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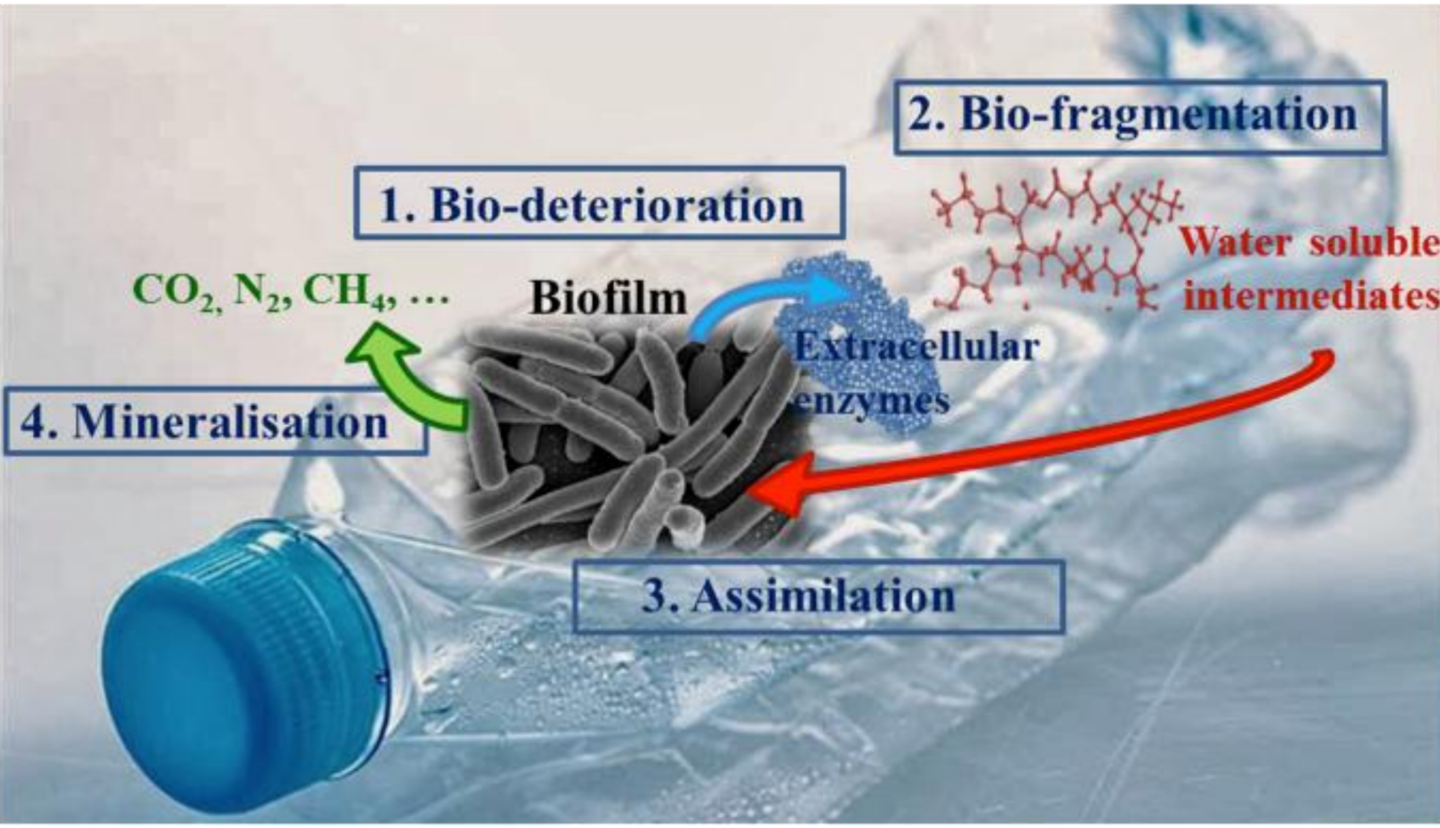
GUIDE Net E - Newsletter



Dear Readers!

As we grasp the plastic waste globally, this issue will enlighten you on the biodegradation of plastics and their alternatives as a continuation of the previous issue. Biodegradation is a conversion of biochemical compounds by microorganisms by way of colonization on the plastic surface lead to reduction in the molecular weight of plastics. Microbial enzymes, reduce the polymer to its oligomers, dimers, monomers, and then broken down into carbon dioxide, water, and methane. More microbial strains with the ability of polymer biodegradation are predicted to be discovered by researchers and scientists. As well, industries have begun to think about alternative biodegradable stuff which improve plastic waste management at all circumstances. We believe that the use of biodegradable plastics in human lifestyles will provide a healthy aquatic and terrestrial ecosystems in the future.

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1. Advanced Oxidation Process (AOP) mediated surface modification of plastic for its biodegradation

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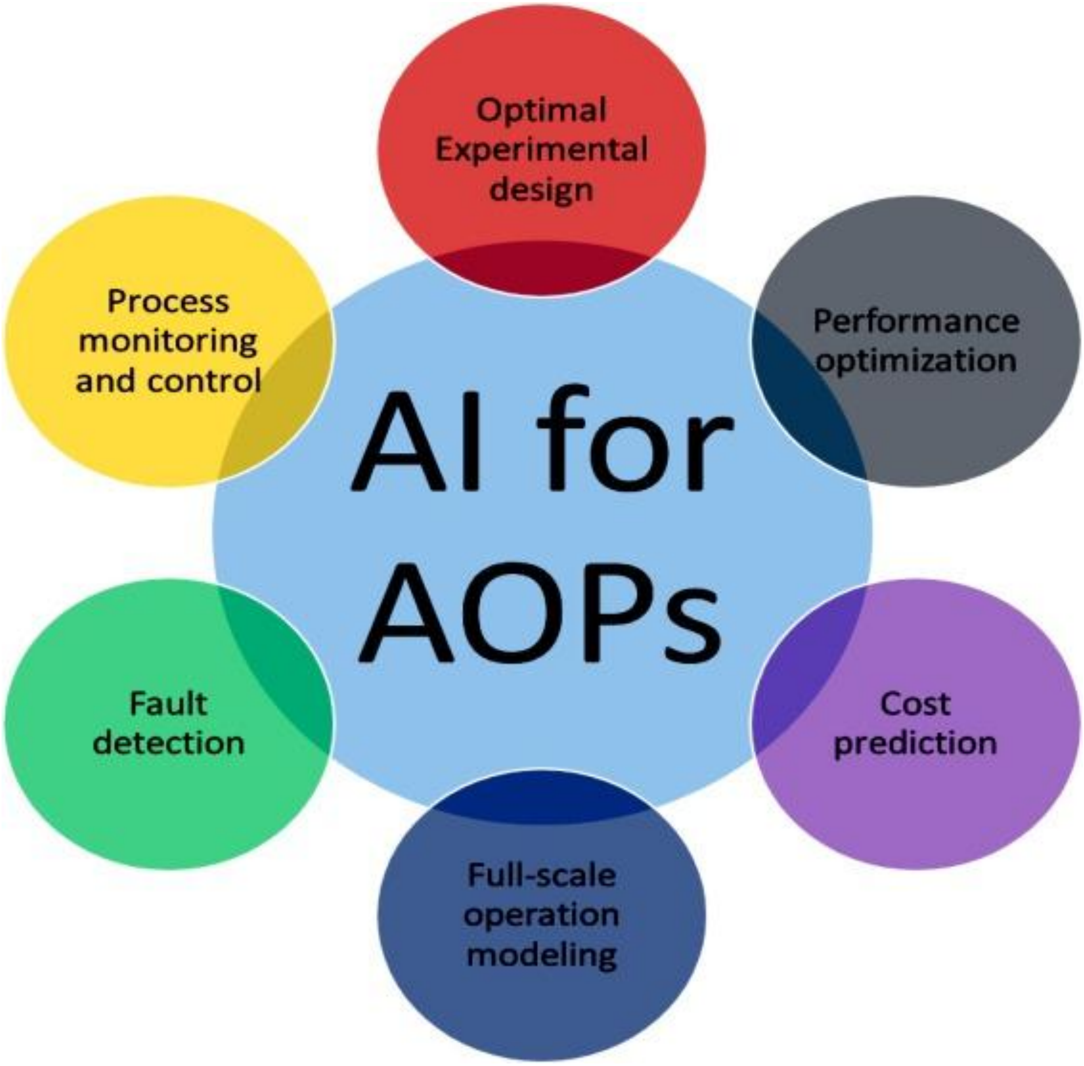
Plastics are widely used for the applications of packaging, household, industrial products, and agricultural activities. Excessive use of plastics poses significant risks to human health and the environment. This has led to the development of several physical, chemical or biological strategies to degrade the plastic wastes such as thermal, ozone-induced, mechanochemical, photo-oxidative, biodegradation, and catalytic degradation. These techniques are time taking since the chemical stability and interlinking of the polymer chain, the rate of biodegradation is slow. Microbial biodegradation coupled with surface modification offers the economical, eco-friendly, fastest and safest solution. The present work was aimed to study a dual approach of plastic biodegradation which included surface modification using advanced oxidation process (AOP) techniques followed by microbial degradation. The surface modification was carried out by photocatalytic oxidation of plastic with the help of solar radiation and ZnO. Surface modification of plastic possibly provides a suitable base for bacterial growth. In this work, the bacterial strain was isolated from the plastic waste collected from the municipal solid waste dumping site. The two types of plastic samples used in this study were polyethylene and linear low-density polyethylene.

The isolated bacteria were grown in liquid culture media supplemented with minimal salt and plastic as sole carbon source. The results have shown that the surface hydrophobicity of the treated plastics was decreasing when compared with untreated sample. The change in surface chemistry was perhaps due to oxidation of polymer chains and the addition of some polar functional groups on a plastic surface.

Similarly, higher bacterial growth rate was observed with treated plastics when compared to untreated samples. Increased bacterial growth on the treated surface indicated that photo-catalytic oxidation facilitates a suitable surface for the growth of bacteria. All the above findings indicated that following the dual approach can be a promising alternative for plastic biodegradation.



Source: Giwa et al. (2021)

2. Development of starch-based biodegradable Bioplastic from Jack fruit seed

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The natural environment comprises of all living and non-living things occurring naturally on earth. Plastics are manmade long-chain polymeric molecules. In daily life, plastics are used almost everywhere in the world for various purposes because plastics are inexpensive, readily available, durable and versatile. Now plastic is one of the toxic pollutants of the present time. The biodegradable polymers or bioplastics indicate eco-friendlier environment than the conventional plastics, but still, there is a lag in the development of bioplastic. An alternative for a low cost and renewable substrate is the starch-based biodegradable biopolymer. Jack fruit (*Artocarpus heterophyllus*) a member of family Moraceae is a popular fruit which grows abundantly in India. Jack fruit seed and its flour is used in culinary recipes, bakery and confectionary recipes and having a rich source of protein, starch, dietary fibre, and a cheap source of nutrients. The jack fruit seed powder is an effective substrate for the production of starch-based bioplastic. The properties of the bioplastic films are influenced by the composition of the flour mixture and the glycerol concentrations. The jack fruit seed flour contributes the strength and elongation of the film because of its higher amylase content. The acid test, alkaline test, solubility test and flame test were done. FTIR analysis also showed the presence of functional groups. The present study concluded that the bioplastic from jack fruit seed is a feasible solution since it decomposed more easily by microbes, and therefore environment friendly than petroleum based bioplastics.

3. Degradation of low-density polyethylene (LDPE) by fungus isolated from landfill soil and its growth response

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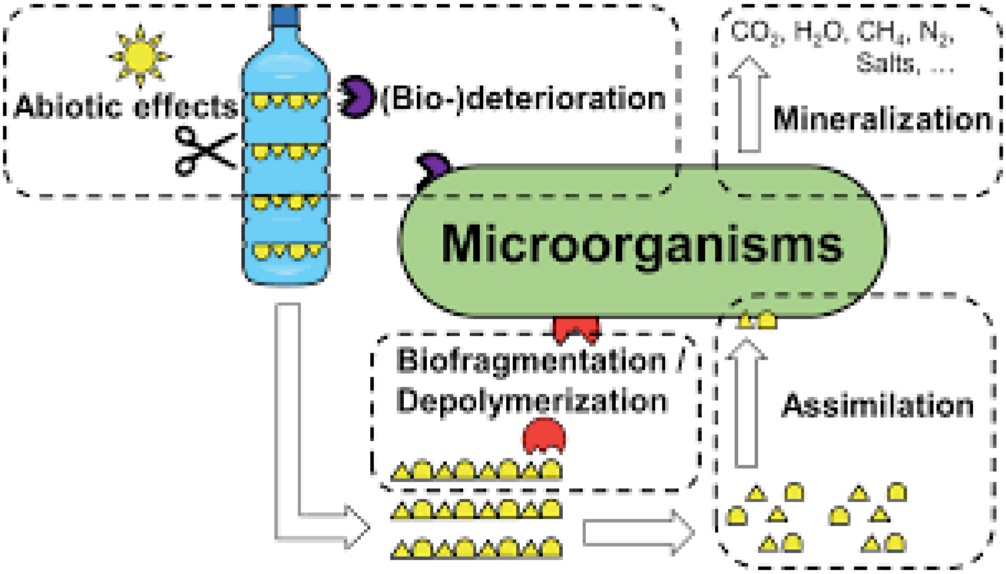
A low-density polyethylene (LDPE) is one of the hazardous polymers accelerates land and water pollution. The present study is focused on standardizing the protocol for degradation of plastics in an aesthetic approach. LDPE can be degraded by microbial enzymes by means of cutting down the molecular chains. Two fungal strains *Aspergillus fumigus* and *Xylaria* sp., showed high degradable activity through the determination of pH variation and carbon dioxide estimation. *Aspergillus fumigus* and *Xylaria* sp., shows pH variation in the culture media containing LDPE strips and was recorded as 6.5 to 8.1 and 6.5 to 7.7 respectively. The efficacy of polyethylene degradation confirmed by CO_2 estimation of culture filtrate was 1.350 g/l in *Xylaria* sp., and 1.460 g/l in *Aspergillus fumigus.* The surface erosion and the formation of pits and cavities on the surface of the LDPE films were also observed using Scanning Electron Microscope and significant disappearance in carbonyl peak with respect to the control band absorbance (2361.61 cm-1) and the formation of new peak (669.03 cm-1) with respect to control indicates structural changes in chemical bond due to degradation process in FTIR study is another strong evidence of the degrading capacity of fungal isolates.



Source: Ren Wei and Wolfgang Zimmermann (2017)

4. Polyhydroxyalkanoates (PHAs): An alternative approach to replace plastic

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Marine bacteria have unusual properties that help in the development of a novel biotechnological process. Marine biopolymers are exploited from a significant and undeveloped biological resource. Bioplastic is well-defined as a form of plastic synthesised from various renewable resources such as plant and microbial species in the form of polyhydroxyalkanoates (PHAs). Polyhydroxybutyrate (PHB) which are highly crystalline thermoplastic polymers belonging to the polyester class called PHA. Polyhydroxybutyrate (PHB) is accumulated intracellularly in microbes as storage granules. Bioplastic has a wide range of applications in agriculture, drug discovery and pharmaceuticals. Soil and water samples were collected from different coastal areas along Gujarat coasts. A total 30 different marine bacteria were isolated from five different sites. The microorganisms were enriched in Zobel Marine Broth (ZMB) supplemented with various salt concentrations (5-20% w/v NaCl). The Sudan black and Nile red staining methods were used for preliminary screening and confirmatory assay for PHB producing bacteria. Out of 30 isolates, 17 were positive for Sudan black and Nile red dye-containing plates. The extraction of PHB was done by using sodium hypochlorite method. The extracted film was quantified on the basis of % PHB accumulation and confirmed by FTIR analysis. Further, the morphologically different isolates of PHB synthesis were characterized by UV-visible spectrophotometry, structural analysis, thermal stability, mechanical properties and 16S rRNA analysis respectively.

5. Development of bioprocess for sustainable management of plastic waste and oily sludge

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Crude oil and petroleum-based products such as petrol, diesel, plastic and others are essential for today's life. In India, annually 28,220 tons of oily sludge as waste is generated by various anthropogenic activities. Research Conservation and Recovery Act (RCRA) has classified oily sludge as independent hazardous waste. Techniques employed for the management of oily sludge leads to incomplete mineralization, ineffective and costlier as well. Apart from this, usage of petrochemically derived non-biodegradable plastics is increased and disposed off in the environment without any treatment. Another concern is depletion of fossil fuel (4%) produced worldwide which is utilized for the formulation of synthetic plastics. The aim of this study to treat oily sludge which is a by-product of bioplastic production. Polyhydroxyalkanoate (PHA) is one such biopolymer, which can be produced by bacteria and can find application as a plastic substitute. A total of 44 bacterial cultures isolated from crude oil contaminated samples using enrichment technique. Qualitative and quantitative Sudan black B assay were performed for determining PHA accumulation capacity. Sodium benzoate (SB) was selected as a model monoaromatic hydrocarbon for investigating oil biodegradation potential. Active culture of 31 isolates had O.D_{560} between 0.6- 0.9 within 6 h of incubation and was considered as fast growers of which 27 isolates could degrade >80% sodium benzoate within 24 h. Nine isolates showed efficient PHA accumulation and SB degradation and were selected for future experiments. The minimal salt medium was spiked with 1% crude oil and cultures were inoculated in it. After 20 days, crude oil was extracted in hexane. The extracted fraction was analysed for determining crude oil degradation using GC-FID. PHA was extracted from the biomass and PHA yield was determined. Physical and chemical cell lysis protocol with solvent extraction strategy was employed for PHA extraction, and characterized. In future, these isolates can be used to treat oily sludge and to produce PHA as a by-product.

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6. Bursting the Myths about Degradable Plastics through Simulation Studies

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Approximately 140 million tons of synthetic polymers are produced every year. As per the United States Environmental Protection Agency in 2011, plastics constituted over 12% of municipal solid waste. The extensive use of plastic poses severe environmental threats to the terrestrial and marine ecosystems, as they are hardly degradable and voluminously dumped. Due to high production and wide usage of plastics, their disposal is a major problem. Microorganisms are ideally suited to the task of contaminant destruction because they possess enzymes to use environmental contaminants as food, microscopic and able to contact contaminants easily. Bioremediation system rely on microorganisms native to the contaminated sites, encouraging them to work by supplying the optimum levels of nutrients and other chemicals essential for their metabolism. Researchers are currently investigating ways to augment contained sites with non-native microbes including genetically engineered microorganisms suited to degrading the contaminants of concern at a particular site. A study was carried out to understand the degradability pattern of three different materials; Polypropylene, Polyethylene and cotton in the land and marine environments. Microbial quantification of simulation environments was undertaken for establishing the best microcosm environment for biodegradability. The degradation rates under different amended soil and marine simulated models have revealed the factors that may help us in understanding the ideal micro environment required for the degradation activities in future for safe disposal.

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7. Biodegradation of PCBs in e-waste and plastics

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The growing demand for consumer electronic equipment and the marketing of new features has caused rapid growth in the generation of electronic waste or e-waste. The pollutants such as Dioxin/Furans, Polycyclic Aromatic Hydrocarbons (PAH), Polychlorinated Biphenyl (PCBs), Silicon, Copper, Cadmium, Mercury etc. are major components of e-waste. Though some of these are used in small quantities, the overall volumes being recycled are so high that the impact is massive. E-waste is growing at about 4% per year and become the fastest growing waste stream in the industrialised world. About 50-80% of the e-waste collected for recycling in industrialised countries end up in recycling centers in China, India, Pakistan, Vietnam and the Philippines taking advantages of the lower labour cost and less stringent environmental regulation in this countries. The manual e-waste recycling activities cause severe damage to the environment and to the workers. Local residents are constantly exposed to toxic chemicals through inhalation, dermal exposure and oral intake (of contaminated food and drinking water). Once taken into the body, the toxic organic chemicals are stored in fatty tissues, bioaccumulation and biomagnifying through the food chains occur. These are a major source of toxins and carcinogens. The report estimated (United Nations) about 500 % growth over the next 10 years in computer waste in India alone. E-waste from television will be 1.5 to 2 times higher in China and India and e-waste from discarded refrigerators and air conditioners will double or triple in India. PCB (polychlorinated biphenyl) is one of the main components in both refrigerator and air conditioners. These are classified as probable human carcinogens (Group IIa) by the International Agency for Research on Cancer (IARC). These also cause silicosis and respiratory tract irritations and also skin chloracne and rashes.

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There is a plan to solve this problem through biodegradation of PCBs using few microorganism and other chemicals. Components will be preheated and valuable components which have least adverse effect during recycling can be recycled and the rest can be degraded by biodigest process comprising-lyophilised culture of *Rhodococcus* RHA1, *Streptomyces viridosporous* T7A, dechlorinating agent (l-ascorbic acid), inducer molecule (biphenyl compounds), along with carrier molecule (peat soil). PCB causes serious environmental pollution, and degradation by a microorganism is regarded as an effective tool for environmental clean-up. Rhodococcus species RHA1, which can grow on biphenyl as a sole source of carbon and energy, is a strong PCB degrader and is able to digest mono-octachlorobiphenyl by co-metabolism with biphenyls. Detailed studies of the genes responsible for biphenyls /PCB degradation in RHA1 suggested that multiple isozymes genes are involved in each degradation step. Many literary shreds of evidence have revealed that these two species are having the best degrading capacities. Both these species are synergistic when two components are working together. Chemical dechlorination is based on reactions with either an organically bound alkali metal or an alkali metal oxide or hydroxide. Chemical processes are well developed to treat liquid PCBs and PCB contaminated soils. The chlorine content is converted to inorganic salts, which can be removed from the organic fraction, by filtration or centrifugation. Reactions take place under inert atmosphere and in the absence of water. The plant can be either fixed or mobile, used on PCB within an operating transformer with the process taking up to a week. Peat is an accumulation of partially decayed vegetation matter. Peat forms in wet land bog moors, muskegs, pocosins *mires*, and peat swamp forest. Peat is harvested as an important source of fuel in certain parts of the world. Nowadays, the number of industries are increased using Waste Electrical and Electronic Equipment (WEEE). An alarming increase in disposal of equipment to make way for the latest technology. Ecosystem balance is affected if not degraded properly. All these provide a huge opportunity for the biodigest plan to be implemented.

8. Invited Talk / Webinar Participation

- Dr. K. Karthikeyan delivered an invited talk on "Multifaceted role of plants in challenging environmental applications" on 1st July 2020 organised by Hajee Karutha Rowther Howdia college, Tamilnadu.

- Dr. K. Karthikeyan presented a special talk on "An Insightful overview on the Role of Plants in Environmental management" on 22nd July 2020 organized by PSG College of Arts and Science, Coimbatore, Tamilnadu.

- Dr. Rachna Chandra delivered a special lecture on "Desert Ecosystem" on 25th September 2020, conducted by UGC-HRDC, Aurangabad, Maharashtra.

8a. Upcoming Seminars / Conference

- The International Conference on Ecology (IC-E-20) on 01st - 02nd November 2020, Kollam, India.
- The International Conference on Environment and Life Science (ICENLISC-20) on 07th - 08th November-2020, Goa, India.
- The International Conference on Marine Science and Aquaculture (ICMSA-20) on 08th - 09th November 2020, Surat, India
- The International Conference on Social Movements (ICSM-20) on 08th - 09th November 2020, Lonavala, India.
- International Conference on Pollution Control & Sustainable Environment (ICPCSE-20) on 23rd December 2020, Goa, India

Gujarat Institute of Desert Ecology (GUIDE), is a research institute established in Kachchh, Gujarat, India in 1995. The mission of GUIDE is to catalyze the process of ameliorating hardships to human beings in desert ecosystems of Gujarat, following sound ecological principles and carefully using scientific knowledge, imaginative technology and capital.

Research processes of GUIDE involve the stakeholders including communities, developmental organizations (NGOs), government departments and industries to find reliable and sustainable solutions to the problems encountered by the dry land and coastal communities of Gujarat. GUIDE has implemented a range of national and internationally funded research and developmental projects in Gujarat and beyond.

We offer consultancy services in the areas of environmental assessments, capacity building and implementation of community development programmes to achieve the Sustainable Development Goals (SDGs).

Services offered by GUIDE

Research and Development

- Ecological Health Assessment
- Terrestrial Biodiversity Assessment and Conservation Studies (Biodiversity Action Plan and Wildlife Management Plan)
- Marine Ecological Impact Assessment Studies of port and coastal industries
- Remote sensing &GIS applications for Ecology, biodiversity conservation & environmental planning
- Climate Vulnerability Studies
- Environmental Impact Assessment (EIA) & Environmental Management Planning (EMP)
- Environmental monitoring of matrices such as Air, Stack, Water, Soil, Sediment & Industrial effluents etc.
- Environmental Auditing
- NABL Accredited Laboratory services as per ISO / IEC 17025: 2005
- Social Impact Assessment (SIA), Social Impact Management Plan (SIMP) and Social Audit
- Feasibility studies for Developmental projects
- Monitoring and Evaluation
    - Forest Resource Survey and Plantation Monitoring
    - Biodiversity Status Assessment and Wildlife Population Monitoring
    - Coastal and Mangrove monitoring
    - 3rd party evaluation for CSR projects
- Geo-tagged, mobile app-based surveys, Data analysis and visualisation

Capacity Building and Knowledge Management

- Provide Trainings , develop knowledge products, education and communication (IEC) materials in the areas of sanitation, hygiene, health, water conservation & safe usage, environmental awareness, biodiversity conservation, Natural Resource Management, Laboratory Analytics, and Mushroom cultivation.
- Capacity Building of NGOs in real time data collection and to take data driven decisions

Community Outreach and Implementation Activities

- Mangrove Restoration and plantation activities
- Implementing Government / CSR funded Watershed development, carbon neutral livelihood projects and environmental conservation initiatives.
- Build community based climate resilience technologies and cool roofs
- Promote social / village forestry in the rural and urban areas to increase biodiversity and to reduce heat stress

Membership

- Global Network of Dryland Research Institutes (GNDRI), Israel
- International Society of Zoological Sciences (ISZS), China
- International Union for Conservation of Nature (IUCN), Switzerland
- Ocean Expert, Intergovernmental Oceanographic Commission of UNESCO

Client Sectors

- Mining and Minerals
- Coastal and marine developments
- Ports and Harbours
- River basin studies and irrigation projects
- Metal Processing industries
- Thermal Power Plant
- Cement Manufacturing (Clinkerisation)
- Jetty Projects (Industries)
- Biomedical Waste Management
- Chemical Manufacturing (Caustic soda etc.)
- CETP of Electroplating association.