THE ENVIRONMENT MANAGEMENT

20 Year

पर्यावरणो रक्षति रक्षिता:

A Quarterly E- Magazine on Environment and Sustainable Development

(For private circulation only)

Vol.: VI | July - September, 2020 | Issue: 3

Current Issue: Sustainable Management of River Ecosystem

Bhatsa River, Shahpur, Thane (M. S.)

CONTENTS

From Director's Desk

Since the time immortal river ecosystems have supported human being in their origin and survival strategy. River ecosystems are habitat for diverse flora and fauna that provide various types of food and fiber for sustaining rural population particularly in developing countries. However, scenario is changing very fast. The major rivers of the world are grappling with the issues of it's over exploitation for providing water for drinking, sanitation, agriculture, transport and electricity generation. Pollution due to disposal of untreated sewage, industrial effluent and agriculture run off is turning rivers in to a drain. In recent decade more than 20% of freshwater species have been reported extinct, threatened or endangered. Although, there is an increasing surge for the maintenance of fresh water biodiversity, goods and services, the demand for water is itself is increasing rapidly. This advocates for better management of river ecosystem and sustaining them for future generations.

A vision of providing 24 x 7 clean drinking water through pipelines in all the parts of India can only be possible when the health of rivers is good with free flowing water to support fresh water biodiversity. The current issue of institute's newsletter 'The Environment Management' is focusing on the theme 'River Ecosystem Management' that will be very useful to researchers, academicians, conservationists and students.

Dr. Seema Mishra

Cauvery: Integrated Catchment Management to Sustain Water and Livelihood in South India

Ramachandra, T. V[a *]., Vinay, S[a]., Bharath, S[a]., Bharath H. Aithal[a,b]

[a] Energy and Wetland Research Group, Centre for Ecological Science, http://ces.iisc.ernet.in/energy
Indian Institute of Science, Bangalore, Karnataka, 560 012, India

[b] RCG School of Infrastructure Design and Management, Indian Institute of Technology Kharagpur, India 721302

*Corresponding Author: tvr@iisc.ac.in; envis.ces@iisc.ac.in ORCID: 0000-0001-5528-1565

River Cauvery one of the 7 major rivers in India, having its significance in the south since the Puranas. The river is also known as Dakshina Ganga due to its sanctity, ability to cure skin disorders, services to mankind (such as food, agriculture, water source *etc*.), supporting numerous flora and fauna, *etc*. The river can be said to have geological history past the Himalayas when linked to the birth of Western Ghats, whereas the mythological history is past Ramayana (Skanda Purana). Originating at Talakaveri, Bramhagiri hills of Western Ghats, near Bhagamandala of Kodagu district of Karnataka State, Cauvery (Kaveri) flows east for distance over 750 km joining the Bay of Bengal at the Paziyar of Nagipattanm District, Tamil Nadu State. Cauvery river catchment spatially is spread across an area over 85300 square kilometers along the states of Karnataka, Kerala, Tamil Nadu and Union territory – Puducherry (figure 1), of which Tamil Nadu encompasses about ~55.3%, followed by Karnataka with ~41.1%, Kerala with ~3.3% and Puducherry with ~0.2% of the catchment area. Population in the catchment has increased from 112 persons per square kilometer in 1901 to 452 persons per square kilometer in 2011.

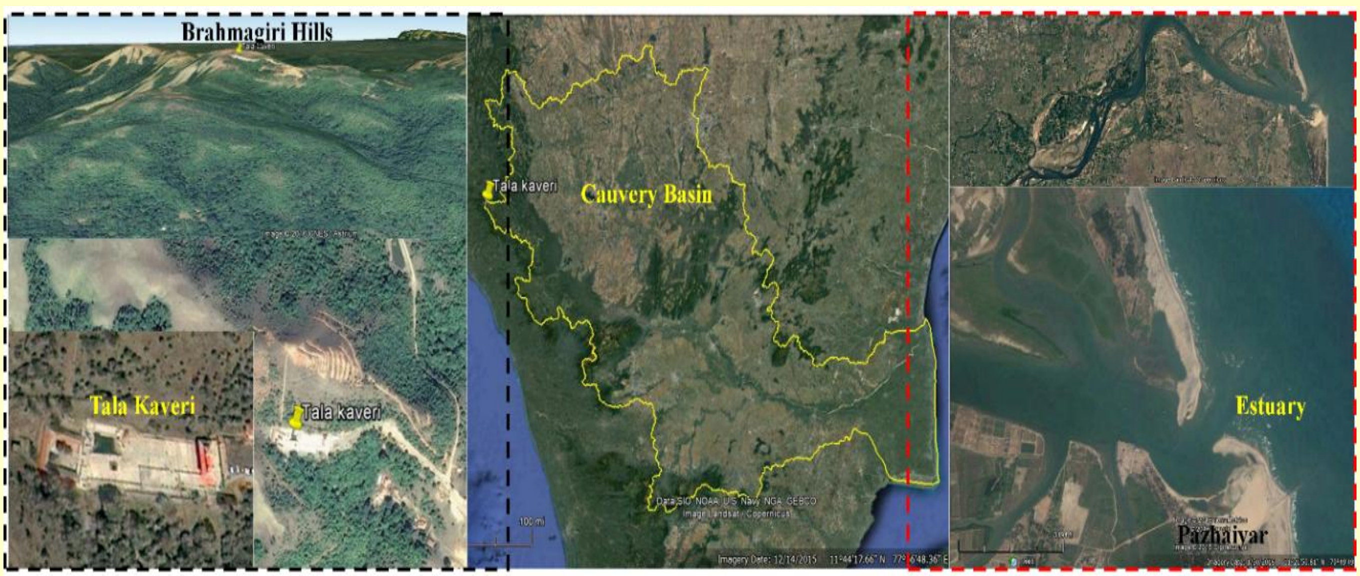


Figure 1: Cauvery Basin, Origin at Talakaveri and Meets Bay of Bengal at Pazhaiyar

The river has been a lifeline to people along riparian states since it is used to cater various domestic and agricultural demands, but improper practices such as over exploitation of water through intense agricultural activities for water intensive crops have led to depletion of both surface and sub-surface resources resource. It can be observed that irrigation lands have increased from 11453 sq.km in 1928 to over 28730 sq.km as on current, whereas the vegetation cover has drastically declined from 33% in 1965 to 18% in 2016. The catchment is dominated by water intensive crops such as paddy (variety of paddy), sugarcane, etc. which is inappropriate for the quantum of rainfall received. Rainfall in the catchment varies between 500 mm at the Plains to over 1000 mm at the Coast and over 2000 mm at the Ghats. In order to store runoff water there are nearly 98 dams/reservoirs (such as Mettur, KRS, Kabini, Hemavathi Harangi, Nugu, Emerald, Avalanche, Siruvani, Bhavani *etc*.) having live storage capacity of 287 TMC and numerous lakes and tanks in the catchment which are used for irrigation, power generation, *etc*.

Deforestation in Cauvery river catchment – Land use analysis showed that the catchment was dominated by Agriculture activities (Agriculture and horticulture) i.e., about 73.5% followed by Forest cover which is about 18%. Dense forest area was 13.3% and Degraded forest area was nearly 4.63%. Between 1965 and 2016, natural vegetation cover has reduced from 28194 sq.km to 15345 sq.km indicating that about 45.55% cover lost in 5 decades. dense vegetation has reduced by 35% (6123 sq.km) and degraded vegetation has reduced by 63% (6727 sq.km). Across the administrative divisions, Karnataka has lost about 57 % (9664 sq.km) followed by Tamil Nadu loosing 29% (2905 sq.km) and Kerala loosing 27% (279 sq.km) of the natural vegetation cover. Sanctuaries and protected areas in the basin include Pushpagiri Wildlife Sanctuary (PWLS), Talacauvery Wildlife Sanctuary (TWLS), Brahmagiri Wildlife Sanctuary (BWLS) Bandipur National Park (BANP), Nagarholé National Park (Rajiv Gandhi Tiger Reserve), Biligiriranganatha Swamy Temple (BRT) Tiger Reserve, M.M. hills Wildlife Sanctuary (MMHWLS), Cauvery Wildlife Sanctuary (CWLS), Bannerghatta National Park (BNP), Adichunchanagiri Peacock Sanctuary (APS), Arabithittu Wildlife Sanctuary, Melkote Wildlife Sanctuary, Ranganathittu Bird Sanctuary, Ramadevara Betta Vulture Sanctuary, Wayanad Wild Life Sanctuary (WWLS), Mudumalai National Park (MNP), Satyamangalam Wild Life Sanctuary (SWLS/STR), Chinnar Wild Life Sanctuary (CHWLS) and Anamudi Shola National Park (ASNP).

Biodiversity: The flora species (486) belong to 116 families across the basin. The Lauraceae, Fabaceae, Myrtaceae, Poaceae, Rubiaceae are the dominant families found in the basin. The region has highly endemic species around (147 species) such as *Artocarpus hirsutus, Atalantia wightii, Blachia umbellate, Cinnamomum macrocarpum, Cinnamomum malabaricum, Cinnamomum travancoricum, Diospyrous paniculata, Garcinia* *gummi-gutta, Holigarna grahamii, Hopea ponga, Ixora brachiata, Knema attenuate, Pinanga dicksonii, Syzygium densiflorum, Syzygium malabaricum, Terminalia travancorensis, Vateria indica* etc. Serving as a prime habitat for several species of amphibians, reptiles, birds and mammals comprising Tiger (Panthera tigris), Asian Elephant (*Elephas maximus*), Indian gaur (*Bos gaurus*), Sambar deer (*Cervus unicolor*), Spotted deer (*Axis axis*), Leopard (*Panthera pardus*), Wild dog (*Cuon alpines*), Sloth bear (*Melurus ursinus*), Smooth coated otter (*Lutrogale perspicillata*), Pangolin (*Manis crassicaudata*), Slender loris (*Loris lardigradus*) and Black naped hare (*Lepus nigricollis*), etc. The elephants move from Pushpagiri Wild Life Sanctuary (PWLS) located in northern top portion of basin to Southern eastern portion of Tamil Nadu state (Satya Mangalam forest, Tali reserve forest etc.,).

Highlights of the current research are:

1) Catchment has witnessed a drastic increase in cropping area.
    a. Tamil Nadu, Irrigation area has increased from 6556 sq.km (13.8%) to 20233 sq.km (42.7%) between 1928 and current decade.
    b. Karnataka, Irrigation area has increased from 1193 sq.km (3.42%) to 8497 sq.km (24.3%) between 1928 and current decade.
2) Enhanced Water demand
    a. Tamil Nadu, Water demand has increased from 429 TMC to 573 TMC between 1928 and 1971.
    b. Karnataka, Water demand has increased from 72 TMC to 171 TMC between 1928 and 1971.
3) Average annual rainfall in the Western Ghats part of Kerala varies between 2700 mm to over 3500 mm across space,
4) Karnataka portion of Western Ghats receives average annual rainfall between 2500 to 5000 mm.
5) Tamil Nadu inlands areas also one of the driest belt next to Karnataka portion of Deccan Plateau in Cauvery basin. This region has an average annual rainfall ranging between 640mm to 1750 mm at transition zones with coefficient of variation up to 0.22.
6) East Coast of Tamil Nadu receives rain average annual rainfall between 845 mm to 1300 mm, with coefficient of variation ranging up to 0.24.
7) Across the Cauvery basin, south west monsoon yields 428 TMC and North East Monsoon yields 302 TMC, Gross yield in the basin is about 786 TMC considering non monsoon showers across other months.
8) Cauvery catchment in Karnataka state has an annual water yield of 348TMC of which south west monsoon caters about 68.5% of the total i.e., about 238 TMC and north east monsoon caters to 21% yield, remaining flow is due to the showers during April and May.
9) Cauvery catchment in Tamil Nadu is also equivalent to that of Karnataka yielding water

about 325 TMC, Tamil Nadu state receives maximum rainfall during north east monsoon i.e., about 67.7% yielding 220 TMC of water and south west monsoon contributes to 25% of the total yield i.e., about 81 TMC.

10) Cauvery catchment in Kerala contributes to yield of 111 TMC of which south west monsoon contribute to 88.7% of the total yield i.e., about 98.5 TMC.

11) Ground water recharge - Across the administrative divisions, Tamil Nadu has highest yield potential about 118 TMC, followed by Karnataka with 109 TMC and Kerala with 41 TMC.

12) Ground Water Recharging Capability in the catchment, across the administrative divisions, Tamil Nadu has highest yield potential about 118 TMC, followed by Karnataka with 109 TMC and Kerala with 41 TMC.

13) Total Domestic Demand in Cauvery basin is about 78 TMC of which Tamil Nadu state has a demand of 45 TMC, Karnataka 30 TMC, Kerala 2 TMC and Puducherry about 1 TMC. Additionally, part of domestic water demand about 180 MLD (2.3 TMC) is catered to Chennai and about 1350 MLD (17.4 TMC) is catered to Bengaluru city.

14) Across the basin, livestock water demand is about 9 TMC of which Tamil Nadu has a demand of 4.8 TMC, followed by Karnataka with 3.5 TMC and Kerala with 0.1 TMC.

15) Across the administrative divisions, with existing scenario of cropping, Tamil Nadu has the highest demand of 585 TMC, followed by Karnataka with 529 TMC, Kerala with 62 TMC and Puducherry with 5 TMC. Entire basins water demand with respect to agriculture is about 1180 TMC. Spatial analysis shows that Karnataka and Kerala areas under agriculture depends majorly on South west monsoon between June to September, whereas majority of Tamil Nadu is dependent on the north east monsoon

16) Cauvery basin on a whole has a total demand 1267 TMC of which Tamil Nadu has a demand of 637 TMC followed by Karnataka with 563 TMC, Kerala with 64 TMC and Puducherry with 5 TMC

17) Hydrological status assessment indicate that catchments in the Ghats and closer to the Ghats have better hydrological status (i.e the ratio of water yield to the demand) with supply greater than 1, whereas the upstream catchment in Karnataka portion of Cauvery indicate severe stresses of water with hydrological status less than 0.5. Interior and Coastal Tamil Nadu portion of Cauvery are also under moderate stresses with existing cropping pattern.

18) ***The basin has the capability to cater about 67% of the total water requirement with existing cropping pattern and at normal rainfall conditions.***

19) COV in the basin ranges between 0.12 to 0.28. Low variability (< 15%) of rainfall was observed in the Ghats and High variability (> 25%) at the plains of interior Karnataka. Coast and interior Tamil Nadu had moderate variations about 18 to 22%.

20) During drought, Rainfall ranges between 364 mm and 4700 mm compared to range of 470 mm to 5500 mm across the basin, on an average, basin receives rainfall of 608 mm.

21) Annual runoff in the catchment during drought year ranges between 85 mm to 830 mm across the basin. Water yield during drought in the catchment is about 535 TMC across the year of which South west monsoons contribute to 302 TMC and North East Monsoons cater to 193 TMC of yield. Across the administrative divisions, Karnataka has yield of about 245 TMC of which South west monsoon has a share of 177 TMC, Tamil Nadu has a water yield of 203 TMC of which North east monsoon contributes 141 TMC, Kerala has a yield of 84 TMC of which South West monsoons cater to 76 TMC.

22) Replacing paddy with less water demanding millets and pulses during monsoon and reducing other crops by 30%. By doing this the total water demand in the basin reduced to 549 TMC against total yield about 558 TMC and all sub basins havelesser stresses compared to scenario 3.

PROBLEMS

23) Inappropriate cropping pattern - Inappropriate crops, multi season water intensive crops and inefficient use of water

24) Catchment degradation without proper watershed programs. Decline in the community participation in watershed management and the absence of water and soil conservation measures

25) Silted lakes and Reservoirs. Lack of de-silting of water bodies or lack of eco-management of either flood plains or buffer (afforestation measures)

26) Unsustainable sand mining in river beds

27) Cauvery conundrum: Erroneous assumptions, flawed estimations and irresponsible decisions – nexus of crooked politicians, greedy consultants, inefficient and incompetent bureaucracy.

28) Impending climate change: Further erratic rainfall due to climate change with the global warming.

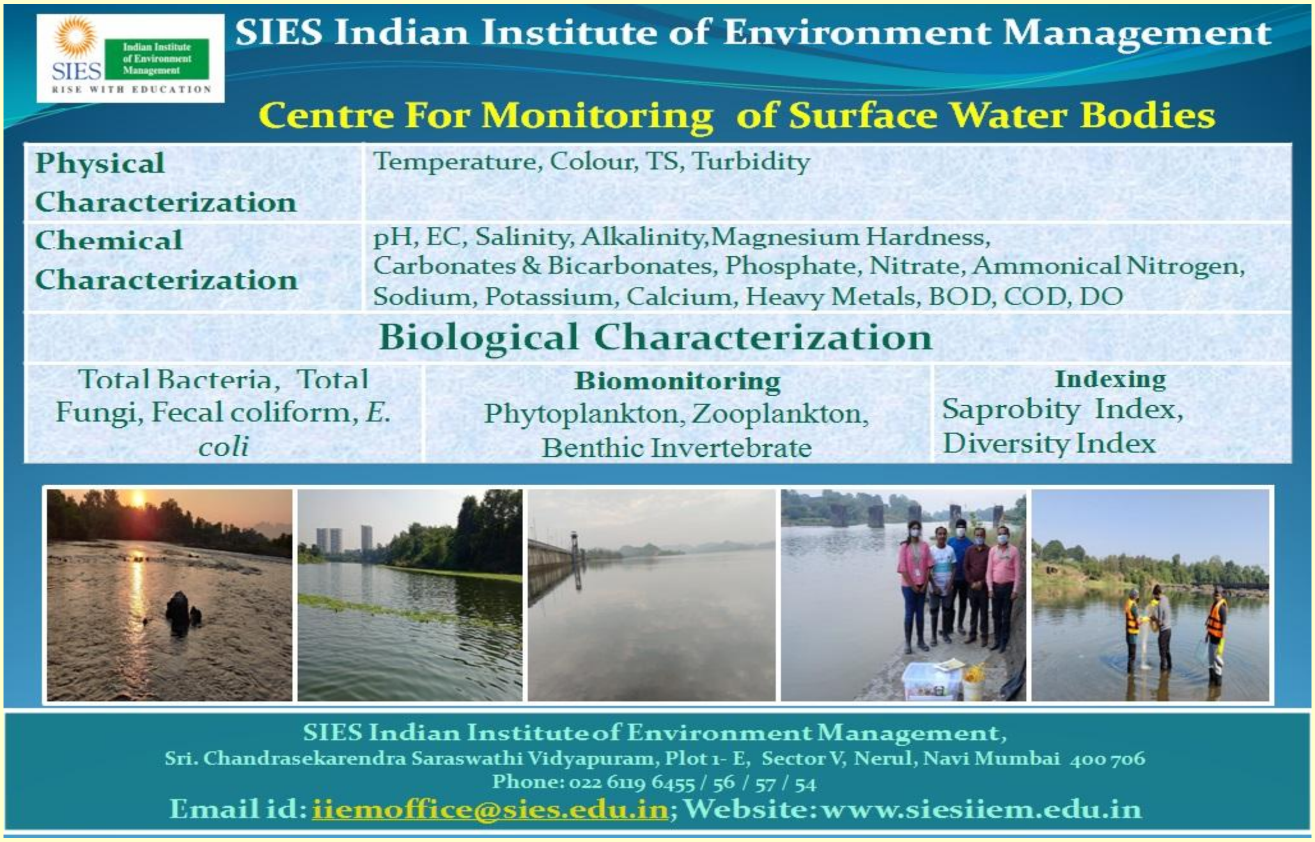
29) Lack of integrated sustainable management of natural resources (land, vegetation cover and water) in the river basin

RECOMMENDATIONS

Prudent management of abiotic and biotic components of riverine ecosystems will ensure the sustenance of the water. This includes

1) The integrated management of catchment with the interlinked natural resources like water, soils and the forest for the wellbeing as well as other forms of life -flora and fauna.
2) Restrictions on large scale water intensive cash crop in the catchment and promotion of organic farming
3) Maintaining forest cover of native species and arresting deforestation and enriching the catchment with native species to ensure sustenance of water
4) Restrictions on monoculture either under social forestry programmes, afforestation programmes or large scale commercial plantations

5) Restrictions on the over-exploitation of groundwater
6) Treatment of sewage through the decentralized treatment plants (Secondary treatment plant integrated with the Constructed wetlands and algal pond as in Jakkur Lake, Bangalore)
7) Setting up effluent treatment plants and ensuring zero discharge from industries.
8) Removal of encroachment of river bed and drains
9) Mapping of flood plains and restrictions on setting up any permanent structures in the flood plains
10) Maintaining the integrity of flood plains (buffer zones) and strengthening riparian vegetation of native species (which will help in enhancing the livelihood prospects while treating surface run-off)
11) Environmental awareness among locals through environment education programmes at schools, colleges and at community levels
12) Ban on plastics and sustainable management of solid waste at decentralized levels



Biomonitoring and Indexing of Riverine Ecosystems for Sustainable Management

Dr. Seema Mishra
SIES Indian Institute of Environment Management
Plot 1 E, Sector-V, Nerul, Navi Mumbai 400706
seemam@sies.edu.in

River ecosystem covers only 0.0002% of the fresh water present on the earth. Still, their relevance is much larger than their size. Since, the time immortal river ecosystems have supported human being in their origin and survival strategy. River ecosystems are habitat for diverse flora and fauna that provide various types of food and fiber for sustaining rural population particularly in developing countries. Today, river ecosystem provides essential benefits and services to the society including, water purification, transport and transformation of organic matter and nutrients, flood control and others. However, scenario is changing very fast. The major rivers of the world are grappling with the issues of their over exploitation for providing water for drinking, sanitation, agriculture, transport, electricity generation and transport. Pollution due to disposal of untreated sewage, industrial effluent and agriculture run off is turning rivers in to a drain. In recent decade more than 20% of freshwater species have been reported extinct, threatened or endangered. Although there is increasing surge for the maintenance of fresh water biodiversity, goods and services, the demand for water is itself is increasing rapidly. This advocates for better management of river ecosystem and sustaining them for future generations.

Biomonitoring of River Ecosystems

Rivers are transport-driven ecosystems, they transport and process water and other materials, dissolved and particulate, organic and inorganic. These materials ultimately come from their drainage basins, what makes rivers intimately dependent on the characteristics of these basins and sensitive to all human impacts occurring there. River networks are dendritic, small tributaries merging to form larger rivers. This spatial organization has strong implications for river conservation, as impacts such as pollution tend to travel fast downstream, and the communities of nearby headwater reaches can only contact each other through long-distance travel, first downstream to the main river stem, and again upstream. Because of their hierarchical arrangement, biological communities exhibit longitudinal transitions along the river; these are predictable in general terms, but their details depend on specific features of individual rivers. This longitudinal transition on species is one reason why rivers sustain so much biodiversity. Pollution is an epidemic threat to rivers. Sometimes pollution can be caused by natural substances when they appear in too high concentrations. This is the case of nutrients, essential elements for primary producers such as algae and other plants, but that in too high concentrations produce fouling of water, lack of oxygen, and declines in biodiversity. Human activities have caused an enormousincrease in the amount of nutrients circulating worldwide, either through diffuse sources such as agricultural fertilizers, or through point or end-of-pipe sources such as urban wastewater. Other pollutants are more insidious, as they are novel substances, synthesized by humans for various purposes, but which nevertheless end up in rivers. Pharmaceutical waste, pesticides, weedicides, herbicides are organic pollutants that reach in rivers and through biomagnifications reach in to the food chain. Globally many studies have reported a positive relationship between organic pollutants, river fauna and drinking water quality based on bioindicators. In the United States, the earliest biomonitoring research originates from Forbes (1887) who invented the biological community concept. Basically, using this concept plant and animal communities of a river were used to assess the degree of organic pollution. Kolkwitz and Marsson, 1908 have developed saprobic system as a bioindicators of organic pollution that is used worldwide for the identification of health of river ecosystems. The diversity approach uses species richness (mostly measured as the total number of taxa), abundance (measured as the number of individuals of each taxon), and evenness (the degree to which each taxon is equally represented) as components of community structure. Unstressed communities are said to be characterized by high diversity (taxa richness) and even distribution of individuals among species.

The Saprobic System

In simple terms, saprobity is a biological state of the waters induced by pollution of water with decomposable organic substances. Intensive decomposition (decay) processes result in lower oxygen contents, which can be tolerated by organisms to a different extent. Consequently, different degrees (intensities) of pollution give rise to different biocoenoses. The saprobic system is used to evaluate the degree of such water pollution by means of a taxonomic and quantitative analysis of all components of the respective biocoenosis from prokaryotes, lower algae, and protozoans to higher plants and macro invertebrates. The saprobity is the state of the water quality resulting from organic enrichment as reflected by the species composition of the community. Kolkwitz and Marsson, 1908 published indicator lists for benthic algae and invertebrates, which served as a valuable tool for water quality assessment for some decades. The acceptance of the saprobic system was increased remarkably by the development of the saprobic index by Pantle and Buck (1955) enabling quantification of pollution intensity. Saprobic score analysis involves a quantitative inventory of the presence of macro-invertebrate benthic fauna upto family/genus/species level of taxonomic precision. As the broad taxonomic classifications are acceptable when empirical relationships involving benthic macro invertebrates are to be developed. A Biological Monitoring Working Party (BMWP) score chart is used for scoring the degree of saprobity. This index ranging from 1 (very good quality) to 4 (extremely poor quality) could be easily interpreted by the end users, which permits the visualization of a river's ecological status as "color-banded."

The power of such mapping techniques to convey complex information in a convincing way is evident in how it has stimulated decision-makers, water managers, and other stakeholders and the interested public to combat pollution. Several countries decided to integrate the saprobic

Table – 1: Water Quality Classes as per Saprobic and Diversity Index

Saprobic System	Range of Diversity Score	Water Quality	Water quality classes	Indicator Colour
7 and more	0.2 – 1.0	Clean	A	Blue
6 – 7	0.5 – 1.0	Slight Pollution	B	Light Blue
3 – 6	0.3 – 0.9	Moderate Pollution	C	Green
2 – 5	0.4 – less	Heavy Pollution	D	Orange
0 – 2	0 – 0.2	Severe Pollution	E	Red

approach into the new integrative methodology for defining the ecological status of water bodies and thus to adjust the saprobic system.

To assess the actual health of water bodies, Central Pollution Control Board (CPCB), MoEFCC, has derived a Biological Water Quality Criteria (BWQC) for water quality evaluation. This system is based on the range of saprobic values and diversity of the benthic macro-invertebrate families with respect towater quality. The system has been developed after extensive field trials and calibration on the saprobity and diversity information of different taxonomic groups of benthic animals collected from artificial substratum and natural substratum of various water bodies. To indicate changes in water quality to different grades of pollution level, the entire taxonomic groups, with their range of saprobic score from 1 to 10, in combination with the range of diversity score from 0 to 1 has been classified into five different classes of water quality (Table 1). The abnormal combination of saprobic score and diversity score indicates sudden change in environmental conditions.

The BMWP is based on grouping benthic macro invertebrates into categories depending on their response to organic pollution. Stoneflies or mayflies, for instance, indicate the cleanest waters and are given a tolerance score of 10. The lowest score (1) is allocated to Oligochaeta, which is regarded to be the most tolerant to pollution. The macro invertebrate communities responses differently for these changes as shown below:

Table 2: Response of Macro Invertebrates as per Water Quality Classes

Water quality	Taxonomic Group
Clean water (Class-A)	Stonefly nymph (Plecoptera): Baetis, Brachytera. Mayfly nymph (Ephemeroptera) Caddis fly larvae (Trichoptera): Caddis hydropsyche, C.~ alimnophilus.
Mild Pollution (Class-B)	Dragonfly (Odonata)
Moderate Pollution (Class-C	Prawn (Crustacea) Beetles (Coleoptera) Riffle Beetle (Stene/mis,Elmidae); Dineutus (Gyrinidae); Hydrophilus (Hydrophilidae); Dytiscus (Dytiscidae). Bugs

	(Hemiptera)- Lethocerus (Belostomidae); Notonecta (Notonectidae); Sigera (Corixidae); Hydrometra (Hydrometridae); Gerris (Gerrldae)
Highly polluted water (Class-D)	Chironomus larvae (Chironomidae-Diptera) Mollusca
Serverly polluted water (Class-E)	Chironomus, Tubificidae (Tubifexsp .-sludge worm); Tubifera, (Rat-tailed maggot).

The Multivariate Approach

Multivariate or model-based procedures are predictive systems that assess the deviation between the observed aquatic community and reference conditions predicted from environmental parameters, (e.g., reference condition approach). Models are developed to explain the composition and variability in the aquatic communities among reference sites. The models include a range of environmental parameters. Based on multivariate procedures, the model then predicts what biota should be present at an undisturbed "target" site or river type with a given set of environmental attributes. A study site can be considered in a "very good" or "reference condition" if the aquatic community found at the test site is similar to the predicted one. A study

site is considered disturbed if the benthic community observed at the test site is different from the prediction. Different predictive tools have been developed in different courtiers based on the type of community, reference conditions and observed conditions in various countries.

Application of Biomonitoring and Indexing in River Health Management

The biological monitoring of river ecosystems characterizes the river health and provides us information on the level of pollution due to anthropogenic activities. The eco restoration studies mainly focus on physical and chemical aspects and only on keystone or bioindicator species in biological characterization, it often fails on biological endpoints. Communicating the condition of biological systems, and the consequences of human activities to those systems, is the ultimate purpose of biological monitoring. Effective communication can transform biological monitoring from a scientific exercise into an effective tool for environmental decision making. Further, linkages of indices with regulatory system is mandatory to manage our river resources effectively because healthy river is a natural living ecosystem, deterioration of its quality will affect human health and poor sustainability indices of a nation.

Reference

Stephen Forbes, 1887: Local Knowledge, Environmental Politics, and the Founding of Ecology in the United States and "The Lake as a Microcosm" .
Kolkwitz, R. & Marsson, M. (1908) Ber. dtsch. bot. Ges., 26a, 505.
Pantle R, Buck H. 1955. Die biologische U¨ berwachung der Gewa¨sser und Darstellung Ergebnisse. Gas und Wasserfach 96:604–624.

Current Trends in Bio-Monitoring and Indexing of River Ecosystems for Pollution Management with Perspective to Zooplankton

Dr. K. Altaff
Department of Marine Biotechnology, AMET University, Chennai, Tamilnadu

Due to ever increasing urbanization, industrialization, agriculture and other anthropogenic activities, water is becoming highly polluted with different harmful contaminants. High levels of organic and industrial pollutants in river water cause changes in many physicochemical parameters (Fakayode, 2005). The present status of pollutants in the rivers has impacted the water quality in a level that in such cases it cannot be used for drinking, irrigation or recreation (Xiong *et al.*, 2020). The Biomonitoring is the measurement of effects of pollutants on natural aquatic test organisms ranging from bacteria to fish. Biomonitoring response variables recommended to detect incipient community changes include the relative abundance of pH sensitive species, overall crustacean and rotifer community composition plotted in abundance ordination space, crustacean and rotifer species richness, and the relative abundance of acid tolerant species (Xiong *et al.*, 2020).

Zooplankton includes diverse taxa such as protists, rotifers, copepods and cladocerans, many of which are microscopic (Altaff, 2004). Multiple studies have made a consistent and crucial realization that zooplankton taxa are rapid responders to many environmental stressors, such as hydrological changes, climate changes and anthropogenic activity induced water pollution. Specifically, previous studies have indicated that zooplankton communities were significantly impacted by excessive loading of nutrients, and also negatively affected by microplastics, pharmaceuticals and personal care products. As such, researchers have identified their usefulness as ecological indicators to water pollution. For instances, rotifers are used to diagnose ecological impacts of freshwater toxicants, such as endocrine disruptors, bioconcentration of lead, and synthetic toxicity. Yang *et al.*, (2017) indicated that zooplankton communities could be used to predict ecological thresholds of ammonia nitrogen. Payne *et al.*, (2013) listed and recommended seven key reasons for the use of protists as good bio-indicators in aquatic ecosystems. Azevêdo *et al.*, (2015) showed that zooplankton communities played a complementary role to macroinvertebrates in indicating variation of the trophic status of waters. Thus, biomonitoring zooplankton communities have become a widely accepted and irreplaceable aspect in ecological conservation and management of aquatic ecosystems.

The riverine composition of phyto and zooplankton and ratio of nematode to copepod density in the meiofauna is vital pollution indicator. The diversity of zooplankton is traditionally identified by morphological techniques (Altaff, 2004). This traditional technique is considered to be useful for the identification and enumeration of phytoplankton and zooplankton, and thus providing invaluable information on species identification. For instance, Humes (1994) have reported approximate 11500 morphological species of copepods. Kreutz and Foissner (2006) edited a book of protozoological monographs, recording 670 species of protists, micro-metazoans, and bacteria. And Altaff (2004) published identification manual for Zooplankton especially for freshwater and marine copepod.

With the advent of morphological identification by electron microscopes, the scanning electron microscope (SEM) has become a powerful analytical tool. The use of SEM significantly increases the resolution in specimen identification and helps detection of taxonomy keys precisely. For instance, by using SEM, several rotifer species with differentiated trophi were identified in an apparently morphological uniform genus (Seger, 1995). Papa *et al*., (2019) updated taxonomic status of crustacean zooplankton in a lake in Philippines using a combination of light and scanning electron microscopes. Hines (2019) studied the biogeography of freshwater ciliates (protozoa) species identification by SEM. The taxonomy of some the marine and freshwater copepods from Indian waters were investigated with the help of classical methods, SEM and molecular taxonomy (Zehra and Altaff, 2002; Dharani and Altaff, 2004; Dilshad Begum et. al. 2018; Saboor and Altaff 2020). Thus, using these morpho-molecular complementary tools the diversity and distribution of riverine zooplankton have to be regularly undertaken to monitor the health of the riverine ecosystem. Such an approach will ensure early detection of pollution to take remediation measures to sustain the attributes of the riverine systems to the mankind.

Reference

Altaff, K. (2004). A manual of zooplankton. University Grants Commission, New Delhi, 1-155.

Azevêdo, D. J. S., Barbosa, J. E. L., Gomes, W. I. A., Porto, D. E., Marques, J. C., & Molozzi, J. (2015). Diversity measures in macroinvertebrate and zooplankton communities related to the trophic status of subtropical reservoirs: Contradictory or complementary responses?. Ecological Indicators, 50, 135-149.

Dharani, G. and Altaff, K. (2004). Facultative sex reversal in the freshwater plankton *Sinodiaptomus (Rhinediaptomus) indicus* Calanoida: Copepoda. Current science, 82(7), 794-795.

Dilshad Begum, B. Dharani, G., and Altaff K. 2018 Molecular systematics of freshwater diaptomid species of the genus Neodiaptomus from Andaman Islands, India. Genetics of Aquatic Organisms, 2: 13-22.

Fakayode, S. O. (2005). Impact assessment of industrial effluent on water quality of the receiving Alaro River in Ibadan, Nigeria. African Journal of Environmental Assessment and Management, 10, 1-13.

Hines, H. (2019). The biogeography, phylogeny, and dispersal of freshwater and terrestrial free-living ciliates in Florida, USA (Doctoral dissertation, Bournemouth University).

Humes, A. G. (1994). How many copepods?. In Ecology and morphology of copepods Springer, Dordrecht.

Payne, R. J. (2013). Seven reasons why protists make useful bioindicators. Acta Protozoologica, 52(3).

Radek, R. (2006). The Sphagnum Ponds of Simmelried in Germany: A Biodiversity Hot-Spot for Microscopic Organisms, M. Kreutz, W. Foissner. Protozoological Monographs, vol. 3. Shaker-Publishers, Aachen (2006)(267pp.,€ 30.00, Paperback, ISBN: 3-8322-2544-7).

Saboor , A and Altaff K. (2020). Redescription of Onychocamptus bengalensis lang, 1948 (copepoda, Harpacticoida, Laophontidae) - A new record from Adyar estuary, India. International Journal of Life Sciences Research ISSN 2348-3148, 8 (1), 57-63.

Segers, H. H. (1995). A reappraisal of the Scaridiidae (Rotifera, Monogononta). Zoologica Scripta, 24(2), 91-100.

Xiong, W., Huang, X., Chen, Y., Fu, R., Du, X., Chen, X., & Zhan, A. (2020). Zooplankton biodiversity monitoring in polluted freshwater ecosystems: A technical review. Environmental Science and Ecotechnology, 1, 100008.

Yang, J., Zhang, X., Xie, Y., Song, C., Sun, J., Zhang, Y., ... & Yu, H. (2017). Ecogenomics of zooplankton community reveals ecological threshold of ammonia nitrogen. Environmental Science & Technology, 51(5), 3057-3064.

Zehra, A., & Altaff, K. (2002). Redescription of *Mesocyclops aspericornis* (Daday, 1906) (Copepoda: Cyclopoida) from an Indian pond. Journal of plankton research, *24*(5), 481-493.

Environmental DNA (eDNA) for Biomonitoring and Sustainable Management of Rivers

Dr. Devayani Savant

SIES Indian Institute of Environment Management, Nerul, Navi Mumbai
devayanis@sies.edu.in

The continuous decline in Earth's biodiversity represents a major crisis and challenge for the 21st century. The challenge is impeded by lack of knowledge on state and distribution of biodiversity. Conservation efforts to save biodiversity depend on monitoring of species and populations (biomonitoring) to obtain reliable distribution patterns and population size estimates (Thomsen, & Willerslev, 2015).

Conventional techniques of biomonitoring includes collection of biological samples from a site, identification of species, finding their abundance and calculation of various indices. However, this method has certain limitations which include

1. Correct identification of species especially juvenile species is difficult
2. There is continuous decline in taxonomic expertise
3. Non-standardized sampling
4. Invasive nature of the survey/sampling techniques and
5. It is time consuming and labour intensive

To overcome these problems a new methodology is emerging. It is called as Environmental DNA or eDNA biomonitoring. Environmental DNA (eDNA) is defined as the genetic material obtained directly from environmental samples (Soil, water or sediments) without any obvious signs of biological source materials. The DNA is then amplified using suitable primers and sequenced. The data obtained is analysed for identification of taxa and species abundance using bioinformatics tools and used for calculation of pollution indices as shown in Fig.1.

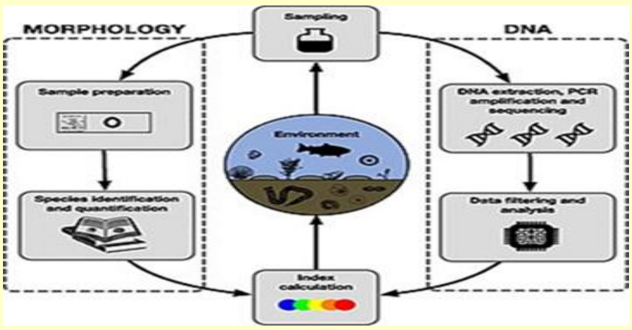


Fig. 1: Conventional Vs eDNA technique (Source: Pawlowski et al., 2018)

eDNA biomonitoring involves an **efficient, highly sensitive, rapid, non-invasive and easy to standardize sampling**. The data obtained is **reliable**. It can give information regarding present as well as past biodiversity. Compared to conventional biomonitoring, eDNA monitoring is far superior with respect to **accuracy, cost and time**.

Rivers are vital for our survival on this planet. They are the prime source of freshwater which is needed for most of our activities. Besides they are important for transport, processing and recycling of organic and inorganic nutrients. Riverine ecosystems are most diverse ecosystems and are important for maintaining structure and functioning of rivers. Today, these ecosystems are threatened due to heavy pollution from various anthropogenic activities. Conservation of the **water quality** and **biodiversity** of rivers is therefore crucial and indispensable.

Water quality is commonly monitored by analysing physical and chemical parameters. It can identify many contaminants that may be present in water but biological monitoring integrates responses to combinations of all the contaminants and to other sources of environmental stress thereby indicating overall effects in a water body. Many a times it reflects the effects of physical and chemical conditions to which the parameters were exposed over a period of time. Biological monitoring is therefore considered as complementary to physical and chemical monitoring. (Bartram and Ballance, 1996)

eDNA biomonitoring of rivers can be used in two ways:1. Monitoring of target species (Active Monitoring). and 2. Monitoring of a community as a whole (Passive Monitoring) (Refer Fig.2). These techniques have been successfully used for detection of particular species such as invasive species, keystone species, indicator species, flagship sp., umbrella sp., etc. DNA metabarcoding has been used to assess community composition i.e. baseline data establishment for biotic communities, identification of taxa and understanding effects of environmental stressors across time and space (Li et al., 2018, Ruppert et al., 2019).

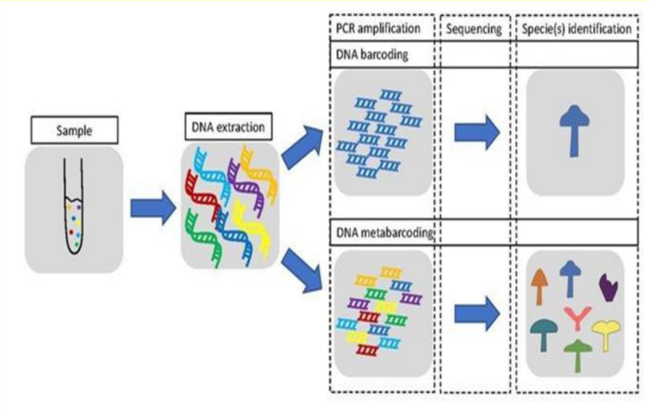


Fig. 2: Schematic representation of DNA barcoding and metabarcoding (Source: Wikimedia commons)

These techniques can also be used to assist communication between regulators and policy makers and stakeholders before any new decision is taken. They can help in prevention of environmental degradation as well as restoration of degraded sites e.g. construction of barriers for invasive species, channel modifications, etc (Liu et al., 2020).

Future applications of this technology may include public health and epidemiological applications i.e. tracking and monitoring disease transmission and evaluation; third party validation i.e. increase accountability of environmental consulting; extend eDNA to eRNA i.e. functional monitoring of an ecosystem across time and space i.e. should be able to give early warning before taxon loss (https://youtu.be/9SWZKJpO_P4).

Full potential of eDNA monitoring techniques is yet to be harnessed and is expected to be a powerful tool in maintaining river health and sustainable management of river ecosystems.

References:

Li et al., (2018). Application of Environmental DNA Metabarcoding for predicting anthropogenic pollution in rivers. Env. Sci. Technol. 52(20) 11708–11719.

Ruppert, K. M., Kline, R. J., & Rahman, M. S. (2019). Past, present, and future perspectives of environmental DNA (eDNA) metabarcoding: A systematic review in methods, monitoring, and applications of global eDNA. *Global Ecology and Conservation*, 17, e00547.

Pawlowski et al., (2018). The future of biotic indices in the ecogenomic era: Integrating (e) DNA metabarcoding in biological assessment of aquatic ecosystems. *Science of the Total Environment*, 637, 1295-1310.

Bartram, J., & Ballance, R. (Eds.). (1996). Water quality monitoring: a practical guide to the design and implementation of freshwater quality studies and monitoring programmes. CRC Press.

Thomsen, P. F., & Willerslev, E. (2015). Environmental DNA–An emerging tool in conservation for monitoring past and present biodiversity. Biological conservation, 183, 4-18.

Liu, Q., Zhang, Y., Wu, H., Liu, F., Peng, W., Zhang, X., Chang, F., Xie, P. and Zhang, H. (2020). A Review and Perspective of eDNA Application to Eutrophication and HAB Control in Freshwater and Marine Ecosystems. Microorganisms, 8(3), 417.

https://youtu.be/9SWZKJpO_P4

Report of Webinar Conducted on World Environment Day 2020

A Webinar on World Environment Day on the topic, 'Biodiversity Conservation and Sustainable Development: Current Scenario and Future Prospects'. In this event three lectures were organized on the themes:

- Biodiversity conservation, significance and source of livelihood generation
- Ecosystem services and natural capital assessment
- International and National Policy Frameworks
- City Biodiversity Index
- India Biodiversity and Business Initiative
- Passion leads to biodiversity conservation

In this event total 256 participants had registered. Out of that 124 have attended. The BPCL and Greenko company have celebrated World Environment Day Pan India with us. Apart from that researchers, academicians and students have participated from 65 institutions (Universities, Agric. universities, IITs, NITs, ICAR institutes etc.) of our country with representation from 22 states.

Report of Webinar on the theme, 'Opportunities for Professionals in Sustainable Environment Management in Post Covid – 19 Era'

Report on the Webinar on the theme, 'Opportunities for Professionals in Sustainable Environment Management in Post Covid – 19 Era' organized on Friday, 24th July, 2020
The webinar was organized to sensitize students and working professionals about the challenges in environment, health and safety area in post covid era, skill mapping for industries and required skills in future in the areas of sustainable environment management. More than 160 participants registered from different institutes, universities and industries. Dr. N. T. Joshi, Chairman and MD, Padmaja Aerobiologicals delivered his lecture on the topic, Environment Management Sector in Post Covid Era' wherein he has covered emerging

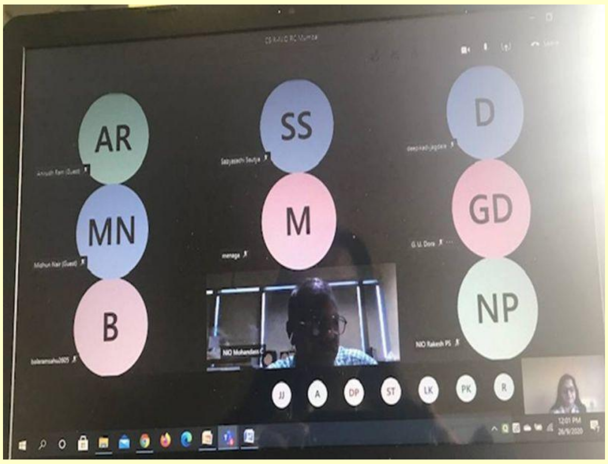
Sectors in environment management. A lecture on the topic, 'Sustainable Health and Safety in Post Covid Era' was delivered by Shri. Vinod Sant, Ex. DG, National Safety Council. Mr. Rahul Datar, Principal Consultant, Environment Matters, has covered the theme, 'Environment Sustainability Sector in Post Covid Era' in that he has presented skill mapping in environmental sustainability sector. The event was well appreciated by the participants.

Online Training Programme on the theme, 'Maintenance of Kharif Onion Crop in Variable Climatic Conditions' under the project 'Climate Change Adaptation of Onion Crop'

An online farmer's training programme on above theme was conducted on Wednesday, 23rd September, 2020 for the farmer's from different talukas of Nashik (M.S.). The training programme was conducted in two days, on first day 50 framers were trained for participating in online meetings and on second day, training on above topic was conducted. Out of 50 farmers 15 could participate successfully. The main areas of emphasis in the training programme were maintenance of onion crop in excess or low rainfall, potential of organic and biofertilizers, agronomic practices etc. The farmers have participated in the training programme from their field and discussed problems in onion crop with experts Dr. Satish Bhonde, Ex. Associate Director, NHRDF, Nashik (M. S.) and Dr. Seema Mishra.

Invited Lecture Delivered in Conference / Seminar/ Workshop

1. CSIR Foundation Lecture 2020 was delivered at National Institute of Oceanography, Regional Centre, Mumbai on 26th September, 2020 on the topic Climate Change Management in Coastal Ecosystems.
2. Invited lecture was delivered at Pillai’s College, Panvel on 26th September, 2020 in National Seminar on Environment Management. The topic of presentation was – Biotechnology as a tool for the Climate Change Mitigation.
3. Invited lecture was delivered in online Conference on the topic, ‘Climate Change, Environmental Health and sustainable Development Goals in Post COVID -19 World on 4th June on the topic, ‘organized by University College of Environment Management, Guru Gobind Singh Indraprastha University, New Delhi.



Salient Technologies Transferred to Industries by SIES IIEM

Sr. No.	Areas of Consultancy	Major Deliverables
1.	Mass culturing of AM Fungi	Development of novel culture of AM fungi for mass application Development of lab for culturing of AM fungi and other biofertilizers
2.	Ethanol Production from Rice Industry Waste	Ethanol extraction from rice industry waste
3.	Treatment of leachate from Hazardous Waste	Low cost efficient technology for leachate treatment from hazardous waste management facility
4.	Disinfection of Ballast Water	Low cost disinfection techniques for ballast water
5.	Sewage Treatment / Recycling Plant	SBR model for the treatment of sewage waste
6.	CO_2 sequestration studies of afforestation projects	On site monitoring, data collection, interpretation and validation
7.	Water and energy auditing	Identification of potential losses and defining strategy for conservation
8.	Solid Waste Management	Characterization of waste, strategies for waste management and efficient technologies

All previous issues of 'The Environment Management'can be viewed at: http:// www.siesiiem.edu.u

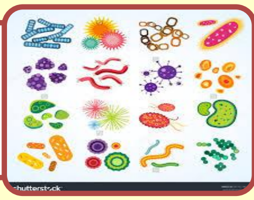
SPECIFIC AREAS OF EXPERTISE AT SIES IIEM IN INDUSTRIAL R&D AND CONSULTANCY

Environmental Pollution Monitoring, Assessment and Control

- Waste water treatment technologies
- Zero discharge
- analysis of samples
- Hazardous waste management
- Lab analysis services and desginig of lab

Ecology and Biodiversity

- Assessment of ecosystem services and biodiversity indexing
- Mapping of resources and modelling
- Eco restoration of resources



Microbial interventions in Environment Management

- Bioremediation and phytoremediation
- Mass production of Biofertilizers and biopesticides

Environment Management

Desigining of policies and plans as per agenda 2030 of Sustainable Development for industries and institutions
Climate change vulnerability assessment, identification of adaptation and mitigation technologies
CO_2 neutrality assessment in industries

Execution of CSR Initiatives

Defining of strategy, planning, implementation and execution of activities
Capacity building and skill development
Community mobilization for livelhood generation by developing theme based hubs

Other services

Survey and data analysis
Preperation of DPR, proposals, SOPs
Training Programmes, Customized events

MAJOR AREAS COVERED UNDER OUTREACH ACTIVITIES AND COMMUNITY MOBILIZATION AT SIES IIEM

Technology Parks for Resource Management and Livelihood Generation

Implementation of ecotechnologies, resource mobilization, establishment of market linkages

Skill Development

Pollution monitoring
Waste Management
Eco- friendly nursery, Aquaculture, Herbal and medicinal garden
Agriculture, organic, biofertilizers & pesticides

Training and Awareness Generation

Waste managment

Water conservation and management

Climate change and strategies for adaptation and mitigation

Biodiversity and nature trails

OUR PARTNERS

Government

- Department of Science and Technology
- Board of Reserch in Nuclear Sciences
- Department of Biotechnology
- MOEFCC, CSIR, DRDO
- Maharashtra Pollution Control Board
- MCGM & NMMC

Non -Government

- MMR- Environment Improvement Society
- Ashoka Trust for Research in Ecology and Environment
- Indian Centre for Plastics in Environment
- Balwant Rai Mehta Panchayati Raj Kendra
- SEAL Ashram
- SOSVA

Industries

- BPCL
- Kukyo Camlin
- JSW
- RCF
- Mumbai Waste Management Ltd.
- Agrisearch India Pvt. Ltd.
- Diva Envitech Pvt. Ltd.

Environment in News Headlines

Microplastics More Readily Taken Up by Living Cells in Natural Environment

The environment is polluted by microplastics worldwide. The tiny particles enter food chains, and thereby the digestive systems of animals and humans; moreover, they can be inhaled. Instead of being excreted, small microplastics can be incorporated into the body tissue. A research team at the University of Bayreuth has now discovered that microplastic particles find their way into living cells more easily if they were exposed to natural aquatic environments, i.e. fresh water and seawater. Biomolecules occurring in the water are deposited on the microplastic surfaces, which promote the internalization of the particles into cells.

Science Advances, Dec. 2020

Climate Crisis Making Autumn Leaves Fall Earlier

Global heating appears to be making trees drop their leaves earlier, according to new research, confounding the idea that warmer temperatures delay the onset of autumn. The finding is important because trees draw huge amounts of carbon dioxide from the air and therefore play a key role in managing the climate. The rising temperatures also mean that spring is arriving earlier and, overall, the growing season for trees in the planet's temperate zones is getting longer. However, the earlier autumns mean that significantly less carbon can be stored in trees than previously thought, providing less of a brake on global heating.

The Guardian, Nov. 2020

New species are more likely to emerge in extreme environment 'coldspots' rather than 'hotspots' like the Amazon rainforest

The Amazon rainforest is one of the most biodiverse 'hotspots' of the world. Yet, it may not be the best place for new species to emerge. A new study published in Science calls this the 'paradox of diversity'. It concludes that extreme environments like deserts, mountains or other 'coldspots' would be better equipped to handle rapid diversification of species than tropical regions, which are already crowded with existing species. It's not that the hotspots aren't important. While coldspots are relatively empty, they are also dry and unstable environments. This is why once new species emerge and evolve, they move to more comfortable environments — like the tropical biodiversity hotspots.

Business Insider, Dec. 2020

MCZMA asks BMC to set up Environment Cell for Coastal Road

The Maharashtra Coastal Zone Management Authority (MCZMA) has directed the BMC to set up an environment management cell for effective implementation and monitoring of the environment management and marine biodiversity conservation plans for the ambitious coastal road project.

The Indian Express, Dec. 2020

Articles, photos etc. are invited for next issue (April - June, 2020) of the Newsletter on the theme 'Opportunities for Environment Management Professionals in Post Covid- 19 Era'

SIES Indian Institute of Environnent Management,
Sri. ChandrasekarendraSaraswathiVidyapuram
Tel.: 022 6119 6454 / 55/ 56 ; FAX: 022 27708360
E- mail:iiemoffice@sies.edu.in; Website:http://siesiiem.net