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Q6

Discuss several ways in which microorganisms can help in meeting the current fuel shortage.

UPSC Civil Services Mains 2023 · GS III · 10 marks · Indian Economy

Indian Economy and issues relating to planning, mobilization of resources, growth, development and employment.

Core demand of the question

- **Discuss real microbial routes to fuel:** bioethanol, biogas, algal biodiesel, microbial hydrogen
- Name existing Indian programmes and plants; do not invent facilities
- Link them to the present fuel shortage and import bill

Revision summary

Yeasts and 2G microbes make ethanol; India blends it under the Ethanol Blended Petrol programme toward **E20**.

Indian Oil's **Panipat 2G** plant and **Numaligarh's** bamboo bio-refinery are real second-generation sites.

Anaerobic bacteria make biogas; **SATAT** and **GOBARdhan** upgrade it to transport and village fuel.

Algal biodiesel and microbial hydrogen exist in CSIR and institute pilots, not as large national supply.

These routes cut a slice of the oil shortage only with real plants and disciplined feedstock.

Introduction

India still imports most of its **crude oil**. Microbes cannot replace every barrel. They can make **alcohol, methane, lipids and hydrogen** from sugar, dung, residue and algae, which cuts a slice of the shortage and the import bill if plants actually run.

Body**Bioethanol**

- Yeasts such as **Saccharomyces** ferment sugarcane molasses and grain starch to ethanol; bacteria and fungi are used in **second-generation** processes that break rice-straw and other cellulose.
- India blends ethanol in petrol under the **Ethanol Blended Petrol** programme, with an **E20** (20 per cent) target.
- First-generation supply is molasses and surplus grain. Second-generation plants exist at scale in a few places, including **Indian Oil's 2G ethanol plant at Panipat** and the **Numaligarh** bamboo-based bio-refinery in Assam; other oil-company 2G units have been under construction rather than all online.

Biogas and compressed biogas

- Anaerobic bacteria in digesters turn cattle dung, press-mud and urban wet waste into **methane-rich biogas**.
- Upgraded gas is **Compressed Bio Gas**, sold as a transport fuel under **Sustainable Alternative Towards Affordable Transportation (SATAT)** with oil marketing companies as off-takers.
- **GOBARdhan** supports village and cluster plants. This is a working rural fuel, not a laboratory story.

Algal biodiesel

- Microalgae can store **lipids** that are transesterified to biodiesel and can grow on non-arable water bodies.
- Indian work sits mainly in **CSIR, DBT and IIT** pilots. Commercial algal diesel is **not** a large operating source of national fuel yet; it is a research path with high harvest cost.

Microbial hydrogen

- Some bacteria and cyanobacteria make **hydrogen** by dark fermentation or photolysis of water.
- This remains **pilot-scale**. India's hydrogen mission is still dominated by electrolysis and industrial by-product gas, not by microbial farms.

Meeting the shortage

- The honest contribution today is **ethanol blending** and **SATAT biogas**. Algae and microbial hydrogen are future options.
- **They help only with** feedstock discipline: food-versus-fuel for grain ethanol, and residue collection for 2G, must stay explicit.

Flow diagram

Microorganisms -> Bioethanol EBP 2G
Microorganisms -> Biogas SATAT GOBARdhan
Microorganisms -> Algal biodiesel pilots
Microorganisms -> Microbial hydrogen pilots
Bioethanol EBP 2G -> Cut oil import slice
Biogas SATAT GOBARdhan -> Cut oil import slice

Conclusion

Microbes already add ethanol and biogas to India's fuel mix through EBP, Panipat-type 2G plants, **Numaligarh**, **SATAT** and **GOBARdhan**. Algal biodiesel and microbial hydrogen are real science, not yet national supply. They ease shortage only where plants run and feedstock is honest.

Facts & figures

E20

National target to blend 20 per cent ethanol in petrol, using molasses, grain, and some 2G cellulose ethanol.

Panipat 2G

Indian Oil's second-generation ethanol plant at Panipat uses agricultural residue; it is a commissioned 2G site.

Numaligarh

Assam bio-refinery linked to Numaligarh Refinery uses bamboo as a cellulosic feedstock.

SATAT

Sustainable Alternative Towards Affordable Transportation: oil companies offtake Compressed Bio Gas from waste and dung plants.

GOBARdhan

Union support for cattle-dung and agri-waste biogas in villages and clusters.

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