth, without emphasising on environmental quality. But at a higher level of growth, people reduce their productive activities which are responsible for environmental degradation, and this in turn improves the environmental quality.

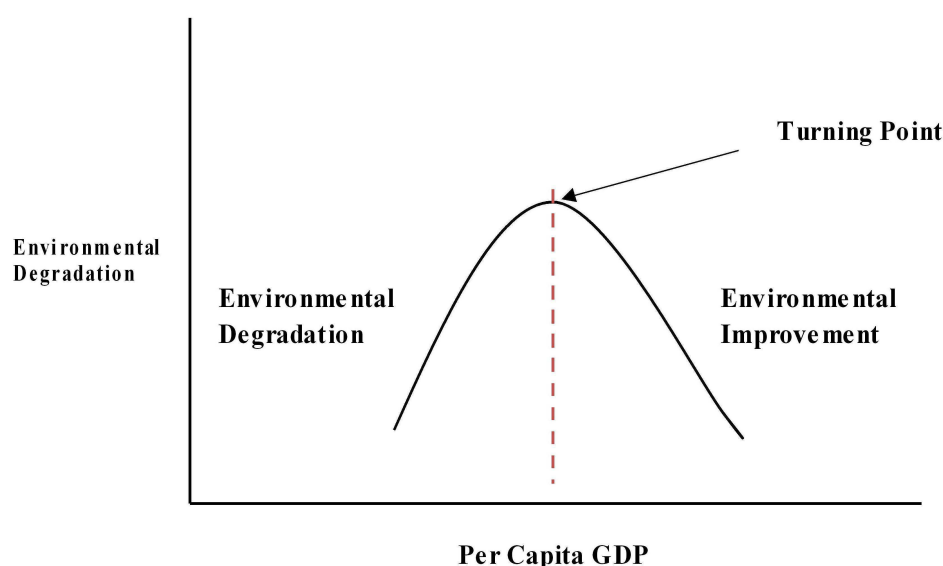


Figure 1

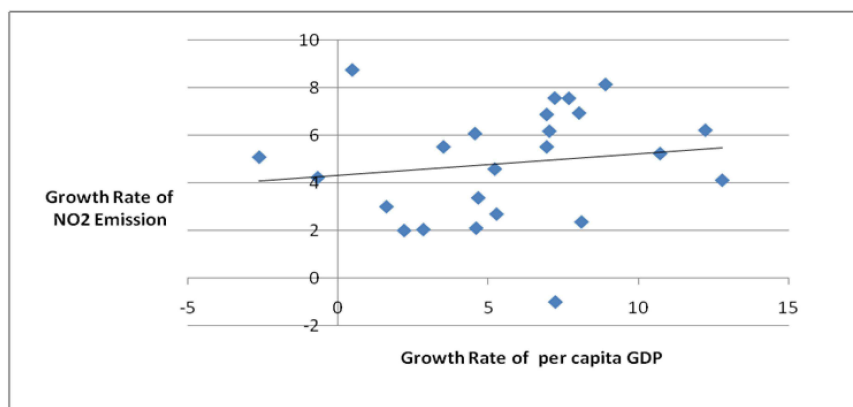
### IV. DATA SOURCE AND METHODOLOGY

The present study has analysed the relationship between economic growth and environmental degradation on the basis of secondary data. Data on GDP per capita, PPP (constant 2011 international \$) and CO<sub>2</sub> emission from solid fuel consumption (kiloton) and Nitrogen dioxide (NO<sub>2</sub>) emissions (thousand metric tons of CO<sub>2</sub> equivalent) have been collected from World Bank National Accounts Data 2015 and OECD National Accounts data files. Scatter diagrams have been used in the study for examining the aforementioned relationship. The range of study period is from 1990 to 2014.

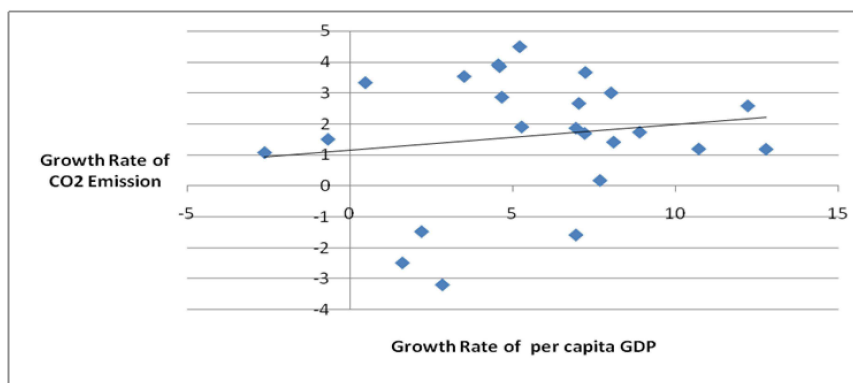
## V. CONFLICT BETWEEN ECONOMIC GROWTH AND ENVIRONMENTAL QUALITY IN INDIA

To derive the relationship between economic growth and environmental degradation, the present study considers Carbon dioxide ( $\text{CO}_2$ ) and Nitrogen dioxide ( $\text{NO}_2$ ) emission as the representative of air pollution or environmental degradation. This selection has been made on the basis of the fact that air pollution is one of the most severe environmental problems in the economy; and that Carbon dioxide ( $\text{CO}_2$ ) and Nitrogen dioxide ( $\text{NO}_2$ ) gas cause serious respiratory diseases in human beings; and  $\text{NO}_2$  pollutant creates acid rain causes serious impact on cultivation. Per capita GDP has been considered in the study as an indicator of economic growth. The scatter diagram between growth rate of  $\text{CO}_2$  emission and per capita GDP in India (Figure 2) shows an upward trend, i.e. as growth rate of GDP per capita increases, growth rate of  $\text{CO}_2$  emission also shows an increasing trend but does not indicate any downward trend after certain limits of growth. Figure 3 also shows an upward straight line relation between growth rate of GDP per capita and emission of  $\text{NO}_2$  in India; and also does not show any decreasing trend of emission at any particular level of economic growth (Turning point in Figure 4).

But according to Simon Kuznets' hypothesis, environmental degradation increases along with per capita GDP up to a certain point and then it starts declining, and the relationship indicates an inverted U shaped curve. It is clear that the relationship between economic growth and environmental degradation in India does not support the inverted U shaped Kuznets' Hypothesis. In the present study, growth and environmental degradation shows an upward linear trend in India (Figure 4).

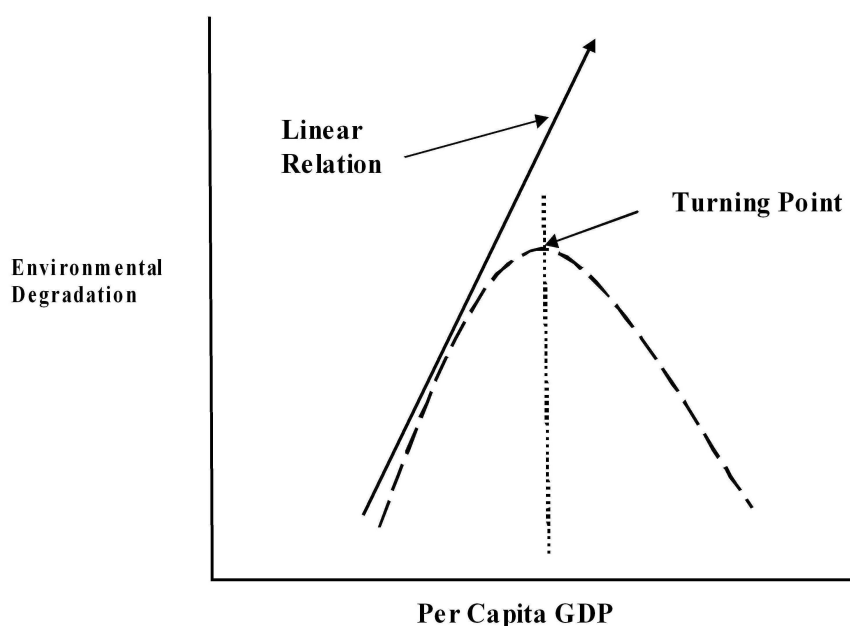


**Figure 2**  
Scatter plot between growth rate of per capita GDP and emission of  $\text{NO}_2$  in India



**Figure 3**

Scatter plot between growth rate of per capita GDP and emission of CO<sub>2</sub> in India



**Figure 4**

Linear relation between growth rate of per capita GDP and emission of CO<sub>2</sub> in India and Environmental Kuznets Curve

The upward linear relation between the emission of air pollutants (CO<sub>2</sub> and NO<sub>2</sub>) and economic growth indicates that as per capita increases, emission of CO<sub>2</sub> and NO<sub>2</sub> also increase. As a result air pollution or environmental degradation may hamper the well-being of people by imposing costs associated with health-related expenses and reduce the availability of productive resources. But contemporary national accounts systems do not adequately consider the costs incurred due to the degraded environment. It is very important to consider the costs associated with the degraded environment at the time of national income accounting. Integrated environmental and economic accounting has introduced a new concept to overcome the limitations of national income accounting. The main objectives of this concept are to include all environmental and economic accounts with the assessment of environmental costs and benefits and accounting for the maintenance of tangible wealth.

To achieve sustainable development, national income account must take into account the economic damage and depletion in the natural resource base of an economy and it will help to measure sustainable

level of income. This measure can be secured without decreasing the stock of natural assets and it requires the adjustment of the system of national income accounts in terms of stock of natural assets. The computation of Gross Domestic Product (GDP) would be replaced by a measure of national output that includes the economic cost of degrading natural resources which are required to produce goods and services directly and indirectly. By considering economic damage and depletion in the natural resource, NDP can be measured in the following way

$$NDP = GDP - DN - R - A$$

Where,

**DN**= Depreciation of the monetary value of natural assets during the year.

**R**= Expenditure required to restore environmental capital (forests, fisheries, etc.), and

**A**= Expenditure required to avert the destruction of environmental capital (air pollution, water and soil quality, etc.). (See P. Todaro and C. Smith)<sup>[8]</sup>

## VI. ENVIRONMENTAL QUALITY - A ROLE OF ENVIRONMENTAL FISCAL INSTRUMENTS (EFIs)

The term 'Environmental Fiscal Instruments' (EFIs) refers to an instrument of taxation and pricing that can discourage the use of productive factors which have a harmful impact on the environment quality, and which raise fiscal revenues that can be used for reducing environmental degradation. EFI also encourages efficient use of natural resources and environmental friendly economic activities and production processes. This instrument is effective for strengthening the restrictive and protective system, and environmental management; and it also helps to achieve the environmental objectives much more efficiently and cost-effectively. In line with global trends, India has also adopted some EFR measures such as deregulation of petrol prices and, coal cess.

EFI reduces environmental degradation in two ways:

1. By reducing the depreciation of the monetary value of natural resources (DN) and conserving available resources which promote sustainable development, and
2. By raising fiscal revenues which can be used for restoring environmental capital (forests, fisheries, etc) (R) and averting the destruction of environmental capital (air pollution, water and soil quality, etc) (A).

The revenue collected through EFI may be utilised for the following purposes:

- a) Creation and development of facilities that will improve environment quality and maintain appropriately the environmental services and ecological security of the State; and
- b) Revenue used for improving various projects, directly or indirectly restore the ecological balance of various areas in the economy.

If EFI fulfils the above objective, then the relationship between economic growth and environmental degradation will show a downward trend after the 'Turning point' (Figure 4) and this in turn, will



display an inverted U shaped function; otherwise Indian economy will experience an upward linear relation between the emission of air pollutants (nitrogen dioxides and carbon dioxide) and per capita GDP.

Hence Environmental Fiscal Reforms (EFR) indicates a range of economic instruments that help to reduce the devastating impacts of environmental degradation and generate revenues that will be used to provide incentives for environmentally friendly activities and proper use of natural resources for sustainable development. But the implementation of EFRs has frequently been delayed and constrained by various factors such as political, social and institutional. Economists and policymakers are facing problems and challenges in combining aspects of environmental fiscal instruments and economic efficiency and political and social acceptability. So a balanced approach among aforementioned factors is the fundamental requirement for ensuring environmental sustainability and efficient resource management. EFR instruments have been facing a lot of constraints and challenges because the use of EFR may reduce the growth rate of GDP as growth is associated with natural resources and environmental fiscal instruments make productive factors costlier. For example, the effect of environmental fiscal reforms with the green shift may have a negligible adverse effect on growth but a positive impact on employment. To make EFIs a hazard-free environmental policy, need careful attention for designing the instruments, proper monitoring for its implementation and the overall policy and environment goals of the nation. Various educational and awareness programmes may also play a significant role to make EFI policy an effective one in India.

## VII. CONCLUSION

In India, natural resources including environment have been degraded due to a variety of reasons, some of which are production and consumption related. Due to increasing level of CO<sub>2</sub> and NO<sub>2</sub> emission, air pollution creates a serious threat to human health and their longevity. Proper and adequate use of natural resources and environmental management are essential not only for our survival but also for attaining and sustaining economic growth and development. Environmental Fiscal Instruments (EFIs) play a crucial role in mitigating the problems of environmental degradation and also helps to restore and avert the destruction of environmental resources. Hence, at the initial stage of development, economic and productive activities degrade the environment but after the turning point environment will be improved, if EFIs have been used efficiently and appropriately in India. As a result Indian economy may follow the inverted U shaped Kuznets hypothesis-a relationship between economic growth and environmental quality. EFI will be more effective if education and awareness of people and strong political and administrative will at the national and state levels use this instrument to mitigate and improve the environmental degradation in the large interest of society as a whole.

## APPENDIX

**Table 1**

Per Capita GDP, PPP (Constant 2011 International \$) and Growth Rate of per capita GDP in India.

Year	GDP per capita, PPP (constant 2011 international \$)	Growth Rate of per capita GDP
1990	405430.9	-
1991	434774.2	7.24
1992	455096.7	4.67
1993	479108.2	5.28
1994	504106.2	5.22
1995	521810.4	3.51
1996	558066.1	6.95
1997	583753.4	4.60
1998	579774.7	-0.68
1999	620042	6.95
2000	633701.6	2.20
2001	643881.2	1.61
2002	662153.9	2.84
2003	692344.3	4.56
2004	741104.4	7.04
2005	798071.2	7.69
2006	855698.1	7.22
2007	931927.7	8.91
2008	1007497	8.11
2009	1088421	8.03
2010	1093532	0.47
2011	1210840	10.73
2012	1365785	12.80
2013	1329933	-2.63
2014	1492751	12.24

Source: World Bank Report, 2015<sup>[9]</sup>

**Table 2**

Quantity of Carbon Dioxide (CO<sub>2</sub>) and Nitrogen Dioxide emission in India

Year	CO <sub>2</sub> emissions from solid fuel consumption (kiloton)	Growth Rate	Nitrogen dioxide emissions (thousand metric tons of CO <sub>2</sub> equivalent)	Growth Rate
1990	169598.5	-	1754.86	-
1991	175819	3.67	1737.62	-0.98
1992	180863.3	2.87	1796.53	3.39
1993	184313.6	1.91	1845.15	2.71
1994	192612.9	4.50	1930.11	4.60
1995	199435.7	3.54	2036.80	5.53
1996	203160.7	1.87	2149.37	5.53
1997	210998.1	3.86	2194.90	2.12
1998	214188.3	1.51	2288.05	4.24
1999	210800	-1.58	2445.75	6.89
2000	207700	-1.47	2495.05	2.02
2001	202543.2	-2.48	2570.43	3.02
2002	196076.9	-3.19	2623.33	2.06
2003	203758.4	3.92	2783.00	6.09
2004	209205.1	2.67	2955.20	6.19
2005	209587.6	0.18	3178.83	7.57
2006	213150.1	1.70	3419.93	7.58
2007	216862.4	1.74	3698.78	8.15
2008	219944.4	1.42	3786.63	2.38
2009	226562	3.01	4049.81	6.95
2010	234135.9	3.34	4404.70	8.76
2011	236945.5	1.20	4635.88	5.25
2012	239755.1	1.19	4827.56	4.13
2013	242355.2	1.08	5073.61	5.10
2014	248633.5	2.59	5389.90	6.23

Source: World Bank Report, 2015

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# Ecological and Behavioural Investigations of Two Ghost Crabs Occurring in the Sandy Beaches of Bakkhali, Sundarbans: A Field Study of Ecosystem Assessment

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**Abstract:** Aspects of the ecology and behaviour of two shore ghost crabs, *Ocypode macrocera* (Edwards) and *Ocypode ceratophthalmus* (Pallas) were studied on the exposed sandy beaches of Bakkhali island (21°33'48"N and 88°15'34"E) located at southern proximity of West Bengal, falling within the Sundarban mangrove ecosystem. Present study was undertaken to provide a detailed habitat distribution pattern on the shore along the variations of tidal zone and investigate burrow excavation pattern and their morphology. To achieve the aims, quantitative transect and quadrat sampling were done to access the habitat distribution, their abundance and the relative density by stretching three parallel belt transects on across-shore intertidal and supratidal zones respectively. Each quadrat, measuring 2m x 2m were placed at marked intervals along each transect and counting was done from each quadrat considering each burrow being inhabited by a single crab. The number of crab holes, their distribution and diameter of the burrows were seem to vary with maturity from seaward to landward area.

The feeding activity and pattern of burrow excavation were the major behavioral activities observed among the two *Ocypode* crabs. Juveniles dug simple and shallower burrows in contrast to adults, which create deeper and complex burrows. Data suggested that *O. macrocera* were relatively abundant with greater population density preferring almost dry supratidal above the high tide level. Their activity in the upper intertidal sandflats was related to feeding activity forming pellets (mud balls). The routine burrowing and feeding activity of shore crabs frequently alter the physical and chemical characteristics of the sediment. Hence, periodic assessment and biological monitoring of burrowing shore crabs on exposed sandy beaches may be a useful tool for anthropogenic impact and ecosystem assessment.

**Keywords:** *Ocypode macrocera*, *Ocypode ceratophthalmus*, population density, abundance.

## I. INTRODUCTION

Brachyuran crabs of tidal influenced shores serving as keystone species and bioindicators are vital components of the marine food chain and playing important role in the maintenance of ecosystem<sup>[1]</sup>. The intertidal brachyuran shore crabs constitute the most dominant macrobenthic faunal components along the coast of West Bengal. The crabs being vital components of marine food chain and food web play important role in controlling the ecological functioning by feeding on detritus or the organic matter. Two semi-terrestrial shore crabs of genus *Ocypode* (Family Ocypodidae) are typical inhabitants of tropical and sub-tropical sandy beaches. The semi-terrestrial shore crabs, *Ocypode macrocera*, H. Milne Edwards, 1852 and *Ocypode ceratophthalmus*, Pallas, 1772 are predominant

burrowing species distributed along the coastal shoreline of West Bengal that faces daily tidal influences of Bay of Bengal. They are typically predators, scavengers and deposit feeders and play an important role in ecology of sandy beaches<sup>[2]</sup>. Their routine burrowing and feeding activity frequently alter the physical and chemical characteristics of the sediment. These crabs depend directly upon mangrove influenced coastal ecosystem for survival, feeding, predation and reproduction by constructing unique architectural burrows<sup>[3]</sup>. Burrow morphology of adult *Ocypode macrocera* shows great variability, resembling the letters I or J with spiral configurations<sup>[4]</sup>.

Studies on ecological functions of burrowing behaviour as well as burrow morphology of shore crabs in specific ecosystems have gained importance over the last decade. Although various workers have studied the ecology, behavior and burrow architecture of *Ocypode macrocera* in unique ecosystems of Sundarbans, there has been scant data regarding distribution pattern and population structure of shore crabs along the coastline of Sundarban mangroves. Hence, present study has been undertaken to obtain a better ecological understanding of shore crabs, *Ocypode macrocera* and *Ocypode ceratophthalmus* serving as keystone species at the sandy beach of Bakkhali coastal area, which is gaining much importance as tourist spot. Due to accelerated involvement of human agents for residential, commercial, agricultural, industrial and tourism purposes, the habitats of shore crabs are being destroyed resulting in decrease of their population. The study also aims to provide a detailed habitat distribution in relation to varied degree of environmental parameters, along the variations of tidal zone. To achieve these aims, quantitative transect and quadrat sampling was done to assess the population density, relative density and its relative abundance.

## II. MATERIALS AND METHOD

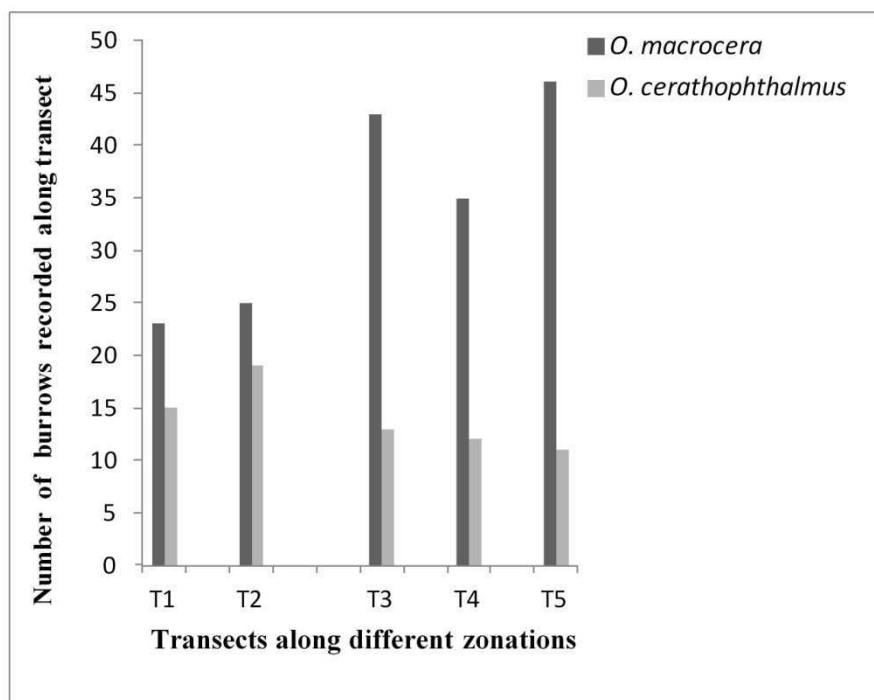
### *Study site and sampling design:*

Field investigations and sampling was carried out during the month of June, 2017 on exposed sandy beaches of Bakkhali island (21°33'48"N, 88°15'34"E), which continuously faces tidal influences of Bay of Bengal. Line drawing with placing of transects and regular interval quadrats were based on considerations of study site. High tide line (HTL) and Low tide line (LTL) were identified by deposition of litter. The number and length of transects selected were based on across-shore length of various zonations of the beach. Two parallel interrupted belt transects (T1 and T2) of 66 meters each were drawn across LTL and HTL with the help of measuring tape perpendicular to the shore line. A total of 15 square quadrates, each measuring 2m x 2m, made of nails and ropes were placed at marked intervals of 2 meters along each transect and random counting was done from each quadrat considering each burrow being inhabited by a single crab. Similarly, randomly placed three interrupted transects (T3, T4 and T5) of 40 meters each from HTL to HHTL (Highest high tide line) was used to determine the distribution of burrows across the supratidal zone. Mean density and diameter of burrows were analyzed by using 10 quadrats per transect from seaward to landward<sup>[5],[6]</sup>. The population structure was analyzed indirectly by counting burrows and measuring the diameter of their openings. The diameter of burrows was measured with the help of vernier caliper. The important physiochemical parameters of study site were measured using Digital pH meter and Digital TDS meter (Hanna, Taiwan make); Digital Salinometer (Erna, Japan make) and digital thermometer.

### III. RESULTS AND DISCUSSION

#### *Crab distribution, habitat preference, number and size of burrows:*

The number and diameter of the burrows varied greatly along transects placed through different zonations. At the time of sampling, the mean atmospheric temperature was found to be 32.6°C, mean water temperature recorded was 28.3°C, salinity of 1.013 (dissolved), % ge =15 and total dissolved solids as 3999 ppm. Within the study area, distribution of the crabs seemed to vary with the maturity from seaward to landward area. The number of crab holes and diameter of the burrows varied greatly among transects covering different zones (Figure 1). There were two distinct size groups of *O. macrocera*, the juvenile ones had burrow openings of diameter 1.5-2.8 cm inhabiting lower intertidal, whereas the larger adult group inhabited burrows measuring 3.5-6.8 cm in supratidal. Similar type of observation on *Ocypode macrocera* was demonstrated by Dubey *et al.*, 2013 at Sagar island of Indian Sundarbans. Burrow opening diameter of *O. cerathophthalmus* was found from 2.4 to 3.5 cm for adult ones, while juvenile burrow opening measured 1.0-1.5 cm in almost upper intertidal. A similar relationship was found between size of the crab and position on the beach for *Ocypode cursor* population at northern Israel.<sup>[7]</sup>



**Figure 1**

The number of burrows of *O. macrocera* and *O. cerathophthalmus* recorded in different transects of 66 m stretch (T1 & T2;  $n = 15$ ) from intertidal and 40 m stretch (T3, T4 & T5;  $n = 10$ ) from supratidal;  $n$  = number of quadrats.

The quantitative characteristics calculated on the basis of data of quadrat sampling revealed that average population density of *O. macrocera* at the exposed intertidal sandflat along the transect T1 and T2 was 0.22 individuals/m<sup>2</sup>, while for *O. cerathophthalmus* only occurred at 0.2 individuals/m<sup>2</sup>. On

transect further beyond the HTL (T3, T4 and T5), *O. macrocera* maintained an average density of 0.8 individuals/m<sup>2</sup> and *O. cerathophthalmus* at 0.3 individuals/m<sup>2</sup> (Table I). Hence, data suggests that *O. macrocera* is relatively abundant and prefers inhabiting almost dry supratidal above the high tide level. Their activity in the lower intertidal mudflats below the HTM was related to feeding activity forming pellets (mud balls). The *O. cerathophthalmus* generally had maximum burrows in the upper intertidal zone closer to the high tide mark. From the present investigation it is also suggested that habitat dependency of *O. macrocera* are related to several physiochemical parameters like air and water temperatures, different sediment conditions and varied salinity zonations due to tidal fluctuations.

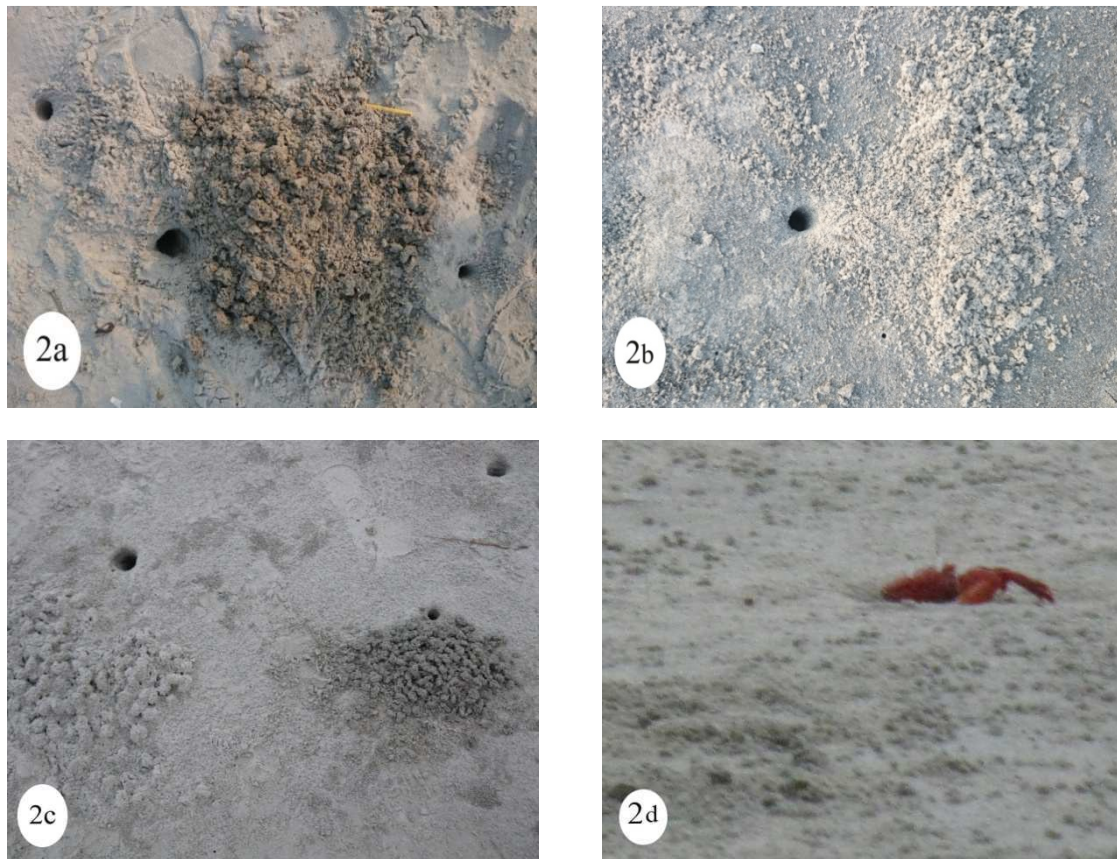
Table I: Quantitative characteristics calculated on the basis of data shown in Figure 1.

PARAMETERS	TRANSECT T1 & T2 (n = 15 each)		TRANSECT T3, T4 & T5 (n = 10 each)	
	<i>O. macrocera</i>	<i>O. cerathophthalmus</i>	<i>O. macrocera</i>	<i>O. cerathophthalmus</i>
POPULATION DENSITY (INDIVIDUALS/ M <sup>2</sup> )	0.4	0.28	1.03	0.32
RELATIVE DENSITY (R.D.) IN %	58.53	41.46	76.07	23.92
FREQUENCY OF OCCURRENCE (%)	76.66	63.33	76.66	60
ABUNDANCE/QUADRAT	2.08	1.78	5.39	2.16

#### **Behavioural observations of crab activity:**

The survey carried out in June, 2017 demonstrated that *O. macrocera* showed more activity before sunshine than during the day. The sole major activities observed were searching of food, digging burrows and deposit feeding leaving huge amount of characteristic pellets on sandflats. The main behavioral activities observed among both the crabs were of feeding activity and burrow excavation. At Bakkhali island beach, both the crabs seemed to be involved in burrowing activities twice in a day after receding the tides. They preferred inhabiting self-constructed wide range of burrows, each occupied by single individual and deeper burrows being constructed by adults away from the shore above high tide mark. Usually, adult *O. macrocera* inhabiting supratidal and upper intertidal near HTL was found to leave the dugout sand near the burrow opening to form a huge mound where excavated sediments were piled in a single direction (Fig.2 a-c). Sand piles near burrow openings had been reported for a number of species, like *O. mortoni*, *O. cursor*<sup>[8]</sup>. In the process of burrow excavation shown by *O. ceratophthalmus* (Fig. 3a & b), sand was repeatedly carried from a burrow and deposited around the opening with wide spread, sometimes forming a mound at one side (Fig. 3d). Burrow openings of *O. ceratophthalmus* with accumulated sand mounds had been reported by many workers<sup>[8],[9]</sup>. Activities of *O. ceratophthalmus* were similar to that of *O. macrocera*, involved in searching of food, digging variable burrows and deposit feeding forming small feeding pellets on sandflats (Fig. 3c). *O. ceratophthalmus* spent most of the time within the burrow with periodical activity greatly influenced by tidal cycles. Juveniles feed in vicinity of their burrows while adults move long distances in search of food. Juveniles were also found to move out of the burrows frequently to renew their respiratory water. They dig simple and shallower burrows in contrast to adults, which create deeper and complex burrows<sup>[9],[10]</sup>.

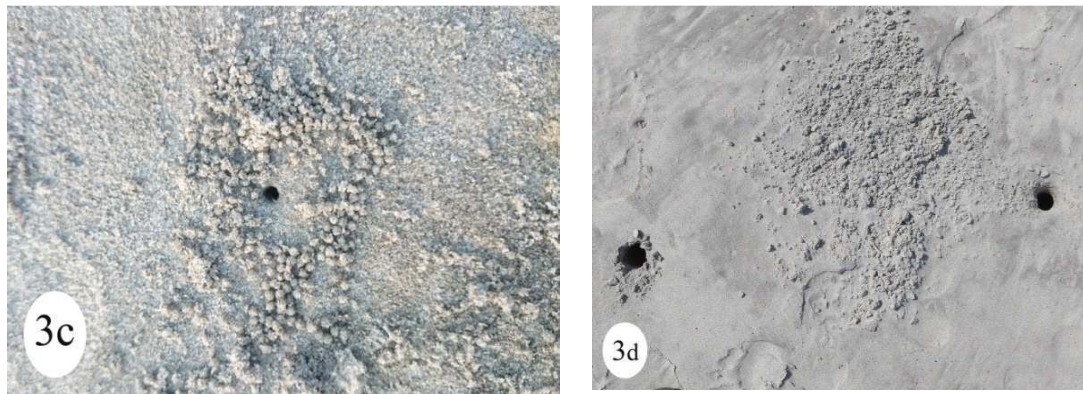




**Figure 2.**

Burrow morphology of *Ocypode macrocera*. Note the variation of arrangements of sediment piles around the opening; **a**, Burrow opening of adult depicting bigger untidy sand balls piled in a single direction forming a mound in upper intertidal; **b**, leaving dug out sand around burrow opening in supratidal; **c**, burrow opening of juvenile; **d**, Adult in the process of excavation.





**Figure 3**

**A & b**, Adult male and Juvenile (magnified) of *Ocypode cerathophthalmus*; **c**, Burrow made by juvenile surrounded by feeding pellets, **d**, Burrow opening at upper intertidal depicting the pattern of excavation.

Shore crabs of exposed sandy beaches involved in bioturbatory processes at particular ecosystems have gained attention over the recent decades. Their burrowing behaviour has been considered as one of the major *bioturbations* affecting the physical and chemical characteristics of the substratum, thereby promoting sediment turnover and biogeochemical cycling<sup>[12],[13]</sup>. The bioturbatory processes exhibited by shore crabs on sandflats resulting into varied biogenic structures, control various ecological processes for maintaining the stability within marine ecosystems. Ghost crabs are *excellent regenerators* as well as excavators which dig and continuously maintain burrows in the sediment thereby transferring sediment from various depths to surface and playing an important role in *biomixing*. Their frequent digging activity enhances nutrient recycling, oxygenation in the sediments and promotes decomposition of organic materials<sup>[14]</sup>. They play important role in the maintenance, modification and regulation of the biotic environment by influencing both the abiotic and biotic components. Through feeding activity, they scrap the upper organic rich layer of the sediments regulating the organic content and the algal covering, on the other hand, their byproduct from gut enriches the sediments with minerals like nitrogen and phosphorus<sup>[15]</sup>. Thus brachyuran crabs serving at different trophic levels in the food web of marine ecosystem could be used as key bioindicators of human impact on benthic communities.

#### IV. CONCLUSION

The two Brachyuran shore crabs of family Ocypodidae dig unique architectural burrows on exposed sandy beaches of Bakkhali Island along the variations of tidal zone thereby reflecting non-competitive habitat distribution pattern. The two species found to be absent in lower intertidal. The *Ocypode macrocera* remained clustered above high tide line while *Ocypode cerathophthalmus* clustered in upper intertidal below HTL, creating different ecological niches along across-shore zonations, thereby reflecting resource partitioning. Hence, crabs showing diversity and density and serving at different trophic levels of marine food web could be used as a bioindicator species for the health of substratum. The present investigation conclusively opines that biological monitoring of coastal sandy beaches and periodic assessment of population density and abundance of burrowing species inhabiting there may be a useful tool for anthropogenic impact assessment on exposed sandy beaches.

## ACKNOWLEDGMENT

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# Impact of Pisciculture Practices on the Aquatic Macroinvertebrate Diversity of the Waterbodies around the Periurban Localities of Calcutta

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*Abstract: Aquatic macroinvertebrates are imperative factors in the trophic dynamics of freshwater ecosystem. These organisms act as bioindicator by reacting swiftly to the fluctuations in the water quality, triggered by pollution and degradation. Among them, most of the insects serve as the food of commercially significant fishes, while others forage upon spawns and fries or compete with them directly for nutrition and habitat. Some of the zooplankton species predate heavily upon the mosquito larva and thereby limit their population size. Some of the aquatic macroinvertebrates, like fresh water molluscs, are strong competitor of the fishes for food resource. Some macroinvertebrates belonging to class Gastropoda and Bivalvia are edible. In fish culture ponds, fishermen withdraw these aquatic insects and molluscs, which eat up the natural food of the cultivated fishes and use chemical & bio-pesticides to kill them. Thus cultural practices due to economic processes become lethal to these aquatic organisms and lead to substantial loss of biodiversity.*

*Diversity of macroinvertebrate fauna is also associated with submerged and floating macrophytes, which are withdrawn from the fish culture ponds for the better growth and easy movement of the cultivated fishes. On the other hand, ponds with cemented banks at all sides harbor only a small amount of macrophyte in it.*

*The study was carried out, from the ecological point of view, realizing the importance of the presence of these aquatic macroinvertebrates, to study their diversity, habitat structure and community dynamics in periurban ponds of Kolkata. Current study also shows the effects of hydrophytes, fish culture and pond management process on the diversity of aquatic macroinvertebrates.*

**Key words:** macroinvertebrates, freshwater ecosystem, biodiversity, fish culture.

## I. INTRODUCTION

Aquatic macro invertebrates play important role in the trophic dynamics of the freshwater ecosystem. These macroinvertebrates take part in indicating the changes in the quality of water due to pollution or degradation because of their spontaneous ability to counter to such changes<sup>[1]</sup>. Macroinvertebrate are good food resources for cultured fish in manipulating the fish culture process<sup>[2]</sup>. Most of the insects serve as the food of commercially important fishes, while others feed upon spawns and fries or compete with them directly for natural food. Some predate heavily upon the mosquito larva and there by limit their population size<sup>[3]</sup>. In aquatic macroinvertebrates, some fresh water molluscs, of class Gastropoda, are strong competitor of the fishes for fish feed<sup>[4]</sup> and others belonging to class



Gastropoda and Bivalvia, are edible. It is estimated that about 3 % of the total macroinvertebrates are aquatic, spending at least a part of their life cycles in the water which include nearly 25,000–30,000 species<sup>[5]</sup>. The highly diverse aquatic forms are spread over to 15 orders<sup>[5],[6]</sup>. Among them, some taxa belonging to groups as Basommatophora, Coleoptera, Diptera, Ephemeroptera, Hemiptera, Mesogastropoda and Odonata show dominance in the freshwater wetlands of the south West Bengal<sup>[3]</sup>.

In fish culture ponds, fishermen withdraw these aquatic insects and molluscs, which eat up the natural food of the cultivated fishes and use chemical & bio-pesticides to kill those macroinvertebrates<sup>[7]</sup>. Thus cultural practices due to economic processes become lethal to these aquatic organisms and lead to substantial loss of biodiversity<sup>[8],[9]</sup>. Diversity of macro invertebrate fauna is also associated with submerged and floating macrophytes, which are withdrawn from the fish culture ponds for the better growth and easy movement of the cultivated fishes<sup>[10]</sup>. On the other hand, ponds with cemented banks at all sides harbor only a small amount of macrophyte in it.

Presence of the aquatic macroinvertebrates is essential for accurate utilization of aquatic resources that leads to economic benefits; provide employment along with buffering the ecosystem which is very significant to maintain the integrity of the aquatic ecosystem and makes the foundation of the current study<sup>[11]</sup>. In the light of the above, the present study has been commenced to know the community structure and dynamics of the macroinvertebrate fauna, their habitat and effect of fish culture on the aquatic macroinvertebrates.

## II. MATERIALS AND METHODS

The interests of resource consumption vary in urban and rural stakeholder population which leads to alteration in resource use practices<sup>[9]</sup>. In the urban-rural interface the anthropogenic interests and practices mostly clatter. This interesting observation triggered us to choose the study ponds in the peri-urban Kolkata. The hydrophytes, macroinvertebrate fauna and fishes were collected from 13 such waterbodies which are situated from the heart of the city of Kolkata to the rural fringes. Depending on the use and management practices these waterbodies are categorized in commercial ponds and wild ponds where no commercial fish cultivation are practiced and are majorly eutrophicated throughout the year. The study took place from January to June in 2008. Hydrophytes and fish species were identified using standard literature (<sup>[12]</sup> and <sup>[13]</sup> consecutively). For macroinvertebrate fauna, qualitative collection was made with the help of hand-operated nets of finely meshed polyester mosquito curtain cloth by randomly netting different study points of the wetlands. Macrophytes-associated insects were collected with the help of a hand operated sweep net from littoral zones only. The surface, shallow-surface and benthic zone were sampled along with macrophytes to get a wholesome understanding of the macroinvertebrate species diversity. Macroinvertebrate samples were preserved in 70% alcohol. Identification of the macroinvertebrates was done following standard literature<sup>[14],[15],[16],[17]</sup>. Identification of macroinvertebrates was mainly based on the adults collected from the waterbodies<sup>[18]</sup>. Information about the management of the sample ponds were collected from the fishermen and local people. For quantitative analysis,

hydrophyte cover, areas of the ponds, are calculated by using Google Earth software. Species richness, species density and Shannon Diversity Index (H)<sup>[19]</sup> were calculated using Past 3 software.

### III. RESULT

#### ***A. Pond habitat and surrounding***

Total thirteen ponds were sampled, ranging from 44450 sqm (pond B) to 800 sqm (pond L) water area. Four ponds were not used for fish culture (Table 1). Among them, two were wild ponds - one with eutrophication. Nine ponds were used for household purposes. These ponds are mostly multipurpose ponds, used in various routine domestic practices like bathing, washing clothes and utensils etc. Amongst 13 ponds, 11 ponds are situated amidst the locality whereas 2 are little isolated. The 11 ponds are surrounded by road-side vegetable market, meat shops, food centers, retail shops, garbage heaps, vehicle service centers, roads and houses. According to the local people, owner of the fisheries and fishermen, wash out from the food centers, vegetables and meat shops and vehicle service center situated on the bank beside roads, occurs throughout the year whereas, along with that, run off from nearby houses also takes place during monsoon season. Domestic inlets were present in all those 11 ponds. E and H ponds were used in domestic purpose only.

#### ***B. Fish culture practices and management***

Routine treatment with commercial fish food, fertilizers and chemical insecticides were reported in profitable fisheries like pond F, G and J which were used for extensive fish culture. Fishermen use Mahua oil cake as both insecticide and fish food. They use Lime as disinfectant whereas cow dung as bio-fertilizer and potash i.e. various mined and manufactured salts that contain potassium in water soluble form, as chemical fertilizer. Wheat husk along with Mustard oil cake were used as organic fish food in the ponds like pond A, B, C, D, I and M which are the moderate fish culture ponds. All the fish culture ponds were used as both rearing and stocking ponds.

#### ***C. Pond preparation for fish culture***

Local fishermen practice some management procedure to prepare ponds for fish cultivation. According to them, 290 kgs of Mahua oil cake were added per bighas of waterbody area for pond preparation. Near about 15 days after adding mahua oil cake, 25-30 kgs of lime and 1000kgs of cow dung per bighas were added. Then the pond became ready for fish culture and fries were released to the cultivation ponds. After fry release, Potash and 200 kgs of cow dung were added per bighas per month to produce natural food in the pond. After two to three months of fry release, when fry grows to fingerlings, 4 kgs of lime and 135 to 140 kgs of cow dung were added per month.

After releasing fry, fish food and fertilizer were added to the pond on a regular basis. Wheat husk and mustard oil cake were mixed in 1:1 ratio and added to the pond for fish food whereas commercial fish food were also used with the mustard oil cake and wheat husk in the intense fish culture ponds like pond F, G and J. For fries, food was added externally once per month as the main food source for them was the natural food. After fry release, fishermen continued netting once in

every month for the upcoming two to three months. This practice ensured rapid growth of the fries as netting ensures the movement of fishes and also confirmed proper food intake by the cultivated fishes. After six months, per month netting was done in order to catch fish that have reached the desired size. The process was continued until next season of fry release commenced.

**Table 1:** Description of sampling ponds.

Pond sl. code	Pond name	Location	Surface area/sqm	Fisheries management status
A	Ajaynagar pond	22°29'25" N, 88°23'43" E	10400 sqm	Commercial fisheries and domestic uses
B	Chakgoria pond	22°28'59" N, 88°23'36" E	44450 sqm	Commercial fisheries and domestic uses
C	Commint Park pond	22°28'49" N, 88°23'29" E	4200 sqm	Commercial fisheries and domestic uses
D	Baghajatin Park pond	22°28'49" N, 88°23'32" E	4000 sqm	Commercial fisheries and domestic uses
E	Panchasayar pond 3	22°28'39" N, 88°23'34" E	10800 sqm	Domestic uses only. No commercial fishery practice
F	Narkel Bagan pond	22°29'36" N, 88°23'31" E	14500 sqm	Commercial fisheries and domestic uses
G	Survey Park pond	22°29'28" N, 88°23'39" E	3500 sqm	Commercial fisheries only
H	Peerless Hospital pond	22°28'48" N, 88°23'44" E	4400 sqm	Domestic uses only. No commercial fishery practice
I	Panchasayar pond 1	22°28'45" N, 88°23'45" E	11200 sqm	Commercial fisheries and domestic uses
J	Survey Park Stadium pond	22°29'39" N, 88°23'29" E	2500 sqm	Commercial fisheries only
K	Ballygunge pond 1	22°31'36" N, 88°21'43" E	2400 sqm	Little domestic uses No commercial fishery practice
L	Ballygunge pond 2	22°31'37" N, 88°21'51" E	800 sqm	No commercial fishery practice, Eutrophication, Wild pond
M	Panchasayar pond 2	22°28'42" N, 88°23'49" E	11100 sqm	Commercial fisheries and domestic uses

#### D. Hydrophyte diversity

Total 27 species of aquatic plants were reported from the sampling ponds (Table 2). These 27 hydrophyte species belong to 11 orders and 18 families. The richness of the Hydrophyte species was reported to be highest in pond F. Total 15 species of aquatic plants were present there. '% hydrophyte cover' was highest in pond L followed by pond E with 34.52 '% hydrophyte cover' and lowest in pond J. Density of periphyton dwelling macroinvertebrates were highest in pond E with 0.053 individuals per sq.cm and lowest in pond J as no such macroinvertebrates were found there. *Eichhornia crassipes* was found to dominate as the floater hydrophyte in most of the ponds.

**Table 2:** Check list of hydrophytes found in and around the sampling ponds.

Order	Family	Species	Clade
Alismatales	Araceae	<i>Colocasia esculenta</i>	Monocotyledon
		<i>Lemna perpusilla</i>	Monocotyledon
		<i>Pistia stratiotes</i>	Monocotyledon
		<i>Spirodela polyrhiza</i>	Monocotyledon



Order	Family	Species	Clade
	Hydrocharitaceae	<i>Vallisneria spiralis</i>	Monocotyledon
Asparagales	Amaryllidaceae	<i>Crinum viviparum</i>	Monocotyledon
Asterales	Asteraceae	<i>Eclipta alba</i>	Eudicots
		<i>Enhydra fluctuans</i>	Eudicots
		<i>Mikania micrantha</i>	Eudicots
	Menyanthaceae	<i>Nymphoides hydrophylla</i>	Eudicots
		<i>Nymphoides indica</i>	Eudicots
Caryophyllales	Amaranthaceae	<i>Alternanthera paronychioides</i>	Eudicots
		<i>Alternanthera philoxeroides</i>	Eudicots
		<i>Alternanthera sessilis</i>	Eudicots
	Polygonaceae	<i>Polygonum plebeium</i>	Eudicots
Ceratophyllales	Ceratophyllaceae	<i>Ceratophyllum demersum</i>	Monocotyledon
Commelinales	Commelinaceae	<i>Commelina benghalensis</i>	Monocotyledon
		<i>Commelina diffusa</i>	Monocotyledon
	Pontederiaceae	<i>Eichhornia crassipes</i>	Monocotyledon
Lamiales	Lamiaceae	<i>Leucas aspera</i>	Eudicots
	Verbenaceae	<i>Phyla nodiflora</i>	Eudicots
Poales	Cyperaceae	<i>Schoenoplectus corymbosus</i>	Monocotyledon
	Typhaceae	<i>Typha angustifolia</i>	Monocotyledon
Ranunculales	Ranunculaceae	<i>Ranunculus sceleratus</i>	Eudicots
Salviniales	Marsileaceae	<i>Marsilea minuta</i>	Pteridophyta
	Salvinaceae	<i>Salvinia molesta</i>	Pteridophyta
Solanales	Convolvulaceae	<i>Ipomoea aquatica</i>	Eudicots

### ***E. Macroinvertebrate diversity***

A total of 30 macroinvertebrates species were found in the sampled ponds (Table 3). Among them 25 species were present in sewage fed fisheries of southern periurban Kolkata and all 30 species were found to be present in natural ponds. These 30 species of macroinvertebrate belong to two phyla, e.g., Arthropoda and Mollusca. All together 21 Arthropoda and 9 Mollusca species were found belonging to 21 families within the samples collected from wild ponds and fisheries of southern periurban Kolkata. All the 21 Arthropod species were present in wild ponds but 20 were found in fish culture ponds whereas 9 mollusca species were found in wild ponds and 6 species of Mollusca

phylum were found in fish culture ponds. Among 18 families found in fisheries, dominant family was Chironomidae while rare family was Haliplidae. Amongst the 21 families found in wild ponds, dominant family was Notonectidae and the rare family was Libellulidae. *Anisops bouvieri*, *Lamellidens marginalis*, *Lymnaea leuteola* and *Pila globosa* were present in E, H, K and L ponds where no fishery practice take place; but absent in other fish culture ponds. Shannon diversity index values are higher in wild ponds than fisheries. Mosquito larva and juveniles of insects were also found within the sample but were found in less number in fish culture ponds. *Diplonychus annulatus* was also found but in very less abundance. Among chironomous larva, *Chironomous circumdatus* and *Chironomous striatipennis* were found.

**Table 3:** Check list of aquatic macroinvertebrates found in the sampling ponds.

Phylum	Class	Order	Genus
Arthropoda	Arachnida	Araneae	<i>Clubiona drassodes</i>
	Insecta	Coleoptera	<i>Amphiops sp.</i> <i>Berosus indicus</i> <i>Haliphus angustifrons</i>
		Diptera	Chironomous Larva
		Ephemeroptera	<i>Cloeon kimminsi</i>
		Hemiptera	<i>Anisops bouvieri</i> <i>Anisops breddini</i> <i>Anisops sardea</i> <i>Diplonychus annulatus</i> <i>Gerris spinolae</i> <i>Laccotrephes griseus</i> <i>Limnogonus nitidus</i> <i>Neogerris parvula</i> <i>Plea liturata</i> <i>Ranatra filiformis</i>
		Odonata	<i>Brachydiplax chalybea</i> <i>Ceriagrion coromandelianum</i>
Mollusca	Malacostraca	Decapoda	<i>Sartoriana spinigera</i> <i>Macrobrachium lamarrei</i> <i>Scylla serrata</i>
	Bivalvia	Unionoida	<i>Lamellidens marginalis</i>
	Gastropoda	Basommatophora	<i>Gyraulus convexiusculus</i> <i>Indoplanorbis exustus</i> <i>Lymnaea leuteola</i>

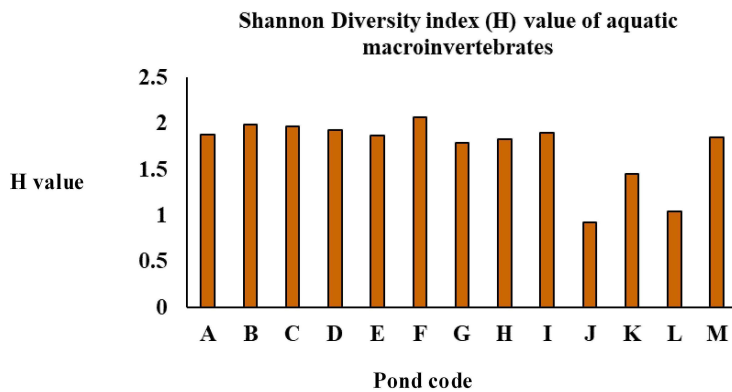
Phylum	Class	Order	Genus
		Littorinimorpha	<i>Gabbia orcula</i>
		Mesogastropoda	<i>Bellamya bengalensis</i> <i>Melanoides tuberculata</i> <i>Pila globosa</i> <i>Thiara scabra</i>

### F. Fish diversity

Fisheries in the southern periphery of Kolkata support local economy by generating employment and livelihood for the society. Total ten species of fish were cultivated. These 10 fish species belong to 2 orders and 3 families (Table 4). Some fishes which were normally present in the waterbodies but not cultivated by the fishermen, were termed as accessory fish. Total 8 species of accessory fishes were present in the sampling ponds. These accessory fishes belong to 3 orders and 4 families. Among the accessory fishes, both the *Chanda nama* and *Chanda ranga* were killed or taken out of the fisheries as they outcompeted the cultivated fishes for food. As per report, *Puntius* spp. is not economically important fish and was thus forcefully wiped from the fishery ponds.

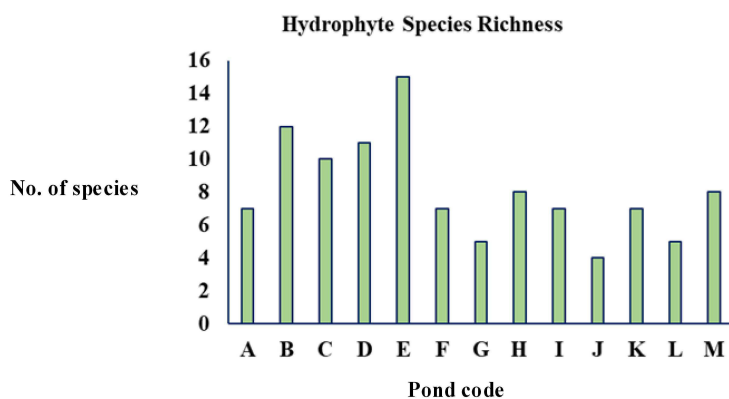
**Table 4:** Check list of fishes found in the ponds of southern periurban Kolkata.

	Order	Family	Species
Cultivated fish	Cypriniformes	Cyprinidae	<i>Catla catla</i>
			<i>Cirrhinus mrigala</i>
			<i>Ctenopharyngodon idella</i>
			<i>Cyprinus carpio</i>
			<i>Hypophthalmichthys molitrix</i>
			<i>Labeo bata</i> <i>Labeo rohita</i>
	Perciformes	Cichlidae	<i>Oreochromis mossambica</i> <i>Oreochromis niloticus</i>
		Latidae	<i>Lates calcarifer</i>
Accessory fish	Anabantiformes	Anabantidae	<i>Anabas testudineus</i>
		Channidae	<i>Channa punctatus</i>
	Cypriniformes	Cyprinidae	<i>Puntius javanicus</i>
			<i>Puntius sarana sarana</i>
			<i>Puntius sophore</i>
			<i>Puntius ticto</i>
	Perciformes	Ambassidae	<i>Chanda ranga</i> <i>Chanda nama</i>



**Figure 1**  
Shannon Weaver index (H) of aquatic macroinvertebrates of different ponds.

Pond J is least diverse among the 13 ponds. Most of the ponds are with more or less uniform Diversity index value. Pond F showed highest Shannon diversity values of 2.062 and pond J showed lowest Shannon diversity value of 0.93 (Figure 1).



**Figure 2**  
Species richness of hydrophytes

Lowest hydrophytes species richness was observed in pond J (4 hydrophyte species) and highest in pond E (15 hydrophyte species). Without any management or fishery practice, pond E sheltered a great number of aquatic plant species which increases aquatic floral diversity (Figure 2).

#### IV. DISCUSSION

Local fishermen practice some management process using traditional knowledge. According to them, for first 15 - 20 days mahua oil cake acted as potent toxin for unwanted fish and macroinvertebrate fauna<sup>[20],[21],[22]</sup>. After approximate 20 to 25 days it turned to biofertilizer and later on acted as fish food<sup>[24],[7]</sup>.

While macrophyte floras of the lake were diverse, the pond was fully covered by monospecific strands of *Eichhornia crassipes* (Table 2). Many commonly occurring taxa of macrophyte-associated macroinvertebrate fauna were recorded. Gastropods were represented by the largest number of taxa (Table 3)<sup>[25]</sup>. Most of the species were common in different ponds. The faunal diversity was considerably high in larger waterbodies throughout the period of investigation, but it was significantly low in smaller ponds as pond B is the largest pond harboring 18 species and pond J being the smallest among the sampling ponds, accommodating 4 aquatic macroinvertebrates species.

Variations within lakes were nested across a range of lake types and showed that macroinvertebrate assemblages can provide meaningful assessment of ecological differences across lakes<sup>[26]</sup>. Pond E sheltered most number of periphyton dweller macroinvertebrates and had highest hydrophyte cover which provides habitat and feeding niche for the macroinvertebrates whereas pond J was barren of any hydrophyte cover and thus unable to shelter such macroinvertebrates. Using external chemical fish feed by the local fishermen in pond J might be the reason.

Absence of hydrophytes (Figure 2), intense fisheries management and cemented banking might be the reason of lowest diversity value in pond J. Eutrophication of pond L may be a cause against the presence of a diverse aquatic macroinvertebrate community<sup>[15]</sup>. As being reported, Thimate was added to this pond to kill invertebrate pests on the previous night of sampling in F pond (Figure 1). Thimate is commonly known as phorate which is an organophosphate type of insecticide<sup>[27]</sup>. Using Thimate might be a reason of resultant high diversity value as the insecticide imparts a toxic effect at the lower surface of the water body and the aquatic insects and molluscs appear to exist in the upper surface of the water body.

## V. CONCLUSION

Current study provides noble account of the traditional knowledge of pond management process practiced by the local fishermen in the periurban Kolkata. Total thirty species of aquatic macroinvertebrates were found in the sampling ponds. Study shows higher hydrophyte species assemblage in ponds with negligible anthropogenic influence. Eutrophication might cause decline in both hydrophyte and macroinvertebrates species richness. Assemblage of benthos and periphyton dweller macroinvertebrates within hydrophyte covered ponds signifies that along with offering habitat, hydrophytes might provide good food resource to these aquatic macroinvertebrates. This information might help to take appropriate steps to supervise and protect multifunctional ponds within periurban locality.

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**Ethical Standards were followed in the current study.**

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# Sapromyophily: Mimicry of the Dead to get Reproductive Success

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**Abstract:** *Plants achieve their reproductive success by transferring the pollens to stigma of another conspecific flower by the process known as cross pollination. Many insects are known to mediate this transfer in exchange of valuable floral rewards. Sapromyophilous plants are known to draw their pollinators by emitting smell of decaying organic matter. Many of such plants belong to families like Araceae, asclepiadaceae, apocynaceae, orchidaceae etc. Sapromyophilous plants usually produce dull coloured flowers, which often attain huge size giving a visual cue to the pollinators. In addition, many of them produce heat which makes their mimicry perfect. Worldwide many instances of Sapromyophily have been studied to understand the chemical ecology of production of such characteristic odour. It has been found that some sulphur containing compounds commonly known as dimethyl oligosulphides are chiefly responsible for such foul smell emitted by these plants as well as their models. In addition, 1- pyrroline, indole, skatole and many other volatiles are produced by various sapromyophilous plants to induce different kinds of putrid smells such as dung, urine, rotting fruit, semen etc. to attract insects which oviposit on such decaying organic matters. This review tried to summarise the available information which may help in further research.*

**Keywords:** Indole, Oligosulphide, Pollination, Pyrroline, Sapromyophily, Thermogenesis

## I. INTRODUCTION

Pollination is the process of transfer of pollens from the anthers of male flowers to the stigma of female flowers<sup>[1]</sup>. In case of cross pollinating flowers various agents such as wind, water or animals such as insects (bees, flies, beetles etc), molluscs, birds, mammals mediate this transfer process<sup>[2]</sup>. In case of animals mediating this process, the pollinators usually get floral rewards of pollen or nectar which have high nutritional values. Flowers usually give chemical or visual or a combination of both types of cues to animal pollinators to draw their attention<sup>[3]</sup>. However, there are instances where either of the parties tries to deceive the partner. Deceit pollination is probably the most extreme untrustworthy plant to animal signals where plants get benefit of their reproductive success without offering any reward to the pollinators<sup>[4]</sup>. Sapromyophily is the case where plants mimic dead animal carcasses and attract many insects (chiefly flies and some beetles) to the flowers to get the job of pollination done but they usually do not give any floral rewards to the incoming insects<sup>[5]</sup>. Studies have reported many plants belonging to families apocynaceae, asclepiadaceae, araceae, orchidaceae to be sapromyophilous. Sapromyophilous plants exploit ovipositional choice of flies for their reproductive success<sup>[6]</sup> with smell of rotting flesh, dung, decaying organic matter and even semen that attract these flies, which thrive on them. The insects which feed on and oviposit on corpses are commonly called carrion flies<sup>[7]</sup>. In addition to the scent, the flowers or even the plant bodies often have unique characteristic colours, many of them bear a fleshy spathe which help to make them look



like corpses<sup>[8]</sup>. In some cases they produce heat, by a process called thermogenesis which also makes their mimicry perfect. Insects attracted to sapromyophilous flowers usually belong to family calliphoridae, muscidae, sarcophagidae, chloropidae<sup>[9]</sup>.

There are studies of sapromyophily worldwide, but most of them usually concentrate on either individual plant species or a group of related plants. Many of them deal with volatile compounds emitted by the plant(s) that are responsible for characteristic smell. Here in this review, we have tried to enlist the names of as many sapromyophilous plants and their chemical profiling as available in literature under one heading. This work will help to lay foundations for future works to further investigate this amazing system of death mimicking pollination system.

## II. WHICH ARE THE SAPROMYOPHILOUS PLANTS?

In this review, we have tried to tabulate names of different sapromyophilous plants studied worldwide. Table 1 enlists some sapromyophilous plants belonging to various families.

**Table 1:** Names of different sapromyophilous plants and the family they belong to

Plant Name	Family
<i>Stemona japonica</i>	Stemonaceae
<i>Photinia serrulata</i>	Rosaceae
<i>Castanopsis sclerophylla</i>	Fagaceae
<i>Helicodiceros muscivorus</i>	Araceae
<i>Arum italicum</i>	Araceae
<i>Sauromatum guttatum</i>	Araceae
<i>Amorphophallus titanum</i>	Araceae
<i>Dracunculus vulgaris</i>	Araceae
<i>Hydrosome rivieri</i>	Araceae
<i>Peltandra virginica</i>	Araceae
<i>Pseudodraconticum</i> sp.	Araceae
<i>Symplocarpus foetidus</i>	Araceae
<i>Ceropegia mixta.</i>	Apocynaceae
<i>Acianthera fenestrata</i>	Orchidaceae
<i>Acianthera aphthosa</i>	Orchidaceae
<i>Zootrophion atropurpureum</i>	Orchidaceae
<i>Phloeophila nummularia</i>	Orchidaceae
<i>Echinosepala aspasicensis</i>	Orchidaceae
<i>Rafflesia kerrii</i>	Rafflesiaceae
<i>Stapelia gigantean</i>	Asclepiadaceae
<i>Orbea lutea</i>	Apocynaceae

### III. WHAT IS THE CHEMICAL ECOLOGY OF SAPROMYOPHILY?

Diversity of phytochemicals is a key component of ecological interactions. Volatile organic compounds (VOCs) are employed by plants to interact with insects<sup>[10],[11]</sup>. In many published research articles, sulphur containing compounds i.e. dimethyl oligosulphides have been reported to be emitted by sapromyophilous flowers<sup>[12]</sup>. In addition, nitrogenous compounds such as indole, skatoles are also found in many studies (see Table 2). These compounds are often found in dung or decaying organic matters, so they are mostly thought to be the main source of such fetid smell in many plants. Other trace volatiles found in the scent of such flowers include various hydrocarbons, nitrogen containing compounds, sulphur containing compounds and terpenoids, heterocyclic alcohols, aldehydes, ketones, acids, esters etc.<sup>[13]</sup>

In addition to mimicking the putrid smell of corpses some sapromyophilous flowers such as *Stemona japonica* (Blume) Miquel have been reported to emit semen like odour<sup>[14],[15]</sup>. Chemical investigation of these plants by using mass spectrometry has shown high amount of 1-pyrroline, 1-piperoline, 2-pyrrolidone etc.<sup>[16],[17],[18]</sup>. Not only that, other volatiles released from sapromyophilous plants include p-cresol and indole to induce dung like smell<sup>[19]</sup>, and aliphatic acids to induce odour of rotting fruits<sup>[20],[21]</sup>.

**Table 2:** List of volatiles emitted by some sapromyophilous plants to attract pollinators.

Plant Name	Name of Chemical (s)
<i>Helicodicerus muscivorus</i>	dimethyl disulphide, dimethyl trisulphide
<i>Stemona japonica</i>	1-pyrroline, 2-methyl-1-butanol, 3-methyl-1-butanol, 3-methylbutanol, dimethyl disulphide etc
<i>Photinia serrulata</i>	1-pyrroline, 1-piperoline, 2-pyrrolidone, 4-amino butanol
<i>Castanopsis sclerophylla</i>	1-pyrroline, 1-piperoline, 2-pyrrolidone, 4-amino butanol
<i>Arum italicum</i>	indole, skatole, methylamine, ammonia, aliphatic amines
<i>Sauromatum guttatum</i>	dimethyl disulphide, dimethyl trisulphide, dimethyl tetrasulphide, indole, skatole
<i>Amorphophallus titanum</i>	dimethyl disulphide, dimethyl trisulphide, dimethyl tetrasulphide
<i>Pseudodraconticum</i> sp.	dimethyl disulphide, dimethyl trisulphide, dimethyl tetrasulphide, indole, skatole
<i>Symplocarpus foetidus</i>	dimethyl disulphide, indole, diethyl phthalate

### IV. FLORAL GIGANTISM

Visual cues are also very important to draw pollinators to the flowers. Insect pollinated flowers are usually brightly coloured<sup>[22]</sup>. Carrion Flowers are often very dull in colouration<sup>[23],[24]</sup> but they employ their huge size to be visible, in addition to odour<sup>[25]</sup>. Flowers in general vary in size from less

than a millimeter to about a meter<sup>[26]</sup>. *Rafflesia arnoldi*, *Amorphophallus titanum* are two sapromyophilous flowers that produce the largest single flower and blossom in the world, respectively<sup>[27]</sup>. It is believed that this large size of flowers ensures greater visitation rate by carrion attracted insects. Female insects prefer larger brood sites for oviposition owing to abundant food resources. A strong evolutionary force might have acted upon large sized carrion flowers as they are capable of attracting more number of pollinators, thereby increasing reproductive success<sup>[28]</sup>.

## V. HEAT PRODUCTION

In a normal aerobic respiration process, metabolically generated energy is stored in ATP molecules. If this process is somehow diverted, heat is generated instead of ATP. Such process is called thermogenesis<sup>[29]</sup>. Thermogenesis is found in many plant families such as Araceae, Arecaceae, Cyclanthaceae, Annonaceae, Aristolochiaceae, Nelumbonaceae, Nymphaeaceae, Magnoliaceae etc<sup>[30]</sup>. Many sapromyophilous plants, especially those belonging to Araceae, produce heat that enhances their mimicry of decaying animal carcasses<sup>[31]</sup>. It may help in convincing insects that they have arrived on a rotting carcass. One possibility is also that the carbon dioxide released along with the heat may also somehow aid in attracting the pollinators<sup>[32]</sup>. But the detailed mechanism and actual purpose is still unclear to science, and hence, much further research is needed.

## VI. SUMMARY

This review work tried to provide some valuable information regarding various sapromyophilous plants. Here, the names of sapromyophilous plants with their respective chemicals are mentioned. Furthermore, the families of different sapromyophilous plants are also tabulated. It is observed that most of the sapromyophilous plants belonged to the families Orchidaceae and Araceae. The chemicals emitted by various sapromyophilous plants play an important role in attracting the insects; and if those particular chemicals are studied in other plants belonging to the families Orchidaceae and Araceae, several other sapromyophilous plants could come into the lime light. Moreover, the chemicals acting as cues to the pollinators could be examined individually so as to find out whether they are being emitted by others plants or not. Also, the other factors enhancing as attractants to the insect pollinators such as visual cues, thermogenesis etc. could be studied separately for exploring more information related to sapromyophilous plants. So, the preliminary information provided by this review work might help in further research works related to death mimicking pollination system. However, further investigations are required regarding the sapromyophilous plants, which would throw some light on the death mimicking pollination system.

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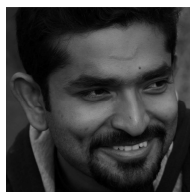
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# Spiders as Potential Biological Pest-Control Agents

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*Abstract: The intensive use of pesticide since the advent of Green Revolution has led to unsustainable agricultural system in India. This practice has not only affected the ecological balance but also adversely affected human health. In this scenario, this paper attempts to explore the potential of spiders as a biological pest control agent, in the hope to restore our harmony with nature.*

**Keywords: Biological pest control, Pesticide, Spiders**

The Green Revolution was initiated in India in the 1960s to increase food production; and was versioned as a solution to put an end to the-then food crisis of the nation. It has been credited with increasing yields through adoption of modern methods accompanied by the intensification of crop production and the development of agriculture using technologies. The Green Revolution package offered high yielding seeds and the promise of double or triple yields. This involved the application of chemicals to enhance the quality of the soil as well as deter pests and insects. Chemical Pesticides have helped control many kinds of insects, weeds, plant diseases, nematodes and rodents, and have, therefore, contributed to crop production in many situations. Furthermore, pesticides and herbicides lead to resistant species, creating further need for chemical applications. The decades since the dawn of the Green Revolution revealed large disparities in the overall benefits to the agricultural activities in India. Long term effects of these practices were not foreseen to be increasingly detrimental to the agricultural land and soil erosion, leading to unsustainable agricultural practices<sup>[1]</sup>. However, over time, there have been increasing evidence and recognition of disadvantages and hazards from the dependence on pesticides. The main problems arising from prolonged and extensive use of pesticides are resistance, pest resurgence, persistence of residues in the environment and in foods, and damage to health. To address this issue, scientists have peered upon the alternatives to chemical pesticides, thus emerged the concept of biological control of organisms, acting as potential threats to crop production<sup>[2]</sup>.

Biological control can be defined as the use of an organism to reduce the population density of another organism; and thus, includes the control of animals, weeds and diseases. Many biological control schemes use predatory insects and mites, insects that parasitize other insects (parasitoids) or nematodes, targeted against insect and mite pests; these are the so-called ‘macrobial’ agents. There are also various ‘microbial’ agents (bacteria, viruses and fungi) that have been developed and applied in arthropod biological control. Herbivorous insects and mites have also been used in the biological

control of weeds<sup>[3],[4]</sup>. Generally three types of biological control are distinguished: classical, augmentative and conservational. Classical biological control aims for long-term control of exotic pests by introducing populations of exotic natural enemies. Augmentative biological control uses mass-produced indigenous natural enemies either to achieve curative control of a pest by mass release (inundation) or to achieve prophylactic control of a potential pest (inoculative introductions). Conservational biological control aims to conserve and promote naturally occurring populations of natural enemies, using various techniques of habitat modification and resource supplementation. Biological pest control is not only widely used in greenhouse vegetable crops, soft fruits and ornamentals, but increasingly also in open field crops and some arable crops.

As the volume of pesticides used (especially insecticides) increased, so did the contact between wildlife and pesticides and their residues. Harm to wildlife and contamination from pesticides developed as a major environmental crisis in the 1960s. Chlorinated hydrocarbons like DDT adversely affected the reproductive systems of raptors and wading birds, causing birds to lay eggs with abnormally thin shells. Eagle, falcon, osprey and heron populations declined; and even disappeared from large areas because residues of stable and fat-soluble pesticides, circulating in the environment, polluted their food chains<sup>[5]</sup>. Faced with the need to reduce pesticide usage on the world's crops and optimize natural biological control, full investigation of the means by which spiders influence pest abundance is long overdue. Spiders have often been thought of as a mere annoyance, filling nets and pitfall traps meant for insect quarry. They have been universally shunned and feared, but few deserve it. They are extremely shy creatures, fearing man more than they are feared. It is, therefore, surprising to learn that spiders have held a prominent role in traditional cultures for centuries. Indeed, the terms "arachnid" and "archaeology" come from Greek mythology. It is clear that spiders have been held in high regard across a global spectrum of cultures for a very long time. Spiders, like insects, belong to the phylum Arthropoda, but they are in the class Arachnida, under order Aranae. Other prominent orders under class Arachnida include the Acarines (ticks and mites), Scorpiones, Pseudoscorpiones, Opiliones (harvestmen or daddy-long-legs). Arachnids are only distantly related to the other major terrestrial arthropod group, the insects; and represent a separate evolutionary transition from marine to terrestrial living, because their closest living relatives are thought to be the marine horseshoe crabs (Xiphosurans) and sea spiders (Pycnogonids)<sup>[6]</sup>. Spiders can easily be distinguished from other arachnids by their lack of visible segmentation and the marked constriction between the prosoma and the opisthosoma, dividing the body into cephalothorax and abdomen, respectively. Spiders occupy nearly all terrestrial environments; and can be found wherever there are other terrestrial animals to prey upon. Research on spider biology, particularly the diversity of their silks, webs and venoms, together with the associated ecology and behaviour, has increased greatly in the recent decades.

Spiders have special adaptations towards a predatory way of life. Their distensible abdomens enable them to consume a large amount of prey within a relatively short period of time, while their rate of predation may increase greatly for short periods when food is locally abundant<sup>[7]</sup>. They have an exceedingly high resistance to starvation, which enables them to survive and maintain normal reproduction during periods of low prey availability<sup>[8]</sup>. Several studies have shown that assemblage of many predator species may be more effective at controlling agricultural pests than single species augmentation<sup>[9],[10],[11]</sup>. Spiders are usually polyphagous and feed on a variety of available prey.



Predation is not limited to adult insects only, but includes the egg and larval or nymphal stages as well<sup>[12]</sup>. Spiders are some of the first predators to colonize newly planted crops, and research has shown the importance of early season assemblages in limiting pest numbers while their densities are low<sup>[13],[14]</sup>. As predators, spiders have a two-fold effect. Not only do they feed directly on their prey, but also their presence causes indirect mortality. However, research has shown that spiders in rice fields can play an important role as predators in reducing the densities of planthoppers and leafhoppers<sup>[15],[16],[17],[18],[19]</sup>. The role of spiders as possible natural control agents of insects and mites needs to be evaluated, specifically for use in pest control strategies in agro ecosystems, functionally significant as predators of other invertebrates. In agricultural areas, a programme based on the use of spiders would naturally lead to a decline in the use of pesticides. In any case, both (spiders and toxins) cannot go together as the pesticides would eliminate the spiders. Studies on the effect of pesticides on spiders have shown that most of the pesticides currently used in agro ecosystems kill off many spiders. Studies have also been made on the effect of various plant-based pesticides on spiders. An agricultural programme that is based on the use of predators like spiders would also create suitable environments for the return of several other beneficial insects, which are unable to tolerate the presence of pesticides.

Spiders are an important group of predators in various ecosystems. However, their role in pest control and crop protection has not been utilised properly in India. Predators help to maintain a balance among organisms, by consuming prey, altering prey behaviour and prey habitat selection. Thus, predators may increase the biodiversity of communities by preventing a single species from becoming dominant. Reviews on the role of spiders in agroecosystems<sup>[20],[21],[22],[23],[24]</sup> indicate an increasing interest in and recognition of spiders as natural control agents of insects and mites in field crops and orchards. Spiders are one of the most ubiquitous predator groups in South African agro ecosystems<sup>[25]</sup>, and inventories have provided valuable baseline information on the abundant species occurring on various commercial crops, including orchards. Several European and American studies have provided evidences that, in undisturbed grassland ecosystems and forest ecosystems, spiders can play an important ecological role as predators of insects and other invertebrates. Also in orchards, not treated with pesticides, that are, to a certain degree, comparable with forest ecosystems, spiders can be abundant predators.

In “biological pest control”, Ground-dwelling spiders, together with the ground-dwelling raptorial Carabidae and Staphylinidae, form an important predator potential in cereal fields. This predator potential can be utilized within “programmes for integrated pest control”<sup>[26]</sup>. Attempts have also been made in Japan to raise the spider density in rice fields artificially by releasing *Drosophila* flies. This additional food then caused an increased fertility in the spiders<sup>[27]</sup>. According to a report of the Chinese News Agency Xinhua on August 15, 1979, in the Peoples Republic of China, spiders are introduced into rice fields as biological control agents of rice pests. There are indications in the literature of many mechanisms, whereby spiders can affect the abundance of invertebrate pests. Direct predation, pest dislodgement and wasteful killing (by both spider and web) reduce pest abundance. Biological control has been applied successfully in many crops, but not in all crops, as natural enemies cannot establish equally well in all crops. Impediments for establishment include (1) a (temporary) lack of prey for predators or hosts for parasitoids; (2) a lack of non-prey food, such as nectar, honeydew or pollen; (3) a lack of suitable oviposition sites and shelter; and (4) the presence of plant traits, which adversely affects predators and parasitoids conclusion.

In summary, spiders can be effective predators of herbivorous insect pests, and can exert considerable top-down control, often catching more insects than they actually consume. Despite the potential for competition and intraguild predation, a diverse assemblage of spiders may have the greatest potential for keeping pest densities at low levels. The focus of most spider research has mainly been on wandering spiders, as web weavers may either be unable to establish webs or catch pest insects. The spiders that are most efficient at capturing pest insects are those that forage on the plant itself. Traditional biological control efforts have focused on using specialist predators to control pest outbreaks<sup>[28]</sup>. Encouraging spider populations may have the effect of keeping pest levels low, and not letting them get out of control. Spiders may be potential biocontrol agents because they are relatively long lived, and are resistant to starvation and desiccation. Additionally, spiders become active as soon as conditions are favourable; and are among the first predators able to limit pests. The risks associated with using spiders to control pests are minimal. Since diverse species of spiders are naturally present in an agricultural system (thus avoiding the problems associated with introductions) and predaceous at all stages of their development, they fill many niches, attacking many pest species at one time<sup>[29],[30]</sup>. Large numbers of a wide range of spider species inhabit agricultural fields. Their presence limits the habitats open to insect pests. Spiders threaten insect pests with various foraging strategies. In addition to consuming large numbers of insect pests as prey, they have the trait of killing all insects living in their territory. For this reason, spiders are a favourable biological control agent in the agricultural ecosystem.

The advantages and limitations of biological control are often expressed by comparisons with pesticides. Chemical control is limited to the area within which the pesticide is applied; frequent application may be required, and this leads to pest resistance. The main limitation of biological control is that, it is slower to suppress pest populations than most pesticides, as parasitised organisms may take several days to die; and also, predators require a period of time to establish an economic level of pest suppression. Development costs of biological control are sometimes described as ‘high’, but these costs are much lower than that required for the equivalent synthesis, toxicological evaluation and marketing of a new pesticide; and substantial profits can be achieved from biocontrol with long term, effective natural enemies. It is now widely acknowledged that successful biological control depends on extensive preliminary studies to gain a comprehensive understanding of the biology and ecology of the pest and natural enemy complex, and of the environments from which they originate, and which they have subsequently colonized, or into which they will be released. It has been suggested that the introduction of a biological control scheme against a pest, and the resultant withdrawal of broad-spectrum pesticides, can lead to new pest problems, but there is no evidence for this in several well-studied agro-ecosystems. Though some research has been conducted evaluating the effectiveness of spiders as bio control agents in agroecosystems<sup>[31],[32]</sup>, there has been scant research on their potential interactions with other predator. Ample evidence are found that spiders can be effective biological control agents, particularly assemblages of several species. Other evidences find that spiders prey on each other and other generalist predators, and as such, are of limited value in biological control. Such predatory interactions between species, which use similar resources, have been dubbed intraguild predation (IGP). The appropriate manner to use spiders in biological control is, therefore, as local generalist predators to help retard population growth of diverse complexes of pests in crops. This can

be achieved through conservation in crops of the local native spiders. Features of spider biology that have important influences on their action as biological control agents include the ability of many species to colonise new areas through ballooning as spiderlings, the relatively high numbers of spiders per unit area of land, and their movements in and out of crops in response to temperature and moisture conditions. Many theoretical predictions suggest that it should be possible to improve crop environments for natural enemies and enhance their pest control potential. However, whether any particular change to the crop or its manner of production will be useful, must be determined by local experimentation. The unstable cycling of insect pests, though rare in natural communities, is a major concern in agro ecosystems. The scientific communities' approach to the problem is an integrated one: emphasis is placed on changes in planting techniques, the use of pest resistant strains of crops, the conservation of natural control factors, and the disruption of the life cycles and reproduction of pest species. The failure to consider the potential of spiders in insect suppression also reflects the current interest in the nation in control that is mediated by specialist (monophagous) predators and parasitoids: spiders, for the most part, are prey generalists (polyphagous). The most striking feature, however, is the number of studies involving lycosids and oxyopids in agricultural systems, and the sometimes high percentage of intra guild prey reported from these spiders (e.g., 40% Araneae in the diet of *Oxyopes salticus*).

Keeping all observations under consideration, it can be observed that the biological control of insect pests is not strictly a 'natural' phenomenon in two respects: (1) it exaggerates the extent to which natural enemies exert top-down control of insect populations; and (2) it overemphasizes the importance of specialist enemies, as in spiders. Consequently, combination of low amount of pesticides and spiders might be an alternative as well as effective way of using spiders as biological control agents.

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# Electronic Waste – An Emerging Global Hazard

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*Abstract: Redundant, outdated or non-working electrical and electronic products, which have reached the end of their useful life, are known as E-waste or Electronic waste. Electronic waste is produced from gadgets like cell phones, VCRs, PDAs, TVs, computers, CD players, fax machines, monitors, printers, etc. These products contain various toxic substances like beryllium, cadmium, arsenic, mercury, lead and brominated flame retardants (BFRs) etc., which are very harmful to living organisms and our environment. Due to the fast advancement of technology, many electronic devices become “trash” after a few short years of use. The quantity of disposed electronic devices is growing rapidly throughout the globe. E-waste management should be dealt with greater importance in the developing countries like India due to its own E-waste, also dumping of E-waste from other developed countries and lack of appropriate infrastructure and procedures for E-waste disposal and recycling. This review article provides a concise overview of the current global scenario of E-waste, health and environmental impacts of E-waste, current disposal, recycling mechanisms in the developed country. Also, India’s current E-waste status, stands on the import of hazardous E-waste, E-waste management and recycling are discussed in great detail.*

**Keywords:** E-waste, WEEE, EPR, waste management

## I. INTRODUCTION

Innovations and technologies are shaping the future and changing the world and play an increasingly important role in our everyday lives. Different electrical and electronic (EE) devices, apps, robots etc. make technology essential to our modern life and many people constantly attempt to own the newest and shiniest gadgets. But because of this advancement of technology, most of the electronic devices become “trash” after a few short years of use. Electronic waste or E-waste for short is a generic term embracing various forms of discarded electric and electronic (EE) equipment, is an emerging problem as well as a business opportunity of increasing significance to developed and developing countries<sup>[1]</sup>.

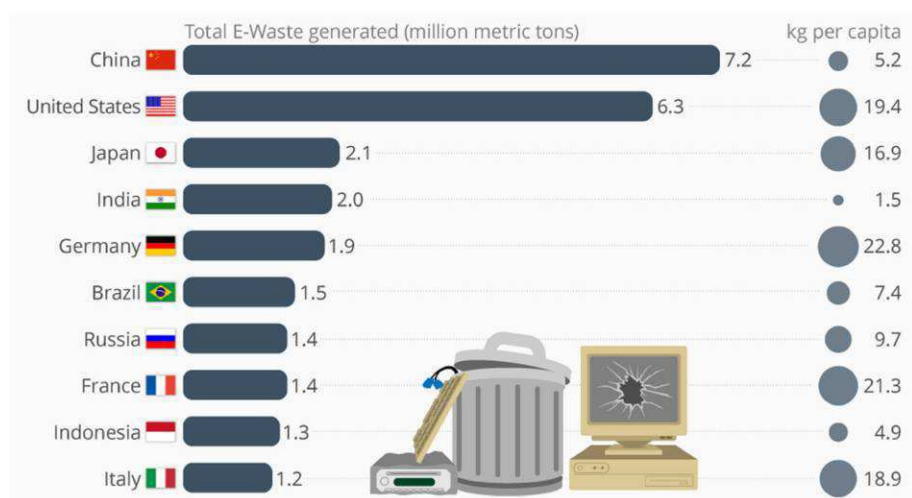
According to the definition of E-waste<sup>[2]</sup>, we can broadly categories into six different classes:

- *Temperature exchange equipment:* In general cooling and freezing equipment e.g. refrigerators, freezers, air conditioners, heat pumps etc.
- *Display Units:* Equipment includes televisions, monitors, laptops, notebooks, and tablets.
- *Lamps:* Typical equipment includes fluorescent lamps, high-intensity discharge lamps, and LED lamps.
- *Large electrical and electronic units:* This includes washing machines, clothes dryers, dish-washing machines, electric stoves, large printing machines, copying equipment, and photovoltaic panels.
- *Small electrical and electronic units:* Typical equipment includes vacuum cleaners,

microwaves, ventilation equipment, toasters, electric kettles, electric shavers, scales, calculators, radio sets, video cameras, electrical and electronic toys, small electrical and electronic tools, small medical devices, small monitoring and control units.

- *Small IT and telecommunication equipment:* Typical equipment includes mobile phones, Global Positioning Systems (GPS), calculators, routers, personal computers, printers, telephones.

Waste electrical and electronic equipment (WEEE) today already constitutes 8% of municipal waste and is one of the fastest growing waste fractions. “The Global E-waste Monitor 2017”<sup>[3]</sup> is a recently published assessment report on global electronic waste, policies and statistics, released by the International Telecommunication Union (ITU) - the United Nations specialized agency for information and communication technology - together with the United Nations University (UNU) and the International Solid Waste Association (ISWA). According to that report Figure 1 shows top 10 countries by the amount of E-waste generated in 2016. The assessment shows that in 2016, 44.7 million metric tonnes of E-waste was generated, up 3.3 million metric tonnes (8%) from 2014. Out of which, in 2016, only about 20% - or 8.9 million metric tonnes - of all E-waste was recycled properly. Researchers predicted a further 17% increase - to 52.2 million metric tonnes of E-waste by next 3 years<sup>[4]</sup>. This report seeks to increase global consciousness and draw attention to the growing world issue of E-waste.

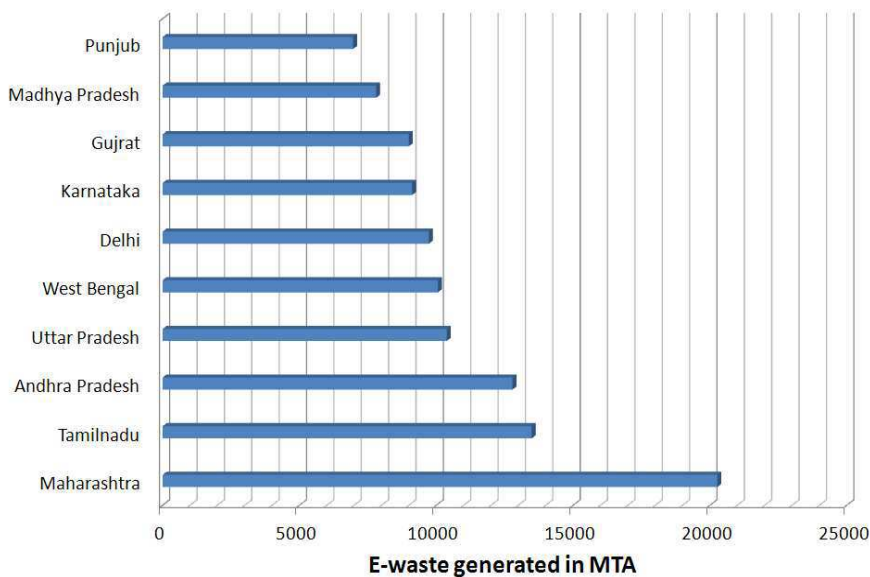


**Figure 1**

Top 10 countries by the amount of E-waste generated in 2016  
(Source: The Global E-waste Monitor 2017<sup>[3]</sup>)

According to The Global E-waste Monitor 2017<sup>[5]</sup>, China generates the highest E-waste quantity both in Asia and in the world (7.2 Mt). In Asia, the total E-waste generation was 18.2 Mt in 2016, Japan generated 2.1 Mt, and India 2 Mt. A bar diagram of E-waste generation in 2009 by top ten states of India is presented in Figure 2. According to Rajya Sabha Report<sup>[6]</sup>, 70% E-waste produced in the country is being produced by ten states only. Among 10 states, Maharashtra ranked first and among cities Mumbai is first<sup>[7]</sup>. Also India is one of the largest waste importing countries in the world. According to a report, in 2009 India generated 5.9 million tonnes of harmful waste domestically, and imported more than that (about 6.4 million tonnes)<sup>[8]</sup>.





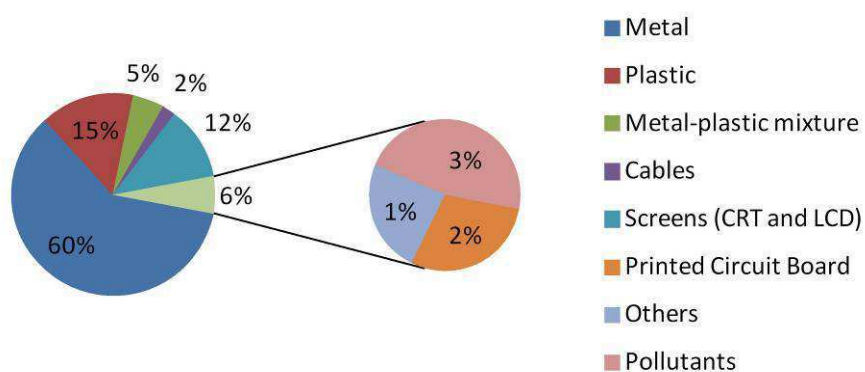
**Figure 2**

State wise E-waste Generation in India (adapted from Consumer Voice 2009).

In this review article, we discuss an overview of E-waste- different component of E-waste and its effect on the environment and the human race. Next, we also point out the legislation and initiatives intended to help manage these growing quantities of electronic garbage produced by different countries. And finally, the present scenarios of India regarding E-waste regulations and Extended Producer Responsibility (EPR) principle of WEEE management are explained.

## II. COMPONENTS OF WEEE

The percentage of Iron and Steel is more than other materials as shown in Figure 3 where plastics occupy a major percentage in the household items<sup>[9]</sup> and are the second largest component by weight representation approximately 21% of WEEE. Non-ferrous metals, including precious metals like gold, copper represent approximately 13% of the total weight of WEEE with copper accounting almost for 7%.



**Figure 3**

Different component of E-waste (Taken from Ref. <sup>[2]</sup>.)

### IIA. ENVIRONMENT POLLUTION FROM E-WASTE

Disposal of electronic waste in developing countries lead to a number of environmental impacts including water pollution, soil pollution, air pollution etc.<sup>[10]</sup>.

1. From cathode ray tube used in computer monitor, TVs, ATM, video cameras different hazardous



heavy metals leaching into the groundwater and release toxic chemicals.

2. Dumping of PCB leads to discharge of glass dust, tin, lead, brominated dioxin, beryllium cadmium, and mercury to river making water pollution.
3. Illegal dumping of chips and other gold-plated components into rivers discharge polycyclic aromatic hydrocarbons (PAHs), heavy metals, brominated flame retardants directly into rivers acidifying fish and flora. Also surface and groundwater get polluted by tin and lead contamination. This kind of unscientific dumping causes air emissions of heavy metals, brominated dioxins, and PAHs.
4. Plastics from printers, keyboards, monitors discharge brominated dioxins, heavy metals, and hydrocarbons.
5. From computer wires, PAHs are released into the water, air and soil.
6. The use of Nickel-Cadmium batteries which contains 6 to 18% of Cadmium has been banned in the European Union except for medical use. It can leach into the soil, harming microorganisms and disrupting the soil ecosystem if not properly recycled.

### **IIB. DIFFERENT ASPECTS OF HEALTH HAZARDS FROM E-WASTE**

Effects of E-waste on human health reveal severe negative outcomes for those dismantling and handling components of E-waste. Different health risks may result from direct contact with different harmful materials such as lead, cadmium, chromium, mercury, brominated flame retardants or polychlorinated biphenyls (PCBs), from inhalation of toxic fumes, as well as from accumulation of chemicals in soil, water and food.

1. Soldering materials are present in the different electronic circuit board, plastic or glass panel or computer monitors. This soldering material consists of lead which is hazardous for the nervous system, blood system, kidney and also affect the brain development of children. A human may develop neurological effects, gastrointestinal effects, anemia etc due to consumption of lead. A typical 15-inch cathode ray tube may contain 1.5 pounds of lead.<sup>[11]</sup>

Lead-acid batteries are the oldest and popular type of rechargeable battery. Different attractive features like very low energy-to-weight ratio, a low energy-to-volume ratio with relatively large power-to-weight ratio along with their low cost, making them very useful in motor vehicles to provide the high current required by automobile starter motors. These batteries are the major source of leads exposure to which found to be dangerous to human as discussed earlier.

2. Cadmium is present in different light-sensitive resistors and conducting wires, rechargeable batteries, solar cell, corrosion-resistant alloys for marine and aviation environments, and nickel-cadmium batteries which is another type of rechargeable battery etc. Cadmium is highly toxic and exposure to this metal cause cancer and affects the body's cardiovascular, renal, gastrointestinal, neurological, reproductive and respiratory systems.
3. Different electronic gadgets like relay switches, printed circuit board, fluorescent tubes, tilt switches (mechanical doorbells, thermostats), ccfl backlights in flat screen monitors contain mercury which is toxic to the central and peripheral nervous systems. It can severely affect the lungs, kidneys,

digestive, nervous immune systems. Health effects include sensory impairment, dermatitis, memory loss, and muscle weakness. Heavy exposure to mercury causes fetal deficits in motor function, attention, and verbal domains<sup>[12]</sup>. Environmental effects in animals comprise death, reduced fertility, and slower growth and development.

4. Circuit board contains brominated flame retardants (BFRs) e.g., pentabromophenol, polybrominated diphenyl ethers (PBDEs), tetrabromobisphenol-A (TBBPA), etc which are artificial organobromine compounds, in general added to a wide variety of industrial products to make them less inflammable. It has potential use in industries to provide fire safety to consumers but can alter liver enzymes, affect thyroid levels, and is associated with developmental reproductive and neurotoxicity.
  - PBDEs exerts endocrine –interfering activity and causes cryptorchidism in newborn babies.
  - Exposure of TBBPA to human population may be an issue of concern
  - Exposure of HBCD Causes thyroid gland hypertrophy and HBCD (>5  $\mu\text{M}$ ) exposed to epithelial cervical cancer cell can enhance TR-mediated gene expression in a human being in the presence of  $\text{T}_3$ .
5. Beryllium oxide is present in some thermal interface materials such as thermal grease used on heatsinks for CPUs and power transistors<sup>[13]</sup>, magnetrons, X-ray-transparent ceramic windows, heat transfer fins in vacuum tubes, and gas lasers. Also, it is present in front-panel of CRTs and Mother Board which causes chronic beryllium disease (CBD), lung cancer, skin and heart diseases etc. The common symptoms of CBD are shortness of breath, unexplained coughing, fatigue, weight loss, fever, and night sweats, muscle weakness etc. CBD can cause chronic obstructive lung disorder, resulting in loss of quality of life and the potential for decreased life expectancy<sup>[14]</sup>.
6. Sulphur found in lead-acid batteries which causes liver, kidney, heart damage, eye throat infection etc.
7. Americium is used as a radioactive source in smoke alarm which is known to be carcinogenic<sup>[15]</sup>.
8. Hexa-valent chromium is used to coat metals to protect from corrosion is known to be carcinogenic<sup>[16]</sup>.

### **IIC. NON-HAZARDOUS COMPONENTS OF E-WASTE**

There are other non-hazardous components of E-waste which can be reclaimed and put to reuse in different industries

- i. Aluminum is found nearly in all electronic goods using more than a few watts of power (heatsinks), electrolytic capacitors.
- ii. Copper is used as connecting wires.
- iii. Germanium is used in bipolar junction transistor.
- iv. Gold is used in connector plating in computer equipment. Early generations PCs used to contain up to 4g of gold each.
- v. Lithium is a major component of lithium-ion batteries.
- vi. Nickel is a major constituent of Nickel-Cadmium batteries.
- vii. Glass, transistors, ICs, printed circuit board consisting of silicon.
- viii. Tin is found in solder, and is used to coat component leads.

- ix. Zinc is used to protect steel part.

### **III. E-WASTE MANAGEMENT**

In this section, we review the various aspect of E-waste management such as Extended Producer Responsibility (EPR), different WEEE initiatives etc. Waste management involves production-modification, recovery of E-waste, re-use of materials and techniques, quantity reduction, roster management etc.<sup>[17]</sup>. For example, reduction of hazardous material in equipment could reduce the generated waste. Recovery and reuse of the abandoned instruments could eventually reduce the waste disposal cost, raw material cost and create an alternative income source. Another approach to E-waste management is controlled use of Electrical and Electronic (EE) appliances. EE equipment needs to be purchased whenever it is absolutely necessary and instead of discarding, the old one should be donated to charitable organizations or recycling. Now a day, WEEE recycling emerging as a profitable business and it is growing as an unorganized sector, mainly as backyard workshops<sup>[18]</sup>. E-waste handling in the unorganized sector results to environmental pollution due to open burning of plastics, direct exposure to toxic materials and contamination with municipality waste. Hence proper precautions and techniques should be implemented by the government to reduce the environmental impact, mainly human health (particularly for engaged workers).

#### **IIIA. EXTENDED PRODUCER RESPONSIBILITY (EPR)**

Extended Producer Responsibility (EPR) is an emerging principle of WEEE management. The Organization for Economic co-operation and Development (OECD) defines EPR as an environment policy in which the responsibility of producer is extended till the post consumer stage<sup>[19]</sup>, including the final disposal (OECD, 2001)<sup>[20]</sup>. EPR policy encourages the company to prevent environmental pollution by changes in product design and process technology. By shifting the responsibility away from the municipalities, the producers are advised to include the cost of treatment and disposal into the product cost. EPR can be approached in various ways<sup>[21]</sup>.

- Products take back programs (mandatory or voluntary programs).
- Regulatory approaches like minimal product standards, disposal bans, mandated recycling etc.
- Voluntary industry practices like public/private partnerships, leasing, labeling etc.
- Economic instruments like deposit-refund schemes, fees on disposal, advance recycling fees etc.

The EPR system should be designed with clear and well defined roles of producers, users, authorities and waste managers<sup>[22]</sup>. To design such system one needs careful parameterization of legal regulation, system coverage, system financing, producer responsibilities and ensuring compliances. The importance of these five parameters has been discussed in great details in <sup>[23]</sup>.

#### **IIIB. E-WASTE REGULATIONS AND EPR PROGRAMMES IN DEVELOPED COUNTRIES**

From various perspectives, several initiatives have been taken worldwide to tackle WEEE. The few most important initiatives are:

- i) Basel Convention (1992) and Basel Ban: This is a global agreement which regulates the movements of WEEE among countries. Basel Ban forbids the export of dangerous waste from

OECD to non-OECD countries and it is yet not implemented.

- ii) StEP (solving the E-waste problem) initiative: This is a UN-led initiative started in 2004. The primary goal is to build an international platform to exchange and create knowledge on WEEE systems <sup>[24]</sup>.
- iii) SECO/EMPA E-waste programme: SECO (Swiss State Secretariat for Economic Affairs) and EMPA (Swiss Federal Laboratories for Materials Testing and Research) started this project in 2003 to improve the E-waste recycling systems in different parts of the world.
- iv) There are other initiatives like WEEE forum, Electronics Product Stewardship Canada (EPS Canada), European Recycling Platform (EPR), National Electronics Product Stewardship Initiatives in USA (NEPSI) etc.

Various countries are now working on EPR strategy in WEEE management. The first mandated EPR programme in the world is the 'Green Dot' programme which is Germany's Ordinance on the Avoidance of Packaging waste. Norway, Switzerland, Sweden and Taiwan have approved legislation that requires manufacturers of EE goods to provide free end-of-life care for their products through licensed handlers. United States implemented various EPR schemes on a state level basis by imposing state laws which include mandatory take back system for rechargeable batteries, advance disposal fees, deposit refund system etc. Japan has also implemented take back schemes on EE equipment.

### **IIIC. E-WASTE REGULATIONS AND EPR PROGRAMMES IN INDIA**

Although the E-waste per capita is still relatively small, populous countries like China and India are the fastest growing markets for EE goods. Also these countries are huge producers of WEEE in absolute terms<sup>[25]</sup>. Another important cause for rapid growth of E-waste in such countries is legal and illegal imports of E-waste from developed countries<sup>[26]</sup>. These problems in developing countries are boosted by a lack of regulations and/or lax enforcement in the disposal and recycling sector. Lack of proper regulations and/or lax enforcement leads to uncontrolled and risky low-cost techniques in recycling business. Field studies show that a large part of economically weaker section of India, is depending a lot on recycling trade for earning their livelihood<sup>[27]</sup>. Most of them are not aware of the health risks and the environmental hazards. These workers in the unorganized sectors generally work without taking any protective gadgets like gloves, goggles etc. and only use primitive tools like hammer, hand drills, cutters, electric torch or burners for dismantling process<sup>[28]</sup>. As a result, they are highly exposed to hazardous metals or elements of WEEE.

#### ***i) EPR programmes in India:***

Unlike developed countries, we are yet to explore the full potential of EPR programmes in India. India's first environmental legislation i.e. Management and Handling Rules, 2001 assigns the mandatory responsibility of for the producers to set up collection centres for collection of used batteries. It also includes safe transportation ensurity, public awareness creation activities and proper recycling. The another instance of EPR implementation in Indian legislation is 'buy back' policy under The Recycled Plastic Manufacture and Usage Rules,1999<sup>[29]</sup>. In case of E-waste management, the proper recommendations of EPR are yet to be implemented<sup>[30]</sup>.

There are a few good initiatives like take back policies by the MNCs in the line of EPR which aim

towards reduction in E-waste. MNCs like Lenovo, Dell, Nokia have already started the take back programs for last few years. For example, Lenovo India has collected and recycled 2.12 metric tons of customer returned equipment in 2011<sup>[31]</sup>.

#### ***ii) Policy level legislation in India:***

In India, Ministry of Environment and forests (MoEF) is responsible for environmental legislation and its control. The main bodies active in WEEE management in India are Central Pollution Control Board (CPCB), State Pollution Control Boards (SPCBs), Game Trading Zone (Gtz) and industry associations such as Manufacturers Association of Information Technology (MAIT). These organizations are working under the guidance of MoEF. However, the policy level initiatives regarding WEEE in India are in nascent stage and need immediate attention. A few most important policy level initiatives are:

- *The hazardous wastes (management and handling) amendment rules, 2003*<sup>[32]</sup>.
- *Guidelines for environmentally sound management of E-waste, 2008*: MoEF and CPCB drafted these guidelines in 2008 and classified the E-waste according to its various components and compositions and mainly emphasizes on the management and treatment practices of E-waste<sup>[33]</sup>. The concepts of EPR were also incorporated in these guidelines<sup>[34]</sup>.
- *E-waste Management and Handling Rules, 2011 (notified in May 2011 and effective from 01/05/2012)*: MoEF notified these E-waste rules to evade uncontrolled E-waste generations, to implement modern WEEE management and ultimately transform the informal sector to formal sector. In E-waste Management and Handling Rules, 2011<sup>[35]</sup>, regulations have been applied to every manufacturer, user, collection centers, dismantler and recycler of E-waste. The regulatory agencies involved are State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) and CPCB. According to these rules the uses of hazardous substances have been restricted or they have to be used in reduced amount in EE appliances. Every EE producer has to ensure the devoid of metals and chemicals, which include specified ranges of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls.
- *TRAI guidelines (towards GREEN TELECOM)*: In 2012, TRAI has endorsed the key provisions of regulations issued by MoEF (for a detailed discussion see Ref. <sup>[36]</sup>).

### **IIID. DEVELOPING WEEE KNOWLEDGE PARTNERSHIPS**

In 2003, Switzerland (funded by SECO and implemented by EMPA) initiated a knowledge partnership programme with developing countries like India, China and South Africa. The initial goal was to identify and document the current WEEE handling situation in three urban areas - Delhi (India), Beijing (China) and Johannesburg (South Africa) - and to develop a knowledge base to mitigate the hazards without reducing the attractiveness of this business<sup>[37]</sup>.

### **IIIE. CONCERNS/CHALLENGES IN E-WASTE MANAGEMENT IN INDIA**

The major obstacles for proper implementation of E-waste management in India (also applicable to other developing countries) are:

1. *Lack of reliable data*: There is lack of proper data about the actual E-waste generation. Also there are problems in finding information on WEEE. Most studies have focused on devices like mobile, computer and TVs and information about various domestic appliances are not credible.
2. *Lack of proper policy and regulations*: One of the major problems in India is lack of proper policy

consider all aspects of E-waste including assignment of responsibilities for all stakeholders.

3. *Lack of proper safe E-waste recycling infrastructure*: In India, WEEE collection, transportation, processing and recycling are dominated by the unregulated informal sector. This may pose severe risk to environment and mankind.
4. *Lack of international standards*: Currently the procedures followed by the E-waste collector and recycler (mainly in the informal sector) are not as international standards and this again leads to environmental and health hazards.
5. *Import of WEEE*: In developing countries like India the import of WEEE impose a great threat on the volume of E-waste.
6. *Other causes*: There are other several causes like lack of knowledge and absence of technology, lack of awareness among stake holders and public, lack of fund and capacity in Government etc.

#### IV. CONCLUSION

In current age discarded electrical and electronic goods (WEEE or E-waste) is a global issue to environment and living organism. E-waste can lead to adverse human health effects and environment pollution without proper handling. In India, Government policies should encourage the reuse of the e-waste material to minimize WEEE. EPR do need to have clear rules and policies to authorize the 'take back' action of the companies strictly. The collection, transportation, storage, refurbishment, segregation, recycling, dismantling and disposal of e-waste are necessary to handle the situation.

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