

You & Technology Sep-2019



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GOOD MORNING TIMES S&T (SEPTEMBER-2019)

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General Studies Paper-3 – S&T – September 2019

1) GLOBAL ANTIMICROBIAL RESISTANCE RESEARCH AND DEVELOPMENT HUB

India joins the Global Antimicrobial Resistance Research and Development Hub as a new member.

About Antimicrobial Resistance (AMR) Research and Development (R&D) Hub:

- Launched in May 2018 in the margins of the 71st session of the World Health Assembly, following a call from G20 Leaders in 2017.
- Members: 16 countries, the European Commission, two philanthropic foundations and four international organisations (as observers).
- Functions: Supports global priority setting and evidence-based decision-making on the allocation of resources for AMR R&D through the identification of gaps, overlaps and potential for cross-sectoral collaboration and leveraging in AMR R&D.
- Secretariat: established in Berlin.
- Finance: through grants from the German Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Health (BMG).

Benefits of this partnership for India:

- Opportunity to work with all partners to leverage their existing capabilities, resources and collectively focus on new R&D intervention to address drug resistant infections.

What is antimicrobial resistance and why is it a cause for concern?

- AMR is the ability of a microbe to resist the effects of medication that once could successfully treat the microbe.

- Today, the emergence and spread of antimicrobial resistance continues unabated around the world.

Why is the medical community worried?

- Basically, superbugs are becoming more powerful and widespread than ever. Medical experts are afraid that we're one step away from deadly, untreatable infections, since the mcr-1 E.coli is resistant to that last-resort antibiotic Colistin. Antibiotic-resistance is passed relatively easily from one bacteria to the next, since it is transmitted by way of loose genetic material that most bacteria have in common.

- The World Health Organization (WHO) is afraid of a post-antibiotic world, where loads of bacteria are superbugs. Already, infections like tuberculosis, gonorrhea, and pneumonia are becoming harder to treat with typical antibiotics.

Need of the hour:

- A multi-stakeholder approach, involving private industry, philanthropic groups and citizen activists is needed.
- Private pharmaceutical industries must take it upon themselves to distribute drugs in a responsible manner.
- Philanthropic charities must fund the development of new antibiotics, while citizen activists must drive awareness.
- These stakeholders must appreciate that the only way to postpone resistance is through improved hygiene and vaccinations.

2) QUANTUM SUPREMACY

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Google researchers claim to have achieved a major milestone in computer science known as “quantum supremacy.”

What is quantum supremacy?

- It means only that researchers have been able to use a quantum computer to perform a single calculation that no conventional computer, even the biggest supercomputer, can perform in a reasonable amount of time.

The case of Google:

- This calculation involved checking whether the output of an algorithm for generating random numbers was truly random.
- The researchers were able to use a quantum computer to perform this complex mathematical calculation in three minutes and 20 seconds, according to the paper.
- They say it would have taken Summit 3—an IBM-built machine that is the world’s most powerful commercially-available conventional computer—about 10,000 years to perform the same task.

How do quantum computers work?

- Quantum computers work by harnessing the properties of quantum mechanics.
- Quantum computers use logical units called quantum bits, or qubits for short, that can be put into a quantum state where they can simultaneously represent both 0 and 1.

Difference between classical and quantum computers?

- Classical computers process information in a binary format, called bits, which can represent either a 0 or 1.
- While the bits in a classical computer all operate independently from one another, in a quantum computer, the status of one qubit effects the status of all the other qubits in the system, so they can all work together to achieve a solution.

How the result I’d obtained?

- But while a conventional computer outputs the same answer to a problem every time you run a calculation, the outputs of a quantum computer are probabilistic. That means it does not always produce the same answer. So to use a quantum computer, you have to run a calculation through the system thousands or even millions of times, and the array of outputs converge around the answer that is most likely to be correct.

3) PROJECT NETRA

ISRO has initiated ‘Project NETRA’ – an early warning system in space to detect debris and other hazards to Indian satellites.

Significance of the project:

- The project will give India its own capability in space situational awareness (SSA) like the other space powers — which is used to ‘predict’ threats from debris to Indian satellites.
- NETRA’s eventual goal is to capture the GEO, or geostationary orbit, scene at 36,000 km where communication satellites operate.
- The effort would make India a part of international efforts towards tracking, warning about and mitigating space debris.

Need:

- Currently there are 15 functional Indian communication satellites in the geostationary orbit of 36,000 km; 13 remote sensing satellites in LEO of up to 2,000 km; and eight navigation satellites in medium earth orbits. Their protection is utmost importance for India.

Background:

- Space junk is an ever-growing problem with more than 7,500 tonnes of redundant hardware now thought to be circling the Earth. Ranging from old rocket bodies and defunct spacecraft through to screws and even flecks of paint – this

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material poses a collision hazard to operational missions.

- The rising population of space debris increases the potential danger to all space vehicles, but especially to the International Space Station (ISS), space shuttles, satellites and other spacecraft.

What is Project NETRA (Network for space object Tracking and Analysis)?

- Under the project, the ISRO plans to put up many observational facilities: connected radars, telescopes; data processing units and a control centre.
- They can, among others, spot, track and catalogue objects as small as 10 cm, up to a range of 3,400 km and equal to a space orbit of around 2,000 km.

4) METHANE-POWERED ROCKET ENGINE

ISRO is developing two 'LOx methane' engines (liquid oxygen oxidiser and methane fuel) engines.

Why use methane?

- Methane, which can be synthesised with water and carbon dioxide in space, is often described as the space fuel of the future.
- Unsymmetrical Di-Methyl Hydrazine, along with Nitrogen tetroxide for oxidiser, currently being used by ISRO, is said to be highly toxic and cancer-causing.
- Whereas Methane, apart from being non-toxic, has a higher specific impulse (which means one kg of the gas can lift one kg of mass for a longer time), it is easy to store, does not leave a residue upon burning, less bulky, and, importantly, can be synthesised up in space.

5) ADITYA- L1 MISSION

The Indian Space Research Organization is planning to launch Aditya- L1 mission to study the sun early in 2020.

About Aditya- L1 mission:

• What is it?

It is India's first solar mission.

- Objectives: It will study the sun's outer most layers, the corona and the chromospheres and collect data about coronal mass ejection, which will also yield information for space weather prediction.

- Significance of the mission: The data from Aditya mission will be immensely helpful in discriminating between different models for the origin of solar storms and also for constraining how the storms evolve and what path they take through the interplanetary space from the Sun to the Earth.

- Position of the satellite: In order to get the best science from the sun, continuous viewing of the sun is preferred without any occultation/ eclipses and hence, Aditya- L1 satellite will be placed in the halo orbit around the Lagrangian point 1 (L1) of the sun-earth system.

What are Lagrangian points and halo orbit?

- Lagrangian points are the locations in space where the combined gravitational pull of two large masses roughly balance each other. Any small mass placed at that location will remain at constant distances relative to the large masses. There are five such points in Sun-Earth system and they are denoted as L1, L2, L3, L4 and L5. A halo orbit is a periodic three-dimensional orbit near the L1, L2 or L3.

6) HUMAN SPACE FLIGHT PROGRAMME

ISRO, DRDO sign MoU to provide critical technologies for Human Space Mission.

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• Under the agreement, the technological capabilities existing in DRDO labs for defence applications will be customised to meet the requirements of ISRO's human space mission. DRDO will be providing critical technologies to ISRO such as space crew health monitoring and emergency survival kit, space food, parachutes for the crew module's safe recovery and radiation measurement and protection.

Indian Human Space Flight Programme:

• ISRO aims to launch its maiden Human Space Mission, Gaganyaan before the 75th anniversary of India's independence in 2022.

Objectives of the Mission:

- Enhancement of science and technology levels in the country
- A national project involving several institutes, academia and industry
- Improvement of industrial growth
- Inspiring youth
- Development of technology for social benefits
- Improving international collaboration

Relevance of a Manned Space Mission for India:

- Boost to industries: The Indian industry will find large opportunities through participation in the highly demanding Space missions. Gaganyaan Mission is expected will source nearly 60% of its equipment from the Indian private sector.
- Employment: According to the ISRO chief, the Gaganyaan mission would create 15,000 new employment opportunities, 13,000 of them in private industry and the space organisation would need an additional manpower of 900.
- Technological development: Human Space flights are frontier field in the science and technology. The challenges the Human Space Flights provide to India, and the benefits accruing from taking up those missions will be very high

and will lead to further thrust for technological developments in India

- Spurs research and development: It will boost good research and technology development. With a large number of researchers with proper equipment involved, HSF will thrust significant research in areas such as materials processing, astro-biology, resources mining, planetary chemistry, planetary orbital calculus and many other areas
- Motivation: Human space flight will provide that inspiration to the youth and also the national public mainstream. It would inspire young generation into notable achievements and enable them to play their legitimate role in challenging future activities
- Prestige: India will be the fourth country to launch human space mission. The Gaganyaan will not only bring about prestige to the nation but also establish India's role as a key player in the space industry.

7) SCIENTIFIC SOCIAL RESPONSIBILITY (SSR)

Department of Science and Technology (DST) released a draft of its proposed Scientific Social Responsibility (SSR) policy.

About Scientific Social Responsibility (SSR)

- India is going to be possibly the first country in the world to implement a Scientific Social Responsibility (SSR) Policy on the lines of Corporate Social Responsibility (CSR).
- It is the confluence of scientific knowledge with visionary leadership and social conscience.
- SSR is about building synergies among all stakeholders in scientific knowledge community and also about developing linkages between science and society.

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- It aims to encourage science and technology (S&T) institutions and individual scientists in the country to proactively engage in science outreach activities to connect science with the society.
- SR policy would involve four different categories of stakeholders:
 - o beneficiaries (students; school/college teachers; local bodies; communities; women's groups etc.),
 - o implementers (institutions, science centers, Central Ministries, State Governments etc.),
 - o assessors (Internal assessment cell or external agency) and
 - o supporters (government agency, Corporate bodies etc. providing grants/funds).
- The main objective of SSR policy is to harness the voluntary potential that is latent in the country's scientific community to strengthen science and society linkages so as to make S&T ecosystem vibrant through
 - o Science-society connect: Facilitating inclusive and sustainable development by transferring the benefits of scientific work to meet existing and emerging societal needs.
 - o Science-science connect: Creating an enabling environment for the sharing of ideas and resources within the knowledge ecosystem.
 - o Society-science connect: Collaborating with communities to identify problems and develop scientific and technological solutions.
 - o Cultural change: Inculcating social responsibility among the individuals and institutions practicing science; creating awareness about SSR within society; and infusing scientific temperament into day-to-day social existence and interaction.

Policy directives

- 10 person-days of SSR per year: Individual scientists or knowledge workers will be required

to devote at least 10 person-days of SSR per year for exchanging scientific knowledge to society.

- Outreach activities: It recognises the need to provide incentives for outreach activities with necessary budgetary support. Every knowledge institution would prepare its implementation plan for achieving its SSR goals.
- Appraisal and evaluation: It has also been proposed to give credit to knowledge workers/scientists for individual SSR activities in their annual performance appraisal and evaluation.
 - o No institution would be allowed to outsource or sub-contract their SSR activities and projects.
 - o All knowledge workers would be sensitised by their institutions about their ethical responsibility to contribute.
 - o There should be an SSR monitoring system in each institution to assess institutional projects and individual activities.
- Implementation agency: A central agency will be established at DST to implement the SSR. Other centre & state ministries would also be encouraged to make their own plans to implement SSR as per their mandate.
- National portal: For implementation of the policy, a national portal will be developed up to capture societal needs requiring scientific interventions and as a platform for implementers and for reporting SSR activities. **Conclusion**

The policy envisages strengthening science-society linkages in an organic manner by building synergy among all the stakeholders so as to usher in a cultural change in the conduct of science for the benefit of society at large in the country.

8) VACCINE HESITANCY

World Health Organization, recently included 'vaccine hesitancy' as one of the 10 threats to global health highlighting that overcoming

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‘vaccine hesitancy’ can reduce the global spread of measles infection.

What is Vaccine Hesitancy?

- As per WHO, Vaccine Hesitancy is defined as “reluctance or refusal to vaccinate despite the availability of vaccines” and is influenced by factors such as complacency, convenience and confidence.
 - o Hesitancy in relation to vaccination may be caused by individual, group, and contextual influences, as well as any vaccine-specific issues causing people to reject it for themselves or their children.
- Vaccine hesitancy is a dangerous global trend – in both, populous emerging economies like India and China as well as advanced economies including the United States and Europe.

Measures needed to tackle Vaccine Hesitancy

- Systematic assessment of the factors affecting uptake: WHO is developing a set of tools to support programmes and partners to measure and address the reasons for under-vaccination, and to track consistent and comparable data over time.
 - o In November 2018, a global expert group called ‘Measuring Behavioural and Social Drivers of Vaccination’ (BeSD) was established by WHO, in collaboration with core partners, to oversee development of these tools, which is expected to be finalized in late 2020.
- Improving and sustaining uptake: In most cases, interventions should be dialogue based and directly targeted to a specific under-vaccinated population group.
 - o By engaging collaboratively with health workers, caregivers/parents, and their families and communities, one can generate the insights to develop better quality health services, systems, policies, and communication strategies that support and enable recommended vaccination behaviours.

o Communities also need to be at the centre of drives to improve the quality of immunization and health services, access and equity.

- Need to address misinformation: With social media playing a crucial role in spreading vaccine disinformation, the commitment by Facebook to “reduce distribution” of vaccine misinformation might be helpful against vaccine deniers.

Factors responsible for Vaccine Hesitancy

A complex web of historical, political, sociocultural and economic factors including everyday community social networking processes shape parents’ choices not to vaccinate their children.

- Rise of the anti-vaccination movement in the West, countries such as United States have seen surge in parents resisting and delaying vaccines for their children.
- Fear of risks associated with vaccines and adverse reactions for children following immunisation.
- Influenced by religious suspicions and rumours, mass community resistance surfaced in Uttar Pradesh and Bihar during polio campaigns before the country eradicated the disease in 2014.
- The inadequacy and inequities of the public health system has significantly reduced community trust.
- Often use of force or coercion in administering vaccinations to children contributed to the growing resistance among parents toward specific singledisease mass-immunization programmes.
 - o One major objection is lack of parental consent before the vaccine is given to children at schools. The courts, further supported parents and stalled the campaign in Delhi. Similarly, reports of more than 70 schools in Mumbai also was not supporting the measlesvaccination programme based on parent objections.

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9) E-CIGARETTES

Recently, the Union Cabinet approved the Promulgation of the Prohibition of Electronic Cigarettes (production, manufacture, import, export, transport, sale, distribution, storage and advertisement) Ordinance, 2019.

Background

- This decision has come on the back of an advisory issued by the Government in 2018 to all States to consider banning e-cigarettes. 16 States and 1 UT have already banned e cigarettes in their jurisdictions.
- Unlike traditional cigarettes, e-cigarettes do not contain tobacco and therefore are not regulated under the Cigarettes and Other Tobacco Products Act, 2003.
- Recently, the Indian Council of Medical Research (ICMR), in a white paper on the subject, also recommended a complete ban on e-cigarettes based on currently available scientific evidence.
- These products are usually marketed as being safer alternatives for conventional cigarettes but such notions of safety are false.
 - o Most e-commerce websites sell e-cigarettes as therapeutic products thus increasing appeal.
 - o On the other hand, available literature suggests that these products may act as gateway products to induce non-smokers, especially youth and adolescents, to nicotine-use, leading to addiction and subsequent use of conventional tobacco products.

Key Provisions of the Ordinance

- Prohibition on e-cigarettes- It would make production, manufacture, import, export, transport, sale, distribution or advertisements of e-cigarettes a cognizable offence.

- Punishment- The first offence will attract an imprisonment of up to one year or fine up to Rs. 1 lakh or both.
 - o The subsequent offence will attract an imprisonment of up to three years and fine up to Rs. 5 lakh.
 - o Storage of electronic-cigarettes shall also be punishable with an imprisonment up to 6 months or fine up to Rs 50,000 or both.
- Duties of the producer- The owners of existing stocks of e-cigarettes on the date of commencement of the Ordinance will have to suo-moto declare and deposit these stocks with the nearest police station.
- Relevant Authorities- The Sub-Inspector of Police has been designated as the Authorized Officer to take action under the Ordinance. The Central or State Governments may also designate any other equivalent officer(s) as Authorized Officer for enforcement of the provisions of the Ordinance.

Arguments in favour of banning e-cigarettes

- Lack of convincing proof- that e-cigarettes help quit smoking, rather e-cigarette demand has increased by 77% in the country.
- Leading to further addiction- of smoking against its intended objective of to get people out of their smoking habits. Vaping can get teens addicted to nicotine and they can go on to use other tobacco products.
- Health impacts- Nicotine is considered to promote cardiovascular diseases and may also affect the brain development in foetus.
 - o Smoking e-cigarettes delivers cancer-causing chemicals into the body such as formaldehyde.
 - o Foetal and adolescent nicotine exposure may have long-term consequences for brain development, potentially leading to learning and anxiety disorders.

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• International experience- India is a signatory to the WHO Framework Convention on Tobacco Control (WHO FCTC). In 2014, the WHO FCTC invited all its signatories to consider prohibiting or regulating e-cigarettes in their countries. e-cigarettes have been completely banned in 25 countries including Brazil and Singapore.

Arguments against banning e-cigarettes

- More needs to be done on tobacco- as rather than banning e-cigarettes, the government should have done more on banning original cigarettes to stop tobacco consumption.
- Illegal operations may continue- Already, 16 of 29 states have banned vaping products, but they are still prevalent in stores and available for purchase online.
- Number of smokers has reduced- in India from 275 million in 2010 to 200 million in 2016-17 as per the Global Adult Tobacco Survey, which highlights the efficacy of e-cigarettes.

Conclusion

Rather than a blanket ban on e-cigarettes, experts have suggested that government should work at regulating it and further towards promoting healthy lifestyle among adolescents.

About e-cigarettes

- They are battery-operated devices that produce aerosol by heating a solution containing nicotine, which is the addictive substance in combustible cigarettes.
- These include all forms of Electronic Nicotine Delivery Systems, Heat Not Burn Products, e-Hookah and the like devices.
- Smoking e-cigarettes is also called vaping.

10) INDIGENOUS FUEL CELL

Recently, India's first indigenous fuel cell system was unveiled.

• It is developed by Council of Scientific and Industrial Research (CSIR) in partnership with Thermax Ltd, a Punebased engineering firm.

• It is developed under the flagship program named 'New Millennium Indian Technology Leadership Initiative (NMITLI).

• It will be a 5 kW fuel cell system and will use methanol/biomethane to generate power with 70% more efficiency than other sources.

About Fuel cell technology

- A fuel cell is like a battery that generates electricity from an electrochemical reaction.
- It uses a source of hydrogen as fuel but involves no combustion.
- With the help of oxygen present in the air, oxidation of hydrogen atoms occur and in the process, electrons are released which flow through an external circuit as an electric current.
- The byproducts of fuel cell include heat and water.
- Fuel cells can vary from tiny devices producing only a few watts of electricity, right up to large power plants producing megawatts.

New Millennium Indian Technology Leadership Initiative (NMITLI)

• It is an initiative of CSIR and is the largest public-private-partnership effort within the R&D domain in the country. • It seeks to catalyze innovation centered scientific and technological developments as a vehicle to attain for Indian industry a global leadership position, in selected niche areas.

• NMITLI has so far evolved more than 50 largely networked projects in diverse areas viz. Agriculture & Plant Biotechnology, General Biotechnology, Bioinformatics, Drugs & Pharmaceuticals, Chemicals, Materials, Information and Communication Technology and Energy.

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11) CERAMIC MEMBRANES

Recently, Central Glass and Ceramic Research Institute, Kolkata has developed Ceramic Membranes for treatment of water contaminated with heavy metals.

About Ceramic membrane

- It is prepared from a mixture of inorganic substances such as alumina and clay.
- This filter is able to segregate metals such as Iron, Arsenic, fluoride, Arsenic etc along with the other pollutants when water passes through these membranes.
- Its absorption capacity is upto 8 times higher than other membranes and minimises water wastage and can operate under harsh operating environments.
- These membranes last for around 10-15 years without replacement. They can also be used in other sectors like food and beverage, drug and chemicals, waste recovery and recycling industries and are especially useful in petrochemical processing, where it is not possible to use organic membranes.

Why this technology is significant for India?

- Water borne disease burden According to an estimate, 50-60% of population in urban as well as rural areas suffers from water borne diseases in India. Heavy metals in water causes cardiovascular diseases, developmental abnormalities, neurologic and neurobehavioral disorders, diabetes, hearing loss, hematologic and immunologic disorders.
- Limitations of available technologies Other micro water filters available in India such as RO, UV, UF can remove dissolved impurities, microorganisms, chemicals and salts but are unable to remove metal pollutants in water.

12) SHANTI SWARUP BHATNAGAR PRIZE FOR 2019

Recently, twelve scientists have been awarded the prestigious Shanti Swarup Bhatnagar award for science and technology for 2019.

About Shanti Swarup Bhatnagar prize

- Awarded by: Council of Scientific and Industrial Research. It was first awarded in 1958.
- Purpose: It awarded annually for notable and outstanding research, applied or fundamental, in the disciplines namely:
 - o Physical Sciences,
 - o Chemical Sciences,
 - o Biological Sciences,
 - o Medical Sciences,
 - o Mathematical Sciences,
 - o Engineering Sciences and
 - o Earth, Atmosphere, Ocean and Planetary Science.
- Eligibility: Any citizen of India engaged in research in any field of science and technology up to the age of 45 years. Overseas citizen of India (OCI) working in India are also eligible.
- Prize: The prize carries a cash component of Rs 5 lakh each. About Dr Shanti Swarup Bhatnagar
- Dr Shanti Swarup Bhatnagar was the Founder Director (and later first Director General) of Council of Scientific & Industrial Research (CSIR) who is credited with establishing twelve national laboratories. He was awarded the Padma Vibhushan in 1954 by the President of India.
- He played a significant role in building of post independent S & T infrastructure and in the formulation of India's S & T policies.
- His research contributed to several areas of chemical sciences including emulsions, colloids and industrial chemistry. His pioneering research in the field of magneto-chemistry is acclaimed throughout the world.

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• He played an instrument role in the establishment of the National Research Development Corporation (NRDC) of India.

13) HEAD ON GENERATION (HOG) TECHNOLOGY

Railway Ministry is upgrading all existing Linke Hofmann Busch (LHB) coaches with the Head on Generation (HOG) technology.

• Significance: This would cause the trains to become more cost-efficient and less polluting.

What is Head on Generation (HOG) technology?

• The system runs the train's 'hotel load' (the load of air conditioning, lights, fans, and pantry, etc.) by drawing electricity from the overhead electric lines through the pantograph.

• The power supply from the overhead cable is 750 volts at single-phase, and a transformer with a winding of 945 kVA converts it to a 750 Volts 50 Hz output at 3-phase. This energy is then provided to the compartments.

How is it different from the present EOG technology?

• Under the End on Generation (EOG) system, the train's 'hotel load' (the load of air conditioning, lights, fans, and pantry, etc.) is provided with electricity from two large diesel generator sets, which supply 3-phase power at 750 Volts 50 Hz to the entire length of the train.

• Each coach then picks up the power supply through a 60 KVA transformer, bringing down the voltage to 110 volts at which level the equipment in the compartment is run. The generator cars are attached to either end of the train, giving the system its name.

Benefits of HOG over EOG:

• Since the HOG-fitted trains do not require power from diesel generators at all, they only have one

emergency generator car attached, instead of two regular generator cars.

• The extra space created would now be used for an LSLRD (LHB Second Luggage, Guard & Divyaang Compartment)– meaning more passengers can be accommodated.

• Cost savings would be significant: Once all LHB trains get the new system, NR 1390 crores would be saved every year.

• HOG system is free of air and noise pollution: It would bring down yearly CO₂ and NO_x emissions, which are currently at 1724.6 tonnes/annum and 7.48 tonnes/annum respectively, to zero.

• The reduction in emissions could also help the Railways accrue carbon credits, and trade them on the international market.

• With the noise-emitting generator sets gone, noise pollution would also drop.

14) 'SAMUDRAYAAN' PROJECT

India to undertake deep ocean mining with 'Samudrayaan' project.

About Samudrayaan:

• It is a pilot project of the Ministry of Earth Sciences for deep ocean mining for rare minerals.

• It proposes to send men into the deep sea in a submersible vehicle for ocean studies.

• The project is expected to become a reality by 2021-22.

• The project has been undertaken by the National Institute of Ocean Technology (NIOT).

Significance:

• If the 'Samudrayaan' project is successful, India will join the league of developed nations in the exploration of minerals from oceans.

• India could be the first developing country to undertake such a project.

What are PMN?

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- Polymetallic nodules (also known as manganese nodules) are potatoes shaped, largely porous nodules found in abundance carpeting the sea floor of world oceans in deep sea.
- Composition: Besides manganese and iron, they contain nickel, copper, cobalt, lead, molybdenum, cadmium, vanadium, titanium, of which nickel, cobalt and copper are considered to be of economic and strategic importance.
- Potential: It is envisaged that 10% of recovery of that large reserve can meet the energy requirement of India for the next 100 years. It has been estimated that 380 million metric tonnes of polymetallic nodules are available at the bottom of the seas in the Central Indian Ocean

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7. Ncert Foundation btach.

8. GS-FOUNDATION batch for 2021....

All the Best to all my Economics students...
Hope this material will help you.
God bless...JAI Hind

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