III. COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

1. INTRODUCTION

The Council of Scientific & Industrial Research (CSIR) is a national R&D organisation providing scientific and industrial research of value for India's sustained growth, strategic needs and nurturing of national human resource in S&T. It has countrywide network of 39 laboratories undertaking fundamental and applied R&D in diverse areas of science and technology.

CSIR continued to provide scientific & industrial R&D of value not only for India's sustained development but for meeting its strategic needs as well. The Annual Report for the year 2002-2003 highlights the significant S&T contributions of CSIR in the sectors of Aerospace Science & Technology; Biological Sciences & Technology; Chemical Sciences & Technology; Earth Sciences & Technology; Engineering Sciences & Technology; Food Science & Technology; Information Science & Technology; Leather Science & Technology; Material Science & Technology; and Societal Science & Technology. It also includes activities of CSIR HQ.

1.1 New Millennium Indian Technology Leadership Initiative (NMITLI)

Launched in the year 2000-01, NMITLI, envisages to support innovation centered scientific and technological development as a vehicle to attain for the country, a global leadership position in selected niche areas, in a true Team India partnership mode. It continued its endeavour, during the year, thus, to synergise the best competencies of publicly funded R&D institutions, academia and private industry. Six new projects were initiated. These projects involved 65 research institutions and 27 industrial firms. A specially devised mechanism under the effort monitored closely, 9 ongoing projects for achieving the assigned goals in the given timeframe.

1.2 Tenth Five Year Plan

The Planning Commission constituted a Steering Committee on Science & Technology for the formulation of the Tenth Five Year Plan (TFYP) under the chairmanship of Hon'ble Dr. A.P.J. Abdul Kalam and the Committee in turn, had constituted a Working Group to formulate the TFYP of CSIR in January, 2001. In order to look into the sector specific details and to work out the R&D priorities and programmes, sectoral groups were set up by the Working Group. The sectoral groups were on Aerospace; Biology and Biotechnology; Chemicals; Earth Resources and Natural Hazards Mitigation; Ecology and Environment; Electronics & Instrumentation; Energy; Food and Food Processing; Health Care, Drugs and Pharmaceuticals; Housing and Construction; Information Dissemination and Products; Leather; Materials, Metals and Minerals and Manufacturing. These Groups had several meetings and put in around 500 man-days of expert time. Based on an overall SWOT analysis of the sector and of the CSIR laboratories servicing the sector, the sectoral

group shortlisted specific themes of R&D, projects and specialized facilities to be created to service these sectors. These were then relooked in by CSIR on ZBB basis. The sectoral plans and laboratories plans were integrated and dovetailed to arrive at a draft composite Tenth Five Year Plan for the CSIR.

The Tenth Five Year Plan has been formulated against the backdrop of high expectations in S&T expressed by the highest echelons of government arising from the successful developments in S&T sectors, coupled with the governments resolve to plan for a GDP growth of 8%. This imposes a responsibility and a challenge. It also provides an opportunity to the S&T system to prove its mettle. CSIR being amongst the larger R&D funded organizations in the industrial sector has an added responsibility of helping the Indian industry to regain its lost growth rates and become competitive globally. The draft plan was considered by the Working Group and the final Report was submitted to the Steering Committee in June, 2001. The Working Group recommended initiation of a new scheme on Infrastructure Renovation & Refurbishment, a scheme akin to modernization and upgradation of R&D equipment and facilities. The Report of the Working Group *inter alia* envisaged an outlay of Rs. 4545 crore for the TFYP.

The Steering Committee has desired that network approach be effected in project selection. CSIR has accordingly reviewed the entire plan and submitted the same to the Planning Commission wherein the approach was to evolve and formulate Core Networked programmes amongst which some would be implemented in mission mode.

1.3 Setting up of a World Class Drug Research Institute

In 1951, CSIR set up, the Central Drug Research Institute (CDRI) – a laboratory specifically dedicated to drug research. Since then CDRI continued to develop capability, expertise, infrastructure for new drug development and generated human resources in diverse areas – which has formed the bulwark of Indian pharma industry and has found prestigious position in the best of multinational pharma firms abroad. CDRI has developed 14 new drugs and myriads of leads. However, new drug discovery could not get the due prominence hitherto because of the prevailing patent regime. Thus while its performance was tenable, it could not keep in step with the intensive, competitive modern R&D and management culture of new drug development prevailing abroad. CDRI is housed in a premise, which is 200 years old. The building has been declared an archeological monument. CDRI has been asked to shift from the building. CSIR has taken the advantage of this opportunity on the direction of Hon'ble Minister S&T and has decided to set up a futuristic world class drug research institute in conformity with global thinking and practices not of today but that of tomorrow. Diverse steps needed for the setting up of the new entity have been taken during the year and the progress has been satisfactory.

1.4 Review of INSDOC and NISCOM

A Review Committee was constituted to review and assess the competencies, programmes, activities and functions of INSDOC and NISCOM to gainfully serve and service the S&T information and communication needs of the potential users and to benefit from the emerging opportunities in the IT domain. The Committee carried out a SWOT analysis of the two institutes, deliberated upon diverse issues and has recommended for the merger of INSDOC and NISCOM into a single entity to be named as National Institute of Science Communication and Information Resources (NISCAIR). The mandate and mission of the new set up would be to become the prime custodian of all information resources on current and traditional knowledge systems in science and technology in the country, and to promote communication in science to diverse constituents at all levels, using the most appropriate technologies.

1.5 Review Committee for CSIR Outreach Centres

Over the years, CSIR HQ and several of the CSIR laboratories have set up Extension Units/Centres to undertake locale specific and/or extension activities. By and large, these Units/Centres had fulfilled the objectives/purposes for which they were set-up. The CSIR Review Committee – 1986 had recommended that CSIR divest itself of all such Centres by the end of the Seventh Five year Plan. The Working Group, constituted by the Planning Commission to formulate the Tenth five Year Plan for the DSIR/CSIR, had *inter alia* suggested CSIR to consolidate, refurbish and modernize its infrastructural set up in order to derive the full benefits from its investments. Considering the changing economic, industrial and R&D scenario nationally and internationally, it was felt necessary to review the performance, relevance and utility of these centres/units. Accordingly a Committee was set-up on the approval of Vice President CSIR for the purpose. The Review Committee elicited information on all the outreach centres w.r.t. the resource base (financial, human, infrastructural), performance, output and Director's SWOT analysis and recommendations on the future of each Centre. It assessed the case of each outreach centre w.r.t.: performance in accordance with the mandate and resource endowments; relevance and utility in the present and future context; its continuation or otherwise; revised mandate, if any and stipulations thereto. The Review Committee made recommendations w.r.t. centres that could continue, or closed/merged with other CSIR entities.

1.6 Overall Performance During the Year

The External Cash Flow (ECF) for the period was at Rs. 264 crore. The foreign patent filing crossed the target set for the year and was at 580–a highest figure ever in the history of CSIR. The Indian patent filing was 410, besides 50 copyright and 78 trademarks were obtained as against 25 and 16 in the corresponding period last year, indicating the continued strong CSIR

contribution, even in the domains of other forms of Industrial property. The papers contributed were 1700 in number with IF being at 2882.550 and AVGIF at 1.696. The industrial production based on CSIR know-how was of the order of Rs. 5400 crore.

2. S&T CONTRIBUTIONS

2.1 Aerospace Science & Technology: Science, Technology & Service

2.1.1 LCA flight control laws validated

The maiden flight of the LCA TD-1 aircraft took place on 4 January 2001 and there were 11 more flights thereafter. The successful completion of the first block of 12 flights with fixed gain control laws (designed and developed by the National Control Law team led by NAL) have bolstered the confidence in the aircraft's overall performance and its control law in particular. The performance of the control laws was found to be very satisfactory with the test pilots rating the aircraft as having Level 1 handling qualities in all tasks performed during these flights.

2.1.2 SARAS

The work on the prototype building of the 14-seater multi-role transport aircraft, SARAS, is going on at a brisk pace at various centers in the country including HAL. Assemblies of the fuselage, horizontal and vertical tails, rear fuselage and main and emergency doors have been completed. The problems associated with the wing assembly have been resolved and the wings will reach NAL from HAL, Nasik in Oct-Nov 2002. Structural and engineering testing of various subsystems is progressing well. The sophisticated, and indigenously developed SARAS avionics system is ready. SARAS is expected to roll out by the end of 2002 and have its first flight shortly thereafter.

2.1.3 HANSA: three more aircraft fly away

NAL has delivered all the three HANSA aircraft (VT-HNT, VT-HNU, VT-HNV) that it was contracted to build for the Ministry of Civil Aviation. MCA has positioned these aircraft at flying clubs in Hyderabad, Trivandrum and Indore. With three HANSA aircraft already with flying clubs, NAL's challenge in the HANSA programme now moves from design and development to support and marketing.

2.1.4 Design, development and delivery of 4m x 8m autoclave

NAL completed the task of designing, developing, fabricating, installing and commissioning a 4m x 8m autoclave at HAL, Bangalore. The autoclave, developed in partnership with BHEL, Trichy, is one of the largest of its kind in Asia. It was handed over to HAL on 12 April 2002. HAL will use it extensively to fabricate large composite parts for the light combat aircraft (LCA) production. One of the most challenging tasks in the autoclave development was to meet the stringent performance requirement of realizing the precise cure cycle profiles.

2.1.5 12.88m dia radome for ISRO's Doppler weather radars

NAL teams have successfully developed and installed a 12.88m diameter curved sandwich panel radome for the Doppler Weather Radars (DWR) of ISTRAC and ISRO. After being formally cleared by the qualification agency, the radome was installed at the Sriharikota-Shar Centre in May 2002. Such a geometrically modeled double-curved spherical geodesic sandwich paneled radome of a very large size has been realized for the first time in the country. A new realization of the radome with the same diameter but with a randomized panel geometry (for improved performance) is now being attempted.

2.1.6 Growth of RANS solvers

NAL has now achieved maturity in the numerical simulation of dominantly viscous flows through the computation of Reynolds-Averaged Navier-Stokes (RANS) equations. This is a natural sequel to the growth of reliable software for the solution of Euler equations for complex 3D shapes. Specific codes have now been developed to deal with each of the flow regimes of low-speed incompressible flows, transonic and supersonic flows and hypersonic flows. The demonstrated abilities of these codes include high-incidence flows over aerofoils around the stall conditions where complex viscous effects dominate and the prediction of air loads on bluff bodies under low speed conditions.

2.1.7 Multi sensor data fusion technology

Multi-sensor data fusion technology aims at automation of processes to combine diverse sets of sensed information. The objective is to combine elements of raw or pre-processed data from different sources into a single set of meaningful information. Activity initiated in this area at NAL four years ago has now attained a level of maturity. Current work relates to handling multiple targets in a multi-sensor scenario for range safety applications; towards this end, algorithms for characterization sensors have been developed. Novel factorizations based tracking filtering approaches have also been proposed. Future application possibilities include integration of the identity of targets with kinematic information.

2.1.8 Twenty years of NAL-DLR cooperation

In what must rank as one of the most durable and successful international collaborations of all time, NAL and DLR, Germany have completed 20 years in aerospace cooperation. More than a dozen joint projects in different areas of aeronautics such as aerodynamics, structures, turbo-machinery, flight mechanics and control have been completed. The hallmark of the NAL-DLR cooperation has been the exchange of scientists (over 100 scientists from each side) and the organization of joint workshops. The major achievements of the cooperation include the design, development and testing of a flight worthy Do-228 aircraft rudder, development of system identification algorithms for

aircraft applications and innovative experiments in flow analysis and management.

2.2 Biological Sciences & Technology: Science, Technology & services

2.2.1 Study of human migration to Indian subcontinent by mitochondrial DNA studies

The Indian subcontinent has seen a number of migrations and there have been admixtures with various ethnic groups to form the generic make up of its population. There are unanswered questions regarding the routes taken by modern man while migrating from Africa. It is of great significance to know the genetic diversity and genetic relationships of the large and centrally diverse Indian population using the more precise DNA tools especially since the human genome has been sequenced.

Mitochondrial DNA (mt DNA) can be used to trace maternal ancestry. The mtDNA variation and its geographical distribution is highly informative in understanding population expansion, and migration routes in the distant past. A study of the Indian population representing different geographical region, is being carried out by NCL, using two approaches, high resolution mapping of the entire mitochondrial genome which covers 20% of the mtDNA and sequencing of HVR1, a hypervariable region of the mtDNA D-100p. Caucasian admixture has been found in both the Indo-European and Dravidian language speakers. The `M' haplogroup found at a high frequency in Asians and also recently discovered in Ethiopia, has been found at high frequency in Indians also. Many of the Asian-specific haplogroups are either absent or found at very low frequencies in Indians.

Scientists at NCL have completed a high resolution site-mapping and sequencing of HVRI region of the mtDNA and drawn following significant conclusions:

- More than 60% of the Indians belong to the 'M' haplogroup which is not found in Europeans and Middle Easterners;
- They have found a connecting Indian and African mtDNA haplotype which can suggest a migration of `M' from Eastern Africa;
- They have also found a few caucasian lineages in Indians which are not exactly similar to the European types which suggest that the caucasian migration into India would have been from the middle East and Europe;
- A number of mtDNA types are shared between the Indians and South-East Asian clearly suggesting that there were some migrations from India to South-East Asia.

In conclusion, the Indian subcontinent was populated by migrations from Eastern Africa through a southern routes, caucasian migrations from the middle east and has contributed to the South-East Asians as well as received some admixture from them. This is the first study of Indians using high resolving mtDNA approaches, which has given significant insights.

2.2.2 Genetic markers to resolve species and stock variations

An insight is being developed at NIO to establish genetic variations among marine populations through molecular genetic investigations with a view to having applications in stock management, marine aqua-culture, taxonomy and protection of species. Genetic relationships studied among five species of nemipterid fish strangely showed greater affinity of *Nemipterus japonicus* and *N. peronii* with *Parascolopsis aspinosa* than to the other species of their own genus. Naturally this leads to re-examination the taxonomic status of both genera. Using allozyme analysis, samples of *N. japonicus* from east and west coasts of India showed significant differences in their genetic composition, indicating that these samples may represent genetically distinct populations or stocks. All species of Nemipterid were found to have polymorphic loci that could be used in future stock analysis. Besides, a number of diagnostic loci identified will help in identifying these species in fresh or frozen condition and also at juvenile stages. A major problem in resolving the taxonomy of the nemipterids is that many species are similar in morphology, and fresh coloration has been the main criterion for field identification. Identification from preserved specimens often is difficult, and this has frequently lead to misidentification.

2.2.3 Molecular biochemistry of allergy and infectious diseases

- ☞ Cholera is caused by *Vibrio cholerae* which colonizes in gut and causes diarrhea. It has been shown that immunization with Cholera toxin B-subunit provides partial protection. It is well understood that immunization through mucosal surfaces are more effective in diseases which involve infection through mucosal routes. Oral immunization, thus could be ideal for diseases such as cholera. CBT in collaboration with Plant Molecular Biology Department, Delhi University has expressed cholera toxin B-subunit in tomato. The aim is to finally develop an edible cholera vaccine.
- ☞ Under the endeavour to better understand the molecular biology of host pathogen interaction CBT has identified a new functionally important protein disulphide isomerase (PDI) in *A. fumigatus* having allergenic properties. For the first time a PDI is observed to exhibit specific immunoreactivity to IgG and IgE antibodies in patients of allergic bronchopulmonary aspergillosis (ABPA).
- ☞ The results of investigations carried out at CBT to study the susceptibility of lung surfactant protein genes, SP-A (AKO) and SP-D (DKO), knockouts to invasive pulmonary aspergillosis highlighted the role of SP-A, SP-D and their recombinant forms in protection against invasive aspergillosis and indicated their use as novel therapeutics for lung allergy and infection.
- ☞ Sequencing analysis of SP-A2 gene at CBT indicated two prominent polymorphisms in Indian population, one at 91st

codon resulting in change of amino acid from Proline to Alanine and second at 94th codon. Polymorphism at 91st codon may have an association with pulmonary tuberculosis and allergic bronchopulmonary aspergillosis. The results clearly indicated that these SNPs in the collagen region of SP-A2 may be one of the contributing factors to the genetic predisposition to pulmonary tuberculosis and aspergillosis in Indian population. The observation of clinical correlation with the polymorphisms suggests that these SNP's may find applications in molecular diagnosis of ABPA and tuberculosis and can lead to better understanding of the underlying mechanisms of the host to the susceptibility and resistance to the allergic and infectious diseases.

- ☞ With a view to analyse allergens at molecular level, cDNA library from *Curvularia* was prepared and screened at CBT with the patients sera and rabbit hyperimmune serum raised against the purified protein. One of the clone was sequenced completely. This clone had an ORF of 282 base pairs having homology with Cytochrome C in fungi and other species.

2.2.4 Universal technique to establish species' identity

The effective biodiversity protection and wildlife forensic identification are both linked to the stability of natural ecosystem by means of establishing identity of confiscated animal remains for wildlife law enforcement. Until date, no technique is known which could be used universally to establish species' identity beyond a reasonable doubt. For the first time, scientists at CCMB have developed a novel, simple and quick method which is applied for establishing identity of vast range of animal species in a universal manner. The technique utilizes a pair of novel primers, namely, mcb398 and mcb869 in polymerase chain reaction (PCR). It may revolutionize the area of wildlife identification and be helpful for law enforcement agencies and wildlife curators to control the human violation of wildlife resources. This technique can also be used in food fortification where identity of edible meat sources is to be established. The PCT and US patent for the development has been filed. Based on the invention, CCMB has started providing wildlife identification services. Scientific evidence has been submitted in five sensational cases of wildlife offence.

2.2.5 Use of transgenic flies in drug screening

The transgenic organisms have become indispensable tools for pharmacological studies. These organisms allow the manipulation of the complex processes and identification of the potential targets of the drugs. The study of the biochemical alterations, resulting from the drug-target interactions in the transgenic animals also allows the identification of the new genes with related functions, which can then be exploited to develop more specific and effective therapies. CCMB has generated transgenic flies

(*Drosophila melanogaster*, commonly known as fruitfly), which enable targeted expression of human APC gene in different genetic and physiological backgrounds. Human APC phenotypes in flies are indeed consistent with its biochemical role in human. Scientists at CCMB have successfully used human APC-induced eye deformities as the assay in a genetic screen to identify new genes, which modulate Wnt/Wg signaling. They have further shown that these transgenic flies constitute a novel, fast and inexpensive model system for studying Wnt-signaling and for developing therapeutics for the prevention and treatment of cancers caused by over-activation of Wnt-signaling. Using this transgenic assay system, potential anti-cancer drugs developed by commercial and academic organizations have been successfully screened.

2.2.6 Structure and biochemical studies on potential drug targets from M. tuberculosis

Crystal structure of Rv2118c belonging to a class of conserved hypothetical proteins from Mycobacterium tuberculosis H37v has been determined by CDRI in complex with S-adenoxyl-L-methionine (AdoMet) at 1.98 A resolution using multiple isomorphous replacement (MIR) technique. The structure of the monomer can be functionally divided into two domains: the larger catalytic C-terminal domain that binds the cofactor AdoMet and is involved in the transfer of methyl group from AdoMet to the substrate and a smaller N-terminal domain. The structure of the catalytic domain is very similar to other AdoMet-dependent methyltransferases (MTases). The N-terminal domain is primarily a B-structure with a unique fold not found in other methyltransferases of known structure. Although the crystallographic asymmetric unit consists of a monomer, symmetry related subunits interact extensively, leading to a tetrameric structure. Four subunits related by crystallographic symmetry interact extensively, forming a central antiparallel B-barrel structure. The four subunits extend out of this barrel structure at diametrically opposite corners.

Though no function has been assigned to Rv2118c, it possesses signature sequence motifs that are conserved across the family of AdoMet-Mtases. Database searches revealed a conserved family of Rv2118c like proteins from various organisms. Multiple sequence alignments show several regions of high sequence similarity (motifs) in this family of proteins. A putative function has been assigned to some of these highly conserved regions based on the structure and sequence comparison studies. Some of the sequences that show significant homology to Rv2118c, have been putatively classified as homologs of protein isoaspartyl methyltransferase (PIMT). However sequence and structural analysis clearly reveal that Rv2118c and other homologs form a distinct family of proteins different from PIMTs. Structure comparison studies and homology to yeast Gcd14p suggest that Rv2118c could be an RNA methyltransferase. Molecular surface and electrostatic

surface potential calculations indicate the presence of a large cleft on the surface of the protein, lined with positively charged residues and wide enough (~20-25 Å) to accommodate large substrates including DNA or RNA. Docking studies indicate that this cleft can well accommodate a tRNA substrate.

2.2.7 Modulator of multi-drug transporters against pathogenic bacteria

Membrane located multi-drug transporter (efflux) proteins are known to facilitate multi drug resistance (MDR) in pathogenic bacteria. These are membrane proteins found in almost every cell type and they bind to a variety of structurally and chemically dissimilar compounds and exclude them from the cell, in an ATP dependent process. This results in simultaneous resistance development to two or more structurally unrelated antibiotics. Two multi drug resistant *M. smegmatis* strains have been experimentally constructed at CIMAP; one with enhanced resistance to FQ drugs (MDR-Q) and the other with enhanced resistance to rifampicin, chloramphenicol and tetracycline (MDR-R). Reserpine, a known inhibitor of Bmr mediated drug resistance in *Bacillus* sp. and CCCP, a membrane protonophore which destroys the proton gradient driving force were both able to reverse the MDR phenotype of such mutant strains, indicating the involvement of efflux pump. Using this novel screen, two plant compounds have been isolated as CIM 789 and CIM 1866 which were able to reverse both MDR-Q and R phenotype in *M. smegmatis*. These plant derived bio molecules inhibit the development of efflux mediated multi drug resistance in mycobacteria.

2.2.8 Anthrax vaccine

CBT has developed an expression system for producing large amount of protective antigen (PA) protein of anthrax toxin. The immunization of animals with PA alone could protect the animals against lethal challenge with the spores of pathogen. The technology developed for anthrax vaccine has been transferred for commercial exploitation in collaboration with Jawaharlal Nehru University.

2.2.9 Efficacy of Acalypha indica on Dermal Wound Healing in Rats

The effect of plant products in wound healing has been investigated at CLRI. The influence of *Acalypha indica* on skin wound healing was studied in rats. Full thickness excision wounds were made on the back of rats and *Acalypha indica* extract was administered orally and topically. The granulation tissue formed was used to estimate collagen, hexosamine, protein and DNA. The extract increased cellular proliferation and collagen synthesis at the wound site, as evidenced by increase in DNA, total protein and collagen content of granulation tissues. Quicker and better maturation and crosslinking of collagen was observed in the extracts of treated rats, as shown by the high stability of acid soluble collagen and increase in aldehyde content and tensile strength. The extract treated

wounds were found to epithelialise faster by a factor of 25% and the rate of contraction was higher as compared to the control wounds. The tensile strength of the wounds increased by 40% in topically treated wounds. The results substantiate that *Acalypha indica* produced beneficial effects on the various phases of wound repair.

2.2.10 Herbal antidiabetic drug

RRL,Jammu, as a result of concerted efforts put in for the development of novel herbal antidiabetics is able to identify a plant with significant antidiabetic activity. The effort is underway to develop a commercial antidiabetic product specially for non-insulin dependent *diabetes mellitus* from the identified plant extract.

2.2.11 Antifungals for control of Candida albicans

The fungal infections, especially caused by *C.albicans*, are assuming increasing importance on account of decrease in immune responses mainly because of organ transplant operations, cancer chemotherapy and AIDS. To counter these infections, only a handful of antifungal agents, such as, griseofulvine, amphotericin and nystatin are available in the market. Most of these antifungals are synthetic chemical derivatives with known side effects to humans and animals. Leads have been obtained at CIMAP which provide a strong basis for the development of herbal products useful in general health and skin care. These extracts / oils have shown synergistic interactions with the clinically used drugs such as clotrimazole by significantly reducing its minimal inhibitory concentration. Such synergistic combination of clinically useful drugs and plant products are expected to reduce the dosage and cost of chemotherapy. In addition these would prevent the emergence of drug resistant infections, increase the fungicidal activity and/or the rate of killing *in vivo*, and to enlarge the antimicrobial spectrum for curing poly-microbial infections.

2.2.12 High menthol yielding somaclone for transplanted Japanese mint

A novel high menthol producing *Mentha arvensis* plant named 'M12' has been developed at CIMAP through a unique method of screening of the somaclones for better regeneration. The selected plant adapts quickly to the field condition when shoot cuttings are planted late than the normal planting duration. The essential oil yield is high (0.8%) coupled with the property of being rich in menthol (78%) compared to other existing varieties when planted late from the shoot cuttings. This plant is unique and clearly distinct from all other existing varieties of *Mentha arvensis.* It can be propagated vegetatively through suckers for commercial cultivation.

2.2.13 Processing technology for bakuchiol

Psoralea corylifolia seeds are extensively used in stomachic, deobstruent, anthelmintic, diuretic and also against certain skin diseases, like, leucoderma and leprosy. Bakuchiol, a major and viscous

constituent obtained from the seeds, is a novel phenolic compound with a monoterpene side chain and exhibits antimicrobial and antimutagenic properties. An improved bench scale (25g) process has been developed at CIMAP for the extraction and isolation of bakuchiol from the seeds of the *P. corylifolia*. The process is cost effective and less time consuming.

2.2.14 Desiccation tolerance in tea seeds

Despite the availability of a number of good clones for vegetative propagation, the tea industry is still dependent on seeds for replanting and crop improvement. Any strategy for this aspect requires proper collection period of seeds to avoid immature or non viable seeds. Tea seed being recalcitrant, the strategy for long term storage at proper developmental stage is of utmost importance to identify the maturity index. Studies conducted at IHBT have revealed that viability loss could be prevented to a major extent by storing seeds with intact fruits at mature stage for one month. The relative desiccation of tea embryonic axis at different stages of development was found to be related to the degree of metabolic activity which may be more important than physical property of water in determining desiccation sensitivity. Abnormal development or poor germination is specially attributed to poor or low accumulation of storage reserves especially in desiccation sensitive embryos. The study would help provide post-harvest storage of tea seeds for longer periods without any damage to seed.

2.2.15 Drought induced alterations in tea

Drought stress is a major factor limiting the tea production in peak season in the region of H.P. Different biochemical and molecular factors govern the drought stress induced alterations in tea. IHBT carried out a systematic study to understand mechanism of drought stress induced alterations in tea. It revealed that one of the cloned genes was part of the signaling cascade while the other was stress related gene. The effort has provided insight to the drought stress mechanism of tea, which may help in growing of the tea crop under drought conditions.

2.2.16 End to end technology package of Hypericum perforatum (St. John's Wort)

The products derived from *H. perforatum* are widely used as mild anti-depressant world over. In a very short period, RRL-Jammu has developed a complete protocol for its micropropagation, agrotechnological package, and chemical standardization on the basis of two major molecules - hypericin and hyperforin and six minor compounds. The drug thus standardized conform to the pharmacopoeial standards with hypericin (upto 0.3%) and hyperforin (> 3%). However, in comparison, the other commercially available preparations of *H. perforatum* were found to have the desired levels of hypericin, but the hyperforin content was found to be nil to negligible in almost all the tested samples. These molecules are now available with the laboratory in larger quantities. Earlier, these molecules were only available at exorbitant cost with a

couple of companies. A leading pharmaceutical company supported the entire work on *Hypericum*. The formulation confor-ming to USP has been developed for this company for captive and International market. Based on extensive studies on various aspects of this plant based drug, three patent (US / PCT) applications have been filed.

2.2.17 New methods for detection of Bean Yellow Mosaic Virus (BYMV)

The method employed for detection of BYMV presently is time consuming, as a waiting period of few weeks is required for release of virus from wounded region prior to its detection. Two new methods have been developed at IHBT for detection of BYMV from gladiolus corms. The method developed at IHBT is more sensitive and reduces the time lag from 2-8 weeks to 24-48 hrs. as compared to the methods available.

2.2.18 Neolignan

IHBT has developed a simple and convenient method for preparation of neolignan from phenyl propene derivatives. Lignan / neolignan are well known for exhibiting a wide range of biological activity including antioxidant, anti-inflammatory and anticancer properties. The developed compound was under test for specific bioactivity. It can also be used as a starting material for preparation of a number of biologically active molecules.

2.2.19 Process for aescin

Process for isolation and purification of aescin (Indian horse chestnut), *Aesulus indica* has been developed at IHBT. Aescin (isolated and purified) was tested for antiviral activity against cucumber mosaic virus (CMV) and was found to be better than Amantadine, 2-Thiouracil, Zidovudine and Acyclovir, commercial antiviral products available in the market.

2.2.20 PCR technique for detection of Salmonella spp. in foods

ITRC has developed PCR based assay for rapid, specific and sensitive detection of *Salmonella spp.* in foods. It is based on amplification of 236 bp *Salmonella* specific *hin*/H2 region using Ampli Taq Gold ^{TM} polymerase. The technique is able to detect all the *Salmonella* serovars. The limit of detection is 1 fg of purified target DNA or $Nx10^0$ (1-3 cells) cfu ml^{-1} of pure bacterial culture. This assay could detect $Nx10^0$ *Salmonella* cells g^{-1} of the food sample unambiguously in presence of endogenous microflora following 6 h enrichment. It requires a duration of approximate 10 h for the full processing from DNA template preparation, PCR and visualization of DNA product on agarose gel. ITRC adopted DNA template isolation method simply by boiling the bacterial cells thereby reducing the possibility of contamination, cutting the processing time and cost considerably. This can be an added advantage for the use of this system in a simple laboratory setup. This method of PCR based specific detection of *Salmonella spp.* (food borne pathogens) was applicable to a good number of food materials except egg with high

sensitivity. It has wide application in processed food industry in India where old conventional microbiological methods are still adopted to evaluate all stages of food processing and ensure quality control. Efforts are on to sharpen the method further so that this can be applied for egg yolk and white as well.

2.2.21 Nutraceuticals products

NBRI has developed a range of custom made nutraceutical/functional food products fortified with specific herbs and nutritional components to meet the specific requirements for general health care as nutritional supplement. These products with a combination of well balanced traditional natural nutritional sources of protein, fat, carbohydrate, vitamins and minerals fortified with herbs for general health care and optimum development are for heart, brain and nerve tonic, with antioxidant, immuno-modulator, anti-aging and anti-stress properties. These products are for the good general health of men, women, children, diabetics and aged. Selected herbs/medicinal plants are subjected to physical and chemical processing, followed by fortification with certain ingredients and made into suitable solid (tablet, capsule, powder, granule etc.) or liquid formulation(suspension) for end use.

2.2.22 Cyanobacteria for oil pollution mitigation

Studies at NIO have found that some species of marine canobacteria, namely, Oscillatoria, Plectonema and Aphanocapsa degraded Bombay high crude oil when grown in artificial seawater nutrients as well as in plain natural seawater. Around 45-55% of the total fractions of crude oil were removed in the presence of these cultures within 10 days. Between 50% and 65% of pure hexadecane and 20% and 90% of anthracene and phenanthrene respectively disappeared within 10 days. Mixed cultures of these three cyanobacterial species removed over 40% of the crude. These cultures thus have the potential for use in mitigating oil pollution on seashores, either individually or in combination.

2.2.23 In-vitro release of epicotyl dormancy in Polygonatum cirrhifolium Royle

Polygonatum cirrhifolium Royle (Liliaceae) is an important medicinal plant of temperate Himalayas. It takes 3-5 years to grow to a full size, beginning through seed. RRL, Jammu has developed two step protocol for the induction of germination and *in vitro* release of epicotyl dormancy in *Polygonatum cirrhifolium* Royle for continuous micropropagation with no intervening period of dormancy.

The breaking of epicotyl dormancy in this particular species can be exploited to obtain continuous multiplication of the species with no dormancy period for commercial cultivation. It can also be utilized for raising large populations of genetically heterogeneous seedlings for *in-situ, ex-situ* and *in-vitro* conservation of this threatened species.

2.2.24 Plant based remedy for liver ailments

Despite significant advances in drug research there is no satisfactory treatment available for liver diseases. Corticosterioids or immuno-supressants are the only available agents for the treatment of hepatic disorders but they have their own limitations. Few plant based Ayurvedic formulations are being manufactured by some pharmaceutical concerns. Barring a few, most of the plant based hepatoprotective formulations have not been standardized with reference to standard parameters of plant / part authentication, drying and extraction etc. The testing of plants selected for their effect on liver disorders, led RRL, Jammu to identify an indigenous plant as a potential hepatoprotective. Further activity guided fractionation revealed a fraction as the most active one and the same has been standardized based on the two well defined marker compounds. Efforts are on to develop a commercial hepatoprotective product from the identified extract / active fraction.

2.2.25 Palm oil processing

RRL, Trivandrum has successfully established 25 ton ffb/hr palm oil mills in the States of Goa, Gujarat, Orissa and Tamil Nadu. The ever increasing demand for edible oils and widening gap between demand and supply has forced the governmental agencies and R&D institutions to strive towards increasing productivity in this field. It is in this context that high yielding oil palm with a potential to yield 4 tons per hectare was introduced in our country and major programmes under Govt. of India Technology Mission on Oil Seeds and Pulses (TMOP) have been launched to process the oil palm. TMOP had provided assistance to establish the aforesaid palm oil mills for diffusion of processing technology among oil palm growers. RRL-Trivandrum undertook the task of establishing the palm oil mills on turn key basis through project engineering companies. The technology for red pamolein and zero trans shortening was scaled up and transferred to project engineering companies. Optimization trials were conducted with respect of the unit operations for the production of carotene and tocopherol rich red palm oil, since crude palm oil is a rich natural source of beta carotene and tocopherol. This work was carried out as part of the development of processes for value added down stream products from crude palm oil for health application functional products, supported by TMOP. Pilot plant experiments were carried out for producing zero trans shortening, since the hard fraction obtained from the crude palm oil after winterization is normally a low value product. Value addition of these products has been achieved through vanaspathi like applications.

2.2.26 DNA sequencing service

CCMB provides services to various Institutes/Universities for sequencing and genotyping. It also extended its service to the public to establish the relationship for various purposes such as; organ transplantation, immigration, paternity/maternity,

identifying victims of natural disasters and in wildlife forensics. During the year Osmania University, University of Hyderabad, Owaisi Hospital & Research Institute, Madras Veterinary College, etc. have benefited by getting the DNA sequence done at CCMB. DNA profiling service has been rendered to 37 families (84 individuals). Other than the public, CCMB's DNA profiling report also benefited the: Nizam Institute of Medical Sciences; Apollo Hospital; AP forensic Sciences Laboratory etc.

2.2.27 Diagnostic services

CCMB, apart from training the staff of the Biotech companies for the various diagnostics, provided services to various clinics / patients all over the country. Three main Diagnosis carried out are Medical Diagnosis, Prenatal Diagnosis and Carrier Diagnosis. During the year CCMB has provided the diagnostic services (total no. of 130 cases) for Duchenne Muscular Dystrophy, Autosomal Dominant Cereberal Ataxia, Spinal Muscular Atrophy, Hemophilia, Fragile X Syndrome, Myotonic Dystrophy, Cystic Fibrosis, Thalassemia.

2.3 Chemical Sciences & Technology: Science, Technology & Service

2.3.1 Nanotechnology - NCL's effort

The controlled assembly of nanoparticles synthesized by the colloidal route using electrostatic forces has formed the focus of the research effort at NCL in this area. Recognizing that these forces may also be used to immobilize biomacromolecules such as DNA and proteins/enzymes, the methodologies developed have been adapted to the fabrication of such biocomposite materials. It has been shown that DNA can be immobilized at the air-water interface and in thermally evaporated thin films and very recently, this has been extended to PNA, a DNA mimic. DNA has also been used as a template for the organization of amino acid modified nanoparticles in linear structures. A DNA-chip is currently envisaged using these structures.

Enzyme immobilization in thin lipid films as well as by conjugation with gold nanoparticles has yielded exciting results with commercial application potential. Very recently, fungi have been used to synthesize nanoparticles of gold, silver and cds both extra – and intra-cellularly. This work has received much international attention. Chemical and Engineering news as well as Environmental Science and Technology (both American Chemical Society publications) have covered this work by way of special reports.

The other explorations at NCL in this area include biomineralization in thin lipid films as well as nanoscale alloying in confined matrices.

2.3.2 Polymer nano/micro-spheres and their novel applications

Polymer micropspheres show great potential in many applications such as ion exchange, chromatography, controlled release system, biomedical diagnostics, coatings, paints etc. Polyurethene powders, have potential applications in the field of coatings

and paints as well as carrier materials for encapsulation and controlled release of variety of active agents. Studies at NCL have shown the feasibility of a non-aqueous dispersion polymerization of an isocyanate with a diol to prepare free flowing polyurethane particles, with uniform particle size, in the range of 0.1 to 100 μ. The key to successful particle forming polymerization is the use of novel steric stabilizers. This new class of macrodiol steric stabilizer participate in the urethane forming reaction and is enchained in the polymer. Polyurethane microspheres of desired size (nano to micron) can be obtained by varying molecular weight, copolymer composition and concentration of the macrodiol and the block copolymer stabilizer.

2.3.3 Solid state stray-field imaging

Solid State Stray-Field imaging is one of the potential tools to map spatial distribution of various nuclei in rigid solids. So far proton (^{1}H) Stray Field imaging is relatively well known even though other nuclei are equally important. There are a few nuclei other than protons, *viz.,* ^{7}Li and ^{11}B that have been investigated occasionally by Stray Field imaging.

The gyromagnetic ratios 'γ's of the above nuclei are different from each other and also from the 'γ's of proton and fluorine. Therefore imaging of the above nuclei does not place critical demands on isotope discrimination capability in the stray field. In case of ^{19}F and ^{1}H, however, the γ values are close and as a result the resonance frequencies get perilously close to each other, especially at the relatively low fields that are typical at the magnet fringe. For selective detection of ^{19}F signals, static surface coil system has been adopted and designed at CLRI. The main objective of the static resonator design, *i.e.,* selective detection of ^{19}F, is clearly accomplished. With this STRAFI static resonator simultaneous as well as selective imaging of ^{1}H and ^{19}F nuclei is possible.

2.3.4 Novel stimuli responsive polymers

Azobenzene is a well known photoresponsive chromophore and its photoinduced and thermal geometric summarizations are accompanied by changes in physical properties. When incorporated as a photosensitive chromophore in the backbone of polymer chains, photoresponsive polymers are obtained. Photochromic poly (*acyl*semicarbazides) have been synthesized at CLRI by (i) reacting azobenzene containing diisocyanates with dihydrazides (ii) reacting azobenzene containing dihydrazide with various diisocyanates and poly (urethane *acyl*semicarbazides) by (i) chain extending the azobenzene containing NCO terminated prepolymers with dihydrazides (ii) chain extending NCO terminated prepolymers with azobenzene containing dihydrazides. Both the unsegmented and segmented polymers exhibited photochromic behavior, studied with UV-Vis spectrophotometer. A decrease in absorbance due to the $\pi \rightarrow \pi^*$ transition of the trans form and increase in absorption maximum due to the $n \rightarrow \pi^*$ transition of the cis form upon irradiation of solutions of the polymers in N, N'-

dimethylacetamide with UV light was observed. Such stimuli responsive polymers will have potential industrial applications.

2.3.5 Process development at IICT

IICT has developed and successfully demonstrated thirteen process technologies during the year. The anticipated annual turnover on commercialization of these technologies is of the order of Rs. 200 crores. The notable amongst them are:

- ☞ The first chiral technologies from India for the production of synthetic pyrethroids viz., S-Fenvalerate and Lamda cyhalothrin have been successfully demonstrated to M/s Searle India. A commercial plant with 600 TPA capacity for both pesticides is proposed;
- ☞ First castor oil pyrolysis products viz., undecenoic acid and heptaldehyde have been commercially produced based on IICT technology (600 TPA) by M/s Gujarat Oleo Chemicals and recently exported;
- ☞ Hydrazine hydrate technology, which is based on near zero waste concept employing clean feedstocks and process technology is licensed to M/s Sanmor Chemicals and export negotiations are in progress. A commercial plant of 600 TPA is proposed to be established;
- ☞ Four bulk drug and intermediate technologies viz., Losartan-K, Doxazocin, Amyl meta cresol and Methyl pyrazine have been successfully demonstrated to M/s Cadila Pharmaceuticals, Ahmedabad; SPIC, Tuticorin and Maksons, Ahmedabad respectively. The anticipated annual turnover on commercialization of these technologies is of the order of Rs. 100 crores; and
- ☞ Under the aegis of IICT-IOC (R&D) joint initiative, a globally competitive single step process based on a dual functional catalyst for DME preparation from synthesis gas ($CO+H_2$) containing upto 10% more CO_2 has been developed on laboratory scale. The sponsors are examining the prospects of setting-up an integrated pilot plant.

In addition, following technologies are in advanced stage of process development (pilot scale) and are expected to be licensed:

- ☞ HFC-134a from trichloro ethylene;
- ☞ p and o nitrotoluene from toluene through ecofriendly nitration;
- ☞ Benzaldehyde from toluene oxidation;
- ☞ Tetrabromobisphenol-A (TBBA).

2.3.6 Overseas contract R&D by IICT

IICT has successfully completed a number of overseas project activities during the year. They include novel organic chemical entities – *SB (UK; d*iverse chemical scaffolds – *ArQule (USA); n*ew chemical synthesis - *FMC (USA); s*ynthesis of new agrochemical molecules - *Mitsubishi Chemical Corporation (Japan); a*dvisory consultancy - *Flexys (Belgium);* synthesis of new chemical entities - *L'Oreal (France);*

and Cyclobutanone chemistry - *FMC (Hong Kong).*

2.3.7 Process development for the manufacture of I, l', I'' – Tris (4'-hydroxyphenyl) ethane (THPE)

THPE is a branching agent used in the synthesis of polycarbonates, a high performance engineering polymer. It also finds applications as a starting material for the synthesis of branched epoxy resins for specialized applications. The original process for the manufacture of THPE was developed and patented by Hoechst Celanse, USA. Today, the only known manufacturers of THPE in the world are Salisbury Chemicals, USA – who produce it under license from Hoechst Celanse. NCL has developed an alternative novel route for the synthesis of THPE that is covered by Indian and US Patent applicants. This process has been licensed to a major producer of engineering plastics. It has also been transferred to an Indian company for commercial production and the product is being exported to USA.

2.3.8 Polymer magnet

A basic fundamental work at CECRI in the area of conducting polymers/ organic semiconductors has given the new insight to mechanism of charge transport and charge carrier. Experimental data like ESR, NMR, ESCA, SEM, Spectral, Conductivity Vs Temperature on using nine new type of dopants suggested that changes not only occur on mesoscopic scale but even in bulk. One of the dopant has yielded a polymer magnet at room temperature having a density of 1.1 g / cc and electronic conductivity of 0.1 S/cm. A US patent has been filed.

2.3.9 Thin conducting films

The synthesis of nanostructured polyaniline at CECRI has yielded a material from which a free standing conducting film of 100 microns and conductivity of 100 S/cm can be obtained. The conducting film has diverse applications. Two US patents have been filed for the innovation.

2.3.10 Battery application of conducting polymer

Basic work on conducting polymers by CECRI shows that redox reaction involving doping and dedoping is highly reversible. This aspect of reversibility has been utilized to construct a rechargeable dry cell utilizing available raw material. To establish the reliability of the dry cell a detailed study was carried out. A new solid polymer electrolyte was synthesized and characterized by various techniques.

2.3.11 Epoxy - tar based coating formulation

Paints based on epoxy resins have got very good protective property. Coal tar is a cheap material, which is also having good protective property, but has the drawback of softening at moderate temperature itself. Tar gives good performance in splash zone area. In order to improve the protective value of coal tar, efforts were made at CECRI to blend tar and epoxy. Optimum performance was brought through standardization especially in splash zone areas where the corrosion is very severe. The

process has been licensed and the know-how has been used to give protective coating to concrete/steel structures of the piles of the bridges erected over sea as well as creeks. The bonding and the stability of the coating against constant tidal wave attack and impingement of solid matters is found to be excellent.

2.3.12 Cold applied reflective road marking paint

Road marking paints are applied on the surface of asphalt/cement concrete roads to indicate traffic signals like pedestrian crossings, speed breakers, stop and go signals, central lines, track dividing lines etc. in customary white and yellow colours. Road marking paints currently used are based on imported thermoplastic materials and the coatings are applied as hot melt coatings. The new road marking paint developed by CECRI is 100% based on indigenous materials and is cold applicable. The road marking paint developed by CECRI is: cold applicable; ideal for both asphaltic and cement concrete roads; easily applicable by simple brush and spray; and is available in standard shades of white and yellow.

2.3.13 Synthesis and characterization of pillared clays for organic chemical transformation and as adsorbents

CFRI has standardized a process for the preparation of Al-, Zr-, Ti-, pillared clay using LOBA, Teen Pahari bentonite and Rajasthan bentonite. These pillared clays were stable even at 600^{o}C and a significant increase in particle size has been observed. It was thus inferred that during pillaring the oligomesic species were converted to the corresponding oxides of bigger particle sizes, which would act as pillars in the clay layers. In order to replace the acid-clay process for reclamation of the used oil, work was in progress for reclamation of used transformer oil/mobil oil by an environmental friendly process using CFRI prepared pillared clays by both hot and cold methods.

2.3.14 Brine purification resins

The brine purification resins are useful for final polishing of brine to remove last traces of alkaline earth metal ions (Ca^{++}) to <20 ppb before charging it to the membrane cell for alkali production. For the first time a brine purification resin, non-styrenic and totally aliphatic in nature has been developed at CSMCRI. It does not require the conventional chloromethylation route for functionalisation that requires highly carcinogenic chemicals. Being aliphatic, it is more water loving and has wider scope for being used efficiently in aqueous medium. An aminomethyl phosphonic acid type resin is more specific for alkaline earths than iminodicarboxylic acid type resin currently being used in the industry. Users of this technology would be the chlor-alkali industry in general.

2.3.15 Detergent grade Zeolite – A

Zeolite – A developed by CSMCRI is an eco-friendly substitute for Sodium tripoly phosphate (STPP) commonly used in the manufacture of detergent. The technology for production of Zeolite – A from

sodium aluminate liquor, a down stream effluent produced during leaching of bauxite with alkali, was released to National Aluminium Corporation (NALCO), Bhubaneshwar through NRDC for setting up a 10,000 TPA plant. The Institute has provided all required support and the plant has since been installed and commissioned. CSMCRI has concurrently upgraded the whiteness (>99%) of Zeolite-A, which could enhance the marketability of the product.

2.3.16 Upgradation of straight run light naphtha into high octane gasoline

IIP jointly with GAIL developed a catalyst and process called NTGG process for the production of Liquified Petroleum Gas (LPG) and high octane gasoline from low value Natural Gas Liquid (NGL) feedstocks over a novel zeolite catalyst. The catalyst utilized for the above process required hydrothermal treatment to modify its strength of density of the acid sites. The proposed process operates in swing bed mode with 24 hr cycle length. Exploratory studies have been carried out by synthesizing noble metal promoted H-ZSM-5 catalyst with 0.2 to 0.4 wt. % from different Pt precursor salts. Catalyst performance evaluation studies in micro-reactor indicated the formulation of 60 wt % of aromatics yield over light naphtha (IBP-30^0C) received from Numaligarh Refinery. The important feature of this process is that it can enhance octane number of straight run naphtha by 34 units with over all liquid yield of 85 wt % on feed basis. Experiments have been planned to estimate the run length of this process. Attempts are being made to optimize the Pt content in HZSM-5 zeolite catalyst to maximize aromatic or LPG. A patent has been filed for the development.

2.3.17 Zeolite based reforming catalyst for aromatic production

IIP has developed a process for platinum metal dispersion improvement upto ~85% level by using different additives. Development work for promising zeolite based reforming catalyst with the objective of maximizing aromatics from light naphtha is in progress. Some catalyst formulations with different binders and varying amount of platinum metal are under evaluation. Efforts are on to prepare catalyst formulations by exchanging platinum metal on Ba/KL zeolite and extruding it with neutral or basic alumina to minimize support acidity.
Metabolic interaction of oxygenate additives, viz; alcohol/ methanol in gasoline using rodent model system
Acute studies through dermal application of blended gasoline samples with varying concentrations of benzene (1,3 & 5%) indicated a dose of more then 2 gm/kg as the dose –50. However, gross observation did not reveal any signs of clinical significance and there were no noticeable alterations of clinical significance in vital organs. Further, the subchronic studied by IIP revealed that the cytochrome P - 450 dependent mixed function oxidase activities were induced in preparations having lower concentration of benzene. In view of the current scenario towards search for alternate fuel, the data might be considered as an important input in

providing a new insight into understanding the adverse impact on man & environment if any, on the use of alcohol/ methanol as a safer oxygenate for petroleum products. Further studies in this regard are under way.

2.3.18 Application of Ecorite PAC-2018 in the treatment of sewage cum tannery wastewater

NEERI has developed process for application of Ecorite PAC-2018 in the treatment of sewage cum tannery wastewater. The process involves addition of 100 mg/L Ecorite PAC-2018 in the wastewater and flash mixing at 100 rpm followed by slow mixing at 30 rpm and then settling for 30 minutes to remove suspended / colloidal solids from wastewater. The treated effluent complies all the standards except TDS and sulphides prescribed by the MEF/the UPPCB for discharge of effluents into inland surface water. To remove sulphides, addition of requisite quantity of iron salts will be of great help. NEERI developed application of economically low quantity of chemical coagulant (PAC) to treat sewage cum tannery wastewater from UASB plant enable to comply effluent discharge standards prescribed by the regulatory authorities. Settling of sludge in case of PAC is faster as compared to other conventional coagulants. The treatment with Ecorite PAC-2018 minimized sludge production as compared to other conventional coagulants and help in sludge handling problems. Implementation of technology developed by NEERI at STP, Kanpur, resulted in final treated effluent complying all standards except TDS and sulphides prescribed by the MEF/the UPPCB for discharge of effluent into Inland Surface Water. This assignment gave NEERI high industrial credibility and further strengthened the Institute-Industry and Municipal Local Body link.

2.3.19 Treatment of antibiotic wastewater through biological systems

Physico-chemical treatment methods, (coagulation and flocculation) were tried on various wastewater streams (spent broth, column wash) by NEERI to achieve substantial BOD and COD removals. Various coagulants viz., lime, alum, ferrous sulphate, magnesium hydroxide and flocculants viz., polyelectrolytes (cationic and anionic) were tried. The process scheme developed is applicable to all pharmaceutical wastewaters. The treated effluent is effectively being used for farming as well as green belt development. The treated effluent meets the prescribed standards and does not have any deleterious effect on land and water. The studies revealed no significant reduction in BOD and COD concentrations. Also a anaerobic treatability studies were carried out for treating wastewater from spent broth alone and mixture of spent broth, column wash and mixed with the penicillin stream. The results of the anaerobic studies for spent broth treatment indicate 49-54% removal of BOD and 34-36% reduction in COD. Anaerobic treatability for combined spent broth, column wash and streams from two ETPs reveals the BOD and COD reduction 52-54% and 33-34%, respectively. Based on the results obtained from

the above mentioned studies six treatment options have been arrived at and suggested. All Pharmaceutical industries will be the beneficiary of this development.

2.3.20 Assessment of existing waste management in health care units

Government Medical College and Hospital, Nagpur is a tertiary health-care hospital with a bed strength of 1401 and generates large quantity of biomedical waste. Hospital authorities are making efforts for the implementation of Biomedical Wastes (Management and Handling) Rules, 1998 prescribed by MoEF. As per the rules, category-wise quantification of wastes was carried out. The quantity of waste generated in different health care units varies between 0.3 and 0.6 kg of biomedical waste per patient per day depending upon the type of healthcare facility. The relevant information, viz. organization structure, existing storage, collection, transportation, processing and disposal is collected. The prevailing situation of waste management was evaluated by NEERI. After finding the shortcomings in the system, waste management plan is being developed taking into consideration the statutory requirement.

2.3.21 Long luminescent powder

Many a times mishaps take place at home or on roads due to poor visibilities, at nights or in dark situations, and due to lack of signs indicating emergencies, exits etc. These are examples of unmarked speed breakers on roads approaching a city/town on a highway during nights or late evenings when long distance visibilities may be substantially low. An unmanned railway crossing without any warning lights and without any barrier gates have been claiming many a lives in the country. In house holds, the elderly persons need sufficiently lit areas to attend to their emergencies at night. Such a need can't be met with, in the absence of a power failure. All these issues are addressable by using a glow sign capable of emitting light without the need of electrical power even for energizing its activity. The answer to this critical societal need has been addressed by the development of a long decay, free flowing, luminescent powder by NPL which once energized even by the sunlight emits visible radiation up to at least 100 hours, well suited for dusk to dawn of about 13-14 hours during winter months. A patent has been filed of the invention in INDIA,US Japan. The powder can be manufactured by an entrepreneur having skills in the. area of chemical sciences and manufacturing. The novelty of powder is that it is free flowing and can be easily applied on to a flat surface of plastic etc. for making a convenient display sign as per the requirement in any given situation. Not only this, it can be used to manufacture artistic wall hanging suitable to decorate room in a house or any establishment.

2.3.22 Paint technology

A novel paint technology has been developed by RRL, Bhopal in association with Building Materials Technology Promotion Council (BMTPC), New Delhi, which

involves utilization of industrial wastes like fly ash for the production of economically viable paints. This technology involving utilization of industrial waste, in the formulation of paints together with easy availability of raw materials will help to reduce the total cost of the paints and lead to partial replacement of conventionally used extenders by fly ash. The close resemblance of chemical composition and properties of the fly ash with conventionally used extenders reveals the potential of the industrial wastes as extender in paints. Excellent abrasive nature of the fly ash used in this novel technology imparts good resistance towards abrasion, which is one of the major causes of destruction of commercially available paints. Using the industrial wastes as extender both priming as well as finishing paints have been formulated. These compositions have been compared with the commercial paints. The high cost barrier of resin systems in commercial paints have been overcome by incorporating the industrial waste as extenders. The effect of industrial waste as extenders on paint properties and film characteristics have been studied and the results show that the fly ash based paints are superior with respect to their properties such as chemical inertness, low oil absorption and specific gravity values, improved corrosion abrasion property without any adverse effect on other properties like drying time, thickness, brushability and gloss. Since the manufacturing process involves incorporation of more than 30% of industrial waste, it is under the purview of excise duty exemption on final product.

2.3.23 Battery grade nickel hydroxide

Nickel hydroxide is the major ingredient in nickel hydride and nickel-cadmium batteries. Presently India imports all of its requirements from abroad. A process has been developed at RRL, Bhubaneswar for production of battery grade $Ni(OH)_2$ by urea decomposition. $Ni(OH)_2$ is characterized by various parameters such as tap density, charge-discharge capacity, sphericity etc. $Ni(OH)_2$ produced through the process developed posses majority of the properties except that of tap density. Efforts are on further for obtaining higher tap density.

2.3.24 Cell for Industrial Safety & Risk Analysis (CISRA)

Computer Aided Emergency Operations Management & Alert System for Maharashtra Gas Cracker Complex (MGCC), Indian Petro-chemical Corporation Limited, Nagothane, Maharashtra has been taken up. After the MGCC accident investigation, a computer aided alert system has been recommended by CLRI for any accidental release of the hydrocarbon. MGCC and CISRA completed it successfully, by providing specific release scenarios of hydrocarbon in the storage area of MGCC, Nagothane. The plan also linked the same with the software ALOHA (Area Location of Hazardous Atmosphere), which presented the dispersion distances immediately on the site plan with the emergency action plan on the computer screen.

2.3.25 Low cost jewelry manufacture

In order to help small entrepreneurs in the field of jewelry production experiments were carried out by CECRI to identify suitable gold strobe and plating baths with good deposition characteristics and with improved throwing power. Based on these studies the process of gold plating for the production of jewelry and novelties was handed over to ten parties in and around Tamilnadu and Kerala. The consultancy encompassed gold plating on stainless steel, calculations on thickness, cost of gold etc. and the technique was demonstrated to the parties. A large amount of gold plating jewelry produced employing the techniques developed.

2.3.26 Management and Functioning of Fuel Testing Laboratory, NOIDA

The Society for Petroleum Laboratory (SFPL) has assigned a project to IIP to manage the FTL, NOIDA. It is the first laboratory of its kind set up in India under Supreme Court orders to monitor the quality of fuel supplied to consumers. The activities include: providing suitable supervisory staff; testing of petroleum samples as per specification; submission of test reports.; training to recruited manpower at FTL. IIP is providing an effective mechanism to monitor fuel quality and is thus helping pollution abatement, so critical for society, through the project.

2.4 Earth Sciences & Technology: Science, Technology & Service

2.4.1 SROSS-C2 Aeronomy Satellite Mission carrying NPL's RPA as the primary payload comes to an end after 7 years of very successful operation

SROSS-C2, the second aeronomy satellite of India weighing about 113 kg was launched on May 4, 1994 from ISRO's Sriharikota Range using ASLV-D4 satellite launch vehicle and carried two scientific payloads. The satellite carried a Retarding Potential Analyzer (RPA) designed and developed by NPL as the primary payload to study the dynamics and the thermal structure of the F region of the ionosphere over the Indian subcontinent. The satellite also carried an astronomy payload built by ISAC consisting of scintillation detectors for monitoring gamma-ray bursts. *The satellite completed its mission life on July 12, 2001 after operating successfully for more than seven years in its orbit.* During this period RPA, that consisted of specialized electron and ion sensors, has given an enormous amount of valuable data on the ionospheric plasma related to F-region electron and ion temperatures, total ion densities, irregularity structure in electron and ion densities, composition of positive ions and supra-thermal electron flux with energies exceeding 30 eV crossing the satellite passes over the Indian region. During the seven years of its operation, the RPA data has been recorded using services of three ground stations for more than 3800 passes. The longitude range covered in the data is from 40-100°E and

latitude from 40°N to 5°S, occasionally extending up to as much as 40°S in latitude when data was collected from Mauritius earth station. Major chunk of the *in-situ* data collected covered a height region of 400 to 600km. However, during the initial phase of the SROSS mission the height coverage of data went up to 900 km and also during the terminal phase to as low as 200 km. NPL along with 7 university groups are involved in the scientific analysis of the RPA data. Other interested groups are welcome to contact NPL for satellite data for research purposes.

2.4.2 Underwater archaeological explorations

The underwater archaeological explorations carried out by NIO found:

- At Sunchi Reef wreck-site off Goa, elephant tusks, Martaban pottery, swivel cannons, metal hook, a number of well dressed granite blocks, broken wine glass bottles, and a Indo-Arab type anchor stone in 3 to 9 m water depth. On the basis of TL date analysis of Martaban pottery (360±40 years), it appears that the wreck belongs to the 17^{th} to 18^{th} century AD.
- In Bet Dwarka, remains of amphora shreds and lead ingots probably belonging to the Roman period including a large number of stone anchors. Also, a historical site near Khuda Dost Dargah, which gets submerged during high tide, suggested the change of sea level in the region.
- More than hundred stone anchors of various types, datable to 8th to 14th century AD in Dwarka waters, suggesting that Dwarka was one of the busiest port town during early to late medieval period.

2.4.3 Glacial to holocene fluctuations in hydrography and productivity

Oxygen isotope and sedimentological records of a sediment core from the southwestern continental margin of India were used at NIO to reconstruct the fluctuations in sea surface hydrography and productivity during the last deglaciation. Significant variations in $\delta^{18}O$ during the holocene and a high glacial-interglacial amplitude in $\delta^{18}O$ values suggest large fluctuations in sea surface hydrography related to monsoonal precipitation on land. The results suggest that although the last deglacial events are coherent in time with the regional and global climatic events, fluctuations in sea surface salinity during holocene were unique to this region. Maximum monsoonal precipitation appears to have occurred after 9-8 ka BP. Unlike the records from the western Arabian Sea, biological productivity was maximum between 18 and 15 ka BP and substantially diminished between 13 and 6 ka BP. The increased strength in the winter monsoon during the glacial period could have enhanced convective mixing and nutrient injection, leading to high primary production. Reduced surface productivity during the early Holocene may be attributed to the complex dynamics of the circulation

system and hydrological cycle along the southwest coast of India.

2.4.4 Respiratory enzyme activities in the oxygen deficient waters of the Arabian Sea

Denitrification in the oxygen-poor waters at intermediate depths in the Arabian Sea is very intense. Depth profiles of nitrite and the activities of the electron transport system (ETS) and dissimilatory enzymes such as nitrate reductase and nitrite reductase within the nitrite-bearing waters, display depth-mismatched maxima. There are indications of contribution by both dissimilatory nitrate reduction and nitrification to the nitrite enrichment of the secondary nitrite maximum (SNM) between 150 and 350 m. The water below the SNM, not bearing nitrite but within the oxygen minimum zone, are also potentially denitrifying. Analyses of the relationships carried out at NIO between various parameters indicate the existence of a layered ecosystem in which nitrification and denitrification activities are present in several closely spaced layers. This is probably caused by the inflow of different water masses into this hypoxic region, as suggested by the strong maxima and minima in enzyme activities at equivalent depths.

2.4.5 Emission of carbon dioxide from a tropical estuarine system

Efforts have been made at NIO to study carbon dioxide species in Mandovi-Zuari system, a tropical estuarine complex influenced by strong monsoonal run-off, with implications to build up and air-water exchange of CO_2. Total carbon dioxide (TCO_2) behaved conservatively during the estuarine mixing. Partial pressure of carbon dioxide (pCO_2), evaluated from TCO_2 and pH couple, and carbonic acid dissociation constants, exhibited super-saturation with respect to atmospheric CO_2 round the year. Average pCO_2 in estuarine system were nearly three times to that in atmosphere in non-southwest (SW) and SW monsoon seasons. This study strongly suggests that the pH regulation by soil-water interaction is important, besides biological processes, in river and estuarine systems.

2.4.6 Crustal thermal structure of the godavari graben and coastal basin

Two-dimensional thermal modelling has been carried out by NGRI to delineate the crustal thermal structure of the Godavari graben axis and coastal basin along the said DSS profiles by using available geological and geophysical data. The study revealed that the Moho temperature is approximately 625 – 640 º C along the Paloncha – Narsapur profile whilst it is 600ºC along Kallur – Polavaram profile. The calculated surface heat flow values were found to vary between 57 to 59 mW/m^2 along the Paloncha – Narsapur profile and 59 – 105 mW/m^2 along the Kallur – Polavaram profile. The results indicated that the Curie isotherm in this region lies approximately at a depth of 36±2 km which are in conformity with the depth of Curie isotherm obtained from the interpretation of MAGSAT data.

2.4.7 Global positioning system

Global Positioning System (GPS) based Geodesy had become capable of yielding sub-cm precision in location by the early 1990s and the possibility of it being used to determine crustal strain rates in India was recognized at C-MMACS in 1993 following the Khillari earthquake. Research at C-MMACS, has since yielded fairly well constrained figures for the velocity of the Indian plate and partitioning of strain from Kanya-Kumari to Ladakh in the trans-Himalaya. Over the years C-MMACS has also taken up the arduous task of setting up GPS stations in remote locations in the country to generate required database. Analysis and modelling of GPS data as well as other modelling studies on geophysical processes have generated valuable insight for understanding geological / geo-physical processes over the Indian region, paving the way for rigorous quantification of earthquake hazard.

2.4.8 Deterministic seismic hazard map

The deterministic modelling of hazard for the Indian territory provides a powerful and economically viable scientific tool for seismic zonation and hazard assessment. The main advantage of the method lies in its ability to directly estimate the effects of source mechanics and wave propagation, while local site effects are roughly considered when using the design spectra to obtain the DGA from the synthetic response spectra. One way to mitigate the destructive impact of the earthquakes is to conduct a seismic hazard analysis and take the remedial measures. A seismic hazard map of the territory of India and adjacent areas prepared by C-MMACS using the input data set consists of structural models, seismogenic zones, focal mechanisms and earthquake catalogue. The synthetic seismograms have been generated by the modal summation technique. The seismic hazard is expressed in terms of maximum displacement (DMAX), maximum velocity (VMAX), and design ground acceleration (DGA). The estimated values of the peak ground acceleration are compared with the observed data available for the Himalayan region and found in good agreement. Three metropolitan and biggest cities of India, with relevant industrial and economical importance, namely Delhi, Mumbai and Kolkata lie in the hazardous zones of the DGA map.

2.4.9 Technique for finding temporal location of a signal

A technique involving the generalized harmonic transform is developed by NGRI to find the temporal location of a signal of a given phase in the background noise which is white gaussin. A new and direct relation is established between gravity and magnetic fields of an arbitrary 2D and 3D objects which facilitate construction of a unified algorithm for simultaneous computation of gravity and magnetic fields. The new algorithm is more efficient than the well known Poisson's relation.

2.4.10 Palaeomagnetic studies

NGRI has carried out extensive

palaeomagnetic studies in Shillong plateau. The area covered included Langpar, Shella and Simsang Formations (Jaintia Group). The sediments studied revealed that the Shillong Plateau has undergone clockwise rotational movements in its northward migration after breaking away from the Gondwana land. The findings are of tremendous value.

2.4.11 Geotransect studies

Integrated crustal density model along the Kuppam-Palani geotransect suggest collision tectonics along transition zone and subsequent delamination beneath the Palghat gap. A technique to estimate depth of anomalous sources from the scaling power spectra of long non-stationary gravity profile has been established by NGRI. Using this technique more accurate depths of the anomalous sources have been obtained. The technique is tested with a synthetic gravity profile and applied to Nagaur-Jhalawar and Jaipur – Raipur transects in western and central India. Gravity data along Siliguri – Lachung profile across Sikkim Himalayas and its integration with satellite gravity data provided the details of collision tectonics across Himalayas and Tibet along this section.

2.4.12 New method for monitoring fluoride concentration in groundwater

NGRI has developed a geostatistical method for optimal monitoring of the fluoride concentration in groundwater. The method was developed using cross-validation technique and priority index of the monitoring wells. It was tested extensively for optimal monitoring of fluoride in Maheshwaram watershed.
Evidence for multiphase folding of the central Indian ocean lithosphere
The central Indian Ocean lithosphere, south of the Indian subcontinent, has responded to the continuing collision of India with Asia by buckling and cracking at different time periods in the past. Analysis of lithospheric cross sections carried out by NIO (produced by seismic reflection data) has shown that the lithosphere was buckled by the formation of 2-3 km high mountains as well as cracked vertically of as much as 800 m in three folding phases. These phases are Miocene (8.0-7.5 Ma), Pliocene (5.0-4.0 Ma) and Pleistocene (0.8 Ma). Formation of folded mountains and their rise in the middle of the lithospheric plate was unusual and against the fundamental concept of plate tectonics. The folded region of the later phase is accompanied by most active faulting and high magnitude earthquakes. The analysis further indicated that the timing of faulting generally coincided with the phases of folding. Faults terminate below the fold-related unconformities, implying that the locus of crustal shortening has migrated with the folding. Magnitudes of the fault throws were found to be higher in a region where the lithosphere had deformed more than once.

2.4.13 Crustal structure and tectonics of the Ninetyeast Ridge from seismic and gravity studies

Crustal structure of the Ninetyeast Ridge was modeled at NIO using

seismic refraction and gravity data. The crustal thickness of ~22 km, greater than the average thickness (7 km) of oceanic crust estimated in the Central Indian and Wharton Basins was shown. The ridge was compensated by flexure of layers 2A, 2B, and 3A to the extent of ~2 km and by a 12 km thick deep crustal body (layer 3B) of underplated material. Upper crustal velocities (layer 2A) beneath the ridge were lower, up to 3.4 km s^{-1} than in adjacent basins because of weathering process and hydrothermal circulation of the waters in the tectonized blocks. While velocities in deep crustal body (layer 3B) were higher, up to 7.8 km s^{-1} and seem to have resulted from magmatic rocks accreted within the lithosphere.

2.4.14 Pockmarks and gas seepages along western continental margin

Pockmarks are often *indicative* of the venting of natural gas, mainly methane gas. The NIO carried out high-resolution seismic reflection profiling that revealed the occurrence of acoustic masking, pockmarks, gas seepages and plumes on the inner shelf, middle shelf and upper continental slope of western India, between 20 and 50 m, 60 and 75 m, and 170 and 260 m water depths, respectively. A typical 40-km long seismic section trending in a NW-SE direction - from the upper slope was characterized by anticline-syncline structure and culminated towards the NW. In some places fluid or gas escape features and plumes appear 2-12 m above the seafloor. Active and relict-type pockmarks were noticed. Out of thirty well-recognized pockmarks along the section, six were buried. In general, the pockmarks were 80-130 m in diameter and 0.75-2.5 m deep. Biogenic gas due to organic-rich sediments in the slope or thermogenic gas emanating from deep-seated faults, fractures and lineaments in the region may have given rise to these features.

2.4.15 Regional parameterization of the International Reference Ionosphere (IRI) model

For research and application of Earth's ionosphere the IRI model, set up through coordinated international observational and research efforts conducted over past decades under the umbrella of the International Union of Radio Sciences, is the accepted standard reference for electron density profiles and other parameters characterizing ionosphere at various heights over any location around the globe. This model finds extensive applications in the fields of satellite tracking, orbit determination, radio communication through ionosphere, geodesy, etc. Most of the observations that have gone through in defining IRI are from mid-latitudes. NPL is one of the very few institutions that have taken up efforts to validate the model through analysis of low latitude ionospheric observational data available in the World Data Centre. Outcome of three such analyses by NPL have been accepted this year and will be available to the IRI user community interested in studying or using the low latitude ionospheric region for various applications. One of the analysis by NPL leads to refining the parameters governing the vertical density profile below the

height where electron density peaks, the second relating to an improved description of the dependence of the height of the F2-peak region with solar activity cycle and the third relating to the dependence of the critical frequency foF2 associated with the F2 layer of the ionosphere with solar activity.

2.4.16 Sodar system

The basic sodar system operating in monostatic /doppler mode is used for boundary layer studies, air pollution metrology, now casting air pollution, metrology, hazards, Environmental Impact Assessment, education etc. It is the most effective acoustic remote sensing tool developed by NPL for probing the lower atmosphere upto a height of 1 Km from the ground. Information obtained is useful in boundary layer research, EIA & EA, mining, snow and avalanches, microwave communication, environmental education, air-sea interaction, ocean environment and several practical applications particularly air pollution monitoring and control. The knowhow of sodar system has been patented and transferred for commercial exploitation.

2.4.17 Support through calibration and test services

NPL provided calibration and test services to various industries, Government organisation, and strategic sectors during the period. In order to maintain traceability and equivalence of the national standards, periodic international inter-comparisons were carried out. They include:

- Ultrasonic Power (US-1) in the range 100 mW to 10W under CC- key comparison of BIPM, France;
- DC Voltage Ratio (CCEM.K 8) under CC-Key Comparison of BIPM, France;
- AC-DC Transfer Standards under Asia Pacific Metrology Programme; and
- High Voltage AC-DC Transfer under Asia Pacific Metrology Programme.

2.4.18 New calibration facilities

NPL has established the following new facilities for high voltage calibration and pressure standard during the period:

- The Standards for calibration of DC high voltage up to 100 kV in collaboration with PTB, Germany;
- 1 GPa, Controlled Clearance Piston Gauge, a primary standard for pressure which has improved the measurement uncertainty and has extended the pressure range from 500 MPa to 1Gpa.

2.5 Engineering Sciences & Technology: Science, Technology & Service

2.5.1 Gravitational settling chamber for pollution control in brick kilns

CBRI has provided a simple and cost effective design of gravitational settling chamber to arrest suspended particulate matters (SPM) before they are allowed to enter the stack. No electricity and/or water are used nor there are any moving parts. The design was field demonstrated in a

number of kilns in the state of Haryana and pollution emission studies were carried out. It was observed that the CBRI designed gravity settling chamber is able to reduce SPM concentration from about 1250 Mg/M^3 to 250 Mg/M^3. Subsequent to this demonstration, the developed design has been successfully implemented in over 2000 brick kilns in the state of Haryana, Punjab, Rajasthan and UP.

2.5.2 Determination of coal barrier thickness

Determination of coal barrier thickness between two adjacent underground mine sites where one side of the area is waterlogged and unapproachable has great significance to prevent mine disaster due to inundation. Experimental trial has been carried out by CMRI at two places of a coal seam at Khottadih colliery of ECL at a depth cover of 170 to 200 m where rise side of the area is waterlogged for more than thirty years. A low cost probing instrument has been used with adequate planning, and engineering judgement as per the prevailing geo-mining conditions to determine the coal barrier thickness upto a fair degree of accuracy. The delineated barrier thickness at two places has been found to be 46 and 26 m which were earlier found to be 50 and 30 m respectively through conventional approach.

2.5.3 Monitoring and communication system for toxic and combustible gases

CMRI undertook development of an integrated monitoring and communication system for toxic and combustible gases in mines using ceramic-based sensors. Reliable metal oxide thin film sensors for CO and CH_4 , as well as compatible signal conditioning processors and display unit were fabricated. The sensors were calibrated and tested rigorously in mining environment. A software was also developed for routine gas analysis and simultaneous transmission of data to central control unit. An automatic decision making process was developed and a low frequency communication channel was provided for communication through earth crust in normal as well as post disaster conditions. Field trials of the complete monitoring system including sensors have been carried out in mines. The results of the field trials are satisfactory.

2.5.4 Design of safe blasting pattern

A harbour was planned to be built by the Ministry of Defence, Govt. of India near Karwar in Karnataka. Dimensional blocks of granite of different sizes were being generated for this purpose by drilling and blasting from a nearby hill. It was presumed that the environment to the villages situated around 400 to 500 m from the quarry might be affected. Therefore, a project was taken up by CMRI to design a safe blasting pattern for the control of environmental problems associated with day-to-day blasting in the quarry. Blast induced ground vibration, noise /AOP and fly-rock produced from different experimental blasts were measured by CMRI and the previous blast data as recorded were simulated with the

experimental data. On the basis of analysis of the results, optimal blast design parameters were evolved to contain the side effects of blasting within safe limits.

2.5.5 Rural road planning

Rural road network planning based on functional accessibility approach has been evolved and applied by CRRI using GIS. Based on the network philosophy, the unconnected villagers will travel to the nearby facility centre to fulfill their missing functions such as education, health, marketing etc., using the existing fair weather roads, track and paths. Based on the construction cost and accessibility benefits the most optimal links can be established to provide the connectivity to the unconnected villages with an all-weather road facility. The methodology has been applied to a development block. A FORTRAN based software has also been developed for this methodology.

2.5.6 Automatic vehicle counting, classification and axle load weighing system for highway vehicles

CRRI in collaboration with ECIL, Hyderabad has developed an 'Automatic Vehicle counting, classification and axle load weighing system for highway vehicles'. The system developed monitors vehicles employing inductive loops for detecting the vehicle presence and piezo sensors, for classification and detection of load on each axle. The piezo sensor data is used to compute axle spacing and classifying the vehicle on the basis of axle-spacing and number of axles. The axle weight can also be used for classification purposes. The system has applications in traffic and load analysis for highway design and safety studies, detection of over-loaded vehicles to enable enforcement of weighing and inspection reducing thereby traffic delays and traffic backups, toll gate applications and industrial security as the system records the classification and weight data along with the time.

2.5.7 Concrete abrasion resistance tester

CRRI has developed a Concrete Abrasion Resistance Tester (CART) for evaluating the abrasion resistance of concrete product. The in-situ abrasion of concrete paving surfaces can be simulated using the equipment through accelerated testing of samples. The equipment is useful to: predict in-field performance of concrete paving surfaces; choose appropriate materials and design for concrete products having the appropriate level of abrasion resistance; evaluate the abrasion resistance of concrete products; compare various concrete products under simulated abrasion; and to verify products to meet specifications.

2.5.8 35 mm Mini Pan camera

The 35 mm Mini Pan Camera designed and developed by CSIO is intended to be a compact light weight suitable for use in low speed aircraft operating at low altitude. The camera is used for military reconnaissance as it resolves small ground detail extended from horizon

to horizon. The entire land area from horizon to horizon under the aircraft could be imaged on a single frame through this camera. Three nos. of mini pan camera for remotely piloted vehicle, NISHANT, have been developed and supplied. The unit has successfully passed the field trials. User's trials of the camera are in progress.

2.5.9 Low-vision aids: plastic aspheric lenses

CSIO has initiated a project on low vision aids at the instance of Ministry of Social Justice & Empowerment, and specially developed 20-D plastic aspheric lenses for people suffering with low vision, reduced refractive power and retinal sensitivity. The lenses developed are under user's trials. The work on the development of 16-D lenses is in progress.

2.5.10 Arsenic analyzer

Natural arsenic enriched rocks are the major source of arsenic contamination of ground water. In order to analyse and quantitate the presence of arsenic in ground water a field deployable arsenic analyzer based on anodic stripping voltametry, has been developed by ITRC. The analyzer has been designed to act as a quick, reliable, sensitive cost effective technology for the estimation of As in ground water. In this analyzer a special type of re-usable arsenic electrode is used for the electrochemical detection of total arsenic. The detection limit of the analyzer is 10 ppb ± 15% . This technology has been transferred for commercialization. Regulatory agencies and other private and public sector organization involved in As testing programmes would be direct user of this technology.

2.5.11 Hydrogen thyratron

CEERI has developed 22 KV, 1 KA hydrogen thyratron finds applications in pulse power systems. These systems deliver pulse power (maximum peak power: 12 MW) up to 1 KHz of repetition rate. The specific design of the thyratron makes it suitable for switching nanosecond pulses in suitable circuits at even higher repetition rate switching. It is specially suitable for radar (strategic as well as civilian), medical, linear accelerators, kicker magnets and high power gas lasers because of very low jitter.

2.5.12 Voltametric technique for the simultaneous estimation of lead and copper in blood and natural water samples

The problem of lead and copper contamination in water is increasing day by day due to unsafe disposal of industrial effluents and hazardous waste. Injudicious disposal of such wastes is adversely affecting the human health and environment, as lead and copper reaches to ground water through percolation making it unfit for human consumption. In view of the above, a voltametric technique based method has been developed for simultaneous estimation of lead and copper using a special type of electrode and electrotype. The acidified or neutral samples can be used for the estimation of lead and copper with a detection limit of 10 ppb and 50 ppb in water and blood samples,

respectively without any interference of common ions/chemical present in the sample. A patent has been filed and ITRC is looking for a suitable entrepreneur to transfer the technology. The regulatory agencies, private and public sector including medical institutes undertaking involved in lead and copper testing programmes in water & blood samples would be directly benefited from this technology.

2.5.13 Metallic substrate-based catalytic convertor

Auto exhaust catalytic converters should be applied to all automobile vehicles to reduce the quantity of pollutants released into the atmosphere. Use of such technology is beneficial to preserve the air environment and is also helpful in minimizing the adverse impacts of vehicular emission on human health. NEERI has developed an indigenous low cost, non-noble metal based catalytic converter. A number of vehicle specific catalytic converters have been prepared, and evaluated on engine dynamometer for various parameters. Passenger car converter has been tested for its mass emission conversion efficiency on chassis dynamometer, following the standard procedure. These results confirm the compliance with Indian 2000 emission norms (EURO-I) . Several other tests including the field trials have been carried out to critically evaluate the converter performance and durability. The metallic substrate catalytic converters are designed and tested on two wheelers. also. The test results indicate compliance with EURO-I (Indian 2000) norms. The catalytic converters developed by the Institute for the catalytic conversion of pollutants viz. carbon monoxide (CO) and unburnt hydrocarbons (HCs) from automobile exhausts are economical and cost effective. The performance of these converters is as good as that of conventional noble metal catalysts.

2.5.14 Mathematical model for catalytic converter

A mathematical model has been developed by NEERI for designing the catalytic converter. A sub-system has been defined and artificial neural network was used for prediction of the performance of catalytic converter with respect to a particular engine. A model is being developed to predict the performance of converter on mass emission test using engine dynamometer data. This will facilitate defining the design parameters for optimal performance of the converter.

2.5.15 2D dynamic process model for the blast furnace

The 2D-dynamic process model for the entire blast furnace has been divided into several sub-models : model for burden distribution – a tripartite Agreement between IIT, Madras, ARDEE Business Ltd., Vishakhapatnam and NML has been signed after extensive deliberations by experts from the respective organizations; model for heat & mass transfer and reaction kinetics – MoU has been signed with IIT- Bombay; model for the flow behaviour of gas, liquid and solids is being developed solely by NML. As part of this activity, a dedicated computational

facility is being set-up by NML to handle the huge computational load of the modelling. Offer received from C-DAC for installing a parallel processor (PARAM-10000) is being evaluated. Negotiations for upgrading the existing PHOENICS and procurement of FLUENT, CFD software have been undertaken.

2.5.16 Commercial flotation column for cleaning of graphite

RRL, Bhubaneswar has designed a commercial column of 7m height and 1m diameter with the capacity of 3 tonne/hr. for cleaning of the rougher concentrate of a running graphite plant. The column advantage is that of obtaining the final concentrate in a single stage in place of four stages using conventional cells. By this way the manpower and processing cost of the product has come down drastically by adopting the column process. Detailed engineering drawings were provided for fabrication of the column and associated units. All the units were installed and tested at plant site. The column is now being used continuously to produce final concentrate of the plant. It is possible to produce graphite concentrate more than 90% fixed carbon from the rougher concentrate of 55% fixed carbon in a single stage. The novelty of this design of flotation column is to float coarse flaky particles by putting both horizontal and vertical baffles and reduced reagent consumptions in the cleaning process. The unique type wash out system has been provided, so that there is no chance of entrainment of gangue slime particles in the concentrate. The system has directly been used by the sponsor.

2.5.17 Batch digester control system

An integrated PLC based electronic batch digester controller system has been developed by CEERI. It would help paper industry to produce uniform quality pulp. The implementation of this enhances pulp yield and reduces steam usage per ton of pulp with degas/relief valve controls by controlling the cooking cycle operations, namely chip charging, liquor charging, cooking and blowing operations, in each batch.

2.5.18 Studies on vibration control of structures and foundations

- Protection of industrial structures and buildings against earthquake induced excitation is of paramount importance. Towards this goal, SERC, Chennai had taken up the study of the dynamic characteristics of selected types of vibration isolators and to develop standard criteria for analysis, design, and evaluation of isolator supported machine foundations. Studies were conducted to investigate relative efficiency of base isolation techniques for protection of buildings against earthquake induced excitation.
- Dynamic experiments on rubber based industrial isolators under shear and combined loading were carried out. The behaviour of rubber isolators was analytically modelled using a three-element viscoelastic model. A computer program was developed for

carrying out dynamic analysis of block foundation supported on industrial isolators. Viscoelastic passive energy dissipators (PED) using natural rubber, neoprene and butyl rubber have been developed to suit earthquake resistant design application. RC models consisting of single and three storied buildings and bridge piers were constructed and tested both to evaluate the basic dynamic characteristics like natural frequency and associated damping and the response under known seismic excitation.

- ☞ Analytical and experimental studies were carried out on an isolator-supported foundation with varying input parameters. The study showed an increase in isolator stiffness for an increased excitation frequency and mean stress levels. In general, the dynamic response predicted from the analytical study broadly matched with the experimentally measured dynamic response, thus validating the analytical model developed in the frequency range of industrial isolation.
- ☞ A single degree of freedom system of a cantilever type with a heavy tip mass was simulated, and subjected to shake table tests for different mass levels and excitation levels of a synthetic earthquake spectrum with and without X-plate metal elasto-plastic energy absorbing device to study the response reduction. The experimental study showed a 75% response reduction for an addition of 15% in the system stiffness for the given excitation level showing the adaptability of such devices for seismic response control.
- ☞ The effect of base flexibility on the increased rocking oscillation of the base isolated structure was studied through a typical example. It is found that beyond a stiffness ratio of 10, the rocking plays a major role in the seismic response. The effect of permissible design torsional eccentricity was studied, and it was found that even 5% eccentricity created a large torsional response on the structure.
- ☞ A three storey frame model with and without base isolators was studied under base excitation. A single storey frame model with visco-elastic damper attached in the form of a brace was studied under base excitation and the results were compared with the case of the frame without dampers. It was found that, under the given El-centro earthquake, the dynamic response of frame with visco-elastic device showed lesser acceleration level compared to without any visco-elastic device. Further research and development towards vibration control of buildings and structures under seismic excitation has been taken up.

2.5.19 Semi-empirical model for prediction of across wind response of chimneys with circular cross section

- ☞ Tall, slender chimneys of circular section are subjected to vortex shedding and the maximum across wind responses occur relatively at low wind speeds. While there is a good

understanding on the mechanism as well as the prediction of along wind response of a chimney, present knowledge on prediction of its across wind response is far from satisfactory. A probable reason is that the roles played by Reynolds number and turbulence on the parameters influencing the across wind force and response are less clearly understood.

- Realising the fact that the two basic components viz., vortex shedding and lateral turbulence, contributing to the across wind response, have two different scales, the scientists of SERC have proposed - based on research conducted in-house - a novel approach to separate the respective contributions of these two components on the rms lift coefficient. It has been shown that the modified rms lift coefficient only due to vortex shedding takes a value of 0.089 which is independent of Reynolds number regime of the flow. This is a new contribution to the science of understanding across the wind aerodynamic parameters. Similarly, while the universal Griffin Strouhal number has been shown to be equal to 0.065 ± 0.005 for circular cylinders with smooth or rough surfaces tested under uniform flow, scientists at SERC, have established that the above Griffin number of about 0.065 is also valid for circular chimneys / prismatic cylinders tested under simulated atmospheric boundary layer flow conditions in a wind tunnel. Some of the full-scale experimental data have also been analysed to validate the above proposition. These findings were suitably employed to develop a semi-analytical model to predict across wind response of a chimney including lock-in region. Unlike the existing methods wherein the increased response to across wind forces is addressed through a negative aerodynamic damping, in the present method, the increased correlation of the vortex shedding is accounted through a parameter "fact". The effectiveness of this method is validated by considering wind tunnel experimental data conducted by SERC and other wind tunnel and full-scale test data reported in the literature.
- SERC's new technique of separating the contributions of lateral turbulence and vortex shedding on circular cylinders, which has resulted in a near constant value of 0.089 independent of Reynolds number regions has been applied to additional models of an octagonal and an irregular plan shape with a corner recess. The latter two models have been tested for pressure measurements using wind tunnel at SERC. It is interesting to note that the above value for the case of an octagonal cylinder model has been obtained as 0.084 and that for the model with an irregular plan shape has been obtained as 0.083, which are very close to 0.089 obtained earlier for a circular cylindrical model. The studies tend to reveal that the modified value of rms lift coefficient due to vortex shedding alone, approach a value of 0.089, although additional

experiments on different shapes are required to confirm this observation.

- ☞ The SERC's proposition to suitably segregate the relative contributions of vortex shedding and lateral turbulence on the total rms lift coefficient has been commended as a novel and successful approach in defining a non-dimensionalising scheme which has led to a universal collapse of wind tunnel and full-scale experimental data. The work carried out at SERC has opened up a new insight into the understanding of role of Reynolds number on the modified value of rms lift coefficient due to vortex shedding alone. It is planned to examine the validity of the above semi-analytical method developed for prediction of across wind response on prismoidal structures with other shapes i.e. rectangular, square, etc.

2.5.20 Evaluation of wind-induced response of tall chimneys using wind tunnels

Currently boundary layer wind tunnel experiments are recognised as the only available rational and reliable design tool for evaluating wind-induced response of tall chimneys, either in isolation or surrounded by similar other chimney, or power plant structures. In particular, this is essential for prediction of across wind response of an isolated chimney, and that of both along wind and across wind responses, in the case of an interference study. The boundary layer wind tunnel (BLWT) facility created at SERC is a world-class facility and many of its capabilities are comparable with most of the best BLWTs available across the globe. Satisfactory simulation of atmospheric turbulence in the wind tunnel is essential for rational prediction of chimney responses. With a combination of a longer test section (about 18m) and a wide range for generation of wind speeds (0.5 to 55 m/s), the important role of turbulence on along and across wind responses of chimneys can be better investigated using wind tunnel facility at SERC. The wind engineering group has undertaken research studies / projects which lead to rational assessment of dynamic wind loads on important industrial structures such as tall chimney. Service has been rendered to following prestigious agencies: BHEL; Rajasthan State Electricity Board; Fichtner Consulting Engineers (India) Pvt. Ltd.; and ISRO.

2.5.21 Ultrapycnometer – 1000

The ultrapycnometer is specially designed by CFRI to measure the volume and true density of solid objects. This is accomplished by employing Archimeds' principle of fluid displacement and Boyle's law to determine the volume. The displaced fluid is a gas, which can penetrate the finest pores, thereby assuring maximum accuracy. For this reason Helium is recommended due to its small atomic dimension. It behaves as an ideal gas that is also desirable. Other gases such as Nitrogen can be used, often with no measurable difference.

2.5.22 3-Dimension coordinate measuring machine

The machine developed by CSIO is used for comprehensive engineering metrology of high precision mechanical components required in construction of scientific instruments especially opto-mechanical systems and precision engineering products. The machine can be used both in manual for core off components and CNC mode for repetitive work.

2.5.23 Dew point Generator

A simple and compact dew point generator based on two-pressure principle has been developed by NPL. It can generate dew point in the range -10^0 C to $+25^0$ C with an accuracy of $\pm 1^o$ C dew point. The device finds immense use in the calibration of industrial hygrometers/dew point meters. The developed unit is totally indigenous and light in weight so that it can be used as a traveling humidity standard.

2.6 Food Science & Technology: Science, Technology & Service

2.6.1 Bioavailability of spice active principles from cooked foods and methods for stabilization of the active principles

Studies to monitor the loss of Curcumin and capsaicin, the active principles of turmeric and red pepper respectively, were made at CFTRI after subjecting the spices to domestic cooking process. This involved heat treatment of the particular spice (turmeric or red pepper) as in domestic cooking process. Quantitation of curcumin and capsaicin was made after subjecting the respective spices to the cooking processes. The loss of Curcumin was around 80% in pressure cooking. Capsaicin loss from red pepper was comparatively lower and was in the range 30-45%. The loss of spice active principles were comparatively lesser during boiling in water. The studies are being repeated with further more active principles. Studies are also in progress to quantitate the loss of piperine from black pepper during domestic cooking process. A comparison of the influence of heat processed and raw spices – turmeric, red pepper and black pepper on human platelet aggregation indicated that heat processing did not change the ability of the spice to inhibit platelet aggregation much in the case of turmeric and black pepper, while in the case of red pepper, the difference was more pronounced. Influence of water extracts of a few spices – coriander leaves, curry leaves, cardamom and saffron on platelet aggregation in vitro was also examined. These extracts inhibited ADP, epinephrine and collagen induced human platelet aggregation by 50-80%. The inhibition was time dependent and linear.

2.6.2 Prevention of 'patcha' taint (green/fishy off-odour) in black tea

CFTRI has identified causes and conditions responsible for the development of 'patcha' taint in CTC teas. Methods have been worked out (500 kg batch) to prevent the formation of 'patcha' taint by modification of the processing conditions during tea manufacture.

The problem of 'patcha' taint in CTC teas is prevalent in certain tea processing areas (Nilgiris-Wynad) in South India, which is responsible for low quality teas resulting in low prices. Efforts are on to scale up the know-how and transfer it to industry.

2.6.3 Impact of Ultra-high pressure on cell permeabilisation, and its influence on kinetics of osmotic dehydration and rehydration

Osmotic dehydration continues to be widely used in food processing due to its energy saving and product quality related advantages. Since moisture reduction by this process is inherently slow, various methods have been tried to accelerate mass transfer. It is observed at CFTRI that the diffusivity values during osmotic dehydration, increased four-folds (from 0.54×10^{-9} to 2.24×10^{-9} m^2/s) for water and two-folds folds (from 0.71×10^{-9} to 1.39×10^{-9} m^2/s) for sugar. It is postulated that two mechanisms contribute to the enhancement of mass transfer. Firstly, the compression and decompression taking place during high pressure pre-treatment itself causes the removal of a significant amount of water. Secondly, the breakage of cell walls caused by the applied high pressure facilitates the migration of water. The extent of cell permeabilisation caused by high pressure is being characterized by the parameter of permeabilisation index (Zp), which was measured by an electrophysical measurement. As a result of this the cell membrane apparently becomes totally permeable (indicated by Zp values), due to the synergistic effect of high pressure treatment and osmotic stress, which results in significant change in the overall tissue architecture.

2.6.4 Allergens from fruits

CFTRI has put in place a focused effort to study allergens from fruits. The major objectives are: isolation and characterization of allergens (including profilins) from fruits; and to study the possible involvement of profilins from fruits, in allergic rhinitis and asthma. The mechanism of sensitization of mannitol, a low molecular weight allergen from pomegranate, is being studied. A new 20 kDa protein allergen has been detected in the pulp of sapodilla fruit (*Achras zapota*). Studies on profilin from tomato are being carried out in order to explore their possible involvement in allergic rhinitis and asthma.

2.6.5 Nutritious foods

CFTRI has developed:

- ☞ High-Protein Upma-Mix: A ready mix, fairly free flowing without caking and having a uniform distribution of required ingredients. It has a characteristic flavour and taste of semolina and the added spices requires less time. High protein upma mix contains protein in the range of 14-16%, which means it is nutritionally superior than normal upma mix. The shelf life of the product is more than 3 months;
- ☞ Suruchi-Meetha: A low cost nutrient supplement. It has a protein content of 15 % and contains the micronutrients like certain vitamins and minerals. The product contains a combination of cereals and oilseed

flours and jaggery. The product is easy to prepare and has a shelf life of about 6 months and is ideal for feeding programs for school children.

2.6.6 Sugar cane beverage base

CFTRI has developed a process for the preparation of sugar cane beverage base. This beverage base can be reconstituted into a refreshing ready to serve beverage. The process does not involve heating of sugar cane juice, thereby retaining the natural flavor and organoleptic acceptability which retains the natural characteristic flavor of sugar cane juice.

2.6.7 Clarified shelf stable sapota (Achras sapota L) juice

A process for the preparation of the sapota juice has been developed by CFTRI. The novelty of the process developed is that it yields highly acceptable shelf stable clarified sapota juice by pretreating sapota pulp for the removal of astringent principles.

2.6.8 Date (Phoenix dactylifera) beverage powder

A date beverage powder has been developed by CFTRI which provides a beverage formulation containing date fruit solids. The process developed for the purpose facilitates the extraction and drying of date pulp under certain conditions which otherwise is very difficult due to the presence of high amount of reducing ugars in the date fruit. The beverage formulation containing dates can also be incorporated with desirable flavors, colors and nutrients which offers a novel drink formulation based on natural ingredients.

2.6.9 Vanilla micropropagation

Vanilla planifolia, commonly known as 'vanilla' is a native of Mexico and is one of the most economically important orchids, as a source of natural vanilla flavour for food application and as an expensive source of ornamental cut flowers. Due to the requirement of specific agro-climatic conditions for vanilla cultivation associated with slow monopodial type of plant growth and tedious artificial pollination, coupled to elaborated curing procedure, natural vanilla flavour is very expensive. Researchers at CFTRI have developed a unique rapid method for the multiplication of high yielding vanilla plants by applying tissue culture methods.

2.6.10 Flavour improvement of defatted soy flour and use of rice bran as a food ingredient

CFTRI has developed a unique method for flavour improvement of soy flour. It is simple and inexpensive and hence can be of help in introducing defatted soy flour in Indian diet. Compared to wheat and rice bran, use of rice bran in food formulation is not common. The present work has devised means of incorporating rice bran in different categories of foods. Another advantage of using rice bran is supplying nutraceuticals to consumer through food products. The solvent extractors who are the producers of defatted soy flour can diversify the activity by adopting the

technologies of producing soy flour with improved flavour and of food products containing soy flour. Health food manufacturers are the target users of process for manufacturing health foods containing rice bran.

2.6.11 Automated dosa making unit

CFTRI has designed and developed an automatic dosa making unit. It is based on a unique concept of circular rotating hot plate, auto batter discharge with thinning arrangement and an automatic discharge of the baked product. The machine would automatically complete all the operations involved in dosa preparations such as batter spreading, cooking / baking, oiling, curry dispensing, would result in reduction in labour and drudgery on the part of chefs, help in hygienic operations, and enhance uniformity in quality and quantities. The unit is targeted to industrial canteens, students hostels, marriage halls and other similar gatherings where the large demand exist for serving dosas.

2.6.12 S&T Services

CFTRI provided diverse S&T services during the year which included fabrication, testing, safety and evaluation services:

- ☞ Two Gota separators have been fabricated in the workshop for the usage of beneficiary at Gulbarga for separating Gota i.e. whole dhal without skin from dhal with skin. This system will benefit the miller in processing of various varieties of pulses.
- ☞ Utilization of soy meal in food formulation. Soya meal is a protein rich source of vegetable origin. It can supplement vegetarian diet and nutritious foods. Packaging and shelf-life studies have been carried out on soy meal and soy products.
- ☞ Honey being a natural sweetener and having medicinal properties is finding increased use in natural and modified forms. Packaging and storage studies have been carried out on dried honey powder and honey based food formulations.
- ☞ Suitable natural anti-oxidants and mixtures having synergistic effects on the reduction of oxidations rancidity in edible oils has been studied. Appropriate packages based on metallized aluminum and foil-based laminates were evaluated for their protective functions in retailing deteriorative changes in packed oils.
- ☞ Safety evaluation of polymeric packaging materials. Plastic additives pose potential hazards in migrating into food stuffs, especially fatty foods. Safety evaluation methodology has been developed to assess the color leaching and ingredients migrating into specific types of foods such as acidic, oily, fatty and alcoholic. The testing of various plastic materials and coatings for their conformity to specific Indian Standards and others such as US-FDA forms an important segment of packaging material evaluation for service to industries.
- ☞ Packaging aspects, both consumer and bulk packs for various food products such as tea, spice powder, cereal foods,

confectionery and traditional foods have been studied and shelf life studies on the packed product which have been sponsored by various industries were carried out.

- ☞ Preliminary trials have been carried out by transporting graded pine apples of proper maturity from Meghalaya to New Delhi market.
- ☞ Analysis and testing of food commodities received from port health authorities, legal samples from judiciary and, samples from private and public entrepreneurs.
- ☞ Monitoring and surveillance of contaminants (aflatoxin, pesticide residues, heavy metals) in foods and food products.

2.7 Information Science & Technology: Science, Technology & Service

2.7.1 Management Information System (MIS) for highways

CRRI has developed an intelligent road map and the database useful for designing, planning and maintenance of National highways. The database can be easily updated from time to time. It depends on any one particular storage structure and access strategy and can be used for socio-economic and transport development of the region. The database can enable faster disposal of works related to highway widening/expansion, maintenance and policy. A GIS based MIS for a section of National Highway-2 between Varanasi and Aurangabad has been developed.

2.7.2 Ecological economics for sustainable agriculture: valuation indicators for evaluation of soil science research in India

NISTADS's endeavour under this project is to develop and field test valuation indicators that can help decision-makers, farmers and other stakeholders in the assessment of soil science research and technologies there from. This interdisciplinary study hypothesizes that evaluation methods based on neo-classical economics are inadequate to assess Soil Science research for sustainable agriculture. The research agenda here is to identify and explore valuation indicators that can be used to make research decisions in the soil science sub-disciplines. These valuation indicators will draw from a pluralistic ecological economics framework, and will be tested for their adaptability in the institutional and organizational context of the agricultural research system in India. The project has collaboration with two State Agricultural Universities.

2.7.3 Materials and technologies for sustainable development

The issue of technologies for sustainable urban development was examined by NISTADS. The fast growth of large metropolises, and consequent increases in pollution, congestion, and pollution related diseases, raises questions of overall ecological sustainability. During this study, an effort is made to identify sustainable technologies that can contribute to a well managed urban ecosystem. Technologies are discussed in various areas such as waste water management, human

waste disposal, housing, urban planning and layout, transportation etc. to lay the foundations of a sustainable pattern of development. The eventual establishment of an industrial ecosystem with relatively closed materials loop would be necessary to establish full sustainability in any industrial society. In the meanwhile there are a number of technological options that can contribute meaningfully to sustainability.

2.7.4 Ex-post evaluation of soil science technologies: the case of gypsum technology for improvement of alkaline soils

The project used an evolutionary economics framework to analyse the three phases of gypsum technology - from technology generation (research system), through diffusion (extension system) and adoption (farm- and eco-system). The study focused on the alkaline soils of Haryana State, and Karnal district in particular. The district was selected purposively for its adoption of gypsum-based reclamation technology. Being a technology package that complements the major cropping system (Rice-Wheat Cropping System promoted through favourable policies) at the adoption level, the gypsum-based reclamation techno-logy package has been adopted in the district. The study carried out by NISTADS concludes that the adoption of gypsum-technology has not however, reclaimed alkaline soils. The dependence of gypsum technology on standing water (for leaching), rice cultivation (for salt tolerance and standing water tolerance) followed by wheat, repeated irrigation with alkaline waters (containing residual sodium carbonates), and declining water tables, continue to add to the problem of alkalinity. Thus, gypsum is judged successful as a soil science technology that enhances the quality of alkaline soil making it suitable for crop production. But it has had limited success as a technology for restoring the health of alkaline soils and for reducing the dependence of the farming community on Government subsidies.

2.7.5 Eco-development in Kumaon hills of Uttaranchal: A case study of Bageshwar district

The main objective of the project of NISTADS is to facilitate eco-development interventions for improving the livelihood of local communities and sustainable development of the region. Since farming alone can not alleviate the poverty of the region, prospects for horticulture based development needs to be explored. In Garoor block of Bageshwar district, particularly surrounding area of GagriGol and Dangoli villages, pear produce is abundant. This pear is not good for table consumption but can be processed for value-added products like jam and jelly. There is no facility in the region for fruit processing. Hence, farming development packages coupled with horticulture- based industry have good scope in alleviating poverty and ensuring eco-development of the region.

2.8 Leather Science & Technology: Science, Technology & Service

2.8.1 Lime-free fibre opening

A process for lime free fibre opening based on the use of a bio-product has been developed by CLRI. The technology is applicable to all substrates viz. goat, sheep, cow and buffalo. Finished leathers processed through such fibre opening technique were found comparable with conventional leathers in all aspects. When coupled with lime free unhairing, this technology offers possibilities of direct pickling without resorting to deliming after fleshing.

2.8.2 Total Dissolved Solids (TDS) reduction through in-plant measures

Various in-plant measures such as desalting, enzyme assisted hair-saving and unhairing, recycling of lime liquor, recycling of washing (deliming) liquor, acetic acid pickling (for vegetable tanning) and pickle liquor recycling (for chrome tanning) have been studied at CLRI for their effectiveness in the reduction of TDS. Generic options for TDS reduction have also been standardized. Potential for reduction of TDS through these measures has been quantified.

2.8.3 Artwork on leather: a new approach

Traditionally artwork is accomplished on paper, wood, textile and other special materials. Although artwork on leather was performed in earlier centuries, it has completely waned in recent times. Leather as a material has many utilities. However low quality leathers do not find many applications. An attempt has been made to revisit the lower grade leathers for improving not only the quality but also the value of the end product through upgradation of the lower grade leathers by the application of artwork. Low grade EI/Semi-chrome crust leathers have been chosen as raw materials. Several artworks based on a variety of themes have been developed. As an initial trial, the artworks have been performed using Indian ink by hand. Studies are being undertaken to commercialise the process, using screen printing technology. Efforts have been made to match the depth of the colour achieved in hand painting. Tests on fastness of the colour to light, wet and dry rubbing will be carried out. At present, these leathers are targeted for interior decoration such as wall panelling, wall leathers / interior leathers, theme photo for showcasing, place mats, tablecloth, spreads.

2.8.4 Productivity improvement using simulation techniques and optimization

CLRI has developed an indigenous software tool "QUEST". This software enables optimization of productivity in real life systems and can be used for: accurate 3-D modeling of the factory layout; and simulation of the actual work progress of men and machines. The parameters of reduction of manufacturing time, reduction of buffer time and changing orientation of machines are considered to balance the time for source and output in each and every machine.

The software provides a tool to investigate each situation and helps reduce operation time by selection of a suitable layout.

2.8.5 3D visualisation: a biomechanical approach

3D Visualization concepts in foot sizing and last modeling have been worked out by CLRI. In this approach, there are six sub modules viz. image pre-processing (image filtering, noise removal, object enhancements); pattern extraction (fetch various parameters from different views, store the parameters in the database; Reference Frame Transformation (common reference frame, mapping of different frames on common); Last Creation Module (edge detection module, contour generator module, mapping of contours in 3D, general last creator from parameters and 3D contour, storage and retrieval of lasts into a database); Last Editing Module (heel-height and toe-spring modifications, toe modifications, profile generation, search function); CNC Interface (modifying/ developing of system level device drivers for CNC milling machine used, controlling CNC machine via computer interface, mapping of virtual dimensions of the last onto physical dimensions).

The approach has included scanning of the foot images and creating foot envelopes for later conversion to a shoe last conforming to the derived dimensions of the foot. A hardware device to gather data and software to analyse and develop a last modeling routine form parts of this programme.

A foot scanning equipment has also been designed. A device with 5 cameras for grabbing the images from 5 different orthographic views has been built.

The images are taken through these cameras from various angles and passed on to the multiplexer. Cameras are fixed in a pre-defined position. A glass is placed on the slot inside the box. This glass is used as a base on which the foot is placed. The cameras and LEDs are placed in such a way so as to reduce glare. The device enables integration of images collected from various angles through the use of a multiplexer. The device is under close evaluation. Software for the utilisation of grabbed images of foot in the design and modeling of last is under development.

2.8.6 Design and retail analysis

Design and Retail Analysis Program (DRA) is a joint venture of CLRI & Indian Shoe Federation (ISF) under the aegis of National Leather Development Programme (NLDP) and supported by the Council for Leather Exports (CLE). The basic objective of the programme is to gain access to market information in leather in select countries. Traceable impact has been made in association with ISF. Analysis reveals bimodal market segmentation for Indian Footwear – USD 6-7 range and USD 14-16. Designs, Fashions and Trends in fashion capitals of the world captured and analysed (London, Paris, Florence, Dusseldorf, Milan). Information has been disseminated to the industry on rising trends, peak trends, downward trends, future

trends, color emphasis, textures, fashion, style. Design packages have been prepared.

2.8.7 New approaches and methodologies for degradation and utilization of solid/liquid wastes towards zero discharge concepts

Activated carbon is regarded as a porous non sinterable matrix having widely separated energy gap. The application of activated carbon for catalytic oxidation and reduction of organics in wastewater is limited by the available electron in the conduction band. The flow of electron from valence band to conduction band is determined by the width of the energy gap. An attempt has been made at CLRI to increase the Fermi level through doping of the activated carbon. The methodology for the measurement of fermi level in porous and non-sinterable matrix is reported to be nil. Hence, a new measuring device based on thermal and electrical conductivity has been developed. The doping of activated carbon is controlled by variables such as type of dopants used and the characteristic of the material. The characteristics of the material include the pore structure and its distribution. The distribution of the pores in the activated carbon is through proper heat treatment. Heat treatment of carbon also brings about changes in the crystallites of the carbon matrix. One such phase with oxidation resistance up to 350-450°C was developed.

2.8.8 CLRI processor

The prototype of a novel tanning drum has been fabricated at CLRI. Advantages such as reduction in time, saving in energy, water and chemicals for processing leather without affecting the quality of leather have been demonstrated. Efforts are on for commercialization of the processor design.

2.8.9 Kolkata leather complex

CLRI has developed standard layout models for three typical tannery capacities of 1000-1500 kg/day, 2000-3000 kg/day and 7500-10000 kg/day of hides and skins. A strategic plan has been developed for relocation of tanneries and presented to the tanners. The need for implementation of cleaner tanning technologies in the existing location as well as in the relocated site has been explained and a large number of tanners have been enrolled into the programme.

2.8.10 Expertise centre for ecotesting laboratory

Carcinogenic arlyamines are used in large volumes to produce dyes and pigments. However, it is very relevant to identify the hazardous arlyamine isomers from eco benign species so that the products based on carcinogenic species can be kept out of usage. Identification of carcinogenic isomers of arlyamines employing Miceller Electro Kinetic Chromatography (MEKC), a mode of capillary electrophoresis, was taken up by CLRI as it offered better scope for separation science. Success of this analytical method was proved by real sample analysis, which confirmed this as a promising technique for the arylamine species.

2.9 Material Science & Technology: Science, Technology & Service

2.9.1 Enhancing the coal quality for domestic/industrial use

CFRI has developed:

- a binder for utilizing coal fines (40/25mm) for domestic/ industrial use by making suitable briquettes. This will help in utilization of coal fines (wastes) as value added domestic fuel;
- a methodology to cool the domestic coke discharged from the oven suitably without using water for quenching, such that within a specified time of a shift the entire process from coke formation to cooling became continuous. Emission of suspended particles along with steam during quenching could be stopped. The methodology will help in improving the quality of coke and minimize the size degradation of coke.

2.9.2 High radiation resistant optical glasses and fibres for video imaging used in nuclear reactors

CGCRI has developed radiation resistant optical glasses, designed and fabricated a complete device consisting of lens and mirrors to be used in video camera for the coolant tube of nuclear reactor. The device was fabricated by National Instruments Ltd., Kolkata with the glasses designed, fabricated and developed at CGCRI. The device replaces the earlier one having several limitations. The laboratory has supplied 12 sets of lens and mirror units to BARC. BARC has placed repeat order for supply of this system.

2.9.3 Inorganic-organic hybrid scratch resistant coatings on polycarbonate sheets

CGCRI has developed the technology of making abrasion resistant coatings on polycarbonate sheets and ophthalmic lenses. The developed scratch resistant coatings are based on UV-curable inorganic-organic hybrids (epoxy methacrylate-silica) loaded with boehmite nanoparticles. The technology also provides a method of making gold nanocluster doped abrasion resistant coatings, which can be used as decorative coloured coatings as well as nonlinear optical materials. The coated polycarbonates show high abrasion resistant property compared to the uncoated substrates.

2.9.4 Porous hydroxyapatite orbital implant

CGCRI has developed bio-active integrated orbital implant for implantation in human patients in collaboration with Eye Care and Research Centre (ECRC), Kolkata and Institute of Nuclear Medicines and Allied Sciences (INMAS), New Delhi. The lost eye can be mechanically replaced by an orbital implant to fill up the orbital volume lost after enucleation or evisceration to achieve better cosmesis and rehabilitation on the anophthalmic patient without restoration of eye sight. The porous materials act as a scaffold for the rapid in growth or vascularized connective tissues and bone and that is why the implant is capable of giving a natural look of the eye with a fair degree of mobility

mimicking that of the fellow eye in all directions with negligible socket complications. This indigenous product on commercialisation is expected to cost one-tenth of the imported one, which presently costs about 80 US dollar per unit.

2.9.5 Nanocrystalline soft magnetic materials

Fe-Nb-Cu-Si-B based materials are the new class of magnetic materials which in the nanocrystalline state exhibit superior softmagnetic properties. Al and Mn which enhance further their softmagnetic properties have been introduced. The material was prepared by NML using different ferroalloys in the form of continuous amorphous ribbons. The ribbons were heat-treated at a suitable temperature and time to get nanoparticles dispersed in amorphous matrix. The developed materials have a coercivity ~ 0.32A/m and susceptibility ~ $2X10^5$. The developed FeNbCuAlMnSiB material is a strong candidate for the sensor application as it has very low coercivity and high susceptibility. The sensor may be a magnetic field sensor, which can be used for materials characterisation by monitoring the magnetic state of the test materials.

2.9.6 Synthesis of silicon carbide mats using natural fibers

Fabrication of β-SiC mats using natural fibers was investigated by NML by incorporating Tetra Ethyl Ortho Silicate (TEOS) into the micro-tunnels of the jute fibers and pyrolysing them at elevated temperatures. The silicon compound, TEOS impregnated jute mats were first hydrolyzed by adding ammonia solution at room temperature and subsequently the mats containing silicon hydroxide were pyrolysed in inert argon atmosphere at high temperatures to yield the β-SiC mats. The fabricated mats are expected for use as high temperature blankets and for the making of laminated metal matrix composites and also for Functionally Gradient Materials (FGM).

2.9.7 Maximising blast furnace productivity with Indian iron ore

The project is sponsored by the Ministry of Steel (MoS), Govt. of India, under the Steels Development Fund (SDF) scheme. The objective of the project being executed jointly by NML, SAIL and TISCO, is to develop a knowledge base for characterising the process dynamics of the iron making blast furnace to improve the blast furnace performance, especially the furnace productivity and hot-metal quality. The project comprises of 11 research activities, out of which six are led by NML. The progress made in the research activities included:

Analysis of silicon transfer to the molten metal in the blast furnace: The conceptual design of suitable experimental facilities were prepared by NML study: the fundamentals of SiO generation and Si transfer to hot metal under controlled condition; and silicon transfer to the hot metal under simulated BF conditions.

Freeze line model for the blast furnace hearth: MECON – the consultants for the above activity have submitted their first report

wherein certain data for the hearth configuration and cooling system, thermal conductivity values for the refractory bricks and operating data for the designated furnaces have been provided. A heat transfer analysis of the hearth based on the finite element method has been conducted and preliminary results have been reported.

Estimation of remnant lining thickness in a BF using non-invasive techniques: After detailed deliberations with experts at Bokaro Steel Plant and RDCIS (SAIL), the basic design of a mock-up facility has been prepared by NML and NIT is ready for contracting out the work on a turnkey basis. Confirmation from SAIL for the supply of various refractory blocks and a stave cooler required in the construction of the mock-up facility has been received. Technical specifications for the three NDT techniques recommended by IGCAR experts for the purpose have been finalised and NIT released.

Study the softening and melt-down behaviour of iron-ore/ sinter under simulated BF conditions: The technical specifications of a suitable apparatus for studying the softening-melting characteristics of iron-ore/ sinter were drawn by an expert committee, and a global NIT released. The commercial bid of the short-listed bidder for the supply, installation and commissioning of the softening-meltdown apparatus was examined and negotiations conducted for further reduction in the price. Subsequent to the receipt of a formal clearance by the MoS, the purchase order for the equipment is being made ready and will be placed shortly. An MoU has been signed with RDCIS-SAIL to conduct tests and a few reproducibility tests on iron ore and sinters samples from TISCO, Vizag and SAIL plants, using the apparatus at RDCIS. This would help generate an initial database by the time the apparatus is installed at NML.

2.9.8 Beneficiation of low grade chromite ore from Orissa

Two samples of low grade chromite ore from Sukarangi (SUKG) and South Kaliapani (SKLP) mines of M/s Orissa Mining Corporation, Bhubaneswar have been received by NML for beneficiation studies. The samples consist of both ROM as well as crushed ore lots. The basic objective of the project is to develop a flowsheet to upgrade the samples from 25% Cr_2O_3 to 50% Cr_2O_3 with SiO_2 less than 2%. As a part of the project, detailed physical characterisation, determination of granulometry, sp. gr., angle of repose, bulk density, work index and grindability of both the samples have been completed. Representative portions are being analysed for mineragraphic characteristics.

2.9.9 Non-rubbing photo-alignment technique to make twisted nematic liquid crystal display cell

One of the primary requirements for fabricating a twisted nematic (TN) liquid crystal display cell is to produce planar orientation of the liquid crystal molecules on the two bounding surfaces with direction of orientation being orthogonal to each other. A variety of techniques have been developed to produce uniform

planar orientation of liquid crystals with a precise control on the surface tilt angles. They include angular deposition of dielectric materials, surface coupling agents, polymer coating followed by buffing, photo alignment techniques etc.

A new concept to produce twisted nematic display has been developed at NPL based on single shot photo-irradiation of the photo-coated substrates. The two substrates treated with two different kinds of photoalignment materials have been used to make a cell such that one of them produces planar orientation direction parallel to, and the other one produces planar orientation perpendicular to the electric field vector of the linearly UV-polarized light. Such a sealed cell on irradiating with linearly polarized light produces planar orientation on the two substrates, which is orthogonal to each other.

Also NPL has developed photoalignment techniques to produce planar orientation of liquid crystals wherein the direction of preferred alignment could be either parallel or perpendicular to the polarized light.

2.9.10 Recovery of iron ore ultrafines by column flotation

Column flotation technique can be applied to recovery of valuable fines which are otherwise lost in tailing. The benefit of the process is that number of flotation stages can be reduced to single stage. The main objective of the work was to study the feasibility of using flotation column to recovery the ultrafines as iron ore concentrate from hydrocyclone over flow of the existing iron ore washing plant. Flotation studies carried out by RRL, Bhubaneswar using flotation column to recover iron values from primary hydrocyclone overflow of the existing ultrafines recovery plant. The results indicated that reverse flotation of silica from the ultrafines is better alternative technique to improve grade and recovery of existing plant. Results on column flotation indicated that a product with 62-63% Fe can be obtained at 52.5% weight recovery and 63% iron recovery. But keeping in view the advantages of column in recovering fines, it is better to use column flotation technique for this type of material in place of magnetic separation process which gives less yield as well as grade. The novelty of this reverse flotation technique is to float silica and alumina minerals to the maximum extent and to collect all the iron ore minerals by depressing reagent in the tailings. The sponsor will be benefited by recovering most of iron ultrafines by installing columns from view point of mineral, conservation, improving the plant economy and reducing pollution. The technique is better compared to existing techniques adopted in the plant and the firm is planning for setting up 2 tonne/hr pilot plant.

2.9.11 Designing of new p-electronic organic and macromolecular material

RRL, Trivandrum has developed novel strategies for the designing of polymers having near infrared absorption and low band gap energy

which are important in the area of molecular electronics and photonics. Using squaraine chemistry, scientists illustrated the synthesis of conjugated polymers that absorb in the region of 900-1100 nm with intrinsic conductivities ranging from 10^{-5}-10^{-7} S/cm. For the first time, the gelation of structurally modified oligophenylene vinylenes (OPVs) was observed. These nanostructured assemblies may have potential applications in the designing of organic light emitting diodes with tunable emission properties. Future activities in the above areas will be directed towards the designing of new p-electronic organic and macromolecular materials which may find applications in molecular electronics and photonics.

2.9.12 Transparent self-cleaning sol-gel titania nano coatings

Titanium oxide is well known as a semi conductor with projected applications in the fields of electronics, catalysts, pigments, and photo-activity. The possibility of using titanium oxide as an eco-friendly photo active coating material has attracted more attention. Various applications of active compositions of titania as self cleaning coatings for window glasses, covers for mercury vapor lamps, automobile wind shields, catalytic membranes, care-free public sanitation systems, bacteria free patient care centres and in cancer treatment have been actively being considered on global level. India is rich in titania resources in the form of heavy mineral beach sand and the manufacture of titania is more or less for pigment applications. Titanium oxide having particle size in the range 20-30 nm with narrow distribution was prepared by sol-gel route first by hydrolysis-condensation reactions of titanium isopropoxide and later starting from titanyl sulphate obtained from indigenous sources. A variety of dopants were incorporated in the titania sol-gel precursor with an aim to control the particle size, improve the surface texture as well as reactivity. Further a series of modifiers were introduced in the sol-gel precursor to obtain surface areas as high as 250 m^2/g with high temperature pore stability. Further, suitable coating precursors were designed by controlling viscosity and transparent coatings on glass surfaces were developed by dip coating and spin coating techniques. The coatings thus developed by RRL, Trivandrum in collaboration with The Netherlands Institute of Applied Research were evaluated for self-cleaning action in presence of surface contaminants.

2.9.13 Modelling of smart structural systems

The smart composite materials, which are used in high speed aircraft, rocket and launch vehicles possess multi-functional capabilities such as load carrying, sensing, and actuation, that can be simulated properly through mathematical modelling to realize real time smart/adaptive structural systems. The study of hygrothermal effect on smart structural systems (piezoelectric anisotropic actuation behavior) at C-MMACS assumes significance due to the fact that these structural

elements are exposed to temperature and moisture in their service life.

2.9.14 Resource quality assessment of coal

Quality wise assessment of the coal/lignite resources in the virgin areas, 25,071 metre of coal cores obtained from the exploration programmes of CMPDIL, MECL, GSI and other drilling organizations in thirty major coalfields of India were processed and 40566 band by band and overall coal/lignite samples were analysed by CFRI. In addition 7,413 coal/lignite samples were characterized for their quality, petrographic properties, carbonization behaviour and related physico-chemical parameters to provide technical aid to the coal producers and consumers of the country.

2.10 Societal Science & Technology: Science, Technology & Service

2.10.1 Development of field kits for drinking water quality analysis

National level water survey studies have revealed that major problems being faced by the country is due to the presence of Arsenic, Nitrate and Fluorides in the natural waters. Arsenic contamination has been found to be wide spread in West Bengal. Similarly the fluoride contamination in drinking water is wide spread all over the country. High levels of nitrate (limit 45 mg/ as NO_3^-) have presented serious problems in different regions of the country. Excessive presence of NO_3^- in drinking water causes infantile methaemoglobinamia in infants. This also causes gastric cancer. NCL with the support of UNICEF has developed water quality testing kits for the above ions which were found to be extremely user-friendly and can be used by villagers. The kits were tested extensively in West Bengal and Rajasthan. Arsenic monitoring kit has the range of 5ppb to 100 ppm while nitrate and fluoride monitoring kits were of yes and no type.

2.10.2 Improved distillation plant for geranium oil

An improved and low cost distillation plant of one ton capacity has been designed by CIMAP for installation and operation at the farmers' field. The plant consists of two directly fired type distillation tanks of 500 kg capacity each, connected together through a common cohobation column for efficient recovery of the geranium oil and has improved features, like, high heat transfer area for steam generation, lower fuel consumption, higher recovery of oil and lesser pollution at workplace. Benefits to be derived from such improvements in the design of the distillation plant include enhancement in the heat transfer area for production of steam by 75% by incorporating flue pipes in the base of the distillation tank; and minimization of the loss of essential oil taking place with the continuous outflow of oil saturated water from the separation vessel by the addition of a packed column for its countercurrent stripping with steam for recovery of the geranium oil. The units have been designed for easy operation even by the unskilled workers and are to be popularized in the Uttaranchal state under a TIFAC initiated Bio-village mode project.

2.10.3 Improved distillation plant for rose oil

A rose oil distillation plant with a capacity of 100 kg flowers per batch has been fabricated by CIMAP for the Agriculture Department of the State of J & K for rose and lavender flowers growing in the valley. Based on the experience gained from the design and operation of directly fired type rose oil distillation plants, a few changes in the design have been introduced in order to achieve higher efficiency in the recovery of rose oil. The modifications included addition of an intermediate distillate holder of stainless steel to enhance its efficiency and operation. The cohobation system of the plant has also been improved to achieve better mass transfer between the liquid and vapour flowing through the column. The design of rose oil separator has been improved to facilitate efficient separation of rose oil and its collection. To avoid the possibility of any burning note in the rose oil, a stainless steel wire mesh has been provided to separate the raw material from coming in contact with the hot metal surface.

2.10.4 Reverse osmosis plant

CSMCRI's R.O. plant with 30,000 litres capacity was installed & commissioned near Mocha-Gorser village in Porbandar District, Gujarat. The plant was handed over to the Department of Gujarat Water Supply and Sewage Board, Govt. of Gujarat in the presence of Director and Principal Scientific Officer from Department of Biotechnology.

2.10.5 Testing and analysis of drinking water

A facility for testing and analysis of drinking water, wastewater and industrial effluents is established in the Gheru Campus of ITRC to support the industry and regulatory agencies for the assessment of effluents, for effective pollution abatement and control. This helps in the efforts on sustainable development without damage to the environment and helps the society through human health protection measures.

2.10.6 Garden for the physically disabled and visually handicapped persons

A Garden for the Physically disabled and Visually Handicapped Persons has been developed by NBRI in the Botanic Garden campus. The garden is planted with a wide variety of plants viz. trees, shrubs, creepers, bulbous and annuals which bear either fragrant flowers or have aromatic rough leaves so that blinds can enjoy the beauty of the plants by way of smell and touch. Braille System is used to educate the blinds about the features and plants in the garden by providing relevant information.

2.10.7 Nurseries for clonal propagation

NBRI has established protected environment nurseries for clonal propagation. These high tech low cost nurseries are used for clonal propagation, maintenance of germplasm through vegetative propagation. NBRI has transferred this technology on turn key basis for Indira Gandhi Nahar Pariyojna,

Rajasthan Forest Department. Seedlings are being raised there on commercial scale by clonal propagation of tree species important to that region.

2.10.8 Dhokra brass artefacts from Bankura

NISTADS organised a sale-cum-exhibition of Dhokra brass artefacts from Bankura to promote various items on CSIR foundation.

The exhibition inaugurated by MOS, S&T Shri Bachi Singh Rawat was a great success. These artefacts are being made with technical and other assistance from NISTADS by 36 families in a cluster in West Bengal. Though the techniques used by the Dhokra artisans have remained the same, their art has not remained static. Over the years, they have responded to external stimuli by taking to newer and newer forms and motifs.