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JULY - AUGUST 2020

INVENTION INTELLIGENCE

NRDC
Publication

NRDC: Aligning with Indian R&D Labs to Combat COVID-19

Startups *vs* COVID-19: The Role of Indian Innovation Ecosystem in Fighting the Pandemic

CSIR, DST, DBT, DRDO: A Glimpse of the Technological Solutions to Combat COVID-19

एन आर डी सी
NRDC

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Proposals based on Innovative Appropriate Technologies to cater to the need of the local masses are invited from R&D institutes/academia/NGOs and skill development agencies to conduct EDP under the Skill India Scheme on "Empowerment of Youth in the North East and rural areas and across the country. "

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NRDC: Aligning with Indian R&D Labs to Combat COVID-19

Dr. H. PURUSHOTHAM

In over six decades of its existence, the National Research Development Corporation (NRDC), an enterprise under DSIR, Ministry of Science & Technology, Government of India, has developed close partnerships and collaborations with R&D organisations, viz., CSIR, DST, DRDO, ICMR, ICAR, DoD, universities, industries, industry associations, NGOs, etc. to promote innovations in all the domains of science and technology. The value addition made by NRDC to the laboratory-scale technologies propels the translation of innovative research into marketable industrial manufacturing technology. NRDC's endeavours have resulted in transfer of technologies to about 5,000 entrepreneurs in India and abroad, and it has filed more than 2,000 patents. To combat COVID-19, these organisations have come out with various innovations and technological solutions. NRDC has aligned itself with these organisations in the battle against COVID-19.

The SARS-CoV-2 has started a tremendous wave of innovations and rapid technological dissemination and advancements in India. Across the country, research teams, scientists, students, startups and innovators, in a quick response have devised new apps, robots, testing devices, ventilators and treatment mechanisms to help overcome the pandemic. Even educational institutes with trained young engineering and medical talent consider this challenge as an opportunity to find hacks to problems using limited resources.

As experts say, we need to live with SARC-CoV-2 until a vaccine is successfully developed. This uncertainty and crises the humanity is currently facing can only be solved through application of Science, Technology and Innovation (STI).

The researchers and governments across the globe will be continuing their efforts to come out with effective innovation and sustainable solutions for combating the global crises caused by COVID-19 in terms of health and economic challenges.

Artificial intelligence, virtual reality, data modelling, automation and data management technologies have

Dr. Shekhar C. Mande, DG, CSIR & Secretary, DSIR launching the Compendium of Indian Technologies for Combating COVID-19, compiled by NRDC at CSIR-HQs, New Delhi. Dr. H. Purushotham, CMD, NRDC (left) was present on the occasion

also played a critical role in everything from tracking the outbreak and providing scenario planning, to helping quickly build medical devices, repurposing of vaccine candidates and even support for research in finding viable treatment and applying the ICT platform technologies and innovations are going to play a major role in the time to come.

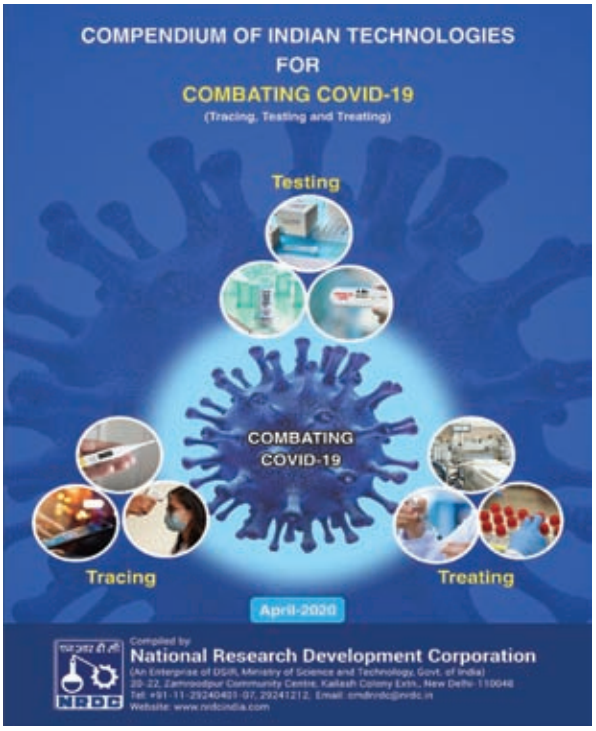
To accelerate the development of technology to combat COVID-19, and its dissemination to all the stakeholders, NRDC has aligned its policies, activities and service delivery models in line with the mandates of national R&D labs to enable the innovations to reach the public fast and on time. In this regard, some of NRDC's initiatives are briefly highlighted below.

Compendium of Indian Technologies for Combating COVID-19

The COVID-19 pandemic has highlighted the pressing need for countries to focus more on advancements in Science, Technology and Innovation (STI) in both policy and practical terms. India's proactive and prolific approach to fight the COVID-19 pandemic started under the eminent leadership of the Hon'ble Prime Minister of India, Shri Narendra Modi. At present, there is no known specific, effective and proven treatment and vaccine available for the disease. In India, about 30 COVID-19 vaccines are in different stages of development. A few are moving towards clinical trial stages. The existing drugs are also being repurposed simultaneously. The six Indian companies in the race to formulate the first COVID vaccine are Zydus Cadila, Bharat Biotech, Indian Immunologicals Limited, Biological E. Limited, Serum Institute of India Pvt. Ltd., and Mynvax. In this critical situation, the Government of India has dynamically activated programmes like 'Make in India', 'COVID-19 Task Force', as also various science ministries, departments and funding organisations to battle this pandemic. To combat COVID-19, all these Government of India organisations have risen to the occasion and come out with various innovations and technological solutions.

The Indian Council of Medical Research (ICMR) has announced its partnership with Bharat Biotech International Limited (BBIL) to accelerate the clinical trials of the indigenous COVID-19 vaccine (BBV152 COVID vaccine).

In two-three months, Indian scientists and the research community have developed numerous indigenous, efficient and affordable technologies to fight the SARS-CoV-2 infection. NRDC has identified the relevant technologies and brought out a widely appreciated *Compendium of Indian Technologies for Combating COVID-19*. The compendium comprises information about 200 COVID-19-related technologies, ongoing research activities, the projects at proof-of-concept stage, technologies available for commercialisation, and initiatives and efforts taken by the Government of India categorised under the 3Ts — tracing, testing and treating. This compendium will serve as a ready reference for policy makers, industries, entrepreneurs, startups, MSMEs, research scholars, scientists and other stakeholders. Most of these technologies can help the entrepreneurs to take the product to the market faster as they do not have to reinvent the wheel. Several technologies related to diagnostics and testing of COVID-19, compiled in the compendium, are approved by ICMR.



The compendium prepared by NRDC was launched by Dr. Shekhar C. Mande, Director General, CSIR and Secretary, DSIR, Government of India at CSIR Headquarters, New Delhi on 6 May 2020. Dr. Mande praised NRDC for this initiative.

NRDC received many inquiries for the transfer of technologies/ products listed in the compendium, like personal protective equipment and masks for frontline health workers, in addition to portable ventilators and isolation chambers, UV sanitization and disinfecting devices, chip-based RTPCR diagnostic testing kits, nasal gels, immunity boosting and health care technologies, etc. NRDC provided the DRDO technologies to the interested entrepreneurs, startups, and MSMEs. Many more technology transfer projects are in the pipeline. Discussions between NRDC, scientists, R&D laboratories and entrepreneurs, startups, MSMEs, and PSUs are underway and this will soon culminate in technology commercialisation activities.

Transferred Technologies to 8 MSMEs for Combating COVID-19

NavRakshak PPE Suit

NavRakshak, a low-cost breathable PPE suit, has been developed by Dr. Arnab Ghosh, a naval doctor of the Indian Navy, posted at the recently created Innovation Cell at the Institute of Naval Medicine (INM), Mumbai. A pilot batch of PPEs was produced at the Naval Dockyard in Mumbai, for the comfort and protection of the doctors. The PPE suit is made of superior-quality breathable fabric while its design eliminates the need of the costly taping and sealing of the seam, otherwise needed in other PPEs available in the market. The fabric, suit and seam meet the synthetic blood penetration resistance criteria comfortably. The PPE was tested and certified at the Institute of Nuclear Medicine & Allied Sciences (INMAS), Defence Research and Development Organisation (DRDO), an accredited lab authorised by

Dr H Purushotham, CMD, NRDC (fourth from right) and Mr RK Nayyar, MD, IGC, Agra (fourth from left), exchanging the documents of Technology License Agreement in the presence of Surg R Adm Dr G Vishwanath, ADG MS, Indian Navy, MoD, New Delhi (second from right), Shri DC Joshi, Chief (BD), NRDC (first from right), Surg Lt Cdr Dr Arnab Ghosh, INM, Indian Navy (third from right), Col Anuj Garg, IPF Cell, DGQA, MoD, New Delhi (third from left) Ms Pooja Goel, Manager (F), NRDC (second from left), and Ms Shefali Nayyar, IGC, Agra (first from left)

the Ministry of Textiles for PPE prototype sample testing as per the prevailing ISO standards and guidelines of the Ministry of Health and Family Welfare and the Ministry of Textiles.

NRDC has transferred the NavRakshak PPE kit know-how to six MSME manufacturers — M/s. Greenfield Vintrade Pvt. Ltd., (Kolkata), M/s. Vaishnavi Global Pvt. Ltd., (Mumbai), M/s. Bharat Silks (Bangalore), M/s. Sure Safety India Ltd., (Vadodara), M/s. Swaps Couture (Mumbai), and M/s. Indian Garment Company (Agra). These manufacturers are planning to mass-produce more than 12 million PPEs per year. NRDC along with the IPFC-DGQA, Ministry of Defence has filed a patent application and for trademark protection of the PPE kit in India.

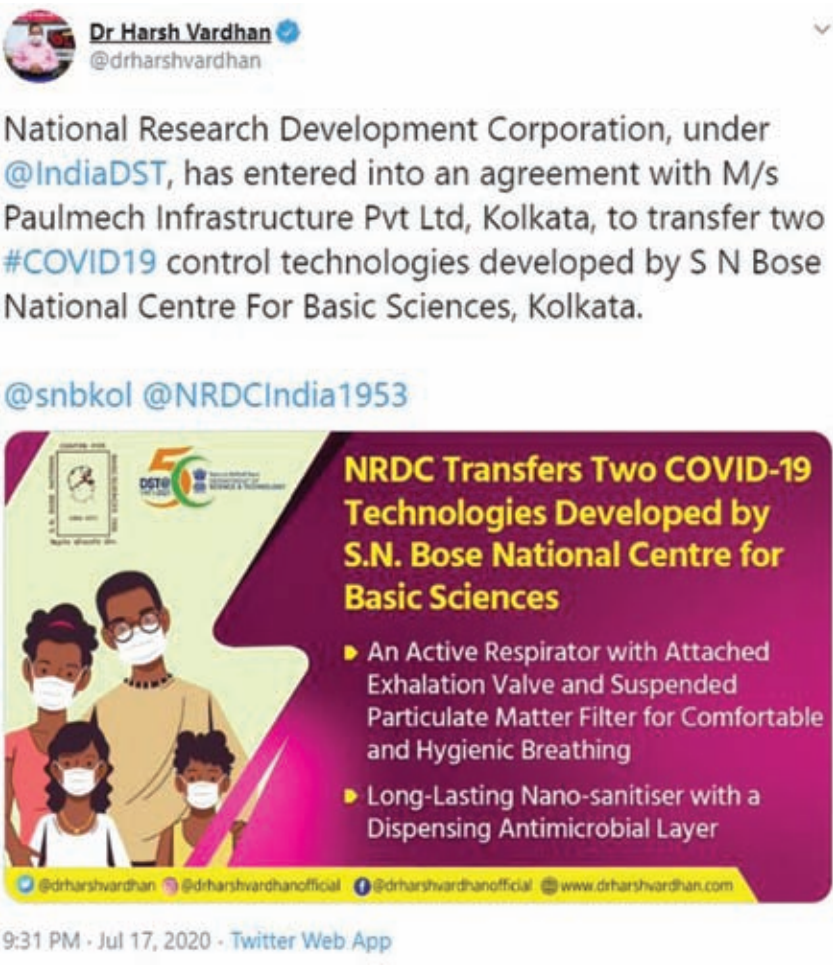
NavRakshak PPE Suit

Transferred COVID-19 Technologies Developed by S.N. Bose National Centre for Basic Sciences

S.N. Bose National Centre for Basic Sciences (SNBNCBS), Kolkata, an Autonomous Research Institute under the Department of Science and Technology, Government of India, has developed two COVID-19 related technologies:

1. An active respirator with attached exhalation valve and suspended particulate matter filter for comfortable and hygienic breathing; and
2. Long-lasting nano-sanitizer with a dispensing antimicrobial layer.

These innovative products will help the users in overcoming the existing problems related to masks and sanitizers available in the market.



NRDC has entered into an agreement with M/s Paulmech Infrastructure Pvt. Ltd., Kolkata, to transfer these two technologies. The agreement was signed online on 13 July 2020 by CMD, NRDC and Shri Shanti Ranjan Paul, Director, M/s Paulmech Infrastructure Pvt. Ltd., in the digital presence of Professor Ashutosh Sharma, Secretary, DST, Government of India and Prof. Samit Kumar Ray, Director, SNBNCBS, Samir Kumar Pal, Scientist Professor, Ms Shohini Majumder, Registrar,

Dr. H. Purushotham, CMD, NRDC and Shri Shanti Ranjan Paul, Director, M/s Paulmech Infrastructure Pvt. Ltd., signing the technology transfer agreement online in the digital presence of Professor Ashutosh Sharma, Secretary, DST, Government of India and Professor Samit Kumar Ray, Director, SNBNCBS, Samir Kumar Pal, Scientist Professor, Ms Shohini Majumder, Registrar, Dr. Soumen Mondal, Nodal Officer, Technical Research Centre (TRC), SNBNCBS, Priyankan S. Sharma, Somavo Gupta of Paulmech Company and senior officials of NRDC

Funding 16 COVID-19 Technologies for Scaling-up and Validation

NRDC has invited proposals from innovators under its DSIR grants-in-aid promotional programme for the development of technologies for commercialisation (PDTC) for upscaling COVID-19 related technologies. This scheme has been launched to fund and commercialise COVID-19-combating technologies, support researchers and innovators to scale-up their lab-scale and proof-of-concept stage technologies to commercial-scale.

NRDC has formulated a scheme to bridge the gap in availability of grant funds for scale-up and prototyping of innovative technologies. This support will help the innovators and startups to accelerate the technology development process and bring innovative technologies into the market in the next one year.

The financial support is given for development of COVID-19 technologies in the area of tracing, testing and treatment, covering process scale-up, pilot plant studies, validation/authentication of the product, registration of the product with regulatory authorities, conducting field trials, generation of toxicology data, and bridging the gap between the lab-scale development and industrial requirement, so that commercial production and marketing of the product becomes successful.

In response to an advertisement, NRDC received 65 proposals seeking funding in the area of test kits, sanitizers, ventilators, PPEs, masks and COVID-hospital effluent treatment. A three-member external Technology Expert Committee was constituted and they have recommended 16 projects for funding. Some of the institutions and companies selected include: IIT Delhi; Sahajanand Technologies Pvt. Ltd., Surat; IDEMI, Mumbai; INM Indian Navy, Mumbai; Omix Research & Diagnostics Laboratories, Bengaluru; VBRI Innovation Pvt. Ltd., New Delhi; FFDC, Kannauj; CIBART, New Delhi; Rudrani Hospitality Solutions, Delhi; LN Inditech Services Pvt. Ltd., Bhubaneswar; SRIT, Anantapur; Ramachandra College of Engineering, Eluru; and a few academic institutions and individual innovators.

Dr. Soumen Mondal, Nodal Officer, Technical Research Centre (TRC), SNBNCBS, Priyankan S. Sharma, Somavo Gupta of Paulmech Company and senior officials of NRDC. Prof. Ashutosh Sharma, Secretary, DST congratulated all the stakeholders for bringing forth the fruits of science and technology to benefit society.

Other Services

NRDC has received many technological innovations in the past four-five months for IPR and technology transfer services. NRDC has evaluated the innovations and facilitated patent filing services to innovations like 'UV-disinfectant portable negative pressure isolation chamber', 'COVID-19 isolation capsule' 'Nano-based anti-viral sanitizers and disinfectants', etc. NRDC also carried out a Global Patent Landscape Study on COVID-19 combating technologies. This was published in *Advanced Materials Letters* (2020, 11(5) DOI 2005 1503).

Way Forward

In building an *Atmanirbhar* Bharat, R&D, innovation, entrepreneurship and startups will have to play a major role. Team NRDC will continue to align its policies, meet the expectations of NIS players and contribute to *Atmanirbhar* Bharat significantly.

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Startups *vs* COVID-19

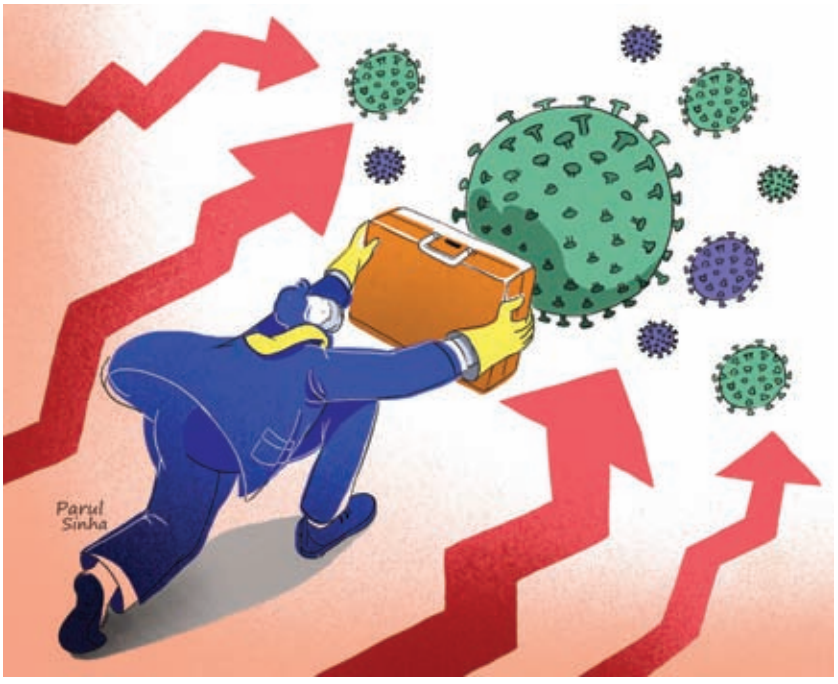
Role of Indian Innovation Ecosystem In Fighting the Pandemic

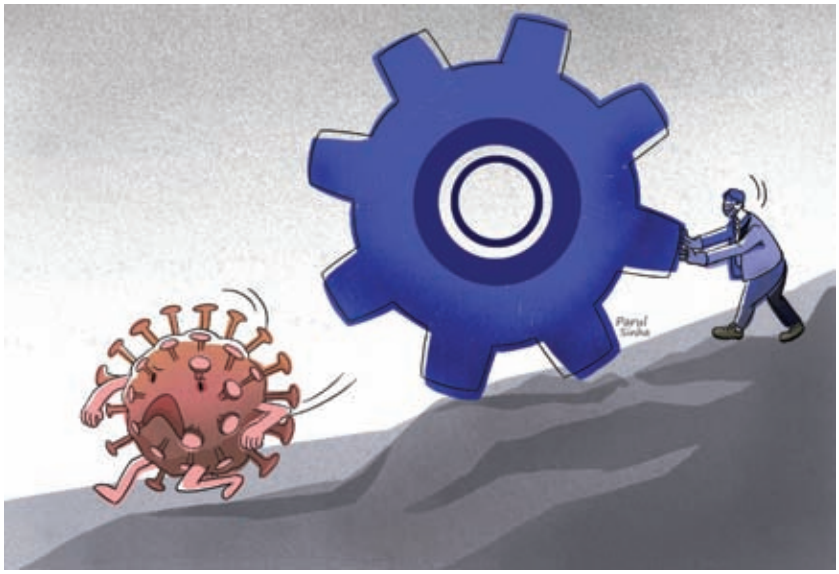
R. Ramanan, Naman Agrawal, and Himanshu Agrawal

The COVID-19 crisis, which has descended upon the world with unimaginable swiftness, has quickly escalated and deeply disrupted lives, livelihoods, and economies everywhere. Its infectious spread has affected people from all walks of life in over 215 countries, accelerated by a complex interconnected world in which we all live, where the movement of people is essential to the economy of almost all countries. The COVID-19 pandemic has left countries gasping in search of immediate solutions, even as the best scientists and researchers in health and biotechnology in the world are diligently looking for a solution or a vaccine to end this crisis.

A crisis of this magnitude which is spreading rapidly requires urgent preventive, and curative solutions in several categories, ranging from high-quality, reliable masks, PPEs, and disinfectants to contact tracking, etc. There is an

The COVID-19 pandemic has left countries gasping in search of immediate solutions, even as the best scientists and researchers in health and biotechnology in the world are diligently looking for a solution or a vaccine to end this crisis. There is an urgent need to test, deploy, and evolve these solutions quickly over the next few months. Not only does this require significant innovation appetite, but it also requires incredible agility on the part of businesses and government institutions to effectively capture and eliminate the threat of COVID-19.





urgent need to test, deploy, and evolve these solutions quickly over the next few months. Not only does this require significant innovation appetite, but it also requires incredible agility on the part of businesses and government institutions to effectively capture and eliminate the threat of COVID-19.

Along with the fight against COVID-19 on the health front, India needs to keep its expansionary economic policy in 2020. However, the room for action is limited and further complicated by the COVID-19 outbreak.

In 2019, India implemented an expansionary economic policy to support the slowing economic growth. Consequently, the country's consolidated economic deficit, which includes Central and local governments' general public balances, and its fiscal deficit in 2020-21, may rise up to 6.2 per cent of the GDP from 3.5 per cent as a fallout of the COVID-19 pandemic, Fitch Solutions said. For 2020, India pledges to keep this expansionary economic policy. Moreover, the COVID-19 outbreak and its consequences pose a significant challenge to the economic stance.

In spite of the limited available opportunities, the Indian government would likely spend more on key projects as a counter-cyclical measure. Specifically, there are four priority areas. The first one is poverty alleviation projects. As much as 68.8 per cent of the Indian population lives on less than ₹150 a day. Over 30 per cent have less than ₹94 available per day: they are considered extremely poor. This makes the Indian subcontinent one of the poorest countries in the world; women and children, the weakest members of Indian society, suffer the most.

Against this background, India announced an economic stimulus package of ₹20 lakh crores to support economic activity in the production sector in a bid to ensure the supply of medicines and daily necessities. The effort is further targeted at encouraging enterprises and people to donate money and goods and at easing the tax and fee burden on industries that are heavily hit by the virus outbreak.

With the difficult task of protecting more than 1.3 billion people from the clutches of SARS-CoV-2, the Indian government is pursuing several initiatives simultaneously to ensure that this global pandemic does not cause ruin in a country with multiple challenges. Despite the diversity, it has the benefit of its innovative and emerging ecosystem with more than 250 incubators and more than 30,000 new active companies.

In fact, it is not surprising that the government wants to take advantage of its active system and one of the fastest-growing ecosystems in the world. For many reasons that go beyond the COVID-19 crisis, the ecosystem of startups is essential to the future of a nation and benefits from its demographic dividend.

In response to the COVID-19 pandemic, a Government of India Inter-Ministerial Working Group has been set up to identify promising startups that can offer innovative solutions to address the current crisis. The Atal Innovation Mission (AIM) and NITI Aayog are managing this initiative in partnership with Biotechnology Industry Research Assistance Council (BIRAC),

Department of Biotechnology (DBT); Department of Science and Technology (DST) — Government of India; Startup India; AGNIi; MyGov; and other relevant ministries, under the guidance and direction of senior government officials from Science, Technology and Health Ministries.

The Central Government-led COVID-19 Solutions Working Group, which comprises senior officials from the group of government experts, has been mandated to coordinate and find innovative solutions that can be implemented in the next three to six months. This is accompanied by the identification of diverse needs for startup support to help them test, deploy, and extend. Support needs range from access to testing, manufacturing, distribution and logistics, supply chain management, qualified and organisational human resources, and publishing. In addition, 11 government committees have been created to ease and facilitate the support needed by representatives of startups, state, and country in a variety of ways to implement specific solutions across India. This working group is also supported by industry bodies like CII, NASSCOM, UNDP, and TiE, which are committed to tackling COVID-19.

The challenges in India are huge. These include controlling the prevalence of COVID-19 in the cities with their share of densely-populated areas, a vast network of villages that lack adequate hospitals, medical or medical staff, and a migrant workforce that earns a daily wage. Consequently, the solutions required are innumerable by nature and must also be personalised according to local needs. Affordability, as well as high quality and accessibility, is a major challenge and a requirement in a country like India.

Some solutions received from applicants are as follows:

1. **Scitech Airon**: Scitech Airon is a negative-ion generator that helps control viruses, bacteria, and fungal infections through COVID-19 positive cases and suspects. It has been scientifically tested to reduce the viral load by 99.7 per cent in a room. The efficacy of the ion generator has also been observed in different types of pathogens like the influenza virus, Coxsackie virus, poliovirus, human coronavirus, a range of allergens, bacteria, and fungi. It could also be useful against floating viruses in the air on public transport, train stations, or airports, or especially within a confined space like a plane cabin, house, hospital ward, and so on. The Department of Science and Technology (DST), Government of India has released ₹1 crore to manufacture and scale-up the product, and 1,000 of them will soon be ready for installation in various hospitals in Maharashtra.

2. **WHIFF Bio Spray**: WHIFF Bio Spray by OMG Innovations LLP is a unique patented technology that has potent antimicrobial and antiviral properties. This property could be used to eliminate and neutralise disease-causing bio-agents in the air quickly, safely, and effectively. Whiff Bio Spray can prevent this spread through the air, both outdoor as well as indoor, and has been tested for drug-resistant pathogens at a NABL-certified lab. It has been successfully pilot-tested for efficacy on drug-resistant pathogens in a hospital environment at All India Institute of Medical Sciences, New Delhi.

3. **VapCare**: VapCare by Coeo Labs is an automated secretion management and oral hygiene system for ICU patients on mechanical ventilation. It provides a completely closed system for intelligent and accurate removal of saliva and secretions in a ventilated patient — without any risk of exposure of the nurse to these secretions. VAPCare also significantly reduces the nursing burden by automating a key nursing step in the management of ventilated patients, which will also be critical in the impending shortage of nursing staff with increased ICU admissions for COVID-19 patients.

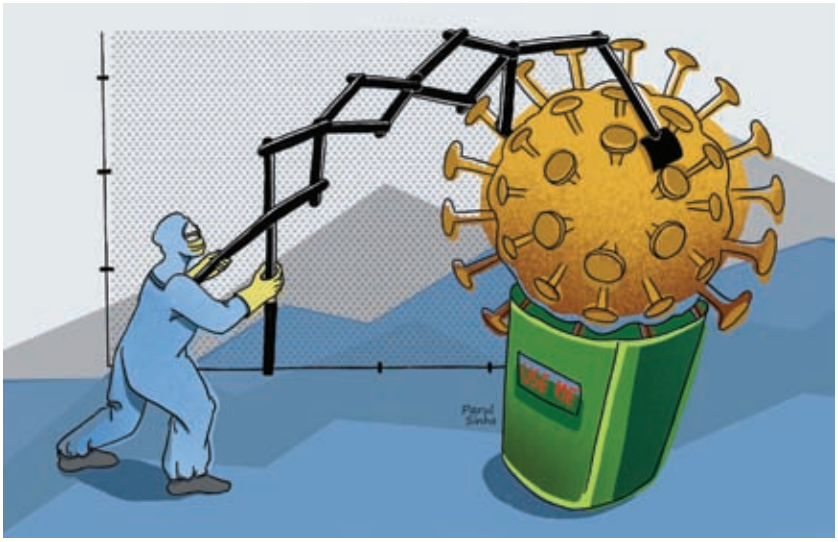
4. **Ozyn-D**: Ozyn-D by Rcupe Lifesciences is an indigenously developed, novel intraosseous (IO) device for pre-hospital and hospital critical care in resuscitation of patients. The manual device gains access to circulation through long bones in less than 10 seconds and infuses fluids and medications in comparable rates as that of IV. The device is usable by paramedics and nursing staff in resource-poor settings (typical of medical emergencies). It is sterile, single-use, disposable, and ready to use at the point of care without any preparation. This highly scalable device is usable in both adult and paediatric patients. The insertion site being away from the face protects the care provider from the risk of infection.

5. **Swachhta Picker**: Swachhta Picker by Sarjan Innovations Private Limited is a manually operated handheld equipment that helps to pick up all kinds of solid and semi-solid waste from a distance without a need to bend or physically touch the waste. It, therefore, eliminates the need for direct contact with waste and hence minimises many kinds of health and safety risks for the sanitation workers. In the context of COVID-19, it has a significant role to protect sanitation workers from the transmission of the disease through contaminated waste. In the current situation, sanitation workers are facing an onslaught of contaminated domestic garbage as millions of people stay home and throw a lot of contaminated masks, gloves, hand sanitizer bottles, used food packets, etc., along with the domestic waste. Direct exposure to this waste is likely to exponentially increase the risk of sanitation workers to get infected with COVID-19. The criticality lies in the fact that even if one frontline sanitation worker gets infected, the whole municipal system in an area may come to a halt, which would be disastrous. This is because most of the workers and staff will then have to be moved to isolation, and it can stir fear among the workers in other areas too. The second major threat is that many of our sanitation workers live in densely-populated areas or slums, and if anyone of them gets infected, COVID-19 will reach the Indian slums, which can have a catastrophic effect. The use of ***swachhta picker*** will add another barrier to such transmission by the physical distancing of waste from sanitation workers and would protect them from getting infected. Hence, proper equipment is necessary to save these bravehearts who are at the front for all of us. Moreover, the equipment is not just for SARS-CoV-2; it would be used in the long term to save the workers from a lot of other health and safety risks on account of their job. Transmission through waste could be another big challenge against the fight with COVID-19. A recent press release by the United Nations on 24 March 2020 has warned about the same. (https://www.unenvironment.org/news-and-stories/press-release/waste-management-

essential-public-service-fight-beat-covid-19)

6. **Net4Medix**: Net4Medix by Periwinkle Technologies Pvt. Ltd. is a cloud-based system with apps on Android, iOS and web for patients and their healthcare providers. It is a multi-specialty system intended to be used by doctors/caregivers to receive diagnostic data from the patients and provide related consultation even remotely. Primary Goal Pandemic Monitoring enables effective management of positive patients/suspect positive patients of COVID-19, and provides a pre-determined level of remote support to non-COVID-19 patients who need medical assistance.

7. **Jiyyo**: Jiyyo is also an AI-enabled Patient Care Coordination Platform (mobile/web) with a focus on telemedicine and networking features for doctor-doctor, patient-doctor, patient-chemist, hospital-referring doctor interactions. Jiyyo is collaborating with the local healthcare workforce (in Tier-II & Tier-III cities, and also in villages) to create a SMART network of thousands of HealthCare Access Points in rural India powered by its Artificial Intelligence Enabled Patient Care Coordination Platform. Built on top of the proprietary telehealth platform, the team has launched a Patient app as well to connect rural and urban patients with qualified doctors.



8. **Noctua M**: Noctua M by Detect Technologies is an effective solution to monitor large and dynamic crowds. Comprising a visual camera and a smart megaphone, it provides a live feed at the client's hand, which helps in the live monitoring of people. With the help of a smart megaphone, the client can access the speaker on the drone through the access given on the mobile phone with one tap on the call icon. While drone surveillance is live, alerts/messages can be passed on to the people under surveillance with the help of the smart megaphone. Noctua M solution can also be equipped with thermal cameras, which help in monitoring people at low-light conditions. Accessing the work areas from the desk in any day/night conditions to pass on the alerts is made easy with Noctua M.

9. **ReMeDi CORONA**: ReMeDi CORONA by Neurosynaptic Communications Pvt. Ltd. is a screening application for self-use by individuals. This application can be downloaded by any individual, and a risk assessment for infection can be obtained by filling up details like travel history, contact history, and symptoms. Further, this screening can be done by an individual often to check the updates in the risk assessment. High risk would prompt the individual to immediately visit a hospital. The location of the individual is also tagged with his/her consent. This kit includes a tablet and IR thermometer as well as a Rapid Test Kit (lateral flow assay) for COVID-19 suspects, and BP, SPO2 for other patients, who might need care but are not COVID-19 suspects. This is ideal for hospitals or NGOs to carry out screenings on a large scale. There is a bridge available for teleconsultation for non-COVID-19 patients who have been indicated as medium or low risk, as they may need consultation.

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CSIR
Combating the Pandemic, Providing Solutions

HASAN JAWAID KHAN

Ever since the Coronavirus pandemic broke out, CSIR has mounted a multi-pronged approach geared towards containing the spread of the virus by providing sanitization and disinfection solutions to equipping the frontline workers and health warriors with protective gear. At the same time, CSIR laboratories have put together their rich experience and expertise to explore repurposing of existing drugs and discovering new drugs and vaccines to provide relief to COVID-19 patients.

IT was on 31 December 2019 that China alerted the World Health Organization (WHO) to several cases of an unknown virus causing unusual pneumonia in Wuhan city. Eventually, the strange and unknown virus was identified as the Novel Coronavirus-2019 on 7 January; on 9 January came the report of the first death in China due to the new virus. Then on 11 February, WHO announced the name of the disease as COVID-19. A month later, on 11 March, as thousands succumbed to the deadly virus, the WHO declared it a pandemic. From then on, the confirmed cases of COVID-19 have crossed 21 million with more than 7.5 lakh deaths in 215 countries as on 17 August 2020.

While the world scientific community scrambled to get an insight into the sinister workings of one the most deadly viruses the world has ever known, the COVID-19 pandemic has shown little signs of abating. Scientists around the world are exploring drugs, vaccines, and other technological solutions to combat the implications of the virus.

In India, the laboratories of the Council of Scientific and Industrial Research (CSIR) also intensified their efforts at combating the pandemic. The CSIR strategy, in collaboration with academic institutions and its industry partners, has been laid out in the form of five technology verticals:

1. Digital and molecular surveillance: Surveillance at the level of the virus, humans and geographical origins and distributions is critical.

- *Digital Surveillance* involves collection of data of confirmed cases and suspected cases, probable cases, contact cases through contact tracing (that may include asymptomatic as well). The data so generated is closely analysed to interpret the spread of the disease and facilitate the government to take necessary action on a timely basis and mitigate community level transmission of SARS-CoV-2.
- *Molecular surveillance* involves sequencing of viral genomes in India to understand the virus spread and mutation frequency and implications for the development of vaccine, drug and diagnostics.

2. Rapid and economical diagnosis: Since the control strategy of the virus pandemic involves rapid and mass testing, there is a need to come up with rapid and cost-effective methods of diagnosis.

3. Development of new drugs/ repurposing of drugs: Since the development of new drugs takes anywhere from five to eight years, CSIR embarked on a strategy to explore repurposing of existing drugs while at the same time exploring natural products and traditional medicines.

4. Hospital assistive devices: With the increasing pressure on hospitals due to the rising number of COVID-19 patients, a major challenge is the severe shortage of ventilators and oxygen enrichment devices and the provision of personal protective equipment (PPEs) to the frontline of defence against the virus manned by the hospital and health workers. There was also the need to equip hospitals and health workers with such equipment in large numbers.

5. Supply chain and logistics: This initiative is to ensure that no organisation (hospital, testing lab, ambulance network, health centre, *mohalla* clinic, police, municipality, etc.) ever runs short of what is needed to address the COVID-19 pandemic.

Ever since the COVID-19 pandemic posed unique challenges for the scientific and medical fraternity, CSIR labs have focused their attention on coming up with innovations and leads that could help in combating the challenge.

Understanding the virus

Without an insight into the working dynamics of the virus it is difficult to either come up with new drugs or treatment regimens. Two institutes — CSIR-Centre for Cellular and Molecular Biology (CCMB), Hyderabad, and CSIR-Institute of Genomics and Integrative Biology (IGIB), New Delhi — are working on sequencing the genome of the COVID-19 virus. A better understanding of the strain of the virus would enable the institutes to establish its family tree and implement better isolation strategies. Generating genome sequences of viral isolates from across the country will also help understand the genetic component influencing the variability in individual response to the viral infection by studying patient genotypes.

India recently crossed the 1,000 mark for the COVID-19 genomes sequenced, with 50 per cent of these from CSIR. So far, CSIR has sequenced more than 700 viral genomes. Of these, 258 viral genomes have been deposited in the GISAID (Global Initiative on Sharing All Influenza Data) database. This would help in

A BSL-2+ virology lab equipped with RT-PCR equipment has been set up at CSIR-IMTECH

understanding the Indian viral strains and specific mutations, if any. The sequencing will help in understanding the origins of the virus, which will further aid in developing vaccines.

Rapid testing

Given the scale and extent of the spread of the virus infection, rapid testing is essential. Scientists of the CSIR-Institute of Genomics and Integrative Biology (IGIB), New Delhi have come up with a low-cost, paper-strip COVID-19 test, which can detect the virus within an hour. The paper-strip test, similar to the test used to confirm pregnancy, utilises CRISPR-Cas9, a cutting-edge gene editing tool. Not only is the test cost-effective — it costs ₹500 as compared to the PCR test being currently used and which costs ₹4,500 — it also does not need dedicated machinery or specialised skill.

Several CSIR labs have also been approved to carry out testing for COVID-19. In fact, 16 labs across the country are carrying out testing via RT-PCR. The latest approach being adopted by CSIR is pool testing in which a number of samples are pooled and tested together. If the result is negative, it signifies all individuals in the group are free of the virus. However, if the test gives a positive result, each sample is analysed individually to trace the COVID-19 positives. This method will bring down the cost of detection and ensure a wider reach and will be able to indicate which sections could be allowed to move around.

CSIR-CCMB has trained medical staff to handle patient samples

CSIR has also entered into collaboration with Syngene for Next Generation Sequencing (NGS)-based sample pooling and testing that will cater to large-scale screening. In this, samples will be labelled with a unique barcode and they will be pooled and shipped to the sequencing facility where multiple pools will be combined, and high throughput sequencing will be done: positive samples will be identified based on patient barcodes. The advantage is that there is no restriction of low occurrence areas and large number of samples per sequencing: ~10,000 to 50,000.

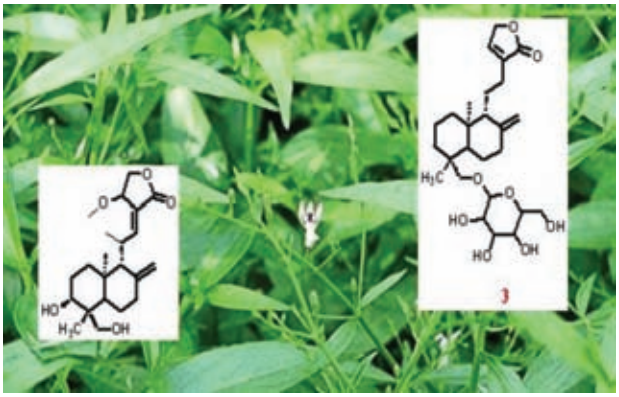
CSIR labs have also made preparations for synthesis of reagents that are required in large quantities for bulk RT-PCR diagnosis. CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad has been able to develop recombinant enzymes (reverse transcriptase and DNA polymerase and two other proteins) that are used in RT-PCR reaction.

CSIR-CCMB has even trained medical staff from several hospitals and medical colleges to handle patient samples and perform RT-PCT detection assays.

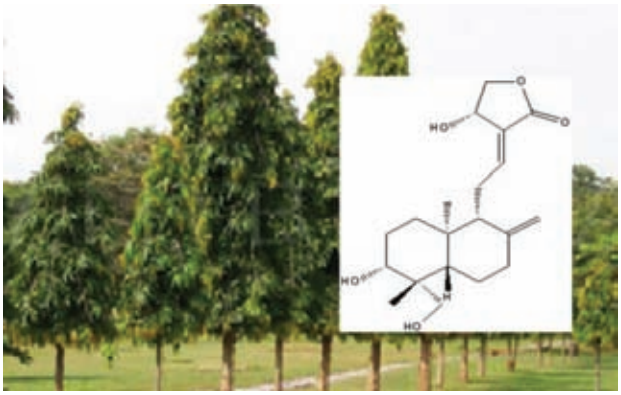
Developing drugs for treatment options

Since it takes anywhere from five to eight years, or even more, for a new drug to reach the market, CSIR's strategy has been to explore existing and approved drugs and repurpose them for treatment of COVID-19.

CSIR has identified the top 25 drugs/drug candidates for repurposing based on global therapeutic pipeline. For instance, CSIR-IICT has already developed the key starting material for Remdesivir, a drug that has recently received FDA approval



CSIR-CDRI has isolated several single compounds from *Andrographis paniculata* commonly called 'Kalmegh' for anti-viral studies



CSIR-CDRI has isolated some single molecules from Ashoka tree (*Polyalthia longifolia*) for evaluation against SARS-CoV-2

for emergency use for COVID-19 patients. Similarly, IICT has also developed a synthetic process for development of another promising drug Favipiravir and transferred it to Cipla, which has submitted the application for regulatory review to the Drug Controller General of India (DCGI) for clinical trials/approval in India.

Favipiravir and Umifenovir (Arbidol) have already been approved by the Drug Controller General of India (DCGI) for clinical trials to treat COVID-19. The regulatory body has approved Favipiravir for the second phase of clinical trials, and multicentre trials are underway across different locations, including Mumbai and Pune.

The Umifenovir drug also has a good safety profile and acts by preventing entry of viruses into human cells. It also works to prime the immune system and is used for the treatment of influenza. Clinical trials to evaluate its efficacy are also underway.

Along with Favipiravir and Umifenovir, other CSIR drugs now in clinical trials are ACQH and Mycobacterium W (anti-leprosy drug). With the focus on repurposed drugs and with 10 in the basket so far, CSIR is hopeful of results in the next two to three months.

Multi-centre clinical trials of phytopharmaceutical ACQH have begun. It is a plant extract found in the tribal belts of Gujarat, Jharkhand and Madhya Pradesh. Another drug, Mycobacterium W (Mw), has been under clinical trials.

The joint trials by CSIR and Cadila on Sepsivac, a drug used to treat a life-threatening infection, sepsis, have shown promising results. Sepsivac is an immunomodulator drug that boosts the innate immunity and also works to reduce the release of inflammatory Cytokine IL-6 that attacks internal organs.

Phase 2 trials were conducted across Postgraduate Institute of Medical Education and Research, Chandigarh; All India Institute of Medical Sciences (AIIMS) Delhi; and AIIMS, Bhopal. Once the necessary data from the phase 2 trials are available, the two parties will once again approach the regulator to see if this drug can be given emergency-use authorisation in the wake of the pandemic. Approval to start two phase 3 trials are in place — one on 600 patients, another on 500 patients. For the third phase, two more sites will be added — AIIMS Raipur and a Banaras Hindu University institute.

CSIR labs are also working to reduce dependency on active pharmaceutical ingredients (APIs) and drug intermediates from other countries. In view of the worldwide COVID-19 lockdown and apprehending shortage of supplies, CSIR-National Chemical Laboratory (CSIR-NCL), Pune, CSIR-IICT and many CSIR labs are working towards self-sufficiency in drug supply chain for India by developing indigenous processes and platform technology to produce important key starting materials (KSMs)/drug

intermediates and APIs in the country.

Apart from repurposing of existing drugs, CSIR is also working on developing new drugs against the SARS-CoV-2 through data mining. It is collaborating with major software companies to use AI and machine learning so that large compound databases can be combed to identify potential drugs for further development.

CSIR is also setting up viral cultures at CSIR-CCMB and CSIR-Institute of Microbial Technology (CSIR-IMTECH), Chandigarh to test the compounds and drugs identified that can act against the SARS-CoV-2.

Most recently, CSIR approved a project to develop human monoclonal antibodies that can neutralise the virus in patients. Led by Bharat Biotech, a vaccine manufacturer, the project aims at generating highly effective and specific human monoclonal antibodies that are capable of neutralising the SARS-CoV-2 virus.

Meanwhile, CSIR is also jointly working with the Ministry of AYUSH to explore natural products that can be used in preventive and prophylactic symptom management and as add-on interventions to modern medicine treatments. CSIR labs have identified *Glycyrrhiza glabra*, *Tinospora cordifolia* and *Withania somnifera* for further explorations.

CSIR-Central Drug Research Institute (CSIR-CDRI), Lucknow has also isolated important andrographolides, neoandrographolides and graphisides from *Andrographis paniculata* (*Kalmegh*) and *Polyalthia longifolia*, commonly known as the 'Ashoka tree', for testing their efficacy against SARS-CoV-2.

The disinfection mantra

With sanitation and disinfection emerging as a major preventive measure against the rampaging virus, CSIR has also come up with innovations that promote sanitation and disinfect surfaces and surroundings.

In Bhubaneswar, the CSIR-Institute of Minerals and Materials Technology (CSIR-IMMT) has developed a hands-free hand sanitizing system. The system is mechanically operated by foot for dispensing liquid soap for hand sanitization and water flow for washing. On similar lines, CSIR-Central Scientific Instruments Organisation (CSIR-CSIO) has also developed a "Foot Controlled Water Tap" for delivering water from a plumbing system using foot. The use of the foot for operation avoids secondary transfer of germs/ microbes of contagious nature through common usage of faucet.

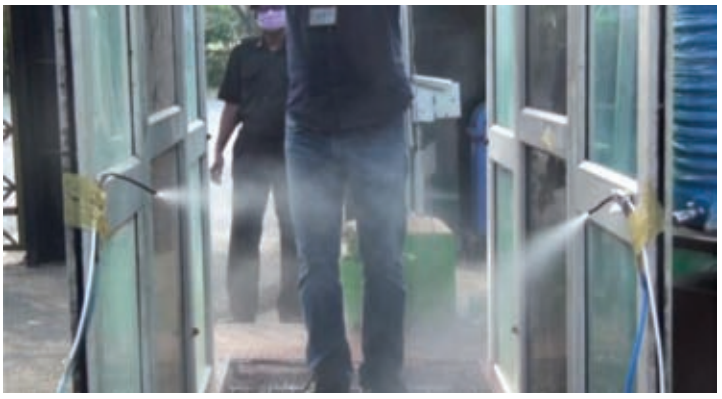
CSIR-CSIO has developed an Electrostatic Disinfection Spray

Electrostatic disinfection machine developed by CSIR-CSIO

CSIR-IMMT's hands-free sanitizing system

CSIR-CMERI's road sanitizing system

CSIR-CSIO's foot-operated water tap



CSIR-CMERI's disinfection walkway

Machine that can disinfect any surface, place or object and can take care of droplets of the size of 10 to 20 microns. The machine can be used in public places, bus stands, airports, and with some customisation, even in homes. The technology has been transferred to BHEL for large-scale manufacturing.

To take care of the safety of medical persons in hospitals while treating coronavirus patients, CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) has customised its Bench-scale Air Purification Scrubber (BAPS), meant for outdoor air pollution, to clean up indoor air pollution as well. The scrubber absorbs dust particles from the air. The Disinfection Walkway developed by CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI) also ensures maximum target coverage with minimum shadow area of an individual or an object. It can be deployed at multiple critical locations such as isolation/quarantine facilities, Mass Transit System entry points, medical centres and any other location with a considerable amount of footfall.

CSIR-CMERI has also come up with a road sanitizer unit — a tractor-mounted road sanitizing system with a span of about 4.9 metres, which uses 15 to 35 bars of pressure to ensure effective delivery of the sanitizer. The system utilises a 3,000-litre tank with a pump of capacity 22 litres per minute (LPM) which can be used to sanitize a road stretch of up to 50 kilometer.

Ventilators and PPEs

With several infection cases requiring hospitalisation increasing and expected to increase further, the availability of ventilators and oxygen enrichment equipment in hospitals for critically ill COVID-19 patients has emerged as a major challenge.

CSIR has started collaborating with BHEL on a war footing to develop ventilators to ensure these are not in short supply when the disease enters the critical stage. So, while CSIR-National Aerospace Laboratories (CSIR-NAL), Bengaluru, is working on the Bi-Level Positive Airway Pressure (BiPAP) system, CSIR-CSIO is working on a respiration assistance intervention device (RESPaid), which is a portable

CSIR-CECRI has developed 3D printed face shields to help protect doctors and nurses treating COVID-19 patients

3D printed protective face shields for doctors and paramedics developed by CSIR-CSMCRI

ventilator. CSIR-CMERI has developed a prototype for mechanical ventilator, which might be deployed to help large numbers of prospective patients, if required.

In addition to ventilators, Personal Protective Equipment (PPE) is also required in large numbers for health workers directly working with COVID-19 patients. Three items — masks, gowns and gloves — are especially expected to see significant increase in demand by the medical fraternity. Several CSIR labs are working on production of self-disinfecting or reusable protective gears to ensure that these are not in short supply.

CSIR-CSIO has designed an easy-to-fabricate face shield, which uses easily available materials for production in volumes with minimum investment in materials and machines. The design is ergonomic with universal head size adaptability, avoids fogging, is ultra lightweight and provides ample room to wear eyeglasses. Similarly, CSIR-Central Electrochemical Research Institute (CSIR-CECRI), Karaikudi has also developed 3D printed face shields to help protect doctors and nurses treating COVID-19 patients.

Scientists of CSIR-CSMCRI have also used 3D printing technology to make protective face shields for doctors and paramedics attending to COVID-19 patients.

Digital IR thermometer using readily available modules from Venture Centre, CSIR-NCL, Pune

CSIR-NCL-Genrich oxygen enrichment unit medical equipment to be manufactured in collaboration with Bharat Electronics Ltd., Pune

Meanwhile, CSIR-NCL has initiated collaboration with Bharat Electronics Ltd (BEL) for the assembly/ manufacture of contact-less digital IR thermometer and oxygen enrichment device, both innovations from CSIR-NCL scientists and CSIR-NCL Venture Centre. Multiple units of prototypes will be manufactured at BEL, Pune.

CSIR-NCL has also developed an Oxygen Enrichment Unit (OEU) that is efficient in providing 35-40 per cent oxygen concentration from air with an adjustable flow rate of 0.5-15 lit/min. OEUs have special significance since patient recovery can be faster with supplemental oxygen in early stages. The technology was licensed to NCL start-up, GEnrich Membranes. About 50 units were assembled and demonstrated in various forums, hospitals and primary health centres (PHCs). CSIR-NCL has now tied up with Bharat Electronics Ltd. (BEL), Pune for the manufacture of OEU, along with GEnrich.

In a major development,

Protective coverall developed by CSIR-NAL

OEU developed by CSIR-NCL, GEnrich and manufactured by BEL

Hand sanitizer developed by CSIR-IHBT

CSIR-NAL, Bengaluru has come up with a coverall protective suit for protection of healthcare workers**.** The polypropylene spun laminated multi-layered non-woven fabric has been developed in collaboration with MAF Clothing and has undergone stringent testing. MAF Clothing intends to manufacture 30,000 units per day of the cost-effective protective coveralls.

Frontline defence

Frequent hand washing has emerged as a major preventive against the SARS-CoV-2. Unsurprisingly, hand sanitizers went out of stock due to panic buying. The laboratories of CSIR, therefore, immediately came up with safe, chemical-free, and alcohol-based effective hand sanitizers and disinfectants based on WHO guidelines and even distributed them among targeted sections.

Till date, more than 50,000 litres of hand sanitizers and disinfectants have been produced in the laboratories of CSIR and distributed among more than 100,000 people belonging to underprivileged sections of the society. The laboratories also networked with local administration to distribute sanitizers and disinfectants among personnel belonging to the police force, municipal corporations, electricity supply undertakings, medical colleges, hospitals, panchayats, and banks. CSIR has also transferred the technology to MSMEs and industries for large-scale production of the sanitizers.

While scientists at the CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), based in Palampur, Himachal Pradesh, developed an alcohol-based formulation of hand sanitizer containing active tea ingredients and natural flavours, CSIR's Hyderabad-based laboratory, CSIR-IICT, standardised the process for the preparation of alcohol-based hand sanitizing gel, 800 litres of which was distributed among Telangana Police and Greater Hyderabad Municipal Corporation workers.

Meanwhile, the CSIR-Indian Institute of Toxicological Research (CSIR-IITR), Lucknow also distributed 2,800 litres of hand sanitizers manufactured by it among people in the essential services. Another Lucknow-based institute, CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), also prepared in its pilot facility and handed over 1,000 bottles of its hand sanitizer (Hankool), 1,000 bottles of floor disinfectant (Swabee) and 50 litres of floor cleaner (Cleangerm) to the Lucknow Nagar Nigam and District Magistrate for distribution. CSIR-National Botanical Research Institute (CSIR-NBRI) also transferred herbal alcohol-based hand sanitizer technologies to two entrepreneurs for large-scale production.

In the North-east, the CSIR-North East Institute of Science & Technology (CSIR-NEIST) distributed around 1,300 litres of hand sanitizers and, in Chennai,

Director, CSIR-IITR with the hand sanitizer developed by the Institute

the CSIR-Central Leather Research Institute (CSIR-CLRI) prepared 1,000 bottles of hand sanitizers for use in the Chennai Corporation.

Scientists from CSIR-Central Salt and Marine Chemicals Research Institute (CSIR-CSMCRI), Bhavnagar made large quantities of alcohol-based hand sanitizers and supplied to Bhavnagar Medical College (BMC).

CSIR's Dehradun-based laboratory, CSIR-Indian Institute of Petroleum, also supplied around 1,000 litres of sanitizers to the Doon Hospital, the Police Department, and the State Disaster Relief Force.

Distribution of food

Consequent to the government-imposed lockdown throughout the country, the hardest hit were the migrant labour. With industries, factories and construction activities grinding to a complete halt and no transportation available to return to their villages, the migrant labour in cities faced problems of food availability as well.

Since CSIR has had a major intervention in food-related research and technology, it decided to take care of the nutritional requirements of the migrant labour stuck in various places in the country.

The country's most prominent food technology research institute, the Mysuru-based CSIR-Central Food Technological Research Institute (CSIR-CFTRI), which has over the years developed innumerable food and food processing technologies, stepped in to provide 10 tonnes of high-protein biscuits, 1 tonne of spirulina *chikki*, 10 tonnes of cardamom-flavoured water, and 5 tonnes of nutritious fruit bars to more than 56,000 migrant labourers, patients, doctors and police in two metropolises. The food items supplied by CSIR-CFTRI have longer shelf life and so sustain for a longer time. They are also supplemented with micro-nutrients that boost immunity and help to fight against the SARS-CoV-2. While the fruit bars contain added vitamin C and zinc which are known to improve the immunity, spirulina *chikki* provides micronutrients from spirulina and vitamin A, beta carotene and easily digestible algal proteins.

In fact, CSIR-CFTRI also supplied 500 kg of high-protein biscuits and 500 kg of high-protein rusks to the All India Institute of Medical Sciences (AIIMS), New Delhi for recuperating COVID-19 patients, on a special request from the institute. The biscuits are 60-80 per cent richer in protein than usual biscuits.

Meanwhile, on being informed by a Panchayat representative that several families of migrant labour who were stuck due to the lockdown were struggling to find food, Palampur-based CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), another institute well-known for its food processing technology, put its act together and supplied 5,000 boxes containing 60 tons of *dal chawal aloo* mix, 2.16 tons of ready-to-eat local (Kangra) cuisine, 1,500 spirulina peanut bars, 1,000 multigrain energy bars, and 1,500 multigrain protein powder not only for the migrant labour but also for frontline workers like doctors, paramedical staff, health workers and policemen. The food is free of chemicals and preservatives, has probiotic effects and its shelf life is 12 months.

CSIR-Institute of Minerals & Materials Technology (CSIR-IMMT) in Bhubaneswar also delivered 10,000 packets of ready-to-eat food (*Khichidi*) to

Food boxes prepared by CSIR-IHBT ready for distribution among migrant labour

Food packets supplied to the needy by CSIR-CIMFR

the Commissionerate Police, Bhubaneswar.

The staff of CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR) posted at the Donimalai Iron Ore Mine in Karnataka also put in their bit by distributing food packets containing essential rations for the needy.

CSIR has plans that look at the bigger picture beyond provision of immediate relief to the migrant labour. The reverse flow of populace to rural and semi-rural areas is likely to create social imbalances and so CSIR is planning to support the creation of Rural/Social Enterprises through rural entrepreneurship with support from Tata Sons and Unilever. This would involve training on synthesis and manufacture of disinfectants, sanitizers, soaps, masks, gloves, food products, water purification kits, etc., through social and voluntary organisations.

CSIR also plans to strengthen MSMEs in rural settings for development/manufacturing of ventilators, rapid housing, and quarantine hospitals/structures, walk-through disinfectant structures etc.

The COVID-19 pandemic and the associated lockdown throughout various parts of the world have severely disrupted the availability of critical healthcare supplies compromising the ability to produce and deliver critical items. To address this challenge, on 12 June, CSIR launched 'Aarogyapath', a healthcare supply chain portal.

It is an integrated public platform that provides single-point availability of key healthcare goods and can be helpful to customers in tackling a number of routinely experienced issues. These issues include dependence on limited suppliers, time-consuming processes to identify good quality products, limited access to suppliers who can supply standardised products at reasonable prices within desired timelines, lack of awareness about the latest product launches, etc.

It also helps manufacturers and suppliers to reach a wide network of customers efficiently, overcoming gaps in connectivity between them and potential demand centres like nearby pathological laboratories, medical stores, hospitals, etc.

Aarogyapath will also create opportunities for business expansion due to an expanded slate of buyers and visibility of new requirements for products. Over time, analytics from this platform is expected to generate early signals to manufacturers on overcapacity as well as on looming shortages. This would help to reduce wastage of resources due to inefficient forecasting and excess manufacturing, generate awareness about the demand for new technologies.

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DST strengthens India's Hands in Fight Against COVID-19

The Department of Science and Technology (DST), the nodal department for organising, coordinating and promoting S&T activities in the country along with its network of scientific institutions is providing scientific and technological support in the country's fight against COVID-19. DST not only provided the necessary boost to encourage the institutions to come up with solutions, but also ensured mechanisms to identify market ready solutions from all corners of the country — R&D institutions, universities, industries, startups and so on — and provided support in bringing them to people. The solutions covered all the problems brought about by the pandemic — detection, disinfection, equipment to manage associated emergencies, strategies for healthcare management, triggering communities to reach out as well as effective communication.

The COVID-19 pandemic came upon us to challenge the way we live, earn our livelihood, and run our healthcare services. It is also testing science, scientific infrastructure and human resource built over the years.

The Department of Science and Technology (DST), which is celebrating its 50th foundation year, along with its network of institutions rose up to the need of the hour to find solutions for detection like the Sri Chitra detection kit and the Chitra Magna RNA extraction kit, disinfection systems, masks and personal protective equipment, ventilators and other R&D products. The DST also set up a COVID-19 task force to identify technologies from R&D labs, academic institutions, startups, and MSMEs to fund nearly market-ready solutions for diagnostics, testing, healthcare delivery solutions, equipment and supplies. It also established the Centre for Augmenting WAR with COVID-19 Health Crisis (CAWACH) to source and support startups that have solutions to fight the pandemic. Technology Development Board (TDB) is proactively supporting the efforts of the scientists, technologists, entrepreneurs, and industrialists who are working towards preventing and containing the spread of COVID-19 by providing financial assistance to commercialise these technologies. In addition, TDB is also scouting for novel solutions to support the country's efforts in tackling the healthcare emergency. These efforts have led to a boost in upscaling and manufacture of several technologies.

Diagnostic kits

Rapid diagnostic test kits are of utmost importance in the current situation. The DST and other institutions have ramped up their efforts to develop technologies that can help detect the virus and the stage of infection.

Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Thiruvananthapuram, has developed a diagnostic test kit that can confirm COVID-19 in two hours at a low cost.

The confirmatory diagnostic test, which detects the N gene of SARS-CoV-2 using reverse transcriptase loop-mediated amplification of viral nucleic acid (RT-LAMP), will be one of the world's first few if not the first of its kind in the world.

The test kit, funded by the DST called Chitra Gene LAMP-N, is highly specific for SARS-CoV-2 N-gene and can detect two regions of the gene, which will ensure that the test does not fail even if one region of the viral gene undergoes mutation during its current spread.

Chitra Magna, an innovative RNA extraction kit, has been developed by SCTIMST as an innovative technology for isolating RNA from swabs for COVID-19 tests. The protocol for the kit uses magnetic nanoparticles to capture and concentrate the RNA from the patient sample to confirm the presence of the RNA of the COVID 19 virus in the sample. This is of significant advantage because even if some viral RNA disintegrates during storage and transportation of the patient samples, all of it is captured by the magnetic bead-based extraction technology.

VNIR Biotechnologies Private Limited, Bengaluru, a spinoff from Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, an autonomous institute of the DST, Government of India launched indigenous fluorescence probes and Polymerase chain reaction (PCR) mix for Reverse transcription polymerase chain reaction (RT-PCR) detection, which are molecular probes used in COVID-19 test kits. VNIR Biotechnologies Private Limited is incubated at Bangalore Bio-innovation Centre (BBC) of Government of Karnataka.

Indigenous fluorescence probes and Polymerase chain reaction (PCR) mix for Reverse transcription polymerase chain reaction (RT-PCR) detection kit

Besides, CAWACH, an initiative by the DST, has selected Bengaluru-based startup Acculi Labs to develop a COVID risk assessment profile called Lyfas COVID score. Acculi Labs is armed with 'Lyfas', a clinical-grade, non-invasive, digital functional biomarker smartphone tool for screening, early detection, root cause analysis, acute event risk assessment, prognosis, and home monitoring of chronic diseases, which they have repurposed to Lyfas COVID score.

The new technology developed with support from the DST, will detect possible infection in an asymptomatic individual to prioritise the conventional testing queue as well as carry out risk assessment of an asymptomatic individual to become symptomatic and risk assessment of symptomatic individual for recovery.

TDB, a statutory body of the DST, has approved financial support to My Lab Discovery Solutions, Pune, for ramping up production of COVID-19 diagnostic kits they have developed. The company has submitted an application in response to its invitation for proposals for technologically innovative solutions towards fighting COVID-19. With support from TDB, they will ramp up the production of the kits through

automation of the facility from the current manual process.

Technologists at SCTIMST have developed two types of nasal and oral swabs and viral transport medium for COVID-19 testing. They are Chitra Embed flocked nylon swabs (co-developed with Mallelil Industries Pvt Ltd), and Chitra Enmesh, polymeric foam-tipped, lint-free swabs with flexible plastic handles which will be available as sterile, ready-to-use devices.

Fast Sense Diagnostics, a startup incorporated in 2018 and developing innovative products for rapid disease diagnosis, funded by the DST is now developing two modules for detection of COVID-19. The point-of-care detection kits of Fast Sense Diagnostics that can provide on-the-spot detection rapidly and without highly trained technicians, could boost India's testing efforts in the fight against COVID-19. The two proposed modules can be deployed at any real location and hotspot like airports, densely populated areas, and hospitals where screening of population can be done to prevent the spread of coronavirus to healthy individuals. The data can be generated with ease in less than an hour. The company is working on the cost to make it more affordable.

The DST has funded Module Innovations, a Pune-based healthcare startup working on point-of-care diagnostics to develop a product for detecting COVID-19 with a 10- to 15-minute test.

Disinfectants to keep the virus at bay

A technology, developed under the NIDHI PRAYAS programme initiated by the DST, by an incubatee company of Scitech Park, Pune has emerged as an effective solution for India's fight against COVID-19. The technology works by reducing the viral load of infected areas within a room significantly, within an hour.

The negative-ion generator titled Scitech Airon, which helps to control viral, bacterial, and fungal infections in a closed environment, could clean up the air and disinfect areas, which are exposed to the infection through COVID-19 positive cases and suspects. Hence, it could ensure the wellbeing of the staff, doctors, and nurses who are working round-the-clock in the quarantine facilities by enhancing their disease resistance power and ability to fight the virus. DST is supporting scaling up of the product, and its installation in several hospitals.

Scientists at SCTIMST have designed a Chitra UV-Based Face Mask Disposal Bin, which is a UV-based system. The bin can be used by health workers in hospitals and in public places where decontamination of used face masks, overhead covers, face shields, and so on are required to break the infection chain.

Scientists at SCTIMST have also designed and developed a highly efficient superabsorbent material for liquid respiratory and other body fluid solidification and disinfection for safe management of infected respiratory secretions.

The material called Chitra Acrylosorb Secretion Solidification System, developed by Dr. Manju S. and Dr. Manoj Komath of the Department of Biomaterial Science and Technology of the Biomedical Technology wing of SCTIMST is a highly efficient superabsorbent material.

Scientists from the same institution have designed and developed a disinfected barrier-examination booth for examining COVID-19 patients. The innovative disinfected examination booth is closed like a telephone booth for examining the patient without direct contact with the doctor to prevent transmission of infection. It is equipped with a lamp, table fan, rack, and ultraviolet (UV) light. The installed UV light in the booth disinfects the chamber after each patient leaves.

The Hyderabad-based International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), an autonomous R&D Centre of DST and University of Hyderabad together with the help of Mekins Industries Ltd. (MIL), have developed a UVC based disinfection trolley for rapid cleaning of a hospital environment.

The technology is based on the

principle that UV light in the range of wavelengths between 200 and 300 nm is capable of inactivating microorganisms, such as bacteria and viruses including coronavirus, thus disinfecting both air and solid surfaces. It can help in rapid decontamination of used patient-care beds and hospital rooms before fresh admission of patients, which is a major requirement in hospitals in view of the limited availability of beds.

To control the spread of infection through baggage, ARCI, Hyderabad, and Vehant Technologies, Noida have co-developed KritiScan® UV Baggage Disinfection System. The compact UVC conveyor system can efficiently disinfect the baggage passing through the conveyor within a few seconds and is suitable for use in airports, railway stations and bus stations, hotels, commercial and private establishments.

UVC based disinfection systems are known for their rapid disinfection capability, and the disinfection process is dry and chemical-free. UVC irradiation at 254 nm is known for its germicidal properties where no chemical residues are left behind. UVC light, when irradiated on an infected surface, quickly disrupts the genetic material in the virus and thus inhibits its multiplication.

Weinnovate Biosolutions, a Pune-based startup supported jointly by DST and Department of Biotechnology (DBT), has come up with a non-alcoholic aqueous-based colloidal silver solution. It is uniquely made from its NanoAgCide technology for disinfecting hands and environmental surfaces.

This liquid is non-inflammable and free of hazardous chemicals and can be an effective sanitizer to prevent the spread of infection through contact — the prime method of transmission of the COVID-19 virus, thereby protecting health professionals and other infected people.

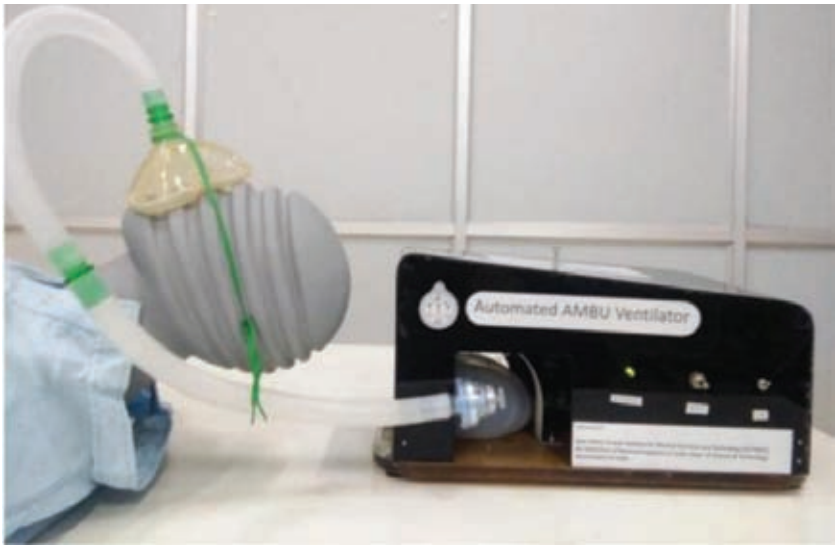
KritiScan® UV Baggage Disinfection System

Ventilator — protection from associated respiratory problems

SCTIMST has tied up with Wipro 3D, Bengaluru to jointly build a prototype of an emergency ventilator system based on Artificial Manual Breathing Unit (AMBU), developed by SCTIMST followed by its clinical trial and manufacture.

The ventilators can help meet urgent requirements arising out of the COVID-19 related crisis. AMBU bag or a bag-valve-mask (BVM) is a hand-held device used to provide positive pressure ventilation to a patient who is either not breathing or is breathing inadequately. However, the use of a regular AMBU needs another person for its operations who naturally becomes highly susceptible to infection, especially since it is advised that no one should be in close contact with a COVID-19 patient. Sree Chitra's Automated AMBU ventilator with inputs from clinical faculty will assist the breathing of critical patients who have no access to ICU ventilators.

Genrich Membranes, a spin-off company, based on proprietary technology licensed from National Chemical Laboratory (CSIR-NCL), Pune is being funded by the DST to scale up membrane oxygenator equipment (MOE) that it has developed to treat COVID-19 patients. Based on innovative, indigenous hollow-fibre membrane technology, the MOE enriches oxygen in



Automated AMBU Ventilator

the air up to 35 per cent under pressure (4-7 bar, using oil-free compressor).

The equipment consists of membrane cartridge, oil-free compressor, output flow meter, humidifier bottle, nasal-cannula, and tubing and fittings. The compressed, filtered air from the compressor is fed to the membrane cartridge, which selectively permeates oxygen over nitrogen offering oxygen-enriched air as the product at the ambient pressure. The membrane cartridge is capable of distinguishing oxygen and nitrogen and restricts the passage of viruses, bacteria, and particulate matter. The product air is of medical grade.

The device is safe, does not require trained manpower for its operation, needs minimum maintenance, is portable, compact, and with plug-and-play facility provides on-site, quick-start oxygen-enriched air.

Technology from the masses

The National Innovation Foundation-India (NIF), an autonomous body of the DST has identified several S&T based innovative solutions through the Challenge COVID-19 Competition (C3), to engage innovative citizens to come up with ideas and innovations to tackle the pandemic.

NIF is providing incubation and mentoring support for further dissemination to the generator of the ideas. A foot-operated device for hand sanitization developed by Shri Mupparapu Raju from Warangal, Telangana, and washing and an innovative sprayer for sanitization are the two recently supported innovations under the campaign. The foot operated sanitizing device has been implemented at various locations (Warangal, Mahabubabad, and others) in the State of Telangana.

The innovative sprayer capable of sanitizing or washing large areas like roads, societies, doors, compounds, walls, etc. is useful for both spacious and congested locations.

Models to predict evolution of the disease

A team of researchers from Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) along with collaborators from IISc Bengaluru have developed a heuristic predictive model for COVID-19 that provides short-term predictions about the evolution of the disease and the medical needs that are generated as a consequence.

The model focusses on the 'Achilles' heel' of COVID-19 response — medical inventory management. By providing key figures for medical inventories such as PPEs and ventilators, this model can greatly aid a systematic and meticulously planned response to the pandemic. It will provide a full

layout of the medical inventory needs, including intensive care, acute care, and medical supplies requirements, district-wise, for the coming weeks. It will not only provide a pan-India overview of the development of the pandemic, but also a state and district-level insight into its progress.

Digital platform for monitoring ground situations with the help of drones

Flyt Base, an enterprise Incubated at Bhau Institute's Incubation Centre, Government College of Engineering, Pune, Technology Business Incubator (TBI), under DST's NIDHI TBI Scheme is offering a digital platform that can monitor ground level situations by working with drones.

The platform called Fly Now allows drones — increasingly being used for aerial monitoring, emergency response, or urgent delivery of blood samples, medicines as well as lockdown surveillance — to be operated remotely for managing different aspects of COVID-19. With the help of Flyt Now, police authorities are now carrying out live, remote drone operations to monitor the overall social situation through an operator-friendly dashboard and taking measures to monitor crowds and maintain public safety.

It has already been implemented in Gujarat, where Dronelab, working with 200 local drone operators, is helping authorities to identify crowded areas and intimating police control rooms in real-time to enable them to take necessary action using the Flyt Now platform. Currently, a pilot is also being done in Bengaluru. If successful, it will be deployed across multiple cities.

Thermal scanners

Handheld thermometers used in checking temperature, a common test for screening symptoms of virus infection, exposes security personnel and health workers to infection. Removal of current restrictions due to lockdown will increase this risk. Therefore, it becomes imperative to have non-intrusive technologies for monitoring the body temperature from a distance and in a crowd. TDB has approved financial assistance to two Bengaluru based companies, Cocoslabs Innovation Solutions Private Limited, and Advance Mechanical Services Private Limited, which are ready to provide these solutions.

Cocoslabs Innovation Solutions plans to commercialise a low-cost solution to identify persons with abnormal body temperature in a crowd and, at the same time, provide an alert system to notify about identified persons to the authorities on their phones and laptops.

Advance Mechanical Services plans to commercialise infrared thermography-based temperature scanner for rapid measurement and real-time decision making by using an uncooled microbolometer and video analytics platform developed using AI and IIOT (Industrial Internet of Things).

Integrated geospatial platform for area-specific strategies and decisions

DST has created an integrated geospatial platform out of available geospatial datasets, standards-based services, and analytic tools to help in decision making during the current COVID-19 outbreak and aid in devising area-specific strategies to handle the socio-economic impact in the recovery phase.

The mobile application Sahyog, as well as the web portal (https://indiamaps.gov.in/soiapp/) prepared and managed by the Survey of India, has been customised to collect COVID-19-specific geospatial datasets through community engagement to augment the pandemic related response activities by the Government of India. Information parameters required as per the Government of India strategy and containment plan for large outbreaks have been incorporated in the Sahyog application.

Nanomedicine to alter oxidative stress to improve immune power

Scientists at S.N. Bose National Centre for Basic Sciences, Kolkata (SNBNCBS) have developed a safe and cost-effective nanomedicine

Hand sanitizer and face shield produced by the S&T-enabled NGO network of the DST

that promises treatment of a number of diseases by altering oxidative stress in the body. The research may provide a ray of hope in India's fight against COVID-19, as the nanomedicine can reduce or increase reactive oxygen species (ROS) in our body, depending on the situation and help cure the disease.

The ability of this research for controlled enhancement of ROS in mammals raises hopes of a new potential for the application of nanomedicine in controlling virus infections, including COVID-19. Animal trial for Redox healing of several diseases has been completed. Now the Centre is looking for sponsors to start clinical trials on humans.

The efficacy of the developed nanomedicine in balancing oxidative stress due to ROS in mice was tested recently by injecting lead (Pb) ions to create higher oxidative stress and liver damage. It was found that the nanomedicine reduces oxidative stress of the mammal due to lead-exposure and also helps remove the toxic ions from the liver (popularly known as chelation therapy in medicine), thereby reversing damage to the organ. Recently, the online journal *ChemMedChem* has highlighted this work on its front cover.

Societal initiatives

The network of S&T enabled NGOs spread across 22 states of India, supported by the Science for Equity Empowerment and Development (SEED) Division of DST have demonstrated capabilities in containing COVID-19 through various S&T interventions and complimented the efforts of the Government at different levels.

Rural Women Technology Park (RWTP) at Basani, Varanasi, supported by the DST has joined India's fight against COVID-19 by extending a helping hand to migrant workers. They are training and engaging women to make face masks as per WHO guidelines, and distributing food as well as hand sanitizers.

In Gugwaal Haar village situated in Hajipur Block of District Hoshiarpur, Punjab, a group of young women, are working tirelessly by making and distributing face masks free of cost to safeguard the residents of their village and around, migrant workers, and ration and food supply distributors from COVID-19 infection. The group is led by the village Sarpanch Sh Narinder Singh.

The Punjab State S&T Council (PSCST), Chandigarh, supported by DST has launched initiatives for the community where women stitch and make homemade cloth masks as per the instructions issued in a manual released by the office of Principal Scientific Adviser to the Government of India.

Apart from face masks, complying with the guidelines of the Office of the Principal Scientific Advisor (PSA) to the Government of India, 3D printed

A glimpse of activities being carried out by a group of young women

face shields manufactured through innovative open-source design were distributed to police personnel and frontline health workers in Maharashtra. Hand sanitizers and hand wash, as per WHO recommendations, have been prepared for distribution among the community. Protocols for manufacturing 100 per cent natural liquid hand wash as per USFDA guidelines using reetha (*Sapindus mukorossi*) and hand sanitizers with ethanol, hydrogen peroxide, glycerol, and extract of mugwort (*Artemisia nilagirica*) and citronella were developed.

Reaching out to Divyangjan and the elderly

The DST has taken several initiatives to mitigate the impact of COVID-19 among divyangjan (disabled persons) and the elderly and identified various challenges faced by them in finding technological solutions.

Through its programme on Technology Interventions for Disabled and Elderly (TIDE), the organisations supported by SEED, a division of DST have been instrumental in developing various assistive tools, technologies and techniques that are affordable and adaptable to the Indian milieu to create inclusiveness and universal accessibility for divyangjan and the elderly.

Under this programme, Rajalakshmi Engineering College, Chennai has developed an e-tool to create awareness and impart health and hygiene related information along with education and entertainment to overcome loneliness of persons with intellectual disabilities due to the pandemic. This will help persons with intellectual disability to learn with fun on their Tabs and mobiles. The e-tool can also be converted to other vernacular languages. The Beta version of the e-tool is being used by 200 specially-abled children.

A wearable sensor device has been developed by PSG College of Technology, Coimbatore to remotely monitor the activities of the elderly and divyangjan staying alone or those who happen to be under quarantine or isolation wards. The device also predicts and detects fall and frailty levels in the elderly. The device costs ₹1,500 when produced in bulk.

Sensor Configuration – a wearable rehabilitation band with real time monitoring and feedback of recovery process through guided rehabilitation protocols has been developed for the elderly with motor function disabilities. The device will help the elderly to get quantified outcomes regarding improvement in muscle strength, muscle flexibility and muscle endurance during the course of rehabilitation, without direct

Screenshot of the e-Tool showing different components of the software /app for divyangjan

and physical interventions from doctors and physiotherapists.

These devices have been tailor-made for the current COVID-19 situation. Further process is on to develop apps for recognition of objects, distances, scene recognition, and people identification and various other assistive devices like automatic hand sanitization scrub for divyangjan. This will eliminate the need to touch things. An action plan has been initiated for large scale production of these devices through the Technology Business Incubators of DST for deployment and further dissemination involving Department of Empowerment of Persons with Disabilities, Government of India.

Socio-economic rejuvenation and resilience

Knowledge organisations across the country have started creating scientific awareness on COVID-19 using social, print and electronic media. They have started initiatives for building resilience at the community level during and post lockdown period in response to the advisory issued by DST as part of their Scientific Social Responsibility (SSR).

DST-funded labs CSIR-NBRI, ICAR Labs, Chandigarh University, Manipur University, Sher-e-Kashmir University of Agricultural Sciences and Technology (SKAUST), Srinagar, and Baba Farid University of Health Sciences, Faridkot, Punjab have contributed their knowledge and resources for the development and distribution of sanitizer as per World Health Organisation (WHO) guidelines, mask preparation as per the guidelines issued by Principal Scientific Advisor (PSA), and services for COVID-19 testing.

The SEED division, the interface of S&T with society at DST, is supporting these knowledge organisations. It is working towards varied societal challenges, to ensure preparedness of the society to face challenges and the threat posed by the growing pandemic and to mitigate the long-term impact of COVID-19.

(Compiled by DST Media Cell)

... Continued from page 15

Therefore, it is encouraging to find new Indian companies and the industry to be incredibly responsive to the special needs of COVID-19. Overwhelming support has been received from the Indian startup ecosystem, despite the survival challenges facing new startups due to the crisis and later obstacles. Over 1,200 innovative solutions ready to be deployed have been received from the Indian startup community for review. It is currently being assessed and evaluated by a network of national experts identified by the COVID-19 Startup Solutions working group of the Government of India and industry partners. Some solutions mentioned above have already been implemented and include contact tracking, low-cost oxygenators, ventilators, masks, etc.

Challenging times and a crisis of this nature require significant government support. It also requires great cooperation between all the ecosystem stakeholders, including universities, government, and industry. While nobody could have imagined an epic crisis of such proportions, the continued support of the Indian government for its startup and incubator ecosystem in recent years has been a silver lining in retrospect. The crisis has also brought industry, academia, and startups collaborating together in a manner not seen before, which augurs well for the future. It is time for Indian startups to rise up to the challenge. Our immediate goals are to overcome the COVID-19 crisis with innovative entrepreneurial thinking. Yes, we can.

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Combating COVID-19: Biotechnological Research in India

Dr. RITI THAPAR KAPOOR

The COVID-19 pandemic has posed one of the greatest healthcare challenges before the world. WHO hosted a Global Research and Innovation Forum to draw up a research roadmap and to mobilise international action in response to the SARS-CoV-2 emergency. This included accelerated research on the evaluation of investigational therapeutics and vaccines and mobilisation of research on rapid point of care diagnostics. As per the recommendations of the Forum, the Government of India's Department of Biotechnology (DBT) announced research plans for diagnostics, vaccines, and therapeutics to combat COVID-19. Furthermore, as per the latest strategy of COVID-19 testing in India, released by ICMR, the laboratories of 11 autonomous institutes of DBT were engaged as diagnostic testing laboratories. DBT has established a new consortium — National Biomedical Resource Indigenisation Consortium (NBRIC) in partnership with Association of Biotechnology Led Enterprises (ABLE) and Confederation of Indian Industry (CII). NBRIC is hosted and led by the Centre for Cellular and Molecular Platforms — C-CAMP. NBRIC aims to be a nation-wide collaborative platform for convergence of research, product resources and services towards developing reagents, diagnostics, vaccines and therapeutics across India.

The Department of Biotechnology (DBT), Government of India and its not-for-profit state owned enterprise — Biotechnology Industry Research Assistance Council (BIRAC) — have planned and funded a bouquet of research projects. They are aimed at generating products that could be used for prevention, diagnosis, or cure of the deadly SARS-CoV-2 infection, currently sweeping over the entire world. The plan

has been designed to utilise the expertise of its scientists, who come from a diverse range of research backgrounds, including chemistry, chemical engineering, biotechnology, molecular biology, nutrition, and nanotechnology. DBT's major research initiatives and projects supported by BIRAC against COVID-19 are presented here.

Vaccine discovery programme

BIRAC has announced that ZyCoV-D, the plasmid DNA vaccine designed and developed by Zydus and partially funded by the DBT has initiated phase I / II clinical trials on healthy subjects, making it the first indigenously developed vaccine for COVID-19 to be administered on humans in India.

The adaptive phase I / II dose escalation and multi-centric study will assess the safety, tolerability and immunogenicity of the vaccine. Human dosing of the vaccine marks a key milestone since the launch of the accelerated vaccine development programme for COVID-19 in February 2020. The DBT has partnered with Zydus to address rapid development of an indigenous vaccine for COVID-19 under the National Biopharma Mission. The National Biopharma Mission (NBM), implemented by BIRAC, is an industry-academia collaborative mission to accelerate biopharmaceutical development in the country. This partnership with Zydus is to serve the country's need for a vaccine to fight the dreaded pandemic.

In the pre-clinical phase, the ZyCoV-D vaccine was found to elicit a strong immune response in multiple animal species like mice, rats, guinea pigs and rabbits. The antibodies produced by the vaccine were able to neutralise the wild type virus in virus neutralisation assay indicating the protective potential of the candidate vaccine. No safety concerns were observed for the vaccine candidate in repeat dose toxicology studies for both intramuscular and intradermal routes of administration. In rabbits, up to three times the intended human dose was found to be safe, well tolerated and immunogenic.

mRNA-based vaccine manufacturing platform

DBT-BIRAC has facilitated the establishment of a 'first-of-its-kind' mRNA-based vaccine manufacturing platform in India. The DBT has provided seed funding for the development of Gennova's novel self-amplifying mRNA-based vaccine candidate for COVID-19.

In collaboration with HDT Biotech Corporation, Seattle, USA, Gennova has developed an mRNA vaccine candidate (HGCO19), with demonstrated safety, immunogenicity, neutralisation antibody activity in the rodent and non-human primate models. The company is working aggressively to ensure the release of the first human injection by the end of the year, subject to Indian regulatory approvals.

Gennova's m-RNA platform supported by the DBT utilises the advances in nucleic acid vaccine and delivery systems. This vaccine candidate that makes use of nanotechnology has shown promise to be effective in animal models. According to a DBT official, "Once proven effective in human clinical trials, the vaccine candidate can be rapidly scaled up."

Efficiency of a recombinant BCG candidate vaccine against COVID-19

SARS-CoV-2 vaccines are many months away from widespread mass deployment. A recombinant BCG may help to ameliorate the severity of the disease and mitigate transmission. Even moderate individual efficacy can have a dramatic impact on the population directly (by reducing severe disease burden on health systems) and possibly indirectly (transmission reduction). Serum Institute of India Pvt Ltd (SIIPL) was awarded funding support under DBT's National Biopharma Mission for phase III clinical trials of a recombinant BCG vaccine candidate for COVID-19. SIIPL has proposed to conduct a multisite, randomised, double-blinded, placebo-controlled trial to demonstrate the efficacy of the recombinant BCG VPM1002 in reducing infection incidence and severe disease outcomes of COVID-19 among high risk

persons of advanced age or with co-morbidities, and high-exposure healthcare workers.

Development of COVID-19 vaccines, therapeutics and diagnostics

The DBT and its 16 research institutes are working relentlessly to mitigate the COVID-19 crisis and are deeply engaged in a multifaceted R&D to offer potential COVID-19 solutions.

A low-cost colorimetric PCR based assay technology and an aptamer-based SARS-CoV-2 antigen detection technology developed by Translational Health Science and Technology Institute (THSTI), Faridabad were transferred to Genei and Molbio Diagnostics Pvt. Limited. In-house IgG ELISA technology by THSTI was also transferred to XCyton Diagnostics Limited. DBT-Rajiv Gandhi Centre for Biotechnology (RGCB), along with POCT services, New Delhi, developed a low-cost viral transport medium and RNA extraction kit that is ready for commercial use.

Biorepositories established at THSTI, Faridabad; Regional Centre for Biotechnology (RCB), Faridabad; Institute of Life Sciences (ILS), Bhubaneshwar; Institute for Stem Cell Science and Regenerative Medicine (InStem), Bengaluru; National Centre for Cell Science (NCCS), Pune and the DBT facility at Institute of Liver and Biliary Sciences, New Delhi are fully functional, to facilitate access to clinical and virus samples by researchers, startups and industry. Sharing of biospecimens accelerates COVID-19 related research towards the development of kits, therapeutics and vaccines. THSTI has distributed over 2,500 sample aliquots in response to requests from the industry, startups and academia. THSTI has also established panels of positive sera from symptomatic patients who tested positive for SARS-CoV-2 infection. These panels will find utility in validation of diagnostic kits.

The DBT-autonomous institutions (AIs), as COVID-19 diagnostic kit validation centres for RTPCR, antibody and antigen tests, are now providing panels to the industry, startups and academia for in-house kit testing before validation.

The DBT-AIs consortia have announced a 1,000 genome sequencing of SARS-CoV-2 to understand viral and host genomics of the COVID-19 outbreak. The aim of this study will be to sequence 1,000 SARS-CoV-2 genomes from the clinical samples. This will then enable an understanding of the evolving molecular phylogeny of the virus and the emerging mutations in the viral RNA as well as help in identifying the host genetic variations that correlate with transmission, susceptibility and disease severity. The findings of this study will aim to assist in the development of efficient and effective diagnostic assays, vaccine, and drug candidates and enable the formulation of policies for containing the outbreak.

Candidate vaccine against SARS-CoV-2

The DBT's THSTI, Faridabad has identified and synthesised synthetic peptides that target neutralising B-cell or T-cell epitopes for developing antibodies against SARS-CoV-2. This elicits a desirable immune response that could block viral invasion. The preliminary non-clinical studies in mice are promising. They have further developed a multiepitope-based

THSTI is developing antibodies against SARS-CoV-2

DNA Fingerprinting and Diagnostics has proposed to undertake a genomic study on COVID-19

vaccine candidate by stitching the desired peptides to produce the protein. This approach is unique as it generates potential neutralising antibodies, while also reducing antibody-dependent enhancement or pulmonary immune pathology, a hallmark of SARS-CoV-2 infection. Researchers all around the world are racing to develop a vaccine and antiviral drugs. Currently, most SARS-CoV-2 vaccines under development focus on inactivated SARS-CoV-2 or its full-length spike (S) protein.

Genomic study on COVID-19

The DBT's Centre for DNA Fingerprinting and Diagnostics (CDFD) has proposed to undertake a genomic study on the ongoing outbreak of COVID-19 in India. This study is being coordinated by National Institute of Biomedical Genomics (NIBMG), along with active participation from DBT-CDFD, DBT-National Centre for Biological Sciences (NCBS), DBT-Institute for Stem Cell Science and Regenerative Medicine (InStem), DBT-National Centre for Cell Science (NCCS) and DBT-Institute of Life Sciences (ILS). CDFD proposes to do a prospective study to sequence the SARS-CoV-2 genome from individuals testing positive for the infection. Efforts pertaining to sequencing of viral genomes from different parts of the country have been initiated under this programme.

New algorithm for COVID-19 testing

Researchers at the DBT's Bengaluru-based InStem is in the process of writing a new chapter in the history of sample testing in collaboration with their colleagues in Tata Institute of Fundamental Research's NCBS and IIT, Mumbai. Random pooling of test samples is an important testing strategy for community surveillance and wide coverage during epidemics. However, this approach is relevant only in areas with low levels of infection and not effective when prevalence rates are close to or higher than 5 per cent in a population. Researchers are working towards developing smart pooling strategies that overcome this limitation.

Probiotics to help control SARS-CoV-2

Researchers at the DBT's ILS, Bhubaneswar have proposed that the infection and transmission of SARS-CoV-2, the causative agent for COVID-19 pandemic, may

India's first I-Lab developed under COVID Medtech Manufacturing Development

be controlled by bioengineered probiotics expressing human angiotensin-converting enzyme 2 (ACE2). A group of scientists at DBT-ILS noted that it has been experimentally proven that ACE2 binds to spike protein (SP) of SARS-CoV-2 making ACE2 as the entry receptor. This finding provides a strong rationale to target the SP-ACE2 interaction for developing therapeutics against SARS-CoV-2 infection. Epithelial cells of intestine, lung, kidney and blood vessels profoundly express ACE2. Lungs have been the most affected organ for SARS-CoV-2 infection, but the human intestinal tract has also been speculated to be an alternate infection route for this virus. Probiotics are known to control multiple gut-associated illnesses. Engineered probiotics expressing ACE2 could be a potential bio-remedy to neutralise SARS-CoV-2.

In-vitro culture facility for SARS-CoV-2

The ILS has established an in-vitro culture facility for SARS-CoV-2. The cultures are from patient sources using vero cells (vero cells are a lineage of cells used in cell cultures). Seventeen virus cultures have been established from swab samples with varying virus loads. This measure will be of great importance for COVID-19-related research in the country.

DBT-AMTZ COMManD

The DBT along with Andhra Pradesh Med-Tech Zone (AMTZ) has initiated the DBT-AMTZ COMManD (COVID Medtech Manufacturing Development) consortia to address the shortage of critical healthcare technologies in India and move progressively towards a stage of self-sufficiency. Under this consortia, India's first I-Lab (Infectious Disease Diagnostic Laboratory) has been built at AMTZ in a record time of eight days to promote last-mile access of testing to rural India. This is a mobile diagnostic unit with a biosafety facility.

Non-alcoholic disinfectant to stop COVID-19 spread

BIRAC is supporting a new non-alcoholic aqueous-based colloidal silver solution developed by Weinnovate BioSolutions from its NanoAgCideTM technology for disinfecting hands and environmental surfaces. Silver nanoparticles have antiviral efficacy against many viruses. Recent reports have suggested the role of silver nanoclusters in inhibiting the proliferation of SARS-CoV-2 also. Nanoparticles are rapidly emerging as an effective solution to a variety of issues related to COVID-19, from disinfection to imaging. Silver nanoparticles-based materials will be able to prevent the contact infection of healthcare workers, besides preventing patient infection. Colloidal silver can affect COVID-19 spread by blocking the RNA replication and reduce infection by blocking the surface glycoproteins. This proprietary technology is gentle on the skin and doesn't require any special arrangement for storage unlike the alcohol-based sanitizers, which are highly inflammable making their production, transportation and storage a risky affair. Another major advantage is that the solution releases the silver nanoparticles on the surface in a slow and sustained manner, which ensures its effectiveness for a longer duration.

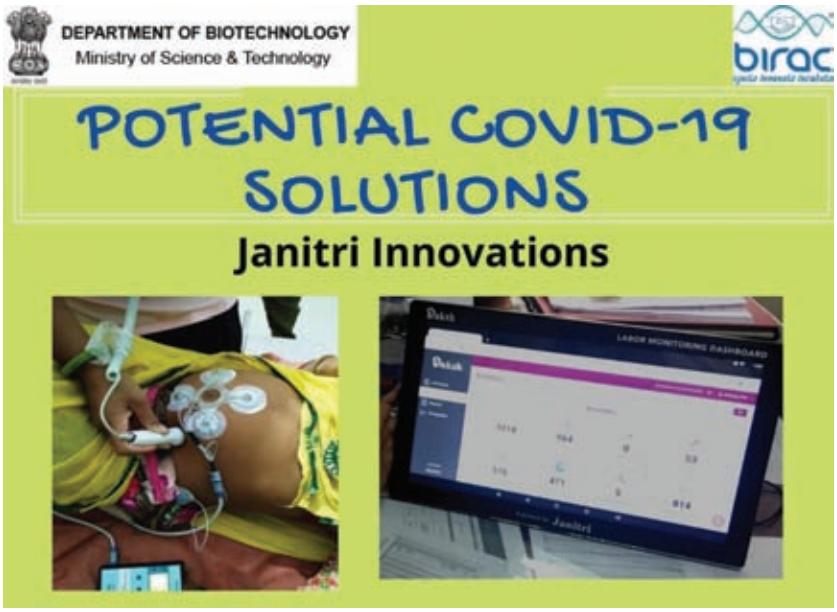
Hand-cranked 'SanMitra 1000 HCT' defibrillator for sudden cardiac arrest

Since sequestration areas inside hospitals for COVID-19 patients

World's first hand-cranked defibrillator "SanMitra 1000 HCT" is useful for COVID-19

need lots of defibrillators, BIRAC supported startup Jeevtronics has developed the world's first hand-cranked defibrillator. Defibrillators are devices that restore a normal heartbeat by sending an electric pulse or shock to the heart. The "SanMitra 1000 HCT" defibrillator is particularly useful for COVID-19-like situations. This device is a dual-powered (hand-cranked and grid) defibrillator. This defibrillator works both on grid electricity and on a built-in hand-cranked generator. Thus, it is more reliable than traditional defibrillators. This low-cost device does not need a battery replacement and can be powered in a few seconds by rotating a small hand paddle. It is proving to be a lifesaver in regions where electricity is scarce. This light-weight innovation does not require inverter backup and has been engineered to be most suitable for ambulances, wherein it can withstand high/low temperatures, vibrations, water ingress, etc.

Lung IQ, a potential solution for monitoring the severity of COVID-19 patients



DAKSH provides for remote monitoring of various patients in the current COVID-19 crisis

Fully automated hand hygiene device

BIRAC supported startup MicroGO has come up with an innovation called GoassureTM, which is an IoT-enabled fully automated hand hygiene device that digitalises the hand hygiene process. The technology assures minimum manual intervention and effort while maximising automation and hygiene. This innovation has a simple motto, "Clean hands, save lives". The product has an innovative design and is made of good durable material considering human safety operations. The innovation is literally plug-and-play with the product being very easy to install. The product is automated and contactless and is backed by real-time data monitoring.

Monitoring severity of COVID-19 patients

Predible Health Pvt. Ltd., a startup, has come up with an innovation called Lung IQ. This innovation is a holistic Artificial Intelligence (AI)-based application for the diagnosis and monitoring of respiratory conditions. The solution enables early detection of lung cancer, characterisation of chronic obstructive pulmonary diseases and monitoring of interstitial lung diseases. BIRAC is supporting the innovation. It is a potential solution for monitoring the severity of COVID-19 patients. It can help radiologists detect, quantify and communicate COVID-19 findings from Lung CT images. The findings of COVID-19 are very

similar to that of other infectious and inflammatory diseases. This ready-to-use product can be helpful in the fight against COVID-19 pandemic.

A potential solution to manage pregnancies amidst COVID-19

BIRAC is supporting a new advanced intrapartum monitoring tool for an automated partograph generation. DAKSH, the patented technology can help a staff nurse to register and enter vital signs of a pregnant woman, remind her to monitor the labour vitals, based on an inbuilt algorithm. With this system, a doctor at a remote location can also view the live labour progress and guide the staff nurse. The technology can be of immense use in the current COVID-19 crisis. During the labour phase, women visit hospitals and get admitted for at least 48 hours. DAKSH provides for remote monitoring. The doctors can guide the nurses without visiting them.

AI-based solution AIkenist QuickDiag COVID-19

DBT's Bengaluru-based incubator Centre for Cellular and Molecular Platforms (C-CAMP) is providing AI-based solutions, AIkenist QuickDiag COVID-19, for faster scanning and better detection, with quick turnaround solutions for healthcare problems. It distinguishes COVID-19 related pneumonia depending on the extent of damage caused to the patient's lung. AIkenist is compatible with existing digital X-ray and CT scanning machines. The chest X-ray and CTscan images are pushed to the cloud service for diagnosis of lung abnormalities among COVID-19 patients. The startup claims that its scan diagnoses the tissue four times faster than the conventional means/methods. The startup is trying to offer affordable AI solutions for scanning common public.

Aptamer-based rapid detection strip is being developed for novel coronavirus

National Agri Food Biotechnology Institute (NABI) and THSTI, Faridabad has developed aptamer-based methods for viral detection. This is a kind of rapid point of care test for COVID-19 using aptamers that will be developed against selected peptides of SARS-CoV-2 membrane spike proteins. Conventional methods for detection such as RT-PCR (Reverse transcription polymerase chain reaction) take 6-8 hours, including lengthy protocol, and require professional expertise, whereas the proposed method can reduce the detection time to approximately 1-2 hours and can be used conveniently.

Production of pseudotype SARS-CoV-2

The NCCS, Pune is envisaging the production of pseudotype SARS-CoV-2 in a biosafety level-2 setting (covers laboratories that work with agents associated with human diseases) using a vesicular stomatitis virus (VSV) platform, for candidate vaccine development and use in biomedical research. This project aims to generate a pseudovirus and assess its ability to induce a humoral immune response.

Scientists at National Agri Food Biotechnology Institute working to develop aptamer-based methods for viral detection

Scientists are exploring vaccine candidates and therapeutic strategies

The NCCS, Pune is developing a mathematical and computational model-based project to explore possibilities to generate peptide-based vaccine candidates. These mathematical model studies would enable identification of those viral sequences, which have evolved with time. These diverse sequences could be utilised for designing peptides with different amino acid combinations. Once the combinations are prepared, these could be tested for their efficacy against the virus.

It is anticipated that, since a combination of peptides identified from diverse viral sequences will be used, these peptides, if found active, could act on diverse COVID-19 variants, and provide cross-protection even if small genetic variations are found. To begin with, the scientists have initiated work on the generation of a machine learning model that is based on patient datasets from China (Wuhan), Italy, and USA, besides India. A peptide library has been generated through machine learning techniques and is screening the peptides towards the solved crystal structure of proteases. If found successful, this strategy could serve as the basis to tackle other similar emergency situations in future, where machine learning could be employed for developing therapeutics in a shorter span of time.

Key COVID-19 research goals for new diagnostics and therapeutics

The RGCB, Thiruvananthapuram, has set out research goals to understand the SARS-CoV-2 fully with a translational approach to bring out novel rapid diagnostics and therapeutics as fast as possible.

Currently, the only test available for early detection of the disease is based on a technology called polymerase chain reaction (PCR). However, this can be done only in specialised laboratories and is costly. RGCB has taken up a project to develop a new diagnostic test, which will be fast (it should not take more than 15 minutes to get the results), cheaper and usable in the hospital (point of care) even by less trained laboratory staff. Another focus is on therapeutics. Currently, there are no specific drugs available against this virus infection. The Centre is establishing rapid assays that can be used to identify the inhibitors for the virus.

Dr Sreekumar E and his team working in the Virology Lab at DBT-RGCB

Flavonoids against SARS-CoV-2

Researchers at the National Institute of Plant Genome Research (NIPGR), New Delhi are working towards finding drugs against SARS-CoV-2. The group is rigorously involved in exploring plant-based natural products, specifically flavonoids that are potentially anti-viral in nature.

The potential activity of the identified molecule/s against SARS-CoV-2 will be tested in collaboration with RCB, Faridabad.

A virucidal coating to prevent SARS-CoV-2 transmission

A team of researchers at DBT's Faridabad-based RCB are working towards prevention of transmission of SARS-CoV-2. For this, they have initiated

a study to engineer virucidal (virus-destroying) coatings.

The study is being conducted in collaboration with THSTI and Department of Textile Technology, Indian Institute of Technology, Delhi. With the expertise in engineering of antimicrobial molecules that can target the membranes of microorganisms selectively, scientists will be extending their expertise on developing molecules that will target the membranes of COVID-19 viral particles selectively. Different surfaces, when provided with a virucidal coating on them, can potentially inhibit the viral transmission. As such, these molecules will be utilised for engineering different surfaces made of glass, plastic, and textiles. Textiles will include the range of cotton, nylon, and polyester.

In another effort to help fight the pandemic, a research group at the Centre is trying to find out how to inhibit the activity of a protein called nsp12 protein. This protein houses the RNA-dependent RNA polymerase activity that is responsible for the duplication of the RNA genome of the SARS-CoV-2 virus. The group has also initiated efforts to identify lead molecules for the development of novel drugs against SARS-CoV-2.

In addition, a group of scientists at the Centre is working to develop a sensitive and specific, rapid, point of care, low-resource-requiring, colorimetric and cost-effective test for COVID-19 detection.

Anti COVID-19 drugs using natural garlic essential oil

The Centre of Innovative and Applied Bioprocessing, Mohali, has planned to work on lignin-derived noble metal nanocomplexes to develop antiviral coating materials, and rose oxide-enriched citronella oil, carbopol and triethanolamine formulated alcoholic sanitizer, under the therapeutics platform. The effort will be focused on polypyrrollic photosensitisers (molecules that produce a chemical change in another molecule in a photochemical process) and their nano formulations for antiviral photodynamic therapy. Additionally, the focus will also be on the development and commercial manufacturing of nasal spray kits that will help in easing chest congestion suffered due to infection from the SARS-CoV-2.

Under the drug discovery platform, in turn, the research will explore separation of therapeutic and valuable medicinal components from the peel and seeds of fruits and utilisation of natural garlic essential oil as an ACE2 protein inhibitor to prevent SARS-CoV-2 invasion. ACE2 plays an important role as a therapeutic target for controlling cardiovascular diseases and outbreaks resulting from Severe Acute Respiratory Syndrome (SARS). Besides, studies are to be conducted for development of lignin-derived nanocarriers (LNCs) with potential for antiviral drug delivery and using curcumin-fortified whey protein powder as a nutraceutical.

Novel germicidal protection for personal protection material

InStem, Bengaluru, has developed a proprietary germicidal molecule, which could be used to produce antigerm face masks and other personal protection material. This molecule can be covalently attached to any type of cotton fabric, including household cotton, and the fabric can then be stitched into a facemask.

The molecule is effective against both Gram-positive and Gram-negative bacteria and even enveloped viruses. Research and testing have concluded that this compound remains attached to the fabric for up to 25 cycles of standard detergent wash (industrial grade). One can use such 'germicidal' masks efficiently and repeatedly without fear by just cleaning them with regular soap wash at home or dipping them in boiling water for five minutes and drying. This also results in better waste management and environmental pollution control. This compound can be scaled at the industrial level.

Humanised monoclonal antibodies to treat COVID-19

RGCB, Thiruvananthapuram, has planned to collect blood samples

from recovered patients, and use immune cells from these samples to develop a type of treatment called humanised monoclonal antibodies. The monoclonal antibodies are antibodies that recognise only specific proteins, called antigens, on the surface of specific bacteria or viruses. To deploy them as treatment, scientists take monoclonal antibodies produced by mice and change their protein sequences to resemble those of humans. These humanised monoclonal antibodies have a lower chance of being rejected by the patient's body and can be mass-produced in mouse cell lines.

Scientists trying to repurpose immunomodulatory drugs for COVID-19

A group of scientists at the National Institute of Biomedical Genomics (NIBMG), Kalyani, is trying to see whether knowledge gained from research on sepsis could help deal with the current pandemic of COVID-19. The occurrence of sepsis is attributed to the release of chemicals in the bloodstream to fight an infection-triggered inflammation throughout the body. This can precipitate complex changes within our body, resulting in multiple organ systems' damage or even failure that can sometimes be fatal. The symptoms of sepsis may include fever, difficulty in breathing, low blood pressure, increased heart rate, and mental confusion.

For example, cytokine storm is a common feature of both sepsis and COVID-19 that significantly contributes to organ dysfunction and mortality. Cytokine storm is a severe immune reaction in which the body releases too many cytokines (broad and loose category of small proteins) into the blood too quickly. Cytokines usually play an important role in normal immune responses but having a large amount of them released into the body all at once can be harmful.

As a follow up, the scientists have initiated a clinical trial to try and repurpose immunomodulatory drugs like Sepsivac, which has a role in inhibiting the cytokine storm, for COVID-19 as well.

Scientists target SARS-CoV-2 genomic RNA conformations for antiviral therapy

Many deadly human diseases are caused by RNA viruses, including the recent SARS-CoV-2 outbreak. It has a single-stranded RNA genome covered by an enveloped structure. The RNA genome of SARS-CoV-2 is one among the largest (size range between 26.2 and 31.7 kb, positive sense) of all the RNA viruses. The coronavirus contains structured RNA elements that are likely involved in key processes such as RNA synthesis, transcriptional regulation, and protein translation that result in multiplication of their RNA genomes. Despite diverse structures and crucial functions compared to proteins, RNA is an under-exploited therapeutic target for antiviral therapy. DBT's RCB has initiated research in collaboration with Panjab University on developing small molecules to target RNA structures in SARS-CoV-2 genome that can block the CoV replication.

The challenge to defeat and overcome COVID-19 pandemic is one of the biggest and most complex in recent times, with nearly 98 per cent of the countries in the world being affected. If left unchecked and uncontrolled, it can lead to one of the biggest disasters ever known to humanity and has the power to wipe out its very existence.

There seems to be universal agreement that concerted and well-planned efforts is the only way forward and that for this, a multipronged approach at multiple levels is required. We need to take everyone forward towards achieving this goal and effective solutions need to be found quickly. This can be in terms of finding a vaccine or finding effective drugs or some other creative approach that can inhibit the spread of the SARS-CoV-2. Department of Biotechnology, Government of India, has taken a lead by taking concrete steps towards this end.

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DRDO Technologies to Combat COVID-19

NIMISH KAPOOR

Defence Research and Development Organisation (DRDO) has been at the forefront of the fight against COVID-19. Our Armed Forces along with DRDO introduced many innovations and technological solutions to help people ideate further in this race to fight the pandemic. Many laboratories and institutions of DRDO have developed several products to combat the pandemic.

There is a long series of technologies developed by Defence Research and Development Organisation (DRDO) to fight COVID-19, which have been developed by scientists, engineers, and technologists of DRDO laboratories located in different parts of the country. These technologies and innovations include: SEWAK — a cost-effective robot for medical use, SAMPARC app, mobile virology research and diagnostics laboratory, contactless attendance system, anywhere erectable isolation shelters, quarantine module, negative pressure shelter intended for isolating and treating the patients, IoT solutions — suraksha kawach, N-99 masks using a nano web filter layer, 3-ply surgical masks, COVID Sample Collection Kiosk (COVSACK), full body disinfection chambers, personnel sanitization equipment, pocket sanitizer and touch sanitizer pen, shoe and driveway sanitizer, body temperature measurement probe, crowd temperature monitoring system, acoustic throat infection analyser, mobile area sanitization system, vehicle sanitization enclosure, paper disinfector, bio suit for medical professionals, remote-controlled trolley to deliver essential items, fire-fighting equipment-turned-spray disinfectants, automatic mist-based sanitizer dispensing unit, portable backpack area sanitization equipment, UV sanitization box and hand-held UV device to destroy microbes genetic material, a microwave steriliser called ATULYA and many more.

Today, we need to understand these technologies in detail so that we can appreciate the tireless diligence of scientists and discuss the developed technologies with our society. In this article, we try to understand the efforts of DRDO scientists in the battle being fought against COVID-19.

SEWAK — A robot to eliminate the risk of exposure to infection

A team of scientists at Centre for Artificial Intelligence and Robotics (CAIR), Bengaluru has customised one of its robotic solutions to come up with a cost-effective robot, named SEWAK. It can be a safe alternative for medical professionals and health workers taking care of COVID-19 patients in the quarantine centres and hospitals. SEWAK can be tele-operated by the hospital staff from a remote location to navigate the quarantine zone and distribute food, water, medicine, etc., to the affected persons. The robot gets power from maintenance-free rechargeable batteries and can work continuously for five hours on full charge. It has the capacity to carry a 30 kg video camera fitted in the front to help navigate the patient's bed. Audio facility provided in the robot facilitates two-way communication between the patient and the hospital staff. This will help the hospital staff to communicate with the patients to understand about their health condition and recovery, explain the dosage of the medicines and give comfort to the patient. All this is possible while the hospital

Cost-effective robot — Sewak, a safe alternative for the hospital staff

staff is positioned in a safe zone while the robot moves inside the quarantined zone. This eliminates the risks of exposure to infection to the frontline workers while taking care of the needs of the patients.

SAMPARC App to track COVID-19 patients

The CAIR, Bengaluru has created a technology-focussed solution to track patients who are under quarantine. A team of 20 scientists have reportedly developed the App in three weeks. It has been named SAMPARC, an acronym for Smart Automated Management of Patients and Risks. The App has already been offered to various state governments to enable Artificial Intelligence (AI)-driven measures to slow the outbreak. It has been hosted exclusively for state governments in India. SAMPARC is a software with an App that would be installed on the smart phones of the patients. It is a server-side application that would be used by the state authorities to track the patients.

Mobile Virology Research and Diagnostics Laboratory

Research Centre Imarat (RCI), a premier laboratory of Dr APJ Abdul Kalam Missile Complex, Hyderabad developed a first-of-its-kind mobile lab called Mobile Virology Research and Diagnostics Laboratory (MVRDL) in India to speed up COVID-19 screening and R&D activities. MVRDL has one Bio-Safety Level 3 (BSL-3) lab and another Bio-Safety Level 2 (BSL-2) lab. Both labs are connected to carry out virology research and diagnostic activities such as diagnostic test for COVID-19, real-time Reverse Transcription Polymerase Chain Reaction (rRT-PCR) test for the qualitative detection of nucleic acid from SARS-CoV-2 in upper and lower respiratory specimens, virus culturing for

Mobile Virology Research and Diagnostics Laboratory will speed up COVID-19 screening and R&D activities

drug screening, convalescent plasma-derived therapy, aid in development of vaccine and development of diagnostics kits. This can be positioned anywhere due to its mobile shelter-based configuration and the entire area is conditioned with a design of 100 per cent fresh air ensuring no re-circulation. It will enable the researchers and medical practitioners to undertake research activities and develop diagnostics assays and therapeutics to understand and conduct surveillance of existing as well as new viruses and in developing diagnostic kits.

AI-based contactless attendance system

RCI Hyderabad has developed an AI-based Contactless Attendance Application that allows non-contact-based personnel verification using the facial features of the person. COVID-19 pandemic has made it unsafe to use contact-based biometric verification. Existing CCTV cameras can be utilised to capture facial images. Facial features of several thousands of employees can be stored in the computer as facial features of each employee are encoded in a small (less than 25 KB) file. The system is scalable since the time for identification and verification for each person remains constant, even as the number of registered personnel increases. It is secure because it works as a standalone system and does not require the internet, since only the facial features are saved in encoded form and the actual face images need not be saved, thereby ensuring privacy and security.

Facial recognition in AI-based Contactless Attendance Application

Contactless disinfecting cabinet for gadgets and bank notes

RCI, Hyderabad also rolls out a contactless disinfecting cabinet for gadgets and bank notes. The contactless sanitation cabinet called Defence Research Ultraviolet Sanitizer (DRUVS), is designed to sanitize cell phones, iPads, printers, currency notes, challans, etc. It offers 360-degree UVC (Ultraviolet C has a range of wavelengths between 200-280 nanometres) access to items positioned within the cabinet. The device runs on the drawer opening and

Contactless sanitation cabinet called Defence Research Ultraviolet Sanitizer (DRUVS)

closing mechanism, and the proximity sensor switches make its operation automatic and contactless. The DRUVS goes into sleep mode once sanitation is over. Hence, it does not require the operator to wait near the disinfecting unit.

The RCI has also come up with a device to sanitize currency notes in large numbers. The device is called Notesclean. Notesclean's role is essential as DRUVS cannot sanitize individual notes in a bundle optimally. Notesclean can disinfect currency notes in a short time. To sanitize currency notes, one can simply place the loose notes at the device's input slot. It takes the notes one by one and moves them through a series of UVC lamps to disinfect them completely.

Face protection mask for healthcare professionals

RCI, Hyderabad and Terminal Ballistics Research Laboratory (TBRL), Chandigarh, have developed a face protection mask for healthcare professionals handling COVID-19 patients. Its light-weight construction makes it convenient for comfortable wear for long durations. This design uses commonly available A4 size overhead projection (OHP) film for face protection. This thermoplastic is derived from renewable resources such as corn starch or sugarcane and is biodegradable. The face mask is mass produced using the injection moulding technique.

Isolation shelters that can be erected anywhere — quarantine module

Research & Development Establishment (Engineers), Pune has developed various shelters, green power sources, chemical toilets and a quickly erectable medical complex under various projects related to field-defence and CBRN protection (chemical, biological, radiological and nuclear protection). These products are recommended to be utilised for activities pertaining to containment of COVID-19. These products will be useful, especially in the remote locations, where there is no medical and/or electrical facility available.

Standalone shelter: This is a three-bed, quarantine, quickly-erectable three-bed shelter with power connection. It can be used as an extension of a city hospital to accommodate patients.

Medical examination shelter with green power source: This metallic structure with waterproof fabric shelter is of size 12′×12′×9′ and can be utilised for medical examination and check-up of suspected COVID-19 patients. This shelter can be erected within one hour by four people. It includes an in-built green energy power source up to 1.5 KW for 24×7 operations. It is a ready-to-use setup along with all essential electrical devices and gadgets. One bed, table, chair, and other essential accessories will be housed in this shelter. It can be easily used in remote and field areas. A shelter of size 14′×14′×9′ can be utilised as a quarantine shelter for two patients. This shelter will have essential electrical gadgets, two beds, tables, and other minimum accessories. This facility can be erected within two hours by six persons.

Four-bed quarantine module: A shelter of size 20′×20′×9′ can be utilised as a quarantine shelter for four patients. This shelter will have essential electrical gadgets, four beds, tables, and other minimum accessories. This facility can be erected within three hours by six persons.

Inflatable shelter module: The shelter can be utilised as a quarantine centre ward for 10 patients. It can be erected in one hour by a team of 10

Isolation shelters that can be erected anywhere

personnel. This has an in-built toilet module.

Integrated medical complex: This will be a genset-powered, quickly deployable, airconditioned medical facility suitable for remote locations. It has the capacity to accommodate 16 patients. This has in-built toilet modules.

Suraksha Kawach — Custom designed IoT device

DRDO has developed a solution for COVID-19 patient tracking and surveillance to fight the situation. It is an ankle or arm band based custom IoT solution. The product, Suraksha Kawach, is a tamper-proof solution for tracking COVID-19 patients. It is a GSM and GPS enabled rugged system for real-time tracking. It is an integrated solution with software for central monitoring and management. It is enabled with geo-fencing, tamper detection, battery status monitoring, mechanism for alerts to urban local bodies, police, and distributed alert mechanism.

The Suraksha Kawach device can also be integrated with Arogya Setu or any other mobile app through server feeds or by introducing a Bluetooth low-energy chip in the current design. The unit has battery capacity to withstand a quarantine period of 21 days or more, so the device need not be removed for charging. This ensures that during monitoring the person under quarantine need not remove the device for charging. The configuration or design modifications allow it to be re-utilised for other tracking purposes after the end of Corona pandemic.

Parakh: Mobile Biosafety Level 3 laboratory for COVID-19 samples testing

In a bid to support corona warriors, Defence Food Research Laboratory (DFRL), Mysore, has developed this quick response asset to deal with a situation arising due to contagious diseases including the COVID-19 pandemic. The laboratory stationed on a mobile platform has been named PARAKH. It provides unidirectional airflow and gradient negative room pressure with class III Biosafety Cabinet (BSC) for entry and safe processing of clinical samples. The facilities in the lab include clean air workstation, cold chain for storing the reagents and samples, provision for treatment of liquid effluents, safe storage of solid biohazard wastes and decontamination by autoclaving. Further, provision for storing and donning PPEs, storage for used aprons, emergency body shower and eye wash, etc. have been provided. Medical Professionals can easily and safely handle and preserve samples from disease outbreaks or during surveillance. The lab has been handed over to the Viral Research and Diagnostic Laboratory (VRDL) of Mysore Medical College and Research Institute to enhance their testing capability.

Collection Kiosk (COVSACK) for healthcare professionals

Defence Research & Development Laboratory (DRDL), Hyderabad, has developed COVID Sample

Parakh — Mobile Biosafety Level 3 laboratory

COVID Sample Collection Kiosk (COVSACK), which is automatically disinfected without human involvement, making the process infection free

Collection Kiosk (COVSACK) for healthcare professionals. The kiosk is automatically disinfected without the need for human involvement, making the process free of infection. After a patient leaves the kiosk, four nozzle sprayers mounted in the kiosk cabin disinfect the empty chamber by spraying disinfectant mist for a period of 70 seconds. It is further flushed with water and UV light disinfection. Voice command can be given through a two-way communication system integrated with the COVSACK.

COVSACK has an auto disinfection facility with inbuilt sprayers of disinfectant solution and water followed by UV lights disinfection. The chamber is designed and built with access to healthcare workers from outside to take a swab from the suspected patient. The shielding screen of the kiosk cabin protects the healthcare worker from the aerosols of the patient while taking the sample. This minimises the use of PPE by the healthcare worker for each sample taken. The auto disinfection by sprayers mounted in the kiosk cabin disinfects by spraying 1 per cent sodium hypochlorite solution for one minute and disinfects the walls of the chamber. It is further flushed with water from the inbuilt sprayers and UV light disinfection.

Personnel Sanitization Enclosure

Vehicles Research and Development Establishment (VRDE), Ahmednagar, Centre for Fire, Explosive and Environment Safety (CFEES), Delhi, and Institute of Nuclear Medicine and Allied Sciences (INMAS), New Delhi have designed full body disinfection chambers called Personnel Sanitization Equipment. This walk-through enclosure is designed for personnel decontamination, one person at a time. Decontamination action is started by using a foot pedal at the entry. On entering the chamber, the electrically operated pump creates a disinfectant mist. The mist spray is calibrated for an operation of approximately 25 seconds and stops automatically indicating completion of operation. As per procedure, personnel undergoing disinfection will need to keep their eyes closed while inside the chamber. This system can be used for disinfection of personnel at the areas of controlled ingress and egress such as entry and exit to hospitals, malls, office buildings and critical installations.

Pocket sanitizer and touch sanitizer pen

A pocket sanitizer has been

Full body disinfection chambers called Personnel Sanitization Equipment

developed by INMAS, Delhi for personal sanitization. This device is ergonomically designed and can be easily carried in the pocket or purse. It has a protection cap that prevents its accidental usage and a control is provided for the dispensing of the sanitizer product. The device can be refilled by the user through the refilling site. This pocket spray device is cost-effective, easy to handle and has a leak proof refillable mechanism. INMAS has also developed a touch sanitizer pen, which helps prevent the spread through lift buttons, electric switches, etc. This touch sanitizer pen is also easy to carry in the pocket or purse. This pen is cost effective, easy to handle and has a refillable mechanism.

Shoes and driveway sanitizer

Shoes have a high potential of spreading the virus from one place to another. In COVID-19 wards 65 per cent of shoes are found to be infected by SARS-CoV-2. Similarly, car tyres also become potential infection spreaders. INMAS, Delhi has innovated a solution to prevent the spread of coronavirus through shoes and car tyres. This solution is kept on a threaded PVC mat to retain the moisture. Artificial grass is the second choice. Rubber and coir mats are, however, not suitable. A sodium hypochlorite gel is used as the disinfectant, which has the advantage of enhanced stability, better moisture retention and non-chlorine composition. This leaves minimum footprint, which can be wiped off easily. Continuing bacteriology tests have shown 2-log scale kill effect and it is safer to handle compared to alternative solutions. The gel should be stored in glass or high-density polyethylene grade plastic bottles and 50 ml gel is to be applied per sq ft wearing gloves. Hands should be washed immediately after handling the gel. One batch of solution can be used for 15 cars/two hours. The mats may require running water wash every two hours. Scientists have claimed that no damage is observed to shoes or tyres after 20-hour dip.

Ultra Swachh — disinfection of PPEs and other materials

INMAS, Delhi has developed a disinfection unit named Ultra Swachh to disinfect a wide range of materials, including PPEs, electronics items, fabrics, etc. For disinfection, the system uses an advanced oxidative process comprising of multiple barrier disruption approach using an Ozonated Space Technology. The system is double layered with a specialised ozone sealant technology assuring trapping of ozone for the necessary disinfection cycle. It also has a catalytic converter to ensure an environment friendly exhaust, i.e. only oxygen and water. It is in compliance with International Standards of Industrial, Occupational, Personal and Environmental Safety. The treatment is automated for a quick disinfection cycle.

Ultra Swachh — disinfection of PPEs and other materials

Negative pressure inflatable isolation shelter for 10 occupants

Defence Bioengineering and Electro Medical Laboratory (DEBEL), Bengaluru has developed a negative pressure shelter intended for isolating and treating the patients without the risk of spreading the contamination to others. This system is suitable for isolating COVID-19 patients since the system is based on negative pressure and the materials used have passed the Synthetic Blood Penetration Test. The system consists of negative pressure-based air handling unit and

inflatable multiple chambers. The system has five air steriliser units and the ducts are uniformly distributed to provide filtered air. It covers a total area of approximately 1,000 sq. ft (93 sq. m) and is manufactured out of a two-layer water and air proof fabric. The structure has separate rooms for decontamination and medical waste and is equipped with modular rest rooms and illuminated with sufficient light throughout.

Medical oxygen plant

This technology is an offshoot of the on-board oxygen generation system (OBOGS), for medical grade oxygen generation, on-board the *Tejas* fighter aircraft. It utilises the pressure swing adsorption (PSA) technique and molecular sieve technology to generate oxygen directly from the atmosphere. Pressure swing adsorption (PSA) is a technology used to separate some gas species from a mixture of gases under pressure according to the species' molecular characteristics and affinity for an adsorbent material.

The oxygen plants will help provide medical-grade oxygen supply during the COVID-19 pandemic in hospitals in urban, rural, and far-flung areas. The installation of these plants will reduce the dependence of hospitals on oxygen cylinders. They will be of great help, especially in high altitude and inaccessible remote areas. Its benefits include reduced logistics of transporting cylinders to these areas, low cost, continuous and reliable round the clock oxygen supply. The facility can be used for filling the cylinders in addition to direct installations at the hospitals. The oxygen generator system has been developed by Bengaluru-based DEBEL.

The technology is being used to install oxygen plants at some of the army sites in the North East and the Leh-Ladakh region. This plant will be useful to provide oxygen supply during the COVID-19 pandemic in hospitals in urban and rural areas.

Body temperature probe

The Naval Physical and Oceanographic Laboratory (NPOL), Kochi has developed a cost-effective solution to detect fever, by innovating a body temperature measurement probe using a miniature high-resolution thermometer. The body temperature probe consists of a very small thermistor on a pen-like attachment, which can detect the body temperature by placing the tip on the mid-arm or forehead region. A hand-held processing unit displays the temperature and highlights whether the person is normal or feverish. The kit has high accuracy with a short response time. This cost-effective product is designed as two variants. The first variant is for industrial use, in which the probe and display-cum-processing unit are separate units connected by a cable. Both the persons, the one whose temperature is measured and the one noting the measurement, are thus separated. The probe is inserted in a holder, which contains a sanitizing medium. In the second variant, the probe and the display-cum-processing unit are integrated in a single casing. This variant draws power from a small battery and can be used for domestic purposes also.

On-board oxygen generation system for medical grade oxygen generation

Crowd temperature monitoring system

This system has been developed using expertise in infrared imaging for missile applications. A DRDO lab, in collaboration with an industry partner, has innovated and developed algorithms for thermography in outdoor conditions. Advanced face detection techniques have been used over thermal images. The system consists of a thermal camera and a desktop/laptop computer. Artificial Neural Network, trained with a very large in-house thermal database, allows face recognition directly on the running video from the IR thermal camera. A large number of people can be thermally profiled outdoors without disturbing their movements. Persons showing more than pre-set thermal threshold can be earmarked, recorded and real-time inputs can be given to the authorities.

Econo-Walk-In Swab Collection Kiosk (WISK)

WISK is a solution for health workers involved in COVID-19 management. An Econo-WISK has been developed by DRDO, which is a very cost-effective and easy to-transport variant of WISK. It also mitigates ergonomics issues like stress points, limited access and bad postures. The Econo-WISK is designed as an assembly of durable rexine and transparent plastic sheet over an easy-to-assemble frame made of square tubes of mild steel. There is a wooden base with a linoleum sheet as well as a detachable table outside the kiosk.

Acoustic Throat Infection Analyser (ATIA)

NPOL, Kochi has developed an ATIA using acoustic data processing techniques used in defence applications. The ATIA aims to detect upper respiratory tract infections by a non-invasive means of acoustic scanning of words spoken by a person. It has been proven that the SARS-CoV-2 infection develops initially in the upper respiratory tract and detection of the infection may give early information even before symptoms like fever, etc. develops. For day-to-day office work, this could give non-contact screening of personnel entering an establishment. Initially using a microphone connected to computer/mobile, etc. voice samples for a healthy person are recorded as per standard operating procedure and added in the database. The recorded data is subjected to acoustic analysis techniques. At any point of time, live voice samples of a person can be compared with the database and distortion in voice due to throat infection is easily captured. The technique can have potential applications in hospitals, industries and offices.

UV-based baggage disinfector

NPOL, Kochi has developed a facility for disinfecting passenger baggage and installed it at the Cochin International Airport Ltd (CIAL). The facility consists of two cubic enclosures fixed to the existing airside conveyors at CIAL, with a configuration of UV lights so placed as to illuminate the volume to the maximum. The UV circuitry was established by the lab as per the required dosage, intensity and exposure, while ensuring sufficient protection of the baggage handling personnel.

UV-based baggage disinfector

It is to ensure that the baggage gets disinfected even before it reaches the customs area.

Paper disinfector

NPOL, Kochi has developed a paper disinfector to disinfect paper or envelopes up to A4 size. It consists of two foldable halves – an upper lid and a lower lid. To disinfect various paper-based items like entry passes, *dak*, tender documents, currency notes, etc. entering an establishment at the security office or at the central registry, the operating person lifts the upper lid and asks the visitor to place the item on the lower lid and then closes the upper lid. The paper-based item is heated between the two lids. Heating is done by means of a nichrome wire of selected resistivity, which is placed inside a glass wool/ mica sleeve and sandwiched on a conductive cloth and further wrapped in velvet for retention of heat. Two such sets of heating pads are used; one fixed on the bottom of the upper lid and the other on the top surface of the lower lid.

Mobile area sanitization system

Based on the experience of dust suppression systems for use in deserts, Defence Laboratory, Jodhpur (DLJ) has joined the fight against COVID-19, by developing a Mobile Area Sanitization System, which uses sodium hypochlorite solution to sanitize larger areas. Two variants have been developed, one for outdoor use mounted on a 'B' class vehicle and another for indoor use mounted on a battery-operated cart. The former can spray to a distance of 6-7 m and the latter to 2-3 m. The performance of the system has been demonstrated to the Indian Army.

Vehicle sanitization enclosure

VRDE, Ahmednagar has conceptualised and established a vehicle sanitization enclosure in about eight hours within its laboratory premises. It is an indigenous system assembled using locally available material. Since it is a very lightweight system with a portable canopy, it can be made operational in less than three hours. An electrically operated positive displacement pump is utilised to create a disinfectant mist inside the tent canopy through which the vehicles are passed. A separate tank of 500-litre capacity is used for storage of the disinfectant, which requires refilling after 200 vehicles are disinfected. The system can be utilised at any location including entry location for sanitization of vehicles. Hospitals, army units and administrative offices having high ingress and egress can deploy this system.

Bio-suit for medical professionals

DRDO has made a bio-suit for medical professionals to help them fight coronavirus. Interestingly, the bio-suit made by DRDO has a unique feature. The DRDO is said to have prepared a special sealant as an alternative to seam sealing tape based on the sealant used in submarine applications. The special sealant used for submarine applications is required because as per DRDO, bio-suit production in India by its industry partners and other industries is being hampered due to non-availability of seam sealing tapes.

Vehicle sanitization enclosure

Remote-controlled trolley to deliver essential items to frontline healthcare staff and others

Fire-fighting equipment turned spray disinfectants

Remote-controlled trolley to deliver essential items

As part of anti-COVID-19 measures the Corps of Electronics and Mechanical Engineers (EME) of the Indian Army has created a remote-controlled trolley to deliver essential items to frontline healthcare staff and others. This remote operated trolley comes equipped with a wash basin and dustbin. The trolley also has storage space, which can be used in hospitals and isolation wards. This remotely operated vehicle can deliver essentials to personnel from 100 feet (30.5 m) as part of social distancing. This will reduce human contact and the chances of infection from spreading.

Fire-fighting equipment turned into disinfectant sprayers

DRDO has tweaked fire-fighting equipment, turning them into machines to spray disinfectants. These machines will be used to sanitize roads and other surfaces. Developed by the CFEES, New Delhi, these machines are spin-offs of fire suppressants. This portable sanitation equipment can be used to spray decontamination solutions consisting of 1 per cent hypochlorite solution for sanitization of suspected areas.

The Indian Navy has made a unique in-house portable oxygen multi-feeder that can cater to six patients suffering from COVID-19 together. Dubbed as the Portable Multi-feed Oxygen Manifold, the device can be used for six patients from a single oxygen cylinder.

Automatic mist-based sanitizer dispensing unit

CFEES, Delhi, using its expertise in mist technology for fire suppression, has developed an automatic mist-based sanitizer dispensing unit. It is a contactless sanitizer dispenser, which sprays alcohol-based hand rub sanitizer solution for sanitization of hands before entering buildings/office complexes, airports, metro stations, railway stations, bus stations and other critical installations. It is also expected to be very useful for the entry and exit points of isolation and quarantine centres. It is based on water mist aerator technology, which was developed for water conservation. The unit operates without contact and is activated through

Automatic mist-based sanitizer dispensing unit — contactless sanitizer dispenser, which sprays alcohol-based hand rub sanitizer solution

an ultrasonic sensor. A single fluid nozzle with a low flow rate is used to generate aerated mist to dispense the hand rub sanitizer.

Portable backpack area sanitization equipment

CFEES, Delhi with the help of its industry partner has developed portable sanitization equipment for spraying decontamination solution consisting of 1 per cent hypochlorite solution for sanitization of open areas. The portable system can be mounted as a backpack and carried by the operations personnel. This system incorporates low-pressure twin-fluid (air and disinfectant liquid) technology to generate a very fine mist. The system is capable of disinfecting an area of up to 300 square metres. The application areas may include a hospital reception, doctor's chambers, office spaces dealing with general public, corridors, pathways, metro and railway stations, bus stations, etc.

UV sanitization box and hand-held UV device

Defence Institute of Physiology and Allied Sciences (DIPAS) and INMAS, both based in Delhi, have designed and developed an ultraviolet C (UV-C) light-based sanitization box and hand held UV-C device of ultraviolet light with wavelength 254 nanometres. The UV-C consists of a shorter, more energetic wavelength of light. It is particularly good at destroying genetic material. The

Ultraviolet C light based sanitization box and handheld UV-C device of ultraviolet light

radiation warps the structure RNA, which prevents the viral particles from making more copies of themselves.

The UV-C kills microbes quickly. Sanitization of items by employing UV-C light avoids the harmful effects of the chemicals used for disinfection. This is environment friendly and is a contact free effective sanitization method. The UV-C box is designed for disinfecting personal belongings like mobile phone, tablets, purse, currency, cover of office files. The COVID-19 virus will be deactivated by using UV-C lamps in one minute if placed equidistantly in a box. The hand held device disinfects office and household objects like chairs, files, postal delivered items, and food packets. The UV lamps used in the sanitization box also emits at 185 nm, which produces ozone and is able to take care of the unexposed area on the surfaces of the objects placed in the box.

Evaporating fogger for sanitization

An evaporator-type fogging device has been developed by DIPAS for sanitization of work spaces and associated accessories. The fogger can be used with any type of chemical suitable for a particular disinfection purpose. The system consists of a small chemical reservoir (CR), suction mechanism, evaporation mechanism and a blower. The size of the reservoir is optimised to avoid wastage of chemical. The main stock of the disinfection fluid remains in a separate chemical chamber (CC), which is airtight and does not allow reaction with air.

Sanitizer with Attendance Gear & Temperature Monitoring (SWAGATAM)

A system has been developed by DIPAS for non-contact card-based attendance and temperature monitoring along with a sanitizer dispenser, simultaneously covering every aspect of safety against COVID-19. The system has an in-built card reader, which is connected to the server via GSM & GPRS. An ultrasonic sensor sends out high frequency sound waves (about 40 Khz) in the direction of the detection and receives the reflection from nearby objects and gives distance reading by processing the echo time. Once, a person punches the card, his/her card number, current date and time of arrival/ exit along with temperature details will be saved on the server. Up to 40,000 records can

be stored in the device itself. This data can be accessed from the server and thus can be used for Employee Attendance System accordingly.

ATULYA — a microwave steriliser

Defence Institute of Advanced Technology (DIAT), Pune supported by DRDO has developed ATULYA a cost-effective microwave steriliser capable of disintegrating the SARC-CoV-2. It can be operated in portable or fixed installations and helps in disintegrating the virus by differential heating in the range of 56° to 60°C temperatures. ATULYA is safe to use in home and office. It can be used on any surface except metal. This system was tested for human/operator safety and has been found to be safe.

ATULYA — a microwave steriliser capable of disintegrating the SARC-CoV-2

Advanced face masks and ventilators

Defence Research & Development Establishment (DRDE), Gwalior has developed five layered N-99 masks using a nano web filter layer, which is being produced by two of the industry partners. INMAS, Delhi has designed three-ply surgical masks that are being produced through an industry partner. DEBEL, Bengaluru and Society for Biomedical Technology have developed ventilators, which are being produced at a large scale.

The large range of these technologies developed by DRDO is benefitting thousands of patients, medical personnel, hospital staff, and all those who are fighting the war against COVID-19. Today, there is a need to understand the efforts of the scientists and the technological developments happening in laboratories and convey them to the people so that they can learn to adopt science and technology as a protective shield.

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A Glimpse of the Technological Solutions to Combat COVID-19 from Leading Indian Academic Institutions

Dr. P. BHAVYA MANJEERA

The SARS-CoV-2 and its resultant disease COVID-19 have reached pandemic levels. WHO declared COVID-19 as a global pandemic on 11 March 2020. The rapid increase of positive diagnosed cases due to the disease has caught the attention of the whole world. India reported the first case of COVID-19 on 30 January 2020 and the country's scientific and research community geared up to battle this new crisis relentlessly with all the available means and methods. Researchers from all fields, such as medicine, chemistry, structural biology, physics, pharmacy, etc., and the Government of India are hard at work towards finding immediate solutions to the ongoing COVID-19 pandemic. The Government of India successfully mobilised researchers in a short period of time and is providing complete and committed support to scientific, engineering, research, and technological fraternity to develop new innovations and technologies to combat COVID-19.

COVID-19 pandemic has initiated constructive collaborations for innovations and economy between the two pillars of India — industry and academia. This association has come up with innovative technologies, tested, scaled up and made them available in the market for societal use to track, test, treat and prevent COVID-19 at a faster pace.

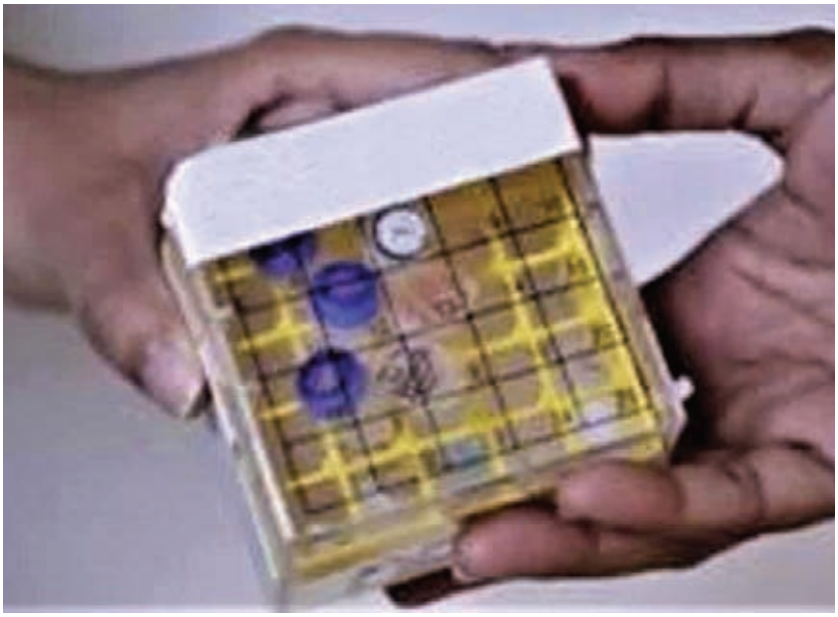
Indian education and science and technology institutes are spearheading initiatives to develop a range of products to control the pandemic. The Indian Institutes of Technology and premier universities associating with their incubated startups are making significant strides and are coming up with tech-enabled solutions through their innovation and research for diagnosing and preventing SARS-CoV-2 infections.

We present here some of the potential technological solutions

developed by the premier Indian academic institutions to fight the COVID-19 crisis. The information is sourced from *NRDC — Compendium of Indian Technologies for Combating COVID-19 (Tracing, Testing and Treating)*

Corosure — probe-free detection assay

Considering the scale of the ongoing pandemic, development of indigenous kits is the need of the hour. Researchers at the Indian Institute of Technology (IIT) Delhi and Kusuma School of Biological Sciences (KSBS) have developed a probe-free detection assay for COVID-19. Claimed to be the world's most affordable kit, the cost of the test with this diagnostic kit will be around ₹650-700, hence affordable for the general public. The kit will be made available at authorised testing labs for public use.



IIT-Delhi COVID-19 test kit

The team has identified alternative methodology at the second and third stage of testing. They are using comparative sequence analysis. With this probe-free detection method, COVID-19 diagnosis gets done at a significantly reduced cost, making it affordable for large sections of the population. Using comparative sequence analyses, the IIT Delhi team has identified unique regions (short stretches of RNA sequences) in the SARS-CoV-2 genome. These regions are not present in other human coronaviruses, providing an opportunity to specifically detect SARS-CoV-2. This method uses primers targeting unique regions of SARS-CoV-2 that were designed and tested using real-time PCR. These primers specifically bind to regions conserved in over 400 fully sequenced SARS-CoV-2 genomes. This highly sensitive assay was developed by extensive optimisation using synthetic DNA constructs followed by in vitro generated RNA fragments.

The COVID-19 test is a three-step process. In this alternative methodology, they are using fluorescent labels combined with different chemical techniques at the second stage of testing to get easy results. At the third stage, amplification is needed, for which a probe is supposed to be used. The team has developed a new method where they are not using a probe, and this would potentially save cost. The probe is a DNA sequence which has fluorescent labels, which signal the presence of coronavirus in humans. The probe is manufactured by private companies and has to be obtained for the purpose of these tests.

The methodology has been optimised and tested for sensitivity. The assay has been validated at ICMR with a sensitivity and specificity of 100 per cent. This makes IIT Delhi the first academic institute to have obtained ICMR's approval for a real-time PCR-based diagnostic assay.

IIT Delhi has named the testing assay kit Corosure. This low-cost test kit was launched on 15 July 2020 by Union HRD Minister, Ramesh Pokhriyal Nishank. The corosure kit is being commercialised by Newtech Medical Devices. The institution has provided a non-exclusive open license to 10 companies for commercial test but at ₹500 for the assay needed for testing.

Safe disposal of used PPE to

BIMAN BASU

With the global spread of COVID-19 in the past few months, the use of personal protective equipment, or PPE, has become an essential part of the overall safety programme to protect healthcare workers taking care of COVID-19 patients. Currently, there is a high production and utilisation of PPE to protect the community of health workers and other frontline workers of COVID-19. There are many different types of PPE — ranging from gloves to full-body hazmat suits (hazardous material suits). In a lot of cases, the PPE can be reused multiple times without any issues, but during the current COVID-19 pandemic, PPE is being designed for single use, followed by disposal.

Once these plastic materials are discharged into the environment they end up in landfills or oceans, as their natural degradation is difficult at ambient temperature. They need decades to decompose. Recycling these polymers requires both physical methods and chemical methods, which cost a lot. Reduction, reuse and recycling are the three pillars of sustainable development that can help to prevent the disposal of plastic to the environment, but dealing with used PPE presents a different challenge — the threat of infection. So, they need to be handled differently.

Used and discarded PPE scattered in a garbage dump in Delhi (Credit: PTI)

The polymer largely used in the making of PPE is polypropylene, a non-woven material, which is the lightest known downstream petrochemical product obtained by polymerisation of monomer propylene. The basic structure of polypropylene is a saturated carbon chain having methyl group attached to alternate carbon atom. The presence of methyl group makes it different from polyethylene and imparts strength to it. The strength and lightweight, i.e., the high strength-to-weight ratio makes it suitable for various industrial applications including making of PPE.

At present, the proper disposal of PPE is being taken care of by the national authorities according to the guidelines provided by WHO. However, the plethora of

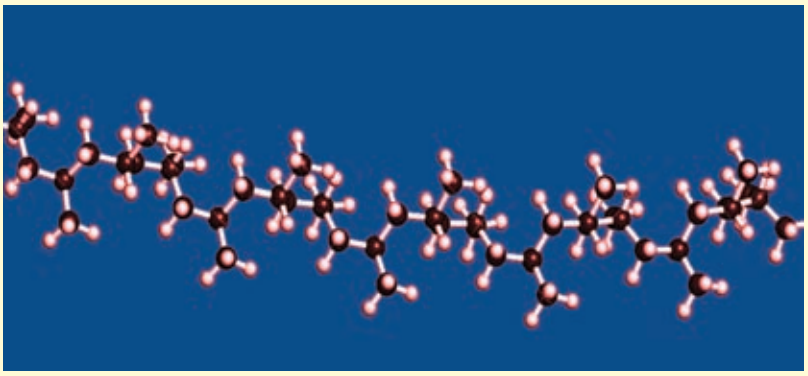
Minus Corona UV Bot test

As a preventive measure against SARS-CoV-2, researchers from IIT Kharagpur, PerSapien Innovations and All India Institute of Medical Sciences (AIIMS) have developed a device titled Minus Corona UV Bot to disinfect hospitals. Inspired by UVD Robots of a Denmark-based company, this indigenous product will be available at a very low cost. Ultraviolet (UV) sterilisation technology has been proven to be extremely effective in killing viruses and microorganisms of any kind, which may remain on surfaces even after the minimum number of standard cleanings.

This device is an ultraviolet light (UV-C-254nm) based robot

safeguard against COVID-19

disposed PPE kits will further increase the burden of polymer on our planet. Already, the safe disposal of hundreds of thousands of used PPE has become a major environmental concern, mainly because of its material, namely non-woven polypropylene, which is non-biodegradable, and if dumped remains in the environment almost for ever. Now, there is a ray of hope. Researchers at the University of Petroleum and Energy Studies in Dehradun, Uttarakhand, have come up with a technique of converting disposable PPE from its plastic state into biofuels using a high-temperature chemical process called pyrolysis. The research has been published online on 3 August 2020 in the journal *Biofuels*. According to Sapna Jain, lead author of the study, the transformation of disposed PPE into biocrude — a type of synthetic fuel — "will not just prevent the severe after-effects to humankind and the environment but also produce a source of energy."



Chemical structure of polypropylene

The research team reviewed many related research articles as they looked to explore the current policies around PPE disposal, the polypropylene content in PPE, and the feasibility of converting PPE into biofuel. They focussed on the structure of polypropylene, its suitability for PPE, why it poses an environmental threat, and methods of recycling the plastic material. Based on their analysis, they hit upon the idea of converting the PPE waste into fuel using pyrolysis — a chemical process for breaking down plastic at high temperature between 300° to 400°C for an hour without oxygen. According to the researchers, "Pyrolysis is the most commonly used chemical method whose benefits include the ability to produce high quantities of bio-oil which is easily biodegradable." They say, the challenges of PPE waste management and increasing energy demand could be addressed simultaneously by the production of liquid fuel from PPE kits. Further, the liquid fuel produced from plastics is clean and have fuel properties similar to fossil fuels.

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that will enable sterilisation of hospital corridors, wards, Intensive Care Units (ICUs) and patient rooms without exposing anybody to the contaminated environment. It comprises a UV-C lamp mounted on a wheeled robotic platform that is operated (front-back, left-right) with a remote control. This is also equipped with a camera that gives the perspective from the driver's seat onto a digital screen to remotely control the UV robot and avoid any obstacles.

UV-tech fitted sanitizing trunk

The fight against the COVID-19 epidemic will not end merely with social distancing and by not stepping out. It is extremely important to be cautious to avoid

UV-tech fitted sanitizing trunk

infection. The infection-causing droplets remain on vegetables, paper, and plastic skins for a long time. Therefore, all external objects need to be sanitized. IIT Ropar has developed a common sanitizing solution for everything.

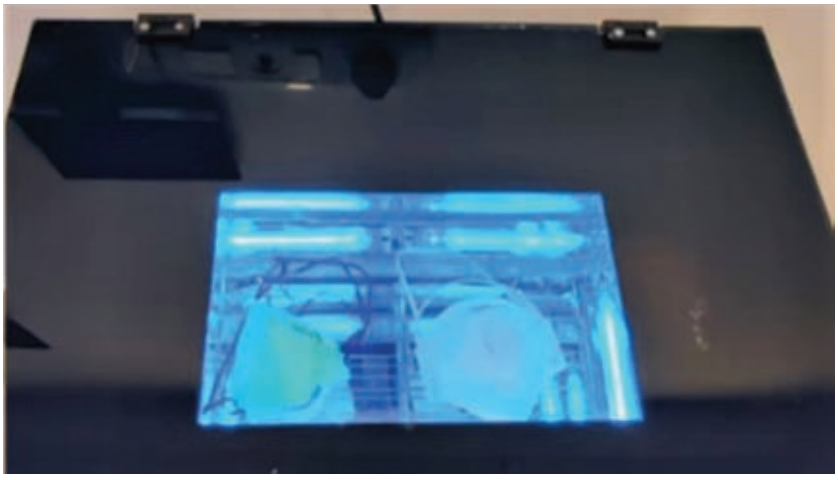
The research team has developed a trunk-shaped device fitted with ultraviolet germicidal irradiation technology used in water purifiers, which they claim could be placed at doorsteps and all items coming from outside, including currency notes, vegetables, milk packets, any items ordered through delivery, wristwatches, wallets, mobile phones, and documents, can be placed inside the sanitizing trunk. The device can be made available at less than ₹500. It will take 30 minutes to sanitize the items and a 10-minute cooling-off period before one takes the items out.

It is strongly advised not to look directly at the light inside the trunk as it can be harmful. It is recommended to place the trunk at the doorstep or may be somewhere closer to the entry. The sanitizing tool makes it super easy to ensure that none of the products one receives from outside is in any way contaminated. The technology for manufacturing the unit has been transferred to a Chandigarh-based firm, Esspee Industries, for commercial production. Esspee Industries is planning on making 20 units per day initially.

Corona Oven

As nations are putting all their efforts to contain the spread of COVID-19, people have become extra cautious about hygiene and careful about handling packages and surfaces around them. To prevent surface-to-human transmission of SARS-CoV-2, a Corona Oven has been designed by IIT Roorkee, Uttarakhand and Log9 Materials (a Sequoia & Exfinity funded startup).

The Corona Oven is a quick, reliable, safe, and effective sanitization system, especially designed for combating SARS-CoV-2. It uses UV-C light in combination with significant design parameters to effectively sanitize the surfaces of various



products/objects of regular use in healthcare and household settings. It is a patent-protected technology that can focus the necessary energy on the entire surface of an object that is kept inside the box to kill viruses and even bacteria. The Corona Oven is designed in a way that every square centimetre of an object placed inside is completely sanitized, helping it to stand out from standard UV technologies deployed in other countries. The product has been specifically designed keeping in mind the cell structure and characteristics of the corona family of viruses.

The product has been manufactured and supplied to many customers and hospitals.

Portable UV sanitizers

A group of students and professors of IIT Bombay has prepared a portable UV sanitizer in the wake of the SARS-CoV-2 coronavirus pandemic. This new portable UV sanitizer will help in disinfecting currency notes, wallets and mobile phones and thereby effectively tackling the SARS-CoV-2 in the country. Sanitizer gel cannot be used to disinfect papers, files, currency notes and mobile phones and these can act as a medium to carry the SARS-CoV-2 coronavirus. In these conditions this portable UV sanitizer will be very affordable and effective. The sanitizer was designed on the basis of a study reported in *Pubmed* database of the US National Library of Medicine. According to the study, ultraviolet-C light can render SARS-CoV-2 ineffective.

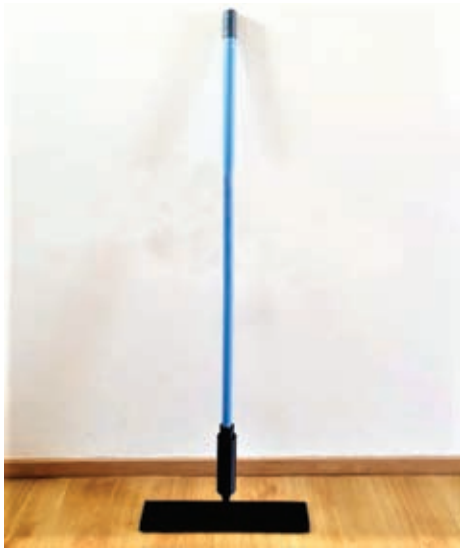
This UV sanitizer can be used for disinfecting currency notes, masks, wallets and mobile phones. The prototype of the portable UV sanitizer was built using a germicidal UV lamp that is used in water purifiers, stainless-steel kitchen containers and aluminium mesh. The portable sanitizer is prepared in four hours.

This device has been designed and developed at a laboratory scale. The team is conducting trials inside the labs. There are currently two prototypes of the device and the innovators are working to scale it up to the possible extent. Though the trial tests were conducted in the laboratory, the final production may take time.

UV-C LED disinfecting system

IIT Guwahati has developed a low-cost UVC LED-based disinfection system that can be used to sanitize large areas and even metro trains, buses, etc. The UV-C system is a proven technology, for sanitizing microorganism infected non-porous surfaces. The system is low-cost and based on UV-C LED technology. By using UV-C, 90 per cent killing rate can be achieved for one of the highly stable viruses MS-2 coliphase with 186 joule dose, whereas 36 J dose is needed for influenza virus, which is similar to SARS-CoV-2. In this project, the team has developed a UV-C LED system capable of providing 400 J dose in 30 seconds, such that a virus-infected surface will be sanitized. The unique design of this UV-C system will ensure uniform UV-C exposure to virus-infected non-porous areas. Another critical aspect of the technology is the safe usage of UV-C system while sanitizing.

Portable UV sanitizers



UV-C LED disinfecting system

The system is equipped with an object movement identification feature so that UV-C exposure to human skin is avoided during the operation. Currently, the team has developed three models for household sanitization and one for bigger spaces like hospital wards, buses, metros, etc., including those transformed for COVID-19 care.

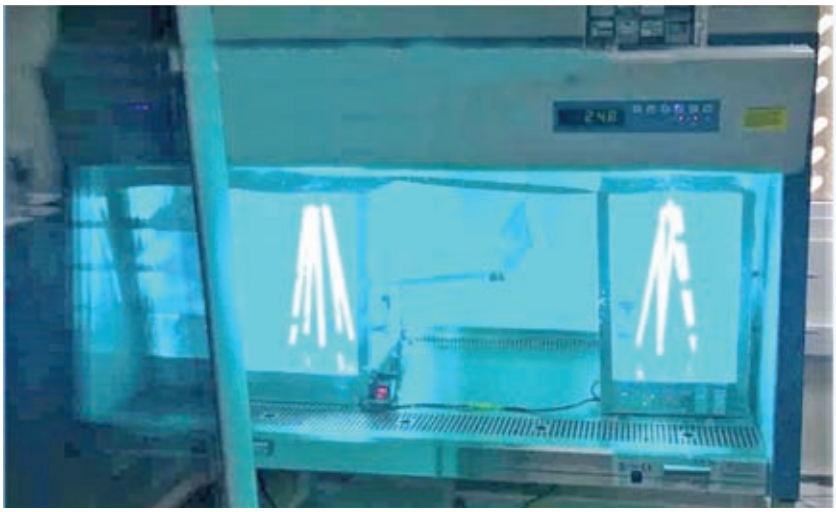
UV-C LED system is under design and prototype development. The industrial partner was able to source required raw material to produce 5,000 floor sanitization UV-C systems. The industrial partners were in the process of getting special approval from the government agencies to start production during the lockdown period. Further, to adopt this technology for porous surfaces, the team is improving the design by integrating UV-C with ozone system so that porous surfaces can also be sanitized. The main purpose of the team is to develop the UV-C system design, prototype (using 3-D technology), and testing it in its laboratory.

3D-printed hands-free objects

Researchers at the National Institute of Pharmaceutical Education and Research-Guwahati (NIPER-G) have come up with a design for the fabrication of 3D-printed hands-free objects. This has been done after detailed analysis of several resources to prevent the spread of the virus through bare hands. In the current situation of COVID-19 pandemic, these surfaces may play a key role in transmitting infection from one person to another as these surfaces are the most germ-infested objects in our surrounding. The 3D-printed hands-free objects can be utilised (both vertical and horizontal) to minimise this risk.

The product is easy to design and amenable to rapid development of prototypes. It is also handy, user-friendly, non-fragile and easy to clean with the existing sanitizers or any alcoholic disinfectants. The 3D-printed hands-free object can be used to open or close windows, drawers (both vertical and horizontal), doors, computer keyboard, and refrigerator handle, or to press elevator buttons, and laptop /

3D-printed hands-free object



Sterilisation system for medical accessories

desktop keyboards, including turning the switch buttons on/off.

Sterilisation system for medical accessories

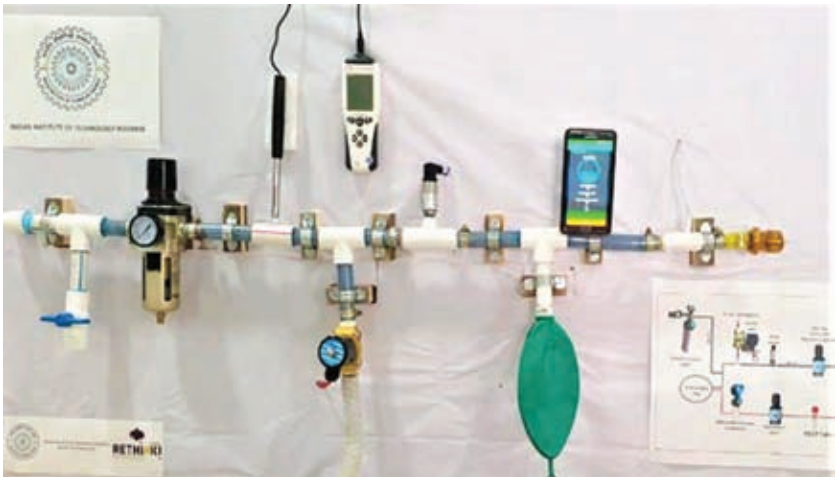
A research team at IIT Jodhpur has developed an Advanced Photocatalytic Oxidation Sterilisation System based on UV-light and metal oxide nanoparticle catalyst panels. It can be used for sterilisation of medical accessories being used by doctors and COVID-19 patient handlers. The current system facilitates the reuse of N-95 filtering face mask respirators.

This system has two indigenous assemblies of UV-light sterilisation systems housed in a portable biological safety environment to kill the bacteria and viruses in a protective environment. Metal oxide nanoparticle catalyst plates are synergistically used in the system along with UV lamps. The process eliminates microorganisms, including viruses, and any other suspended particles, including volatile organic compounds (VOCs). It also has an advanced control system and is semi-automated operation enabled. The sterilisation system has been tested at AIIMS, Jodhpur for its effectiveness. The technology is ready for technology transfer at zero cost to MSME for mass production citing the need of the hour during this pandemic. IIT Jodhpur only anticipates that the product needs to carry acknowledgement to IIT Jodhpur.

Prana-vayu-portable ventilator

IIT Roorkee has developed a low-cost portable ventilator that can be useful for COVID-19 patients. Named Prana-Vayu, the closed-loop ventilator is developed in collaboration with AIIMS, Rishikesh, and is equipped with state-of-the-art features. The ventilator will be useful for a wide degree of congestions in the respiratory tract and is applicable for all age group patients, especially the elderly.

The closed-loop ventilator does not require compressed air and is useful when wards are converted to ICUs. It is a low-cost portable ventilator. The manufacturing cost per ventilator is estimated at ₹25,000-30,000. The ventilator is based on the controlled operation of the prime mover to deliver the required amount of air to the patient. The automated process controls the pressure and flow rates in the inhalation and exhalation lines. The ventilator has feedback that can control tidal volume



Prana-vayu-portable ventilator

and breaths per minute. It can automatically limit high pressure with an alarm system. In case of a failure, the circuit opens to the atmosphere, which prevents choking. Some additional features are remote monitoring by health professionals, touch screen control of all operating parameters, moisture, and temperature control for inhaled air. The prototype has been tested successfully for normal and patient-specific breathing conditions.

This ventilator equipped with state-of-the-art technology and facilities to manage a wide range of critical illnesses has been tested successfully at IIT Roorkee along with endurance testing. The control and monitoring of the ventilator can be done wirelessly.

AIIMS Rishikesh has conducted tests in various medical conditions including human simulator tests with this ventilator and declared it successful in terms of medical technology.

Ultraviolet Disinfection Negative Pressure Isolation Chamber

In the current crisis of COVID-19 pandemic, in an effort to overcome the high infrastructure cost and address the safety concerns of the medical fraternity, Alliance University (AU), Bengaluru researchers Dr. Harinath Aireddy and Dr. Reeba

Korah, have developed a portable isolation ward called, Ultraviolet Disinfection Negative Pressure Isolation Chamber (UDNPIC), for COVID-19 patients.

Ultraviolet Disinfection Negative Pressure Isolation Chamber

The technology is low cost, reusable, durable, easy to operate and does not require any expertise to handle. The UDNPIC system has two chambers, one in which the COVID-19 patient is located and externally treated and a second chamber to extract the virus from the first chamber and kill it instantly. UDNPIC uses locally sourced UV light. The technological innovation can be commercially produced with minimal turnaround time and can be deployed at hospitals across the country at costs much lower than a full-fledged isolation ward. The advantage of UDNPIC is that there is quick turnaround of patients and quicker disinfestation process. The developed set-up comprises many of the individual components indigenously developed like negative pressure chamber, mask filters, axial air ventilating fan, gloves, duct channel, UV-C exposure area, HEPA filter, silicon detector and many other novel features.

This innovation will help the government in setting up infrastructure to fight the pandemic at lower costs, while maintaining high standards of treatment. A 10-bed isolation ward will cost approximately ₹1.5 to 2 crore, whereas a 10-bed UDNPIC will cost ₹6 to 7 lakh (each set-up is ₹60,000 to ₹70,000). The team has approached National Research Development Corporation (NRDC) for patent filing facilitation services for UDNPIC. NRDC has conducted patentability analysis for this technology and filed patent for the technology with the patent application number — TEMP/E-1/26219/2020-CHE. The technology prototype is in the testing trials and is ready to hand over to prospective entrepreneurs for commercialisation.

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Innovative Technologies Available for Commercialization

NRDC is engaged in the development, promotion and transfer of technologies emanating from various national R&D institutions/ universities. The Corporation offers its IPRs and Technology Transfer services in wide ranging areas like: Agriculture, Chemical, Agro & Food processing, Life Sciences, Mechanical, Electrical & Electronics, Energy and Telecom. It acts as an effective catalyst in translating innovative research into marketable industrial products. NRDC has the largest repository of Indian technologies and signed about 5000 licence agreement with entrepreneurs/start-ups/corporate in India and abroad. Some Innovative technologies are available with NRDC for Commercialization having great potential in India and Abroad:

- **Extraction of Azadirachtin from Neem Seeds Kernel and its Pesticide formulation**
- **Super absorbent Hydrogel**
- **Preserved Sugarcane Juice in glass bottles**
- **Potassium Humate**
- **Ready to eat Honey Pan Beeda**
- **Process for the production of Honey Powder with Natural Profiles**
- **Process for preparation of Wheat based Chocolate Bar**
- **Low Cost Jute Based Sanitary Napkin**
- **Karnataka Rice Hybrid (KRH-4)**
- **Silver Nano Particle as Antidandruff Aagents**
- **Live-attenuated Salmonella Typhimurium Vaccine**
- **Trichoderma harzianum, a biocontrol agent against Phytophthora foot rot**
- **Zinc solublizing PGPR for soil drenching**
- **Porous and Ultra-Light MgO and ZnO Nano-Crystalline Powders**
- **Noval method of storing and delivering PGPR/microbes through biocapsule**
- **Seed coating composition and a process for its preparation**
- **Micronutrient compositions for ginger (for soils with pH above 7 & pH below7)**
- **Micronutrient compositions for turmeric (for soils with pH above 7 & pH below7)**
- **Micronutrient composition for Black Pepper**
- **Micronutrient composition for Cardamom**
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- **Ayush-82, Ayush-64, Ayush-56, Ayush SG**
- **Bala Rasayana**
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- **Herbal Hand Sanitizer**
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- **TOCO (Toilet Care Unit)**
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- **Pochonia Chlamydosporia liquid formulation**
- **Mosquito larvicidal Formulation based on Bacillus Thuringiensis var. Israelensis**
- **PGPR talc formulation for Ginger**
- **Manufacture of Nata-de-Coco from Coconut Water**

NATIONAL RESEARCH DEVELOPMENT CORPORATION

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Prime Minister Shri Narendra Modi urged the nation to make Mother India plastic-free and exhorted municipalities, NGOs and the corporate sector to come up with ways for safe disposal of accumulated plastic waste. India generates about 10 million tonnes waste plastics per year which to toxic to environment and all living beings.

To move forward in the direction to achieve this environment-friendly goal, an Innovative technology to convert waste plastic into useful products like tiles, pavement blocks and other structural components etc. is available for Commercialization. The technology is Licensed by NRDC. For more details please contact NRDC.

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