GREEN HORIZON

E-Newsletter

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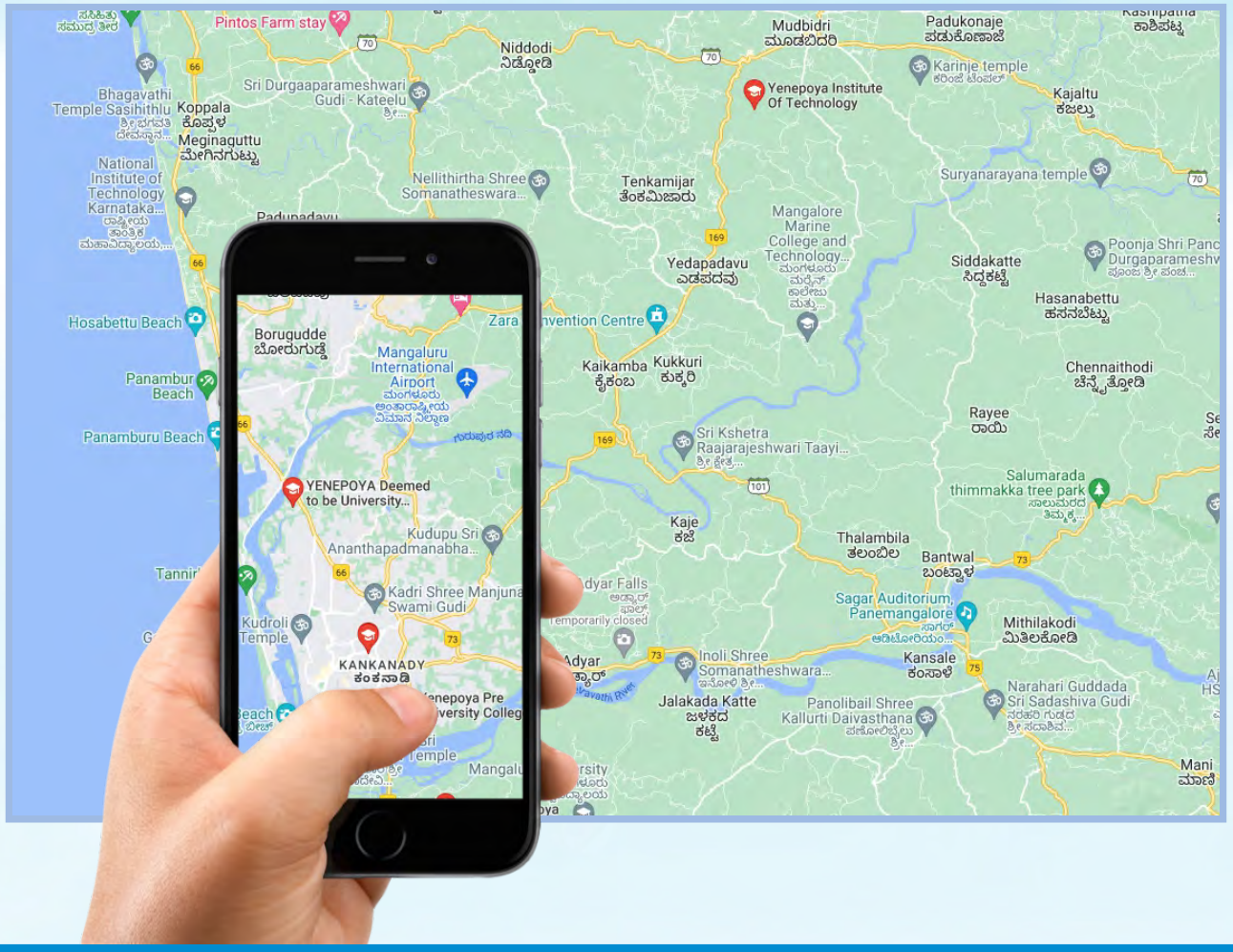

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Centre For Environmental Studies

General Information

Green Horizon is a peer reviewed e-newsletter published in English by the Centre for Environmental Studies, Yenepoya (Deemed to be University), Mangalore in two issues per year during June and December. This newsletter publishes manuscript of different categories like original articles, short communications, opinions, research communications, case study etc. We invite original contributions significantly advancing fundamental understanding and that focus on the interconnection of multiple environmental spheres of environment and nature (biodiversity, plants, animals, microbes, conservation, soil, air, water, climate, pollution, waste management, compost, environmental protection, environmental management and ecofriendly approaches). The authors, editors and reviewers need to adhere to the research and publication ethics to enhance the quality of the newsletter.

Aim and Scope
Green Horizon intends to project and share the knowledge on our environment and its protection for the benefit of society. It brings out quality and original materials exclusively on the environment and welfare of the biodiversity. Emphasis should be given to biodiversity, ecology, conservation, waste disposal, prevention of pollution and innovative ideas to protect and nurture our environment towards prolife.

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CONTENTS

EDITORIAL COMMITTEE

EDITORIAL

I am very pleased to release the second issue of Volume 3 (2022) of GREEN HORIZON. This issue documents many important environmental facts and responsibilities toward restoration and remediation. Interestingly, contributions to this issue are mainly from the student fraternity of Yenepoya Institutions. The editorial team appreciates all students who have contributed as well as the reviewers for their timely help to bring out this issue. Articles in this issue could be divided into three subdivisions: 1) The current status of specific habitats; 2) Technology available for the restoration of ecosystems; 3) The significance of natural manure in soil enrichment.

The first article on geotagging envisaged projecting the significance of environmental concern as well as its importance in our day-to-day life. It is a vital step to follow the degradation, monitoring and rehabilitation of ecosystems and the environment. The second article on mangrove forests (involve in the enrichment and protection of coastal areas) provides contributions, degradation and restoration. Threats and conservation aspects of olive ridley turtle have been discussed in the third article. Frozen ground (called permafrost) is a kind of ecosystem that exists in different parts of the globe, its classification and the impact of climate change have been discussed in the fourth article. According to the fifth article, up to 40% of land in the world is degraded or on the verge of degradation. Causes for such degradation and restoration have been forecasted. Biochar can be obtained by pyrolysis of woody materials (burning in the absence of oxygen), it has multiple applications in the agricultural front is the subject matter in the sixth article. The mineral composition of guano of an endemic insectivorous bat has been given in the seventh article. The role of bacteria in the remediation of oil spills in oceans is the subject matter of the eighth article. The use of plants in the remediation of soil and its quality restoration is the main aspect of the ninth article. The tenth article drew attention to the use of bioplastics instead of synthetic plastics to restore environmental health.

This GREEN HORIZON issue projects many interesting facts about the ecosystems and environment. Insights of technology in rehabilitation of the environment and enrichment of soil to improve productivity are given. These articles will be useful to the readers of this magazine. In anticipation of many more thought-provoking articles for the future volume of GREEN HORIZON…

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Geotagging – New Way of Displaying Information

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Introduction

The availability of advanced technology related to global location has provided an opportunity to explore remote sensing and global positioning on a large scale for various applications. An observation of the target without any contact by a device is the delineation of remote sensing (Barrett and Grant, 1976). Remote sensing is used to analyze many parameters. In the development of forest fire hazard maps, digitally thematic maps were integrated with other layers were used (Chuvieco and Cogalton, 1989). In flood monitoring also remote sensing technology along with the geographic information system (GIS) is the key tool applied (Sanyaland Lu, 2004). Black and white radar imagery and aerial photography can be employed for groundwater exploration, to define some of the hydrological and hydrogeological features (Edet et al., 1998). Remote sensing technology is highly suitable for analyzing urban growth and helps in the formation of the future planning of an area. Even in the monitoring of biological hotspots like mangroves and coastal regions remote sensing technology is useful.

Geotagging Process

Geotagging is one of the new ways used to monitor plants, which is also can be used to promote plant growth. This system became widely used and the continuous improvement in the system helps the adaptability for the various scenarios. Geotagging is the process in which the addition of geographic identification and location will be done to metadata. Mostly in digital media, this process is carried out, which will help in effective picturing (Welsh et al., 2012). The geotagging process was developed from GPS, so it also uses latitude and longitude coordinate systems. Usually, geotagging has coordinates, places, and distances as metadata. Currently, the social media platforms like Facebook, Instagram and others provide geotagging along with images.

Coordinate System

Latitude and longitude are used to identify the position and location on the earth. Geocentric, astronomical and geographic are the three different types of latitude that divide the earth through the equator. Longitude divides the globe east or west through prime meridian (Greenwich). The combinations of parallels and meridians will give the exact location at any point in the globe. These coordinates are expressed in degrees, minutes and seconds (Fig. 1).

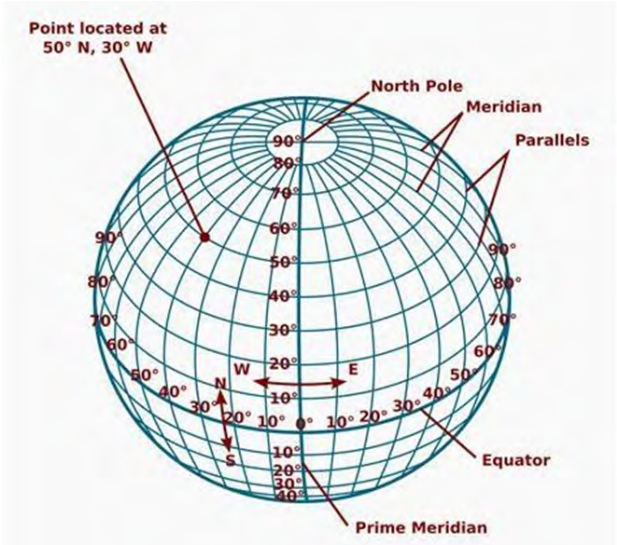

Fig. 1. Latitude and longitude (medium.com).

Global Positioning System

Global Positioning System (GPS) is a radio-navigation system based on satellite (Chetan and Muneshwara, 2021). The GPS is owned by the United States and is currently operated by its space force. Currently, 24 GPS satellites are

revolving around the earth every 12 hours, which is sending synchronized signals. The GPS uses latitude and longitude to coordinate models. Three main parts of the GPS are the satellites, the ground controlling system and the user apparatus. Satellites will send a signal, which holds information regarding the geographical position, the ground controlling system monitors those transmissions and the user apparatus will receive the signal, and display the required information. For error removal, the signal transmits the information when at least four satellites touch the receiver. The GPS has extensive use in soil mapping, field mapping, navigating and others (Fig. 2).

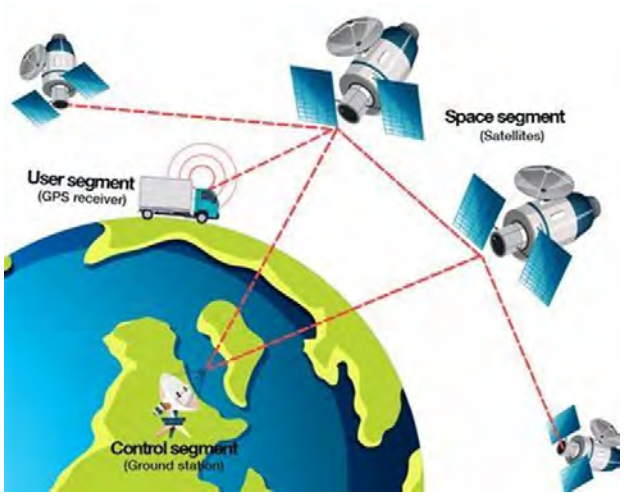

Fig. 2. GPS Working (oneleap.in).

Application of Geotagging

Geotagging can have wide applications in the present scenario. The real estate market is using geotagging for instant identification of available houses for sale with the pictures and required information. Monitoring the plants by geotagging is an innovative way to save and track the individual tree. Social media platforms also customs geotagging to attract more and more users. Geotagging and geo-fencing (setting boundaries for a location) can be used in logistics to manage the timing and economic benefits. E-Commerce is using geotagging to create brand awareness.

Real Estate Geotagging

With a motto of "Think Global act local", the real estate market leans towards globalization (Pődörand Nyíri, 2010). To be successful in the following process providing information acts as the main derivative factor. Spatial data is one of the factors that attract customers and helps to give a better picture of the project. Through geotagging and high-quality image tool, strategic planning can be enhanced. The usage of GPS and geotagging starts with the decision support phase and feasibility study. Geotagging assists to differentiate the sectors of real estate. Geotagging with more attributes like nearest schools at the location, nearest social amenities at the location and crime data or transportation links provide accurate images of the building (Fig. 3).

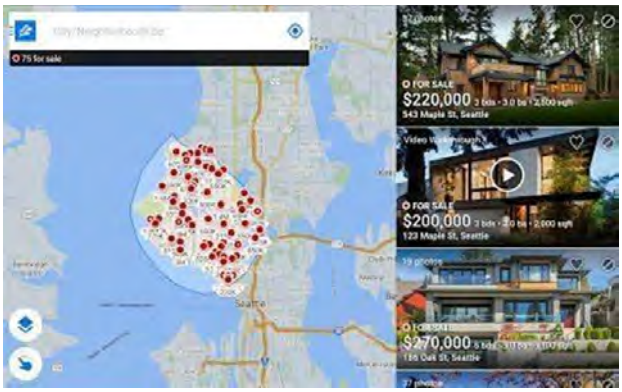

Fig. 3. Geotagging in real estate (pinterest.com).

Geotagging also helps in distinguishing agricultural land and non-agricultural land. With the details of geotagging of many sites, trends like purchasing behavior and demographic behavior can be analyzed. It also relieves locations targeted by competitors. In the valuation of the project, geotagging helps by providing data like the location of the building and its position within the building and helps in valuation.

Monitoring of the Plants by Geotagging

Nature is the accumulative space where living organisms thrive to survive with the coordination of abiotic components. Nature is the main influence allowing human civilization to grow and live to prosper. Air, water, soil and vegetation are the main elements of the environment. Contaminating these factors is proved to be disastrous for mankind. Flora is one of the essentials, which has a significant role in nutrient

cycles and plays a vital role in declining global warming. It is the main source of food for living organisms and provides an aesthetic view that will give economic benefits to the locals. Deforestation poses a huge threat to the survival of human beings for obvious reasons. The rate of deforestation around the world is rapidly increasing. The world has lost 11% of forest cover and 16% of tree cover in the last 20 years (global forest watch). There are many innovative ideas are developed to reduce the cutting of trees and save nature as it is.

Using the geotagging process for monitoring the plant is extensively practiced. Not only plant observation but geotagging for any other process requires appropriate equipment. The availability of smartphones which acts as user apparatus to receive the transmission from ground-controlling system and satellites made geotagging renowned. Other than smartphones, equipment like handheld GPS receivers (Garmin Etrex) can also be used for more precise measurements (Fletcher et al., 2003). Hand-held GPS receivers can only take one attribute for which coordinates for the visual inputs camera are necessary. To synchronize both the data, additional software may be necessary. Smartphones give the opportunity to add spatial data along with GPS location (Fig. 4).

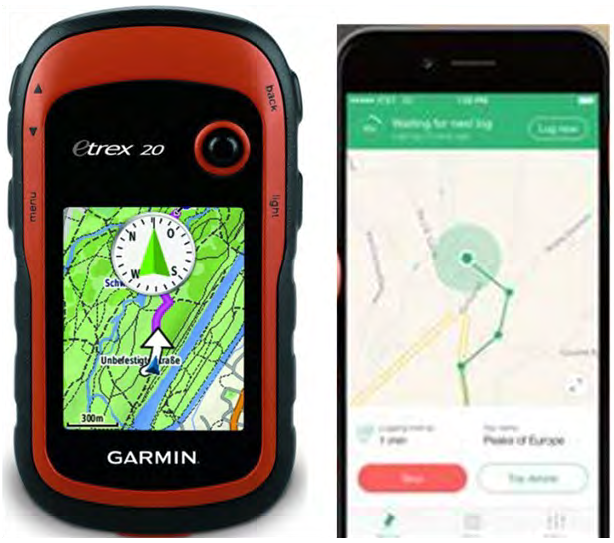

Fig. 4. Hand held GPS receivers (Mobile GPS Apps).

Field study is the usual way to obtain more than one attribute and for the supervision of a plant, field study is vital. Along with location in latitude and longitude, type of the plant, name of the plant, height of the tree, the girth of the tree and much other information can be collected to add digitally. The study conducted with the help of a handheld GPS receiver is also required to take proper images of the trees. A specific field study needs to geolocate all the plants in the study area and record other details accordingly.

Smartphone users required a strong cellular network. High speed and high-capability network are essential to capture proper location mapping. A cellular network with increased capacity with a larger area cover, without the interference of other signals and the use of less power, is ideal for geotagging. To store all these attributes databases are used. There are many real-time fast databases that can be proposed for this purpose. Databases should update the newest data instantly and automatically, it also requires power and a higher capacity of storage. Many smartphones work with Google cloud for the storage of photos along with time and location stamps. This system provides a proper location where plants are planted with other details based on the different attributes added, which will be efficient to track the plant study for long period.

Social Media Platforms

Social media platforms like Facebook, Instagram, Snapchat and others offer geotagging features for their users. Apps provide the option of using real coordinates or the nearest landmark (Fig. 5). It offers content creators to display their location, which helps in their brand enhancement and also the engagement of followers.

Fig. 5. Geotagging in social media (picnotes.org).

Geotagging attracts local buyers for the products and services. Tagged posts of merchandise and amenities aid to post reviews, suggestions, quality surveys and counts. Messages to the customers for their support based on the geotagged social posts develop customer relationships. Geotagging can be done for various types of posts like photos, videos, stories and events, which will show up in 'explore' options and helps to reach the maximum audiences. Action plan development for the use of geotagged posts helps to expose the target viewers. Brands can use geotagging for the posts as social proof for growing audiences.

Logistics of Geotagging

In logistics, geotagging plays a very important role. The location of the nearest storage unit for the farmers to distribute the consumer's geotagging helps the logistics process (Fig. 6). Storing the farmer's product at the nearest location reduces the waste and benefits from getting fair prices. Geotagging of the distribution vehicles provides helps in getting real-time location, route, mileage history, current state and working hours, which can be done by adding more attributes. Such information helps in decision-making on performance and financial benefits. Geofencing alerts or notifications can be triggered when a vehicle over speeds or has rash driving incidents. The supply chain can be controlled with the help of geotagging.

Fig. 6. **Geotagging in logistics (dreamsite.com).**

Geotagging in E-Commerce

E-Commerce is currently concentrated on account-based marketing. Such marketing uses location for the improvement of sales. High-traffic zones will be ideal for geotagging to decide the supply time. Being easy and affordable technology, geotagging aids the notification of the product's arrival to the customers. Verifying small-scale businesses by a large trustful organization like Google marketplace and geotagging seems advantageous. Geotagging also helps in marketing during regional holidays. This technology can be used in search engine marketing, local SEO optimization and lead segmentation of the local market.

Limitations of Geotagging

Easy, low cost and adaptability are the advantages of geotagging, but there are some limitations. Accuracy and privacy risks are some limitations. To get the right information network capacity, satellite placing for the spot and the addition of proper and truthful attributes is the key to geotagging. At least, four satellites need to connect to the receiver to get error-free data. The 3-G or 4-G network is recommended for smartphone-based geotagging for higher accuracy. The right information is required to add as an attribute for the appropriate and accurate geotagging process. Leakage of privacy data is another significant risk processed by geotagging. Location and other attributes like name and address are vital information that may acquire by scammers. That information can be sold to advertisers. Personal details may give different appearances of you. The details of the whereabouts of users may be used to threaten malicious parties. Geotagged photos and attributes associated with that photos will be accessed by anyone.

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Restoration of Mangrove Forests

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Introduction

Mangroves are located in the intertidal zone of tropical and subtropical regions such as estuaries and coastal shorelines. Mangrove forests often called mangrove swamps or mangals have a restricted number of species such as trees that have adapted for intertidal zones.

In mangrove areas, organisms are exposed to changes in salinity, temperature and moisture as a result of changing ocean tidal currents. Thus, mangrove plants must undergo some physiological adaptations to overpower oxygen deficiency, increased saline conditions and frequent tidal surges. The plant species which can endure these changes survive in this environment and hence selected species comprise the mangrove ecosystem.

Around 110 species of mangrove trees grow in this saline swamp, among which only a few are from the Rhizophora genus. Although there are few varieties of trees, they provide habitat for a large number of marine organisms mainly fish and shellfish which depend on them for breeding and reproduction.

Importance of mangrove forests

Mangrove forests play a significant role in the carbon cycle and are reliable carbon sinks in aquatic ecosystems. They are an important source of blue carbon. They provide protection from tropical storms to coastal communities around the world. The flora and fauna together constitute a valuable biodiversity zone that offers various ecosystem benefits to human beings. Since they are rich in commercially important fish and crustacean species, they offer a nourishing and nurturing environment for reptiles, migratory birds and mammals.

They shelter river banks by absorbing floodwaters and controlling the flow of water. When the flow of sediment-loaded water decreases, the residues along with potential toxic matter settles down in the bottom thus enhancing the water quality and maintaining hygiene in coastal regions.

Mangrove forests provide local sources of sustainable income to local communities from fishing, timber harvesting, and from selling valuable forest products. They also play a role in climate change mitigation by eliminating carbon which is significantly comparable to terrestrial forests. Due to these unique characteristics, the conservation of mangroves is a global priority.

Loss and degradation of mangroves

Mangrove trees typically grow in the upper portion of the intertidal zone. The high sea level or lower portion of the intertidal zone may hinder its growth. The type of species selected and the growth factors also affect the success of mangrove plantations. The restoration of mangrove vegetation is of utmost importance due to its degradation which is accelerating more than in tropical rainforests. Recent studies have shown that approximately 20% of mangrove forest has been lost in twenty-five years with only 147,000 km2 left worldwide.

The main cause for mangrove degradation is urbanization projects such as building factories, residential places, aquaculture, agriculture (For example paddy fields), grazing land for livestock, production of salt and tourism activities. In addition, overexploitation of groundwater sources, hydroelectric projects, construction of roads and canals across rivers have further added to the deterioration of

mangroves.

Mangrove forest restoration

To compensate for the loss of mangrove forests, restoration projects have been carried out around the world. These projects aim to regenerate forests in areas where mangrove forests previously existed. It includes growing seedlings in greenhouses and subsequently planting them into salt marshes. The main objectives of restoration projects are the improvement of endurance and tolerance of mangrove vegetation.

Mangrove restoration strategies face a lot of challenges because of their sensitivity toward storms, sediment barriers and changing sea levels. Different methods tackle this problem in different approaches. The most prevalent technique includes planting single-species stands of mangroves in suitable regions which may or may not have accommodated mangroves in the past. However, the drawbacks of this method are that it is not favorable for a long duration due to unsatisfying soil and hydrological requirements.

Many advanced techniques are applied to re-establish ruined forests into their former glory by considering social, ecosystem, cultural and political components. These methods work on the principle of secondary succession where the mangrove forest can mend itself naturally. Here mangroves are not planted physically but allowed to grow on their own under an adequate amount of seedlings and ideal hydrological conditions.

The Ecological Mangrove Restoration method is one such approach, which involves the following steps:

- Study the breeding and geographical arrangement of the mangrove plants at the deteriorated site;
- Determine the elevation of topography and ocean currents which are suitable for the growth of mangrove seedlings;
- Monitor the alteration that occurred at the destroyed site that presently obstructs the natural secondary succession process;
- Construct a rehabilitation strategy that starts recovering the elevation of topography and ocean currents at the site;
- Regular monitoring of the site to check whether the restoration objectives have been met.

Restoration objectives also include structural modifications like detached breakwaters, protecting the degraded site from ocean currents and allowing an adequate amount of sediment to build up on the site. If the secondary succession method fails to achieve its goal of restoration, then physical planting is an alternate choice that has a low success rate.

The traditional technique of restoration is slow and challenging. A modern technique that uses quadcopters has been invented for sowing purposes. The advantage of this method is that it is less time-consuming and can sow in risky places where humans cannot work. Drones can also be used to develop restoration plans in degraded areas and constant monitoring of restored areas.

Mangroves for the Future

Moreover, the Mangroves for the Future (MFF) is an initiative led by the International Union for Conservation of Nature (IUCN) and the United Nations Development Programme (UNDP). The motto of MFF is the recovery of mangrove forests by engaging with local collaborators and initiating the plan.

MFF saw success in Indonesia where 40,000 trees were planted, which brought action from the local government on a large scale (Fig. 1). Restoration of mangroves and their protection is also one of the approaches under COP21 (An international treaty on climate change). The treaty has been signed among different countries which formulate the set of policies and actions called Nationally Appropriate Mitigation Approaches (NAMAs) to reduce GHG emissions. Some of the least developed countries have prioritized mangrove restoration in their NAMAs.

Fig. 1 Planting mangroves in Kendari bay, Indonesia (Source: https://chinadialogue.net/en/nature/mangrove-restoration-scales-up-in-indonesia/).

Further Reading

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Olive Ridley Sea Turtle

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Introduction

The olive ridley sea turtle belongs to the family Cheloniidae and is also known as the Pacific ridley sea turtle. It is the most abundant and second smallest sea turtle found around the world. They are predominant in the Pacific and Indian Oceans and are also found along the warm waters of the Atlantic Ocean.

Taxonomy

The olive ridley sea turtle belongs to the genus, Lepidochelys which is a Greek word where lepidos means scale and chelys mean turtle. This name is due to the presence of many costal scutes seen in this genus (Fig. 1). The origin of the common name "olive" refers to its green-colored shell and the word "ridley" may be derived from "riddle". Lepidochelys consists of two species namely, L. olivacea (olive ridley) and L. kempii (Kemp's ridley). A synchronized mass nesting behavior called 'arribada' is unique to these species where thousands of female turtles gather to lay eggs on the same seashore.

Fig. 1. An Olive ridley turtle coming out of the oceans to mate on the coast of Orissa (Credit: www.wwfindia.org).

Habitat and Distribution

The olive ridley turtles are seen throughout the tropics in the Pacific and Indian Oceans of India, Arabia, Japan, Micronesia south, southern Africa, Australia and New Zealand. It is also noticed in the Atlantic Ocean, particularly on the western coast of Africa, the coastline of northern Brazil, Suriname, Guyana, French Guiana, and Venezuela. In the Caribbean Sea, olive ridley is found in Puerto Rico whereas in the Pacific region they have been found in Baja California, Mexico, Chile, Costa Rica, Mexico, and Nicaragua.

Importance

In ancient times, these turtles have been misused for food, bait, oil, leather, and fertilizer by humans. Although its meat is not valued as a delicacy, eggs are regarded as esteemed everywhere. In spite of the strict regulations on the collection of eggs, it is hardly followed in some countries. In several regions, legal egg harvesting practice is allowed since it contributes to local economies.

The socioeconomic, cultural, and political aspects of egg collection were studied on different arribadas beaches and it showed that the legal egg collection at Ostional and Costa Rica is biologically sustainable and economically viable.

Threats

- *Bycatch in Fishing Gear*

The unintentional capture (bycatch) of sea turtles is a common threat. Bycatch of turtles can happen by using different types of fishing gear such as trawls, longlines, gillnets, and purse seines which may result in their death due to drowning or injury.

◆ *Direct Harvest of Turtles and Eggs*
The large-scale nesting behavior of olive ridley allows the mass hunting of female turtles and the illegal harvesting of their eggs for consumption. Earlier, the long-term collection of eggs was a major issue, however, it has been reduced in recent years due to strict regulations in some countries.

◆ *Loss and Degradation of arribadas*
The rising sea level as a result of climate change and some coastal development projects are the major reasons for habitat destruction. The dry sand which is suitable for successful nesting is lost due to shoreline hardening or armoring (e.g., seawalls). Light pollution due to artificial lighting along the beaches can cause distraction in female turtles which arrive on the shore for nesting. Also, it can deceive baby turtles trying to find their way toward the ocean from their nesting habitat.

◆ *Predatory organisms*
Young hatchlings and eggs are eaten by birds, crabs, raccoons, snakes, feral pigs and dogs whereas sharks feed on adult turtles.

◆ *Vessel Strikes*
Different types of watercraft including boats, ships, hovercraft and submarines pose a great threat to sea turtles, specifically females who migrate to the seashore for reproduction. The marinas and inlets which have high boat traffic can cause injury and death to olive ridley turtles.

◆ *Marine Pollution*
Sea turtles are vulnerable to increasing marine pollution which can cause their death or may deteriorate their habitat. The non-degradable pollutants such as plastics, balloons, floating tar and oil leakage can harm eggs, hatchlings and adult turtles. Some wastes like fishing gear can trap turtles causing their death. Recent studies have reported that fibropapillomas which is a tumorigenic disease seen in many sea turtles are associated with marine pollution.

◆ *Climate Change*
Climate change can result in an expanding ocean and increase sand temperature, which can be harmful to eggs or change the sex ratio of hatchlings produced. Erosion of shoreline due to rising sea levels and natural disasters results in flooding of nests, washing them away.

Conservation
- Establishing international agreements and implementing measures to conserve and protect olive ridley sea turtles.
- Developing strategies to bring changes in fishing gear practices. For example, using large circle hooks and spatio-temporal measures can reduce bycatch.
- Regular monitoring of turtles in their marine habitat and nesting area.
- Studying threats to turtles and developing protective measures to lessen the harm caused by humans.
- Improvising conservation strategies by performing an in-depth study on the biology and ecology of olive ridley sea turtles.
- Creating public awareness by conducting outreach activities and educating people about the importance and threats to sea turtles.
- Raise awareness and protect them from illegal trading.

Further Reading
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Permafrost - The Frozen Ground

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Introduction

Any ground found on land or under the sea, which remains below 0°C for more than two years is called permafrost. It is seen in the northern hemisphere, southern hemisphere and on mountaintops. Around 11% of the earth is underlain by permafrost significantly in Alaska, Canada, Greenland, and Siberia. Though the permafrost ground is frozen, these regions are not always covered in snow. Karl Ernst Von Baer is credited as the founder of scientific permafrost research due to his original study on the perennial ground ice. His studies on the distribution and morphological descriptions of permafrost have been proven to be correct recently.

Permafrost zones

A combination of rocks, soil and sand held together by ice makes up permafrost. The soil and ice components of permafrost can remain frozen throughout the year. A layer of soil near the surface region of permafrost that does not stay frozen all year, which freezes and thaws annually, is called the active layer (Fig. 1). This layer is thin (4 to 6 inches) in colder regions where the ground rarely thaws whereas in warmer regions the active layer is thick. In the deepest depth, geothermal heat maintains a temperature above freezing. The soil in the active layer is rich in organic carbon and the lower permafrost layer soil contains mainly minerals. In the arctic carbon cycle (permafrost carbon cycle), carbon is transferred from frozen soil to plants and microbes, and then to the atmosphere. From the atmosphere, it reaches back to vegetation, and finally to the soil. A small portion of this carbon is carried to the sea and other parts of the earth by the global carbon cycle.

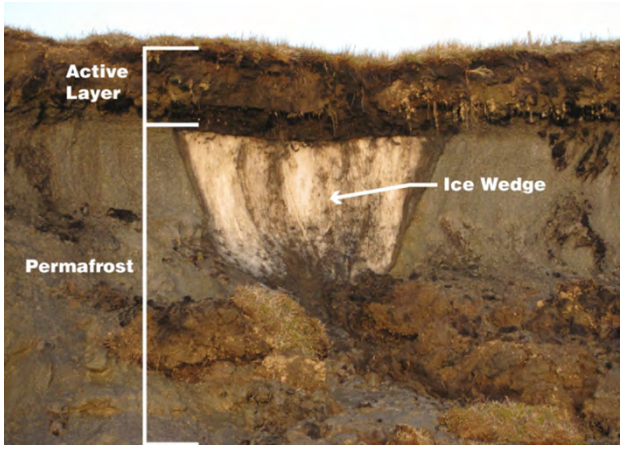

Fig. 1. The layers of permafrost (Credit: Benjamin Jones, U.S. Geological Survey).

Classification

Discontinuous Permafrost

The temperature change in the below-ground region is slower than the air temperature. At a mean annual air temperature of less than 0°C, permafrost is formed sporadically resulting in discontinuous permafrost. It remains discontinuous at the mean annual soil surface temperature range of -5°C to 0°C.

Continuous Permafrost

A continuous permafrost zone is formed when the mean annual soil surface temperature is below −5 °C which is not sufficient to thaw permafrost. The continuous the permafrost is seen in the southern border of the Northern Hemisphere. The line of continuous permafrost differs around the world as a result of changes in regional climate.

Alpine Permafrost

Alpine permafrost is found at elevations with low enough average temperatures to encourage perennially frozen ground. The total area of

alpine permafrost is estimated to be 3,560,000 km^2 and most of it is discontinuous.

Subsea Permafrost
Subsea permafrost is seen below the seabed and forms continental shelves of the polar regions. These regions were formed in the ice age when a large part of the water was arrested between ice sheets at low sea levels. The melting of ice sheets into seawater under warm conditions results in submerged shelves. Therefore, subsea permafrost occurs in conditions where their decline is observed.

Impact of climate change on permafrost
Permafrost is sensitive to climate change, hence it is thawing faster in different parts of the world (Fig. 2). As the earth becomes warmer, the ice in the permafrost melts leaving only water and soil. Melting of permafrost can have the following consequences on earth:

- Destroy houses, roads and other infrastructure in many northern pole countries which are built on permafrost.
- Release of greenhouse gases into the atmosphere as the trapped organic carbon in the permafrost soil starts to decompose.

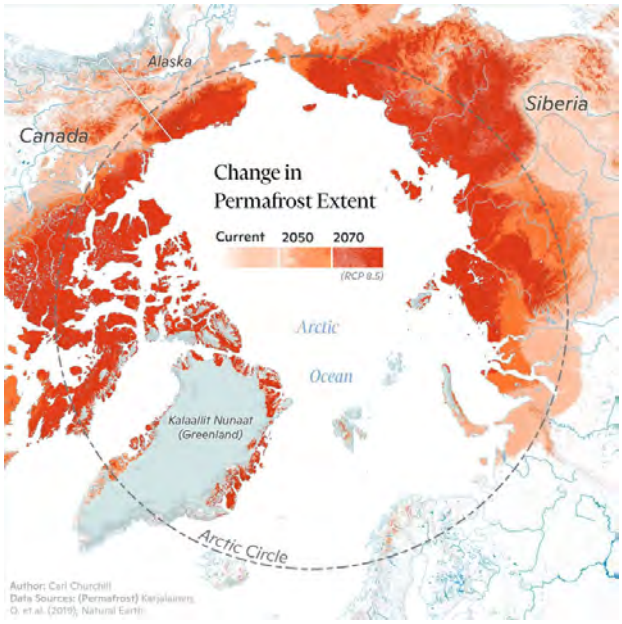

Fig. 2. The extent of change in permafrost. (Credit: Carl Churchill/Woodwell Research Center).

- Release of trapped ancient bacteria and viruses from the thawed ice and soil which may affect humans and animals. Researchers have identified 400,000-year-old microbes in thawed permafrost.

Permafrost has been continuously monitored by scientists due to increasing environmental threats. Satellites are used to scan large areas of permafrost. NASA's Soil Moisture Active Passive (SMAP) mission collects data on soil moisture levels. It can measure the amount of water in the top 2 inches of soil all over the world. It can also give information on whether the water within the soil is frozen or thawed. Hence the amount of water can help in measuring the rate of permafrost thawing around the world.

Conclusions
Although we cannot reverse the thawing of permafrost, we can take initiative to avoid the worst from happening. Permafrost is a climate change multiplier. Hence we have to reduce carbon emissions if we want to stay below 1.5°C (warming) without overshooting. It is basically impossible to grow back permafrost under rising temperatures.

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Land Degradation in India - Challenges and Management

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Introduction

Land degradation is driven by human-induced activities as well as climate change. The way land resources are currently overused and mismanaged threatens the health of the land and all life it harbours. It is the deterioration of the unique quality of land leading to the total loss of production capacity of the soil. Today, 40% of the planet's land is degraded, affecting 3.2 billion people in more than 150 countries and threatening roughly half of the global GDP. Land degradation is a major contributor to climate change it was responsible for annual emissions of up to 4.4 billion tonnes of carbon dioxide with deforestation alone contributing to all human-induced greenhouse gas emissions.

Land degradation is happening at an alarming pace largely due to deforestation and unsustainable land use and is one of the global challenges that affect food production, higher food prices, rising poverty, climate change, loss of soil fertility, destruction of species habitat, loss of biodiversity and deprivation of ecosystem services.

Primary Causes

The key drivers include rapid expansion and unsustainable management of land used for crops, forest conversion, over-cultivation, overgrazing and vegetation degradation. Underlying factors include high consumption lifestyle, increased population growth, commercial development, human settlement, migration, agricultural intensification, over-extraction of natural resources, over-exploitation of minerals and accelerating demand for land products. Water erosion mainly due to excess rainfall and floods leads to the loss of upper strata of soil. Deserts expand in some places, heat waves and droughts turning fertile lands into deserts. Water sources dry up and pressure populations to migrate to more hospitable places.

Impact on Climate Change

Land degradation is one of the causes of climate change. Owing to land degradation, the soil loses its potential to take up carbon triggering climate change, whereby food production increases emissions resulting in greenhouse gases in the atmosphere and loss of biodiversity. Extended heat waves and wildfires have caused major damage in recent years, including tropical storms and monsoon rain and sea level rise threatening livelihoods. The world's cultivated soil has lost between 50 and 70% of its original carbon stock, this makes for abandoned agricultural land that serves no productive or ecological purpose. Land degradation is severely affecting the world's drylands causing droughts and accelerating desertification.

Mapping Degradation in India

India is the 7th largest country possessing 328.72 million hectares area and at present roughly 97.85 million hectares of the total geographical area is degraded. The recent report shows that in 2003-05, 94.5 mha (28.7%) of the total geographical area underwent land degradation and during the time period 2011-13, there was an increase in degraded land i.e. 96.4 mha (29.3%). During 2018-19, about 97.8 mha (which is nearly 30%) of India's land is under degradation. The most significant cause for the country's land degradation was due to soil erosion (10.98%, 2011-13; 10.83%, 2003-05), vegetation degradation (8.91%, 2011-13; 8.60%, 2003-05) and wind erosion (5.55%, 2011-13; 5.58%, 2003-05) (Fig. 1).

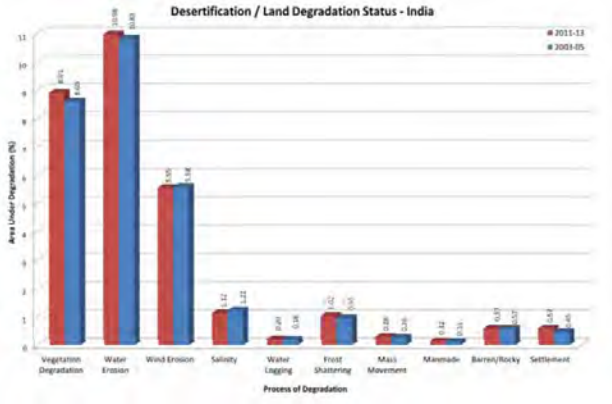

Fig. 1. Process of degradation (Source: Space Applications Centre, ISRO report 2016).

In the past 15 years, most of the Indian states have experienced an increase in land degradation. Among the 97.84 mha of decertified land, about 45 mha were found degraded in the states of Rajasthan (21.23 mha), Maharashtra (14.3 mha) and Gujarat (1.02 mha) (Fig. 2).

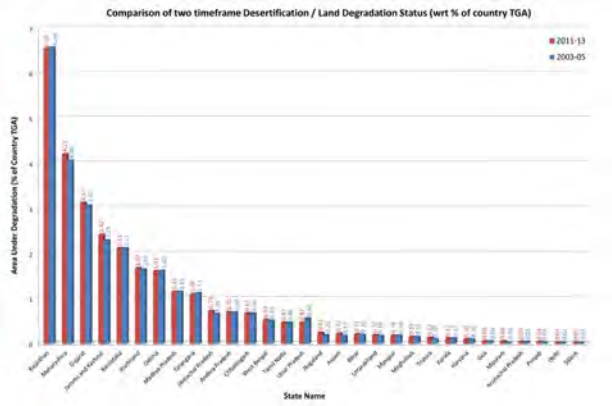

Fig. 2. State-wise status of land degradation in India (Source: Space Applications Centre, ISRO report 2016).

The analysis with respect to the individual states showed that Delhi, Goa, Gujarat, Jharkhand and Rajasthan showed more than 50% area under land degradation in comparison with Arunachal Pradesh, Assam, Bihar, Haryana, Kerala, Mizoram, Punjab and Uttar Pradesh, which contributes less than 10% area under land degradation. Rajasthan reclaimed about 388,000 hectares area, Uttar Pradesh about 285,665 hectares area and Telangana with about 19,974 hectares area.

Certain measures are taken by India to curb land degradation. In 2014, National Mission on Green India aimed at protecting, restoring and establishing forest covers. National Afforestation Ecodevelopment Board (NAEB) has implemented afforestation in degraded forest land since the year 2000. India in the 14th session of the Conference of Parties of the United Nations Convention to Combat Degradation (UNCCD) discoursed restoring land is gaining drive globally on the release of the reports Intergovernmental Panel on Climate Change (IPCC) and Special Report on Climate Change and Land (SRCCL). India has a target to restore 26 mha ofarea (21 mha of forest land and 5 m ha non-forest area) and is challenging to achieve its national commitment to Land Degradation Neutrality (LDN).

Land Restoration

We can protect what we have left and fix much of what we have destroyed, restoration and conservation is the key to survival. Planting trees is the best option to reduce the consequences of deforestation, it can reduce soil erosion. The exploitation of forests for timber can be reduced by the use of mud bricks for construction. Practicing water development and fertilizer application can control overgrazing by providing time for re-vegetation and helps to reduce the overuse of land. Livestock density in a particular grazing area should be controlled. Good crop management practices can reduce soil and water erosion.

Fertile land nearby urban area needs to be protected, because of the tendency of converting such land for commercial purposes. There should be proper discharge and disposal of industrial effluents and wastes after treatment. Using advanced technologies rather than conventional methods for mining, after mining the soil can be refilled and reclaimed for plantation. Tangible practices involve terrace/contour farming, restoration of watersheds and rainwater harvest. Educating and training towards capacity building is necessary for local communities, government officials and planners. Sustainable agriculture and aquaculture should be implemented to reduce the ecological effects. Investments are necessary to sustain and rebuild productive areas,

restore river channels, mitigate the effects of drought and develop green infrastructure.

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Biochar and Its Multifunctional Applications

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Introduction

Biochar is a highly porous, carbon-rich substance synthesized from the pyrolysis of organic biomass. Biochar production is a sustainable solution for waste management as it contains 50% of the original carbon which otherwise is highly unmanageable naturally. The production of biochar helps in carbon sequestration by locking the carbon present in the plant biomass (Fig. 1). The primary composition and structural arrangement of biochar are associated with temperature, heating rate and residence time kept during its synthesis.

Fig. 1. Biochar
(Credit: https://www.grimmsgardens.com/).

A small quantity of bio-oil and gases are produced along with the biochar synthesis, which can be used for the generation of energy and various other chemicals. Soil incorporated with biochar shows an increase in pH and electrical conductivity (EC) which may be due to the presence of carbonates of alkali and alkaline earth metals, some amount of silica, heavy metals, organic and inorganic nitrogen. With its large surface area, biochar helps in increasing water holding capacity, cation exchange capacity (CEC), microbial activity and also reduces the leaching of nutrients by providing nutrient binding sites. It also increases crop productivity, improves soil quality, decreases greenhouse gas emission, decreases the dissipation rate of herbicide in soil, cleansing agent in the cosmetic industry, wastewater treatment and the food industry.

History of Biochar

The term 'biochar' was coined recently although the concept of biochar is not new. Various pieces of evidence indicate the usage of biochar from time immemorial, for example in the Amazon Basin. It has been discovered that the soil up to two meters in depth throughout the Amazon Basin is the regions of terra preta. The soil of this region is dark in color, contains high amounts of organic matter, is highly fertile and supports the agricultural needs of the entire region for centuries. The soil from terra preta has neutral pH and good nutrient retention quality that makes the soil in this region productive compared to the soil in the nearby region. The presence of terra preta near human habitation indicates that they are produced by humans. There are many theories regarding the evolution of terra preta soil. Some assume that in olden times slash-and-char technique was practiced which is responsible for the dark colour soil. This technique involved clearing and burning vegetation within a small plot and letting the litter to smoulder (rather than burn) and later buried under soil, which ultimately leads to the formation of terra preta.

Biochar Production

The carbonization of wood for biochar production has been known to humans since the olden days. The enhanced biochar technology using biomass can contribute to future generation by fulfilling energy needs and improving soil carbon sequestration capacity. Biochar is produced by pyrolysis technologies.

Pyrolysis is a technique that involves thermo-chemical transformation of biomass under low or no oxygen conditions. It is divided into three categories namely fast pyrolysis, intermediate pyrolysis and slow pyrolysis depending upon the operation parameters such as heating rate, temperature, residence time and flow rate of sweeping gas. Slow pyrolysis produces more biochar than other technology involved. It can retain up to 50% of the feedstock carbon. Fast pyrolysis occurs within a few seconds or less.

The physicochemical properties of biochar mostly depend on two factors as properties of feedstock and the final temperature used. Further, the heating rate applied during pyrolysis, the residence time of the char in the reactor and the gas flow rate time also influence its properties.

Applications of Biochar

Biochar as a soil amendment was used in the region of Amazon, known as terra preta several thousand years ago. Biochar is an excellent soil conditioner and possesses various beneficial qualities and therefore, can be used for various purposes. Some of the important applications of biochar are - as a tool for waste management, as a soil conditioner, as carbon sequestration and mitigation of climate change, as treatment of wastewater, building sector, cosmetic industries, metallurgy, food industry, energy production and as a support for catalyst development

The dual benefits of waste minimization and energy recovery can be achieved by biochar production. The weight and volume of initial biomass stock are reduced by pyrolysis, thereby reducing the space needed for its disposal. Also the addition of biochar in the soil assists to maintain the soil nutrient which otherwise would have been withdrawn from the soil. In addition, it helps in the mitigation of GHG emissions such as methane and carbon dioxide that are generated from traditional waste disposal, processing and recycling operations.

Biochar is widely used as a soil amendment in fields. It improves overall soil quality. Biochar enhances the water-holding capacity of the soil thus assisting in water retention for a long duration which is due to its highly porous structure. Hence, it reduces the cost involved in irrigation by minimizing its frequency and intensity. An increase in soil pH of acidic soil when biochar is added has been observed. Thus, biochar possesses a liming effect on soil. Addition of biochar in soil results in increased cation exchange capacity (CEC) which in turn reduces the loss of nutrients, especially NH4+ through leaching. Due to high CEC and nutrient retention biochar increases the nutrient use efficiency of the soil which otherwise gets washed away due to precipitation. When the biomass is converted to biochar, 50% of the carbon present in the biomass gets trapped in its structure which is more stable in nature as compared to the biomass which on degradation releases the carbon back into the atmosphere. Thus, biochar acts as a carbon sink.

Biochar is used for the removal of organic compounds such as pesticides, volatile compounds, chlorine, certain metals and others. Active biochar filters are effective in the removal of sediments, volatile organic compounds, odour, chlorine and taste. The low thermal conductivity and water absorption capacity make biochar a good building material for insulating buildings and controlling humidity. The ability of biochar to adsorb chemicals makes it a popular ingredient in facial masks, soaps and beauty creams. In the food industry, biochar is used in the purification of liquid sugar, decolourization of alcoholic beverages, fruit juices, starch-based sweeteners, and detoxification of fish oils and vegetable oils.

Biochar is a sustainable alternative to coal for the production of energy. A co-product during biochar production, Syngas is used as a fuel in

gas engines and turbines. It can also be converted into clean diesel fuel or be used to produce methanol and hydrogen. Bio-oil can be used as a substitute for fuel oil.

The increasing oil crises and environmental impacts have forced humans to develop and search for other renewable sources of energy such as biofuels. However, the large-scale production of biodiesel is challenging due to its high cost and low yield. For the production of biodiesel in industries, homogeneous catalysts are used to increase the yield and speed up the reaction, but the catalyst has disadvantages like catalyst separation and its re-usability. To overcome such problems heterogeneous catalysts are considered a good alternative and research are going on towards the production of catalysts which is prepared either from biomass or from waste generated in the households. Recently studies have revealed that biochar is a good option for making carbon-based catalysts and more research is being carried out in this field due to the cost-effectiveness and easy availability of biochar.

Potentials of biochar use in India

Production of biochar is the latest technique in India. Activities related to biochar production and applications are restricted to a few groups only. Two NGOs, ARTI (Appropriate Rural Technology Institute) and Janadhar in collaboration with RaGa LLC, are working jointly on biochar production in rural areas from sustainable resources such as organic municipal solid waste, waste biomass, and bagasse.

In India, most of the work on biochar is concentrated on its application in the agricultural sector to improve soil quality and as a sustainable method for waste management. Nevertheless, some research is going on for the production of catalysts, their activation and their analyses for potential use in the removal of toxic elements from soil and water.

Conclusions

Many problems associated with the increasing world population have arisen like increased demand for food, growing energy needs, waste management and environmental degradation. Biochar with its multiple roles can address all these issues in a sustainable manner. Production of biochar and its subsequent use in the field as a soil amendment from agricultural waste fulfills the twin goal of waste management and improvement of soil quality. Biochar reduces reliance on fertilizer and the frequency of irrigation in agriculture. Apart from agricultural benefits biochar also possesses some environmental benefits like mitigation of GHG, remediation of polluted soil and sequestration of carbon. Thus, biochar production and application can be regarded as a viable solution to an array of modern-day problems.

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On the Mineral Composition of Insectivorous Bat Guano

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Introduction

Application of synthetic fertilizers and pesticides in agriculture is responsible for the loss of soil health as well assoil fertility. Use of green manure, farmyard manure and natural manure (e.g., vermicompost) along with bioinoculants is necessary to restore soil health to improve productivity (Kale et al., 1992; Thampan, 1993). Besides farmyard manure (bovine dung and urine), many animal-derived organic manures are valuable for sustainable agriculture (e.g., bat guano, millipede compost, night soil, biochar, poultry manure, sheep manure, silkworm refuge and vermicompost) (Kale et al., 1992; Ndegwa and Thompson, 2001; Ashwini and Sridhar, 2006; Sridhar et al., 2006; Sridhar et al., 2013).

Bat guano is one of the unconventional fertilizers that possess nutrient components to cater to the needs of plant growth and productivity (Sridhar et al., 2007). Assessment of bat guano is helpful to understand their ecology, habitat preference, feeding guilds, prey-predator connections, flight activity, seed dispersal, pollination, mineral content, fertility value and nutrient cycling (Sridhar et al., 2006; Emerson and Roark, 2007; Voigt et al., 2007; Rakotoarivelo et al., 2009; Monto, 2010; Stephenraj and Issac, 2010; Clare et al., 2011). Insectivorous bats, widely distributed in different ecosystems worldwide, are responsible for ecological balance and nutrient cycling. The guano from bats accumulated in caves has been used as natural manure in different parts of the world. Recently, the nutritional value of several insectivorous bats has been investigated (*Hipposideros fulvus*, *Megaderma lyra, Rhinopoma hardwickii*, *R. microphyllum*, *Scotophilus heathii*, *S. kuhlii* and *Taphozous nudiventris*) (Misra et al., 2019). This note examines the mineral composition of guano of an endemic insectivorous bat (*Hipposideros speoris*) in three locations in southwestern India.

Study Area and Guano

Guano (fecal pellets) of the insectivorous bat *Hipposideros speoris* (Schneider, 1800) endemic to India and Sri Lanka (Bates and Harrison, 1997) was collected from three locations in southwest India: Kankol (Kerala) (12˚15' N, 75˚23' E), Konaje (Karnataka) (12˚48' N, 74˚55' E) and Puttur (Karnataka) (12˚78' N, 75˚18' E) (Fig. 1). Kankol and Konaje are the coastal regions, while Puttur is away from the coast and close to the Western Ghats. The fresh bat guano was collected by spreading polythene sheets below the roosting region of bats thrice at monthly intervals (September-November, 2020).The Ca, K and Na of guano were estimated by flame-emission photometry (Systronics, India: MK1/MK3) (AOAC 1995). To determine the rest of the elements (Cu, Fe, Mn, Zn and Mg), guano was digested by a di-acid mixture (HNO_3 and $HClO_4$; 3:4, v/v) and assessed by atomic absorption spectrophotometry (GBC 932 Plus) (AOAC, 1995).

Fig. 1. Snaps of *Hipposideros speoris* in Kankol with fecal pellets.

Mineral Composition

The composition of micro- and macro-minerals of three regions is given in Table 1. Magnesium content was the highest in all guano samples (2.64-3.74 mg/g), while the potassium content was least (0.002-0.004 mg/g) (Fig. 2). Micro- and macro-minerals were in different quantities in guano samples of three regions (Fig. 3).Copper content was the highest in the Kankol sample, while it was slightly lower in the Konaje and Puttur samples. Iron, manganese, calcium, potassium and magnesium contents were the highest in Puttur samples, while zinc, calcium and sodium contents were the highest in samples of Konaje.

Table 1. Mineral composition (mg/g) of bat guano of three regions (n=3, mean).

Mineral	Kankol (Kerala)	Konaje (Karnataka)	Puttur (Karnataka)
Cu	0.11	0.08	0.1
Fe	0.7	0.49	0.85
Mn	0.32	0.18	0.35
Zn	0.43	0.45	0.39
Ca	0.005	0.007	0.01
K	0.002	0.002	0.004
Mg	3.56	2.64	3.74
Na	1.05	0.83	0.55

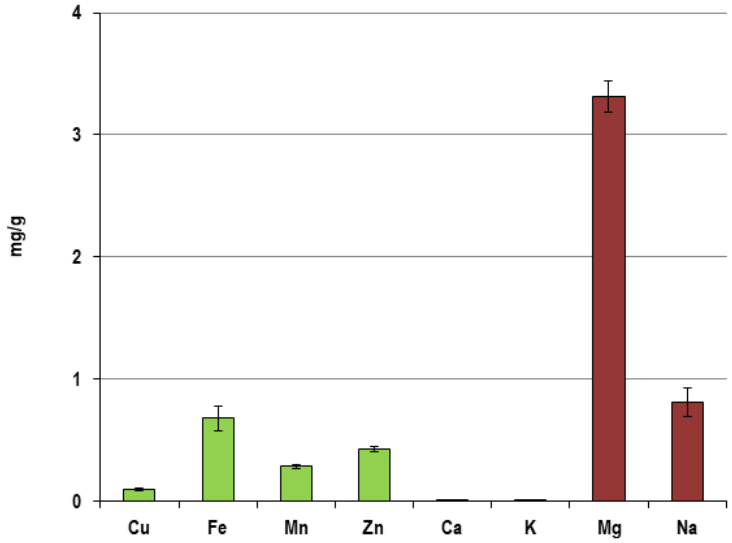

Fig. 2. Mineral composition of bat guano (n=3, meanSE).

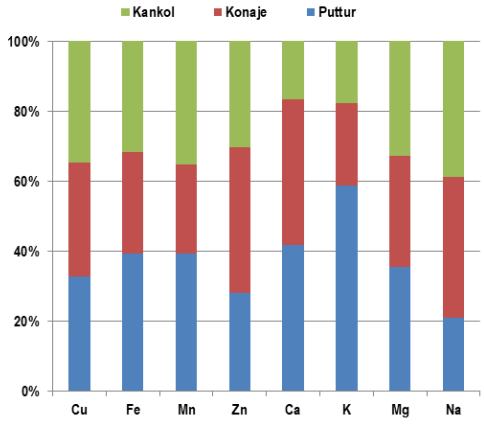

Fig. 3. Percent mineral composition of bat guano in three regions.

Discussion

Insectivorous bat guano possesses high nitrogen content, while the guano of frugivorous bats is composed of high phosphorus (Sridhar et al., 2006). In addition, the guano of *Hipposideros speoris* possesses narrow C/N ratio, which is an additional advantage to the immediate use of nitrogen present in guano by the plants. The mineral composition of bat guano in our study showed differences between the samples collected from different regions. Similarly, calcium, potassium and magnesium contents in another location adjacent to Konaje were higher than the present study (Sridhar et al., 2006). Such variation in the mineral composition of guano is possibly dependent on the diversity and distribution of insect fauna as well as flora of a specific region. The iron, manganese, potassium and magnesium contents of Puttur were higher than in the other two locations. It may be due to the interior region (adjacent to the Western Ghats) compared to the coastal regions. The guano of *H. speoris* obtained from a coastal region amended with loamy soil 1:20 (w/w) resulted in increased shoot length, dry matter, nitrogen content and nitrogen uptake in finger millet (*Eleusine coracana*) as well as black gram (*Phaseolus mungo*) (Sridhar et al., 2006). Depending on the mineral content of agricultural or garden or greenhouse or nursery or pot soils, insectivorous bat guano can be amended in different proportions suitable for plant production.

Conclusions

Owing to human interference (deforestation, intensive agriculture and pollution), the native bat species as well as their habitats (canopies, roosting and swarming) are under severe threat (Monto, 2010). Conservation of insectivorous bats and their preferred habitats has many advantages to harnessing their ecosystem services, especially insect control and the usefulness of guano as nitrogen-rich manure. Assessment of bat guano in different habitats facilitates understanding its mineral composition and to employ suitably as natural manure to amend different soils for plant production. The insectivorous bat guano is known for its high nitrogen content owing to its insect diet. However, micro- and macro-nutrients differ in the guano of the insectivorous endemic bat, *Hipposideros speoris* collected from different regions of Southwest India. Detailed analysis of insectivorous bat guano may facilitate following their insect preference in different regions as well as seasons.

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Role of Bacteria in Remediation of Oil Spills

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Introduction

Oil is a multipurpose fuel that is used to warm up our homes, electricity generation and energy sectors of our economy. However, oil can cause serious problems when it accidentally spills into the ocean by harming aquatic life. Oil spills that can occur in the rivers, bays and ocean are usually caused by accidents of tankers, canal boats, recreational boats, refineries, pipelines, drilling rigs and storage facilities. Spills can occur from natural disasters (hurricanes and storm surges or high winds), carelessness of people, breaking down of equipment, intentional acts by terrorists, war and vandals or illegal dumping. Oils float on the ocean surface spreading rapidly across the surface to form a thin oil slick that looks like a rainbow (Fig. 1).

Fig. 1. Deepwater Horizon oil spill, Gulf of Mexico in 2010 (Source: www.britannica.com).

Impact on Marine Life

Oil spills will be very harmful to marine fauna (birds, sea turtles, fish and shellfish). It disrupts the insulating capacity of fur-bearing mammals and the water-repelling potential of a bird's feathers, leading to death due to hypothermia. Oil can also poison some birds when they swallow oil while cleaning themselves or when feeding oiled prey. It can change breeding as well as growth and cause death in fish and shellfish. It can affect the safe consumption of commercially valued species (e.g., oysters, shrimp, swordfish and tuna). Oil can be mistaken for food by some juvenile sea turtles. When inhaled, oil can affect the lungs, immune system and reproductive potential of dolphins and whales (Fig. 2).

Fig. 2. Juvenile Kemp's ridley sea turtle oiled (left) and striped dolphins (Stenella coeruleoalba) observed swimming in emulsified oil (right) from the Deepwater Horizon Gulf of Mexico oil spill in 2010 (Source: The National Oceanic and Atmospheric Administration).

Role of Bacteria in Cleaning Oil Spills

Common methods for oil spill cleaning include different physical, chemical and biological processes. Biological remediation techniques are preferred among these since they make use of living organisms to carry out the detoxification of polluted sites. Bioremediation techniques are beneficial in an economical way, less labor-intensive, prevent chemical or mechanical damage and are highly sustainable. The agents used to metabolize and remove oil are bacteria, archaea, algae, fungi and some plant species. They help to break down toxic substances into safer constituents. Microbial remediation involves either increasing the microbial biomass or adding oil-eating microbes to the polluted area.

Microbes consume oil by synthesizing oil-degrading enzymes and require optimum environmental conditions to carry out this process. If the oil is heavy, viscous and in a single large slick then the remediation process is slower. In addition to this physical nature, the chemical makeup of oil also affects the degradation process. The hydrocarbons which have unbranched chain structures degrade faster, whereas the hydrocarbons with branched or ring structures are difficult to degrade and thus persist longer in the marine environment. The recalcitrant fractions of crude oil including resins and asphaltenes (non-polar and non-volatile components of crude oil) will last for several years. The availability of nutrients such as nitrogen, phosphate and other nutrients also affects the rate of the remediation process. When the nutrient composition is higher, microbes act faster compared to low nutrient levels. Biodegradation is expected to be slow at cold temperatures and high-pressure conditions.

The Process of Bioremediation

Microorganisms break down oil into simple carbon compounds, which are later utilized for their growth as energy. The simple compounds are used to synthesize sugars, fats and proteins which are incorporated to make new cellular constituents ultimately forming more microbes. The newly synthesized microbes continue the process of oil spill cleanup. Hence the hydrocarbons are not accumulated inside microbes or enter the aquatic food chain. The byproducts are carbon dioxide and water when the bacterial degradation of different oil constituents is complete. There is a possibility of partially degraded oil constituents in some cases. Although these constituents are toxic to marine organisms, they are not as harmful as the original oil components.

Microbial bioremediation can be measured by various methods such as the removal of specific oil components, the presence of byproducts (e.g., carbon dioxide), decrease in oxygen concentration and nutrient levels. Chemical analyses of petroleum components, measuring toxicity levels and increase in the level of the oil-eating bacterial population also can be taken as

evidence for measuring the degradation process. Modern technologies like computational modeling and molecular tools are also available to quantify biodegradation.

Oil-Eating Bacteria

Some of the species of marine bacteria have the capability to degrade oils (e.g., *Alkanivorax, Marinobacter, Oceanospiralles* and *Pseudomonas*). These organisms help in cleaning oil that ends up in the ocean by oil-spill or other natural oil seeps. The marine bacteria *Alcanivorax borkumensis* have the capability to absorb and digest linear and branched alkanes, which are the components in crude oil and its products. This bacterium is rod-shaped, Gram-negative bacteria and aerobic. Saprophytic bacteria, *Pseudomonas putida* is also called an oil-guzzler for its ability to degrade oil (Fig. 3). It converts styrene in the oil into biodegradable plastic, which can be effectively used in the synthesis of polystyrene foam in industries.

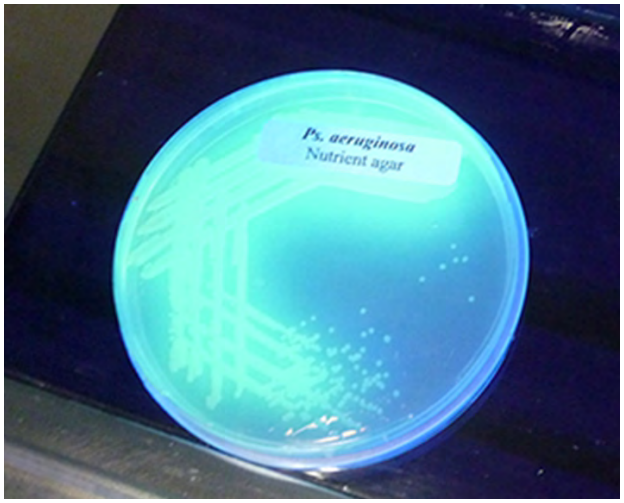

Fig. 3. Pseudomonas aeruginosa fluorescing under ultraviolet light in a petri dish (Credit: Wikimedia user Sun14916/Creative Commons Attribution-ShareAlike 3.0 Unported license).

Conclusion

Bioremediation by microbes is one of the robust and ecofriendly methods for oil spill cleanup. This field requires continued research to identify a pool of hydrocarbon-degrading microbes which can be applied under varying environmental conditions.

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Phytoremediation

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Introduction

Phytoremediation is a technique that uses plants to remove pollutants from soil. It is widely recognized as an eco-friendly approach and a sustainable substitute for engineering procedures that are harmful to the soil. Phytoremediation of polluted sites is desired to attain acceptable levels of pollutants in the environment within a decade. However, this technology is restricted to the rootzone of plants for removing toxic chemicals. Also, another limitation of this green technology is that high levels of contaminants may harm the plants. Phytoremediation technologies are applicable to varied types of pollutants. The technology involves different processes such as *in situ* stabilization, *in situ* degradation, volatilization and extraction of contaminants (Table 1 and Fig. 1).

Table 1. Phytoremediation techniques.

Technology	Action on Contaminants	Main Type of Contaminants	Vegetation
Phytostabilization	Retained *in situ*	Organics and metals	Cover maintained
Phytodegradation	Attenuated *in situ*	Organics	Cover maintained
Phytovolatilization	Removed	Organics and metals	Cover maintained
Phytoextraction	Removed	Metals	Harvested repeatedly

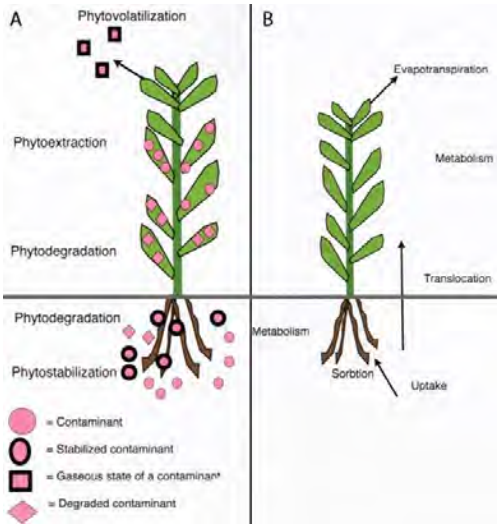

Fig. 1. Phytoremediation technologies (Griepsson, 2011).

Phytostabilization

Phytostabilization is a process to prevent the mobilization of pollutants in the soil. Plant roots modify the rhizosphere and limit the uptake of toxicants thus reducing their harmful effect on the environment. Revegetation of mine tailings is a common procedure to arrest additional dispersal of contaminants. Mine tailings have been remediated using metal-tolerant grasses such as *Agrostis tenuis* and *Festuca rubra*. Arbuscular mycorrhizal fungi (AMF) increase the metal tolerance of plants by metal sequestration in the AMF hyphae. In addition, glomalin (a glycoprotein excreted by AMF hyphae) helps in complex formation with metals present in the soil. Soil microorganisms can reduce the harmful effects of contaminants in the soil. For example, the bacterium *Pseudomonas putida* produces exudates (peptides) which can decrease cadmium toxicity in plants. Plants can also transform contaminants into less toxic forms, or reduce their bioavailability. The roots of certain plants release natural chelates (such as siderophores, organic acids and phenolics) which can form complexes with metals in the rhizosphere. The enzymes found on the roots of wetland plants have the potential to convert toxic Cr(lll) to less toxic Cr(Vl) form. In addition, plants, and their associated soil microbes, can release chemicals which act as biosurfactants thus increasing the uptake of contaminants.

Contaminants in natural and constructed wetlands are stabilized by a process called phytofiltration which involves the precipitation of metals within the rhizosphere. Metal-plaque forms generally on the roots of wetland plants through the release of oxygen through the aerenchyma of roots. Iron oxides precipitate along with other metals and form metal plaque. Metal plaque on roots stores active iron (Fe^{2+}), which in turn increases the resistance of plants toward other toxic metals.

Phytodegradation

Phytodegradation is a process of breakdown of contaminants absorbed by the plants through metabolic processes or by the action of enzymes within the plant system. Plants produce enzymes that can catalyze toxic chemicals and fasten the degradation process. Hence, organic pollutants are decomposed into simpler compounds and are incorporated into plant tissues which helps in plant growth.

Phytovolatisation

Phytovolatilization is a process, where plants absorb contaminants from soil and release them back into the atmosphere through transpiration as volatile forms. This process is facilitated as plants take up water and organic contaminants. The water absorbed by the roots travels to the leaves along the vascular system of the plant, where some of the contaminants move along with water to the leaves and evaporate into the atmosphere. This technique has been widely used to convert mercuric ions to less toxic elemental mercury which is effective in detoxifying mercury.

Phytoextraction

Phytoextraction is a method of absorbing contaminants from the soil and depositing them in the plant stem and leaves. This technique was used to recover heavy metals from soils; however, it is now used for the recovery of other materials in different systems. Greenhouse-based hydroponic systems are currently being researched for the removal of heavy metals from contaminated water. This technique requires plants with high growth rates (>3 tons dry matter/hectare/year) and the capacity to tolerate high metal concentrations in various tissues of the plants (>1,000 mg/kg).

Plants Used for Phyto-Remediation

1) Alfalfa

Alfalfa (*Medicago sativa*) is an edible herb rich in calcium, potassium, phosphorus, iron, and vitamins. Alfalfa is most commonly grown as food for livestock animals (Fig. 2). In humans, it prevents cholesterol absorption in the stomach and is used as a garnish. It is also consumed for diabetes, indigestion, and many other conditions, but there is no good scientific evidence for these uses.

Fig. 2. Alfalfa plant (www.britannica.com).

2) Hybrid poplar trees

The hybrid poplar tree, is an excellent "phytoremediator" (Fig. 3). Willows and specifically hybrid poplar have the ability to absorb harmful waste products and retain them in their woody stems. Municipal and corporate institutions are being encouraged by the benefits of planting hybrid poplar to purify toxic waste.

Fig. 3. Hybrid poplar tree (www.britannica.com).

3) Blue-green algae

Blue-green algae (also known as Cyanobacteria) are photosynthetic prokaryotes (Fig. 4) with an ability to absorb metals such as copper, lead, and cadmium through passive accumulation in cells. They are also widely used for detoxifying water bodies and other environments from toxic metals. Cyanobacteria such as *Spirulina platensis* have shown the accumulation of mercury and lead when grown in contaminated conditions owing to their phytoremediation property.

Fig. 4. Blue-green algae (www.britannica.com).

4) Arrowroot

Arrowroot (*Maranta arundinacea*) is a tropical tuber native to Indonesia (Fig. 5) and is processed into powder and consumed. Due to its high starch content and medicinal properties, it has many health benefits. It helps in treating diarrhea and helps to rehydrate the body. Many studies have shown that it can bio-accumulate heavy metals.

Fig. 5. Arrowroot (www.britannica.com).

5) Sudan Grass

Sudan grass (*Sorghum sudanense* (Piper) Stapf.) has well-developed roots and strong tolerance to heavy metals, so it has been widely used to remediate Ni-pyrene contaminated soil (Fig. 6). The coexistence of pyrene negatively affected the remediation property of Ni during phytoremediation.

Fig. 6. Sudan grass (www.britannica.com).

Advantage of phytoremediation

- Phytoremediation is an autotrophic system, simple to manage, cost-effective, low maintenance, powered by solar energy and hence economically feasible.
- It is an environment and eco-friendly technique since it can reduce exposure of pollutants to the environment.
- It can be applied over a large-scale field and can easily be disposed of.
- It protects from erosion and metal leaching by stabilizing heavy metals thereby reducing the risk spreading of contaminants in the environment.
- It can release various organic matter into the soil and improve soil fertility.

Disadvantage of phytoremediation

- Phytoremediation helps in the relocation of toxic heavy metals, however, it does not remove them from the site.
- It is restricted to the surface area and depth occupied by the roots.
- It requires a long-term commitment
- It is not possible to completely avoid the leaching of contaminants into the aquifer. And the survival of the plants is affected by the toxicity level of the contaminated land and the general condition of the soil.
- Sometimes the metal is bound to the soil organic matter, which makes it inaccessible for the plant to extract.

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Bioplastics

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Introduction

Plastics are synthetic or biosynthetic materials that are made from natural gas, cellulose, crude oil or plant oil. Most of the single-use plastic used is derived from fossil fuel materials. Approximately 4-8% of oil is used globally for the manufacture of plastics which is expected to rise to 20% by 2050. Plastics are widely used because of their low cost, strong, toughness and resistance to light and chemicals. Globally, the production of plastic is steadily increasing from 15 million metric tonnes in 1964 to 359 million metric tonnes in 2018, with a projected 2-fold increase within the next 20 years.

Although these petrochemical products have eased our life, their single-use and durable nature have resulted in a substantial increase in municipal solid waste. Currently, 40% of the plastic market is accounted for packaging, of which most are destined for single-use. In 2010 it was noted that around 12.7 million tones of plastic were dumped into oceans of which 50% was single-use plastic. The leakage of plastic debris, toxic chemicals, and microplastics has a negative impact on coral reefs, marine mammals, and terrestrial life. The plastic industry releases phthalates during the manufacturing process which has caused health concerns in humans with an increased risk of cancer.

The widely employed plastic management methods are landfills, recycling and incineration. However, the drawbacks of landfills are contamination of surrounding water and soil. Repeated recycling results in a decline in its properties. The incineration poses danger to the environment and human health. Plastics are a serious threat to livestock and an alternative to plastics is urgently needed. Bioplastics are made from plant-based products such as starch and cellulose. The use of bioplastics is a sustainable solution and contributes to reduced CO2 emissions. Recycling of biodegradable plastics by anaerobic digestion or composting methods has lower or no negative impacts on the environment.

Bioplastics

Bioplastics are plastics made of biomass materials such as corn, sugarcane and others. These substances have been increasingly spotlighted as means to saving fossil fuels, reducing CO2 emissions, plastic wastes and biodegradability. The demand for bioplastic is increasing for packaging among retailers and the food industry (Fig. 1).

Fig. 1. Bioplastic utensils
(Credit: https://www.indiatoday.in/).

One advantage of bioplastics is that they are not extracted from fossil fuel which is a non-renewable resource linked to environmental impacts. Compared to plastics made from fossil fuel materials, bioplastics have a lower carbon footprint and are ecofriendly. Both non-degradable bioplastics (such as Bio-PET or biopolyethylene) and degradable bioplastics (such as polylactic acid, polybutylene succinate, or polyhydroxyalkanoates) exist whose

degradability depends on their molecular structure. Bioplastics can be recycled similarly to conventional plastics to avoid plastic pollution. As per 2018 statistics, bioplastics constituted nearly 2% of the global plastics output (>380 million tons). With continued research on bioplastics, investment in bioplastic industries and rising restrictions on fossil-based plastics, bioplastics are becoming more dominant in some markets.

Polysaccharide-based bioplastics

Starch-based plastics

Thermoplastic starch is the most broadly used bioplastic, which accounts for nearly 50% of the total bioplastic market. By gelatinizing starch and solution casting, simple starch bioplastic film can be prepared at home. Since pure starch-based bioplastic is delicate, plasticizers (such as glycerol, glycol, and sorbitol) are added so that they can be processed thermo-plastically. By altering the quantity of these additives, the characteristics of the resulting thermoplastic starch can be modified to specific needs. Also, the properties of starch bioplastic are largely affected by the amylose/amylopectin ratio.

Starch-based bioplastics are often mixed with biodegradable polyesters to synthesize starch/polylactic acid, starch/polycaprolactone or starch/Ecoflex amalgamate. These blends are compostable and used for industrial purposes. Starch-based films are used in consumer goods packaging, wrapping fruits and vegetables, making kitchen bags and paper.

Cellulose-based plastics

Cellulose bioplastics are produced using cellulose esters and their derivatives. Cellulosic fibers added to starches can boost mechanical properties, gas permeability, and resistance to water. The application of cellulose plastics includes thermoplastics, eyeglass frames, extruded films, sheets, electronics, rods, etc.

Other polysaccharide-based plastics

Other polysaccharides such as chitosan and alginate can be processed to synthesize plastics. Chitosan is a polysaccharide synthesized by the deacetylation of chitin which is the second most abundant polysaccharide derived from marine invertebrates. It can dissolve under mildly acidic conditions and hence can be easily refined into a plasticised form. The high-viscosity property of chitosan makes it easily blend with plasticizers, nanoparticles, or other forms of biopolymers. Chitosan has antimicrobial activities that decrease the chance of spoilage. Hence its use in food packaging increases shelf life and reduces dependence on synthetic plastics. Alginate can be thermomechanically processed into plasticised films when blended with limited amounts of water and plasticizers. Plasticisers such as glycerol can make the modified chitosan or alginate films flexible.

Protein-based plastics

Bioplastics can be made from proteins from different sources such as wheat gluten, casein and soy protein. Soy proteins have been used as a raw material in plastic synthesis for more than a hundred years. However, it has disadvantages due to its water sensitivity and high cost. Hence, the synthesis of blends of soy protein with some biodegradable polyesters can help to overcome these defects. Protein-based bioplastics have emerged as a leading alternative in food packaging where protein-based films are made from plant and animal proteins.

Aliphatic polyesters

The aliphatic biopolyesters are mainly polyhydroxyalkanoates (PHAs), some of which commercially used are polyglycolic acid (PGA), polylactic acid (PLA), poly-ε-caprolactone (PCL), polyhydroxybutyrate (PHB), and poly(3-hydroxy valerate). They are sensitive to hydrolytic degradation and hence can be mixed with other compounds. These biopolymers are applied in medicine and pharmaceutical industries such as in drug delivery systems, surgical sutures, wound closure, implants and tissue engineering. PLA is produced from maize or dextrose and is used in the production of films, fibers, plastic containers, cups, and bottles. PHB is produced by glucose-processing bacteria and corn starch.

Bio-derived polyethylene

Polyethylene is a polymer of ethylene that can be derived from ethanol. Ethanol is produced by the

fermentation of agricultural feedstocks such as corn or sugar cane. Bio-derived polyethylene is chemically similar to traditional polyethylene and does not decompose but can be recycled.

Lipid derived polymers

A large number of bioplastics have been produced from plant and animal-derived fats and oils. Polyurethanes, epoxy resins and polyesters have been developed which have similar properties to crude oil-based materials. There is huge potential for lipid-derived polymers due to the growing production of vegetable oils and microalgae-derived oils.

Conclusion

Bioplastic can be a better alternative to conventional plastic, but must be disposed of carefully or else it will end up in landfills like the rest of our trash. Bioplastics might not be the answer to saving our planet, but they are giving a more sustainable alternative to standard plastics.

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All submissions to Green Horizon undergo double blind peer review and editorial check for appropriateness and suitability. Authors should respond to the reviewer suggestions and revert with modifications. All modifications should be marked in red. The decision of the editorial board is final in acceptance or rejection of the revised manuscript.

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