Q15

The world is facing an acute shortage of clean and safe alternative freshwater. What are the technologies which can solve this crisis? Briefly discuss any three such technologies, citing their key merits and demerits.

UPSC Civil Services Mains 2024 · GS III · 15 marks · Indian Economy

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

Core demand of the question

- State the freshwater crisis as a global shortage of clean, safe alternatives
- Briefly discuss three technologies that can help, with key merits and demerits
- Do not invent plant-level numbers

Revision summary

The world is short of clean, climate-safe freshwater as rivers and aquifers fail.

Desalination (mainly RO) can supply coasts regardless of rainfall, but it is energy-intensive and produces brine.

Wastewater reuse cuts pollution and freshwater demand if sewers actually reach working plants; public trust is a barrier to potable reuse.

Managed aquifer recharge and rainwater harvesting store the monsoon cheaply; they cannot invent rain or replace a city network alone.

A workable mix uses desalination where there is sea, reuse in cities, and recharge on the land.

Introduction

Rivers, lakes and aquifers are **finite, polluted and politically spoken for**. Climate change makes the reliable litre rarer. The world is therefore hunting **alternative freshwater**: water that is not a clean glacier stream. Three technologies already in the field are **seawater desalination**, **wastewater reuse**, and **managed aquifer recharge** (with rainwater harvesting as its city face). Each makes water. Each has a bill and a brine.

Body

Desalination

Reverse osmosis (and, less often now, thermal distillation) turns seawater or brackish water into potable or industrial water. **Merit:** it is **climate-independent** at the coast and can supply a city that has no river left. Gulf States and some Indian coastal plants already run on this logic. **Demerit:** it is **energy-heavy**, which means a carbon bill unless the plant is paired with clean power. **Brine** returned to the sea can harm local ecology. Capital cost is high, so the water is often too dear for **irrigation**. Inland, there is no sea to draw.

- **Peg:** Coastal RO is the mature large-scale option; brine and power are the constraints that never leave.
- **Peg:** Brackish-groundwater RO is a cousin used in some Indian inland belts, with a concentrate-disposal problem.

Wastewater reuse

Treating **municipal and industrial sewage** to a standard that allows **industrial cooling, horticulture, or, with higher treatment, potable reuse** creates a new river inside the city. **Merit:** it cuts both **pollution** and **fresh abstraction**; the source is located where the demand is. Singapore's reused-water story is the global teaching case; several Indian cities now mandate treated reuse for industry and parks. **Demerit: public distrust** of toilet-to-tap, **patchy sewage collection**, and plants that are built and not run. If the sewer never reaches the plant, the technology is a shed.

- **Peg:** Tertiary treatment plus dual plumbing or industrial offtake is the practical Indian path; direct potable reuse is rarer.
- **Peg:** A dry STP is not a technology failure; it is an O&M failure.

Managed aquifer recharge and rainwater harvesting

Check dams, percolation tanks, recharge wells and rooftop harvesting put monsoon water back into soil and aquifers instead of into a flood drain. **Merit: low energy**, local, and suited to India's **monsoon pulse**. It treats the aquifer as a **reservoir**. **Demerit:** it cannot **create** water in a drought year if there is no rain to harvest. Poorly designed recharge can **push polluted runoff** into drinking aquifers. It does not, by itself, supply a megacity's 24×7 pressurised network.

- **Peg:** Atal Bhujal-style community recharge and city rainwater by-laws are the Indian policy face of this technology.
- **Peg:** Three technologies, three scales: coast, city sewage, and monsoon land. None is a solitary saviour.

Flow diagram

Clean water shortage -> Desalination RO

Clean water shortage -> Wastewater reuse

Clean water shortage -> Aquifer recharge

Desalination RO -> Power and brine

Wastewater reuse -> O and Needs a monsoon and trust and Needs a monsoon and trust

Aquifer recharge -> Needs a monsoon

Conclusion

Clean alternative freshwater will come from desalination, reuse and recharge, not from a new planet. Desalination is sure and costly. Reuse is circular if sewers work. Recharge is cheap and rain-bound. A serious programme mixes all three and pays the power, brine and maintenance bills in public.

Facts & figures

Reverse osmosis
The dominant membrane method for seawater and brackish desalination.

Brine
The concentrated salt waste of desalination; dumping it can damage coastal ecology.

Tertiary reuse
High treatment of sewage for industry, parks or, in some countries, drinking-water blending.

Managed aquifer recharge
Engineering percolation so aquifers store monsoon water as an underground reservoir.

Rainwater harvesting
Rooftop and storm-water capture, the urban end of the same recharge idea.