Paper-based Supercapacitor for Rapid Device Charging

For Prelims: Supercapacitor, Lithium-Ion batteries, Seaweeds, Exclusive Economic Zone, Algal blooming, Bio-ethanol

For Mains: Significance of Seaweeds

Why in News?

Scientists at the **Gujarat Energy Research and Management Institute (GERMI)** have achieved a breakthrough in energy storage technology with the development of a **paper-based supercapacitor.**

- This cutting-edge supercapacitor, **derived from seaweed,** boasts remarkable attributes such as **being lightweight**, **biodegradable**, **and capable of fully charging a device within a mere 10 seconds.**

What is a Paper-based Supercapacitor?

- **About:**
  - The paper-based supercapacitor developed by GERMI researchers is the **thinnest and most lightweight of its kind.**
  - **By leveraging cellulose nanofibers derived from seaweed, the team successfully created an anodic paper** supercapacitor that exhibits exceptional tensile strength, performance, and cost-effectiveness.
- **Applications and Business Prospects:**
  - The applications of **this innovative supercapacitor are vast, spanning electronics, memory backup systems, airbags, heavy machinery, and electric vehicles.**
  - Consequently, it presents a l**ucrative business prospect for industries seeking high-performance energy storage solutions.**
    - The technology's versatility and eco-friendly nature make it an attractive option for both manufacturers and consumers.
- **The Potential of Marine Cellulose:**
  - The paper supercapacitor owes its remarkable properties to the **marine cellulose-based material derived from seaweed.**
    - This **material holds immense potential for integration into various smart electronic devices.**
    - Additionally, the **cultivation of seaweed can serve as a source of revenue for coastal communities,** creating economic opportunities and sustainable development.

What is a Supercapacitor?

- A supercapacitor is an electrochemical charge storage device. They are also known as ultracapacitors.
  - It has significant advantages such as high-power density, long durability, and ultrafast

charging characteristics as compared to conventional capacitors and **Lithium-Ion batteries (LIB).**

- Main components of supercapacitors include **electrode, electrolyte, separator, and the current collector.**

What are Seaweeds?

- **About:**
  - **Seaweeds are macroalgae attached to rock or other substrata** and are found in coastal areas.
  - They are classified as **chlorophyta (green), rhodophyta (red) and phaeophyta (brown) on the basis of their pigmentation.**
    - Among them, chlorophyta holds more potential components — **carbohydrates, lipids, proteins and bioactive compounds.**
- **Significance:**
  - **Nutritional Value:** Seaweeds are rich in essential **nutrients, including vitamins, minerals and dietary fibre.**
  - **For Medicinal Purpose:** Many seaweeds contain **anti-inflammatory and anti-microbial agents.** Certain seaweeds possess powerful **cancer-fighting agents**.
  - **Bioindicator**: When waste from agriculture, industries, aquaculture and households are let into the ocean, **it causes nutrient imbalance leading to algal blooming**, the sign of marine chemical damage.
    - **Seaweeds absorb the excess nutrients and balance out the ecosystem.**
  - **Oxygen Production:** Seaweeds, as **photosynthetic** organisms, play a vital role in marine ecosystems by producing oxygen through photosynthesis, sustaining the respiration and survival of marine life.
  - **Cellulose Content:** Green seaweed that is **collected from the Porbandar coast of Gujarat** has a **high amount of a particular type of cellulose in its cell wall.**
    - Cellulose is found to be the **most suitable biopolymer material for manufacturing paper-based electrode materials** such as batteries for energy storage applications.
      - **Cellulose itself is an insulating material that requires to be coated with conductive material** to make a paper-based energy storage device.
- **Seaweed Cultivation:**
  - Out of the global seaweed production of **around 32 million tons of fresh weight valued around USD 12 billion.**
    - China produces approximately 57%, Indonesia 28% followed by South Korea, whereas India has a mere share of ~0.01-0.02%.
  - By an estimate, **if cultivation is done in ~10 million hectares or 5% of the Exclusive Economic Zone area of India,** it can provide employment to **~ 50 million people, contribute** to national GDP, lead to ocean productivity, abates algal blooms, **sequesters millions of tons CO2, and could produce bio-ethanol of 6.6 billion litres.**

Source: DTE