PHYSICAL SCIENCES CLUSTER

Scientific Excellence

Recruitment potential of a green alga *Ulva flexuosa* Wolfen dark preserved zoospore and its development

CSIR-NIO has tested under different conditions the recruitment potential and the ability of *Ulva flexuosa* Wulfen zoospores to survive darkness. The dark preserved zoospore was cultured under a two-factor experimental design to test the effect of salinity and nitrate, effect of salinity and phosphate, effect of light and salinity, and effect of light and phosphate. The recruitment (germination and growth) of zoospores was significantly affected by light and salinity. The nitrate concentration of 20 μ $mol.l^{-1}$ was found to initiate the process of germination and its subsequent growth and, its effect appeared greatest under 25 psu condition. While nitrate enhances the growth of biomass more than phosphate, both show a positive interactive effect on biomass increase when crossed with salinity. The combined effect of 25 psu salinity and 8 μ $mol.l^{-1}$ phosphate exhibited higher biomass growth. There was a significant effect of light and salinity on the biomass of zoospore, though there was no significant interaction between the two factors. There was an increase in biomass of growing zoospores to increase in light intensity and 80 μ $mol.m^{-2}.s^{-1}$ of light intensity was considered optimal. Similarly, high light intensity condition favored higher biomass growth and there was significant interaction between light (80 μ $mol.m^{-2}.s^{-1}$) and phosphate (4 μ $mol.l^{-1}$) in high salinity (35 psu) condition. The result of this study showed that dark preserved zoospores of *U. flexuosa* have the potential for recruitment and it gives an understanding how different factors play a role in the process of recruitment.

Observational evidence of lower-frequency Yanai waves in the central equatorial Indian Ocean

Analysis of long time series of current meter data from a mooring at 77°SE and the equator during 2003–2007, along with mean sea level anomaly data, by CSIR-NIO throws light on the occurrence of the lower-frequency (24 to 40 day) Yanai waves in the upper water column of the central equatorial Indian Ocean (EIO) during the positive Indian Ocean dipole (IOD) years of 2003, 2004, 2006, and 2007 and its absence during the negative IOD year 2005. This result is in contrast with the earlier studies that observed only the higher-frequency (biweekly period) Yanai wave in this region. A new notion has been proposed for the generation of the lower-frequency Yanai wave in the upper central EIO owing to the positive IOD phenomenon. The strong meridional current shear created by the northward shifting and strengthening of the westward flowing south equatorial current associated with positive IOD and the eastward flowing southwest monsoon current provides energy for the generation of lower-frequency Yanai waves. Vertical stratification of the water column appears to be responsible for the trapping of the different frequency of Yanai waves, with only the higher-frequency Yanai wave in the region of lower pycnocline. During positive IOD the strongly stratified upper water column responds to the lower-frequency Yanai

wave, while the deeper ocean (4000 m) exhibited a longer-period (47 day) oscillation. The expected surface signature of Madden-Julian oscillation seems to be suppressed by strong easterlies during the positive IOD years.

Processes controlling the surface temperature signature of the Madden–Julian Oscillation in the thermocline ridge of the Indian Ocean

During boreal winter, there is a prominent maximum of intraseasonal sea-surface temperature (SST) variability associated with the Madden–Julian Oscillation (MJO) along a Thermocline Ridge located in the southwestern Indian Ocean (5°S–10°S, 60°E–90°E; TRIO region). There is an ongoing debate about the relative importance of air-sea heat fluxes and oceanic processes in driving this intraseasonal SST variability. Furthermore, various studies have suggested that interannual variability of the oceanic structure in the TRIO region could modulate the amplitude of the MJO-driven SST response. In a study carried out by CSIR-NIO, observations and ocean general circulation model (OGCM) experiments were used to quantify these two effects over the 1997–2006 period. Observational analysis indicates that Ekman pumping does not contribute significantly (on average) to intraseasonal SST variability. It is, however, difficult to quantify the relative contribution of net heat fluxes and entrainment to SST intraseasonal variability from observations alone. Therefore a suite of OGCM experiments were used to isolate the impacts of each process.

Autonomous profiling device to monitor remote water bodies

In tropical climates, most freshwater reservoirs, dams and lakes are prone to annual summer stratification during which bottom water layers near the bed become hypoxic (<2 ml/l) with very low concentrations of dissolved oxygen (DO). This has serious implications to human health, and requires frequent and effective monitoring, particularly during summer months when water consumption is highest. These water bodies are frequently located in remote areas away from human habitation, making it logistically difficult to access and monitor their water column properties on a regular basis. The need for monitoring temporal changes in freshwater ecosystems is addressed by CSIR-NIO for use in both coastal and freshwater bodies. The AVP was used in experiments to satellite transmit complete time and location referenced high-resolution profiles of temperature, phytoplankton concentration, turbidity and DO from the remote Tillari Dam - a freshwater reservoir near Dodamarg, Maharashtra. The profiles were received without errors at CSIR-NIO. The benefits of *in situ* time-series profiling with AVP captured the onset of developing hypoxia in early April 2011 over a 9-day unsupervised profiling experiment. A similar 5-day experiment tracked diurnal changes in phytoplankton concentrations through night and day, suggesting a possible interplay between recycled production and photoinhibition.

A study of lead and cadmium speciation in some estuarine and coastal sediments

Chemical speciation of lead (Pb) and cadmium (Cd) in the coastal and estuarine sediments along the Central East coast of India was studied by CSIR-NIO by applying sequential and kinetic extraction methods. The results of this study suggest that concentrations of non-residual and dynamic complexes (which are good indicators of bioavailability) of these toxic metals gradually increase with increasing

total metal loading in sediments. Increase in bioavailability of these toxic metals with increasing total metals concentrations in the sediments can be a potential threat to benthic organisms and aquatic biota in the system. The study by CSIR-NIO shows that total organic carbon (TOC) is one of the key factors which play a crucial role in controlling speciation of these toxic metals in sediments. However, distribution and peciation of these metals are influenced by their total metal loading and trace metal competitions rather than only TOC content in sediments. An attempt was made to identify the key factors which control speciation of these toxic metals in natural system and provides a better understanding to predict and control pollution of Pb and Cd in coastal and estuarine sediments.

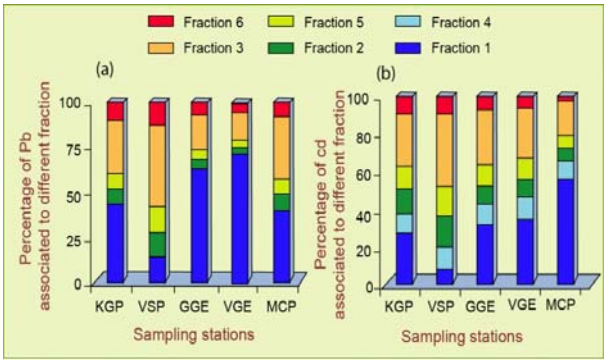

Fig. 1.123 Chemical fractionation of (a) Pb & (b) Cd in five different sediment samples collected at five different environmentally significant sites KGP — Kalingapatnam; VSP — Visakhapatnam; GGE —Goutami-Godavari Estuary; VGE — Vasistha-Godavari Estuary and MCP — Machilipatnam

Bio-prospecting of a few brown seaweeds for their cytotoxic and antioxidant activities

Methanolic extracts (MEs) of seven brown seaweeds occurring in the Indian coastal waters were screened by CSIR-NIO for their cytotoxic and antioxidant properties following various assays. The methanolic extracts of seaweeds in the order of *Dictyopteris australis* > *Spatoglossum variabile* > *Stoechospermum marginatum* > *Spatoglossum aspermum* showed significant cytotoxic activity. A very high DPPH radical scavenging activity was exhibited by the methanolic extracts prepared from *St. marginatum, Padina tetrastromatica, Dictyopteris delicatula* and *S. aspermum*. The total phenolic content of the MEs varied from 13.19 ± 0.32 to 25.29 ± 0.445 gallic acid equivalents (mg g^{-1}) of methanolic extract). The reducing power assay indicated a dose dependency, at concentrations of 0.1, 0.5 and 1.0 and 2.0 mg mL^{-1} of MEs and decreased in the following order: Butylated hydroxy toluene > *P. tetrastromatica* > *D. delicatula* > *S. aspermum* > *S. variabile* > *S. marginatum* > *D. australis* > *S. marginatum. Furthermore, D. australis, S.*

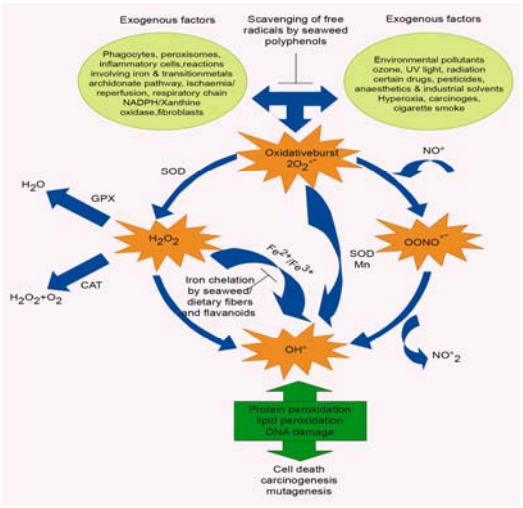

Fig. 1.124 Brown seaweeds and their role in the prevention of ROS-mediated cascade of events

aspermum, S. variabile and *S. marginatum* demonstrated good metal ion chelating properties. This suggests that the antioxidant compounds found in brown seaweeds scavenge free radicals through effective intervention. This decisively promotes them as a potential source of natural antioxidants.

Intra-annual variability of carbon and nitrogen stable isotopes in suspended organic matter in waters of the western continental shelf of India

Intra-annual variations of δ13C and δ15N of water column suspended particulate organic matter (SPOM) have been investigated by CSIR-NIO to understand the biogeochemical cycling of C and N in the Western Continental Shelf of India (WCSI). The key issues being addressed are: how the δ15N of SPOM is affected by seasonally varying processes of organic matter production and respiration and how it relates to the δ15N of sedimentary organic matter that appears to show a decreasing trend despite an apparent intensification of seasonal oxygen deficiency over the past few decades? A secondary objective was to evaluate the sources of organic carbon. Elemental carbon and nitrogen concentrations, C/N ratios in SPOM, along with ancillary chemical and biological variables including phytoplankton pigment abundance were also determined on a seasonal basis (from March 2007 to September 2008), with the partial exception of the southwest (SW) monsoon period.

Screening marine organisms for antimicrobial activity against clinical pathogens

Bacterial resistance to existing antibiotics has led to the search for new therapeutic agents. With this aim, antimicrobial activity of extracts prepared from forty species of marine organisms belonging to different phyla and collected from Mandapam, south-east India, (9° 16'N; 79° 12'E) and Kanyakumari coasts, south India, 8° 4'N; 77° 34'E were evaluated. The extracts were screened against clinical isolates of bacteria including multi-drug resistant (MDR) strains and fungi. The sponge, *Ectyobatzella enigmatica*-extract was quite promising as bactericidal agent especially against MDR Streptococcus pyogenes and except for its ineffectiveness against P*seudomonas aeruginosa* and *Klebsiella* sp. it was as effective as standard streptomycin against each of the bacteria tested. Besides *E. enigmatica*, *Spongia officinalis* and the *echinoderm Pentaceraster affinis* extracts also exhibited good activity against MDR strains of *S. pyogenes* and *Acinetobacter sp.* An unidentified ascidian extract effectively inhibited the growth of *Shigella flexineri* and the soft corals, *Sinularia sp.*(iii) and *Sinularia kavarattiensis* were weakly active against some of the bacteria tested . Both the sea grasses (*Halodule sp. and Halophila ovalis*) were antifungal but not anti-bactericidal. Follow up studies showed that except *Ectyobatzella enigmatica* where the activity was distributed in all the fractions, the activity of the other extracts were concentrated mainly in the low polar hexane and chloroform fractions. Among the 7 fungal pathogens used in the study, *Fusarium sp.* was sensitive at varying degrees to 12 marine extracts while 17 extracts were weakly fungicidal against *Nocardia sp.* The extracts were practically inactive towards the remaining fungal strains. The standard antibiotic (ketoconazole) used was moderately effective only against *Cryptococcus neoformans* and *Aspergillus niger*.

CSIR-NIO team consisting of the five members participated in the Indian Arctic Programme during 16 May to 6 June 2011. The participation was to initiate a joint research programme between CSIR-NIO and NCAOR for "Long-term physical-biogeochemical measurements in the Kongsforden Fjord for Climate Change Studies". The team carried out physical-biogeochemical measurements at 16 stations in the fjord. During 27-28 May CNN-IBN team took video shoot of Indian research in Arctic and this was telecasted on 6 June 2011 on CNN-IBN channel as a part of the climate change study of Arctic.

Seismically Active Zones in Indian Peninsular Shield

Ten stations of the broadband seismic network operated by CSIR-NGRI, connected to a central recording station at CSIR-NGRI through VSAT for online data analysis, recorded 410 earthquakes with M≤4.5 during 2009-2012 periods. Several of the events were located using data from these stations.

The epicenter map prepared for the Peinunsular India clearly brings out the moderately active nature of the Indian shield which is typical Stable Continental Regions of (SCR). The earthquakes are confined to well-known tectonic regimes like the Godavari graben, Cuddapah basin, eastern margin near Ongole, north of Moyar-Bhavani shear, Koyna, the southern margin of Aravallis, Kutch and around Rewa along the Narmada-Son Lineament.

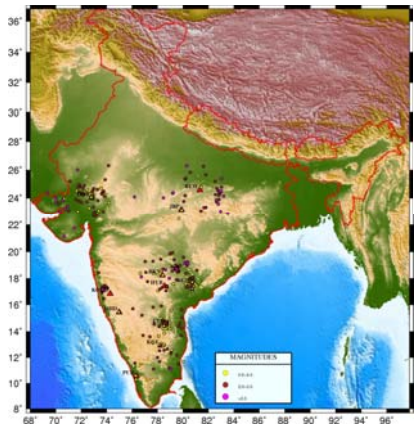

Fig: 1.125a Epicenters of earthquakes recorded by the Broadband seismic network in the Peninsular shield of India during January 2009 to March 2012

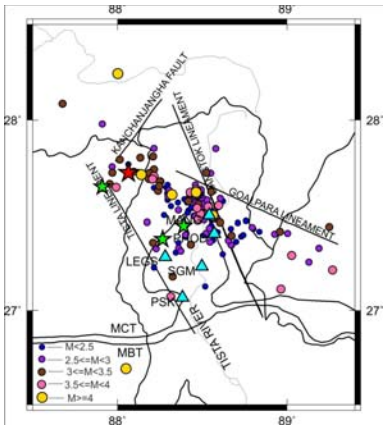

Fig: 1.125b Locations of the seismic stations (triangles) of the CSIR-NGRI seismic network and epicentres of all the aftershocks recorded by at least three stations

Tectonic Implications of the September 2011 Sikkim Earthquake and its Aftershocks

Spatial patterns of 292 aftershocks of the Mw 6.9 Sikkim earthquake of September 2011 were studied by CSIR-NGRI accurately locating them through analysis of three component waveforms registered by a five station broadband network operated immediately after the occurrence of the quake. Refined hypo-central parameters achieved through application of the hypoDD relocation scheme reveal tight clustering of events along a NW–SE trend with focal depths reaching ~60 km. These trends viewed in conjunction with the strike–slip mechanisms of past earthquakes in Sikkim, including the main shock, affirm the predominance of transverse tectonics in this segment of the Himalayas where the Indian plate convergence seems to be accommodated by dextral motion along steeply dipping fault systems.

Active Fault Beneath the Tehri Dam, Garhwal Himalaya- First Seismological Evidence

The first seismological evidence of an active fault beneath the Tehri Dam has been identified by CSIR-NGRI through mapping of the earthquake distribution in the Kumaon-Garhwal Himalaya. The earthquake distribution shows a significant EW trend in the Lower Himalaya following the Tones fault in west and the Ramgarh thrust in the east. The Tehri dam is situated in close proximity of the Tones thrust. Twenty earthquakes (mag 1.6 to 2.8) were recorded in the 20 km radius of the dam which mostly have thrust mechanism. Figure 1.125b shows the depth variation of earthquakes (and FPSs), within 20 km on either side of the SW-NE cross-section through the Tehri dam. These earthquakes fall either on the south dipping Tons fault or where it meets the Main Himalayan Thrust .

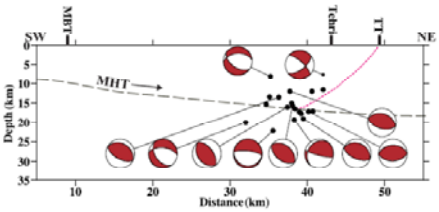

Fig: 1.126a. Distribution of earthquakes recorded by various networks

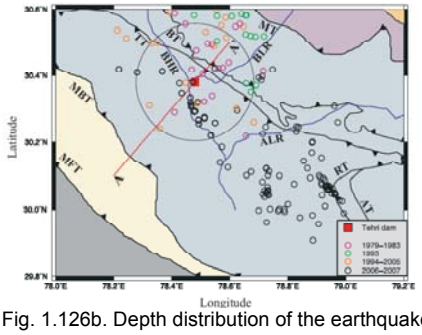

Fig. 1.126b. Depth distribution of the earthquakes occurring within 20 km along the SW-NE cross-section through the Tehri dam

This is perhaps the first seismological evidence of an active fault beneath the Tehri dam. The study reveals that the tectonic loading on this active fault may generate earthquake(s) and provide additional seismic risk in this critically stressed region.

Fe and S isotope Compositions of Hydrothermal Sulphides from the Northern Lau Basin

Massive sulphides belonging to the extinct hydrothermal field of the North Lau Basin were studied by CSIR-NGRI for their Fe and S isotope compositions. Sulphide samples belonging to pedestal slab peripheral chimneys (remnants of white smokers; Fig. 1.125b) and oxide precipitates filling the hollows of pillowed basalts were studied. Detailed mineralogical and geochemical studies on the same set of samples indicated the similarites between the Lau hydrothermal field and the Trans-Atlantic Geotraverse (TAG) active mound. The sulphides of pedetal slab mainly consisting of chalcopyrites and pyrites with minor barite and sphalerite show δ34S values between 8.4 to 9.6 ‰ (V-CDT). The major constituent of sulphides belonging to peripheral chimney is sphalerite, whlie pyrite and chlcopyrite form minor constituents. The δ34S values range from 5.5 to 8.3 ‰. These δ34S values are very similar to those of TAG hydrothermal sulphides. Such high δ34S values for TAG hydrothermal sulfides were interpreted as a result of mixing of sulfur of sulphate reduction origin and that of the hydrothermal fluids. The high δ34S values in case of Lau Basin also corroborate the influence of sulfate reduction. The sphalerite-rich sulfides of the peripheral chimney have slightly depleted δ34S values when compared to the pedestal slab indicating increased effect of hydrothermal solutions in them.

The δ56Fe values of samples belonging to pedestal slab show a range between -0.3 to -1.1 ‰ (IRMM-014), while those of the peripheral chimney vary from -0.6 to -1.7 ‰. The oxide precipitates show maximum fractionation in Fe isotope compositions having δ56Fe values of -0.8 and -3.0 ‰. Among the oxide precipitates, the MnO-rich top layer is characterized by lowest δ56Fe value indicating the influence of temperatures. Further, role of redox conditions can be envisaged in controlling Fe isotope compositions based on the correlation between δ56Fe and Ce anomalies.

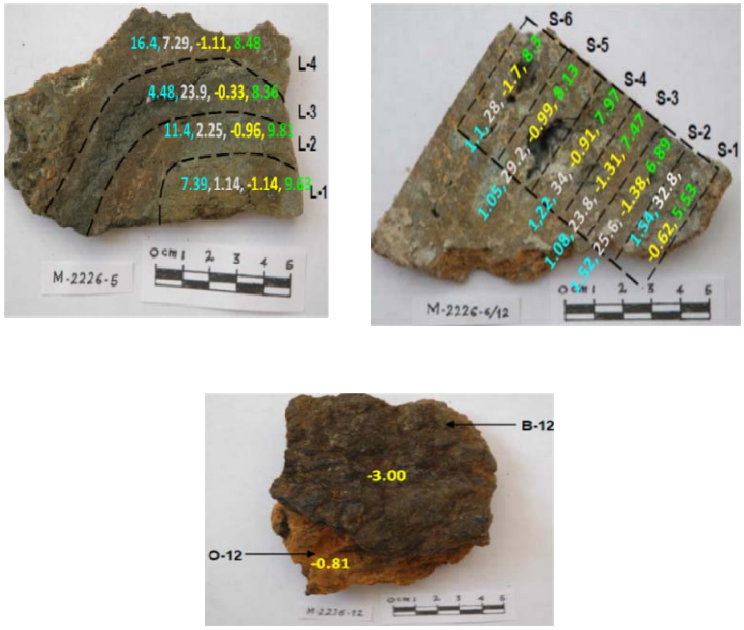

Fig: 1.127 (a) Pedestal slab,(b) peripheral chimney and(c) oxide precipitates of sulfide and oxide samples from the extinct hydrothermal field of the northern Lau Basin. The numbers indicated on the diagram represent concentrations of Cu (blue) and Zn (grey), and 56Fe (yellow) and δ34S (green)

Seismic quality factors across a bottom simulating reflector in the Makran Accretionary Prism, Arabian Sea

The hydrate-bearing sediments above the bottom simulating reflector (BSR) are associated with low attenuation or high quality factor (Q), whereas underlying gas-bearing sediments exhibit high attenuation. Hence, estimation of Q can be important for qualifying whether a BSR is related to gas hydrates and free-gas. This property is also useful for identifying gas hydrates where detection of BSR is dubious. Here, the interval Q for three submarine sedimentary layers bounded by seafloor, BSR, one reflector above and another reflector below the BSR at three locations with moderate, strong and no BSR along a seismic line in the Makran accretionary prism, Arabian Sea were calculated by CSIR-NGRI for studying attenuation (Q_1) characteristics of sediments. Interval Q for hydrate-bearing sediments (layer 2) above the BSR are estimated as 191±11, 223±12, and 117±5, whereas interval Q for the underlying gas-bearing sediments (layer C) are calculated as 112±7, 107±8 and 124±11 at moderate, strong and no BSR locations respectively. The large variation in Q is observed at strong BSR. Thus, Q can be used for ascertaining whether the observed BSR is due to gas hydrates, and for identifying gas hydrates at places where detection of BSR is rather doubtful. Interval Q of 98±4, 108±5, and 102±5,

respectively, at moderate, strong and no BSR locations for the layer immediately beneath the seafloor (layer 1) show almost uniform attenuation. Thus, besides characterizing the sediments, the estimated Q can be used for designing an inverse Q filter to compensate the effects of attenuation for producing improved structural images of shallow submarine sediments including the BSR and other reflectors

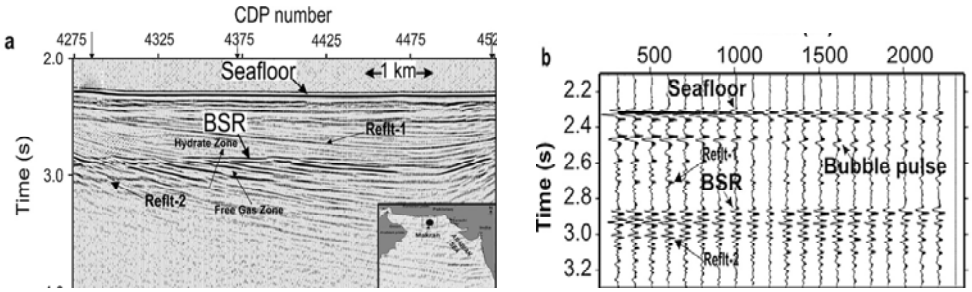

Fig. 1.128 (a). Seismic stack section along a north-south seismic line (inset shows the study area (box) in the Makran accretionary prism). Amplitude spectra have been calculated around four reflectors: seafloor, reflect-1, BSR and reflect-2. (5) NMO corrected CDP gather at CDP 4372, showing the reflections at various offsets from the said four reflectors

Gravity and Magnetic Studies over a part of K-G Basin

Gravity and magnetic (G-M) surveys were carried out by CSIR-NGRI for the delineation of subsurface structural features over a part of onshore Krishna Godavari basin. A total of 2532 gravity and magnetic observations were recorded in and around the area. After applying the necessary corrections to the observed data, gravity and magnetic anomaly maps were prepared for digital analysis and quantitative interpretation. The Bouguer gravity anomaly map of the region shows prominent NE-SW trending highs between Draksharama and Yanam due to the basement up warps referred as "Draksharama/Yanam ridge" and lows on either sides due to basement depressions recognized as "Polavaram and Mandapeta trough" towards SE and NW respectively. Magnetic anomaly map shows well defined NE-SW trending lows associated with gravity high of Yanam ridge whereas the short wavelength and large amplitude magnetic anomalies are interpreted due to presence of varying thickness of Deccan traps overlying the Cretaceous sediments. Modeling of NE-SW trending linear magnetic low associated with basement up warp (Yanam ridge) requires remnant magnetization (Incl= -480 and Decl=450) in the basement rocks which is similar to measured palaeomagnetic directions of Charnockites of Eastern Ghat terrain. Therefore, it is inferred that Charnockite constitutes the basement in this region. While interpretation of the short wavelength magnetic anomalies requires remnant magnetization (Incl= -500 and Decl=3300) for the source which corresponds to the

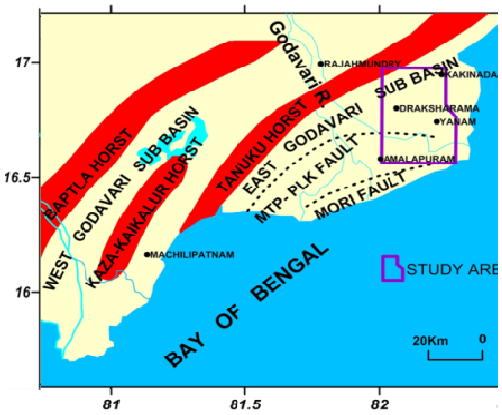

Fig. 1.129 Tectonic element of KG basin showing location of the study area

normal polarity chron (29N) of Deccan stratigraphy which matches with the measured palaeomagnetic direction of Deccan basalts from Rajahmundary

Joint modelling of gravity and magnetic anomalies using constraints from available seismic and borehole information shows significant undulations in the basement (Figure 1.128). It reveals basement as shallow as 2.5km between Draksharama-Corangi and Endamuru and as deep as 6.5km in the south between Mummidivaram and Polavaram and 6.25km in the NW corner to the north of RC Puram. It may be emphasized that in spite of non-uniqueness in potential field modeling, the depth section presented in this report appears to be more plausible due to constraints provided from seismic section and borehole information. The structural faults derived from vertical and horizontal gradient of gravity map coincides with the major discontinuities in the basement. These faults are mostly aligned in the Eastern Ghat and the Pranhita-Godavari- Gondwana tectonic trends.

Delineation of Groundwater Potential Zones in Deccan traps covered - Godavari Rift Zone

Electrical Resistivity Tomography (ERT) studies were carried out by CSIR-NGRI at twenty four sites for delineation of ground water potential zones at deep levels in the form of intertrappeans, faults and fracture zones within the Deccan traps and Gondwana formations below the traps. 2-D resistivity images obtained from inverse modeling of measured apparent resistivity data indicates potential groundwater zones in the form of intertrappeans and fracture zones within the traps and Gondwana formations below traps. 2-D resistivity images for sites P34 and P37 reveal geological formation with resistivity value in the range of 15-30 Ohm-m representing good aquifer, formations with resistivity values in the range of 30 to 40 ohm-m represent moderately saturated aquifer. Formations with >70 Ohm-m resistivity value represent dry massive basalts. ERI at site P30 near Budhla indicates two potential zones of groundwater the first zone between 195 m to 285 m distances and the second zone lies below 405 m distance. At this site, a borewell was drilled, which revealed that the interpreted litho units at this site are in close agreement with the litho units obtained from the borewell. ERI's of sites P28 near Ramgiri and P34 near Sasundri indicate a layer of water-bearing formation in the depth range of 40m to 100 m along the entire length of the profile. This layer is overlain by massive basalt layer. ERI of site P37 near Kohali indicates water bearing layer up to a depth of ~50 m all along the profile. ERI of site P41 near Kohli indicates a water bearing formation bounded by two units of massive basalts. This formation is exposed on the ground surface between 180 m and 290 m. This zone could be a recharge site. At site P43, ERI indicates water bearing formation underneath a ~30-50 m thick layer of massive basalt. The thickness of the massive basalt is maximum around the central points and is minimum towards eastern side.

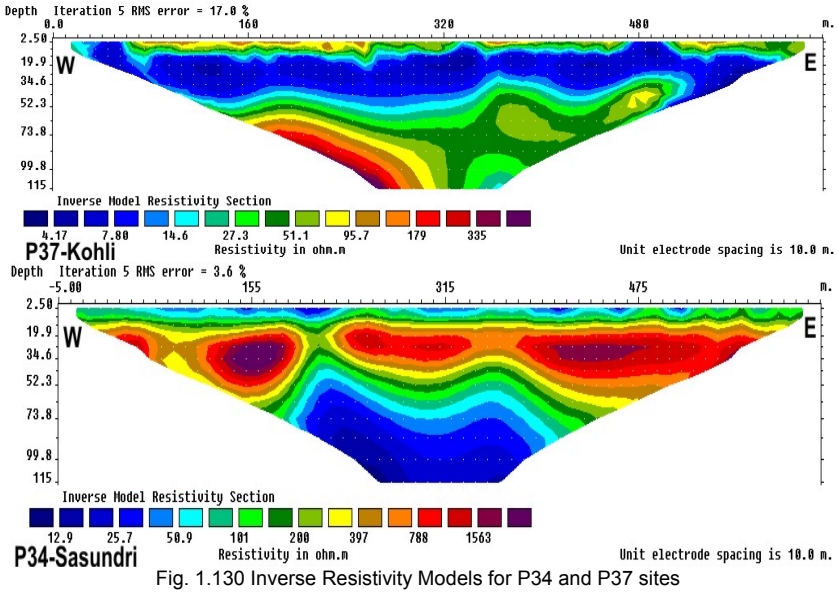

Fig. 1.130 Inverse Resistivity Models for P34 and P37 sites

Geogenic Contamination through Arsenic in Groundwater in Western Bihar: A Sustainable Solution with the Application of Aquifer Modelling

CSIR-NGRI has provided a sustainable solution using aquifer modelling to mitigate the aresenic contamination in groundwater of Western Bihar.

A four layered numerical model has been built with the first layer as an unsaturated zone, 2nd layer as the first and shallow aquifer, 3rd layer as aquitard consisting of clay and the 4th layer as the second and deeper aquifer consisting of medium to coarse sands. The model domain is bound by River Ganga, Son and Thora (taken as a River Boundary) on its northern, eastern and south western side respectively. South eastern side is bounded by a road. The model after calibration for a period of ten years was used for predicting the multi-layer groundwater levels for a further period of 10 to 20 years i.e. up to 2031 for a number of expected scenarios. The principal indicator for the safe withdrawal of Arsenic free groundwater has been the reversal of leakage between the two aquifers. Hydraulic head of the second aquifer (Arsenic free confined aquifer) is higher than the groundwater table in the first (Arsenic contaminated) aquifer in the entire region and an upward leakage exists wherever the intervening clay layer is thin. However, heavy and indiscriminate pumping from the second aquifer will create reversal in the leakage and will contaminate the second aquifer also.

Thus with the expected/projected scenarios, the groundwater levels in both the aquifers were predicted and difference between the two aquifer levels are drawn which predicts the upward leakages in red colour.

Scenario 1: Domestic water utilized from second aquifer

Scenario 2: Domestic and irrigation water utilization from second aquifer

Scenario 3: If projected irrigation water utilization pump in monsoon season from 1st aquifer and during non-monsoonal season from 2nd aquifer.

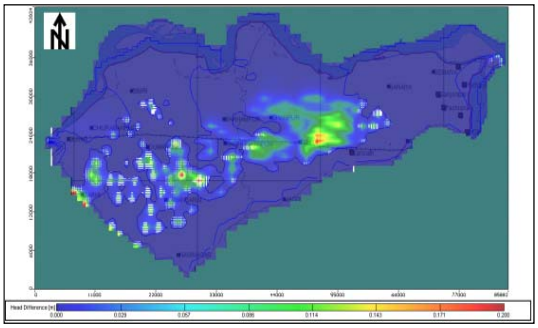

Fig. 1.131a Head Difference scenario 2 for the year 2031

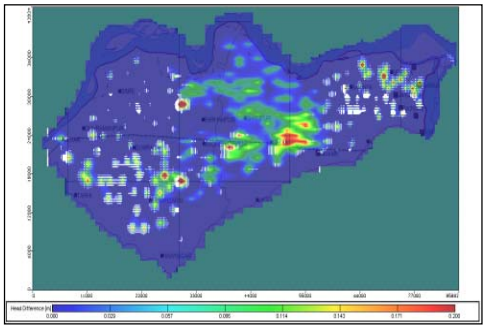

Fig 1.131b Head Difference scenario 3 for the year 2031

Seismic Hazard-Risk Evaluation & Earthquake Precursor related studies

CSIR-NEIST has studied Seismic Site Amplification and shallow sub-surface lithology for Agartala city (N23.70˚ – 23.95˚; E91.24˚ – 91.32˚), and its suburbs cover 120sq km. For this purpose, short period, 3 component weak motion sensors and 3 channel seismic recorders were deployed to acquire ambient noise at 1.0 – 1.5km grid interval covering an area 120sq km. The Ground Penetrating Radar (GPR) survey was conducted to delineate the shallow sub-surface structures and neo-tectonic signatures in all accessible areas including the City suburbs. The data contains a survey length of total 32km recorded in several N-S and E-W profiles. It has been observed that the upper soil horizon within the 3.0 – 8.0mt depth range is a highly deformed silty-sand layer, and it persists throughout the built environment of the city. Below this silty-sand horizon, the impervious clay layer extends up to a depth of about 16m. The available information was incorporated to prepare the microzoning maps helpful in hazard zoning, land use and urban development.

Characterization, beneficiation and utility study of some graphite deposits from Arunachal Pradesh

CSIR-NEIST has developed a beneficiation technology for a fixed carbon of 47.17% with 84.15% recovery by using 10% slurry concentration at pH 10 with 5 minutes settling time. On addition of different doses of sodium silicate viz 0.005gm, 0.01gm and 0.02 gm on 10% slurry concentration at various pH no enhancement on beneficiation was seen as obtained from only distilled water at pH10. The highest fixed carbon of 44.66% with 77.60% recovery has been obtained by using 0.01 gm of sodium silicate to the 10% slurry concentration of graphite at 5min settling time and pH 10. Beneficiation of graphite by chemical leaching method at different temperature using different alkali has also been studied. A highest fixed carbon of 34.16% with 68.11% recovery of graphite has been obtained by this method using NaOH at 5% alkali concentration.

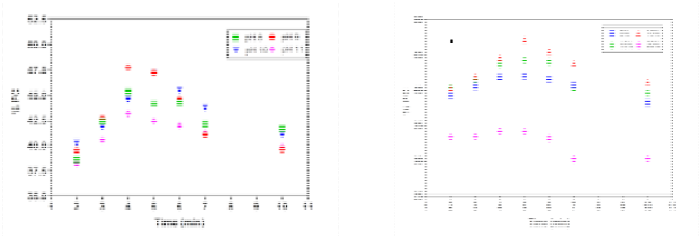

Fig. 1.132 Variation of fixed carbon with time at (a) 10% slurry conc. at various pH and (b) Various slurry conc. at pH10

Determination of degree of unsaturation of edible oils

Total unsaturation of oils and fats used in commercial food products acts as an indicator of their nutritional value. Iodine value, which is a measure of degree of unsaturation, is an important parameter to identify different edible oils. Globally, the available instrumentation for determination of degree of unsaturation involved costly analytical techniques like NMR, FTIR, NIR, Gas Chromatography etc. CSIR-CSIO has been able to record a direct display reading of drop in potential across the sensing electrode and reference calomel electrode which represents the degree of unsaturation i.e. iodine value. Platinum–calomel electrodes electro-chemical system was used for the determination of Iodine number. The change in potential, when platinum and calomel electrodes are immersed in 2% iodine mono-chloride solution (ICl) in acetic acid with respect to iodine mono-chloride solution containing edible oil, has direct correlation to degree of unsaturation of edible oils. A portable system has also been fabricated in which potential change directly relates to iodine number of the edible oils, which is directly displaced on Liquid Crystal Display.

Long period fiber gratings based isolation filter

Wavelength division multiplexing (WDM) is one of the most suitable methods of increasing the transmission capacity of an optical fiber system. In a WDM based system, high isolation loss between adjacent channels is required so that there is less interference from source instability and very little cross talk between neighboring channels. CSIR-CSIO has designed and developed a wavelength tunable WDM channel isolation filter based on two concatenated chirped long period fiber gratings. An inter-grating space (IGS), deliberately introduced between the two gratings, provides an extra phase difference between the core and cladding modes. Changing this phase by heating the IGS without affecting the gratings tunes the channels. A theoretical account of the filter action is also presented and the results are found to be in excellent agreement with the experiments. Unlike the filters based on normal concatenated chirped LPGs without an IGS, the present filter shows a linear tuning over an increased spectral range.

Quantum dots based molecular sensing

Fluorescence-based molecular sensing and immunohistochemistry based cellular imaging are commonly carried out with the application of organic dyes. Quantum dots (QDs), or the semiconducting nanocrystals, are better than organic dyes because they are brighter, size tunable, and more photostable than dyes. Most of the proposed QD-based biosensing systems involve elements of known toxicity, such as Cd and Pb. CSIR-CSIO has developed biocompatible quantum dots based fluorescent bionanoconjugate for protein sensing. Successful bioconjugation was characterized with the absorption and emission spectra showing blue shifts of around 40 and 30 nm, respectively. Gel electrophoresis and particle size distribution studies further confirmed the mass increment of QDs after their functionalization with anti-BSA. Surface plasmon resonance spectrometry has been used to study the affinity of QD-(anti-BSA) probes for bovine serum albumin (BSA). Photoluminescence quenching of the developed probe is observed in the presence of BSA. The proposed

approach may be useful for realizing *in-vivo* applications of the quantum dots for disease diagnosis and cargo transport.

Cost - Effective and Non-Toxic Thermoelectric Material

CSIR-NPL has developed a cost-effective and non-toxic p-type nanostructured thermoelectric material Cu_2Se with a very high figure of merit ~ 2.04 at 1000 K, which is the second highest value obtained so far in any bulk thermoelectric material (patent under process). Other available thermoelectric materials with high figure-of-merit generally contain Pb, Ag, or Te, which are either toxic or expensive. A combination of novel material processing techniques was used to develop this specialty nanoalloy which was synthesized in a few minutes with 25% higher figure-of-merit as compared to its normal bulk counterpart synthesized in few hours employing conventional vacuum melting process. This opens up new technological avenues for the development of cost & energy-efficient thermoelectric devices.

Technology Developed

Rubidium Atomic Frequency Standard

CSIR-NPL has developed and transferred a critical technology of Rubidium atomic frequency standard for space applications to ISRO. A prototype model has been developed at CSIR-NPL and is undergoing further refinements at the Satellite Applications Center (SAC), ISRO before being integrated with the payload of the Indian Regional Navigation Satellite System (IRNSS).

The critical process for development of glass and vacuum technology for filling the Rubidium bulbs and cells is being carried out at CSIR-NPL aimed towards complete indigenization of the space qualified Rb clock.

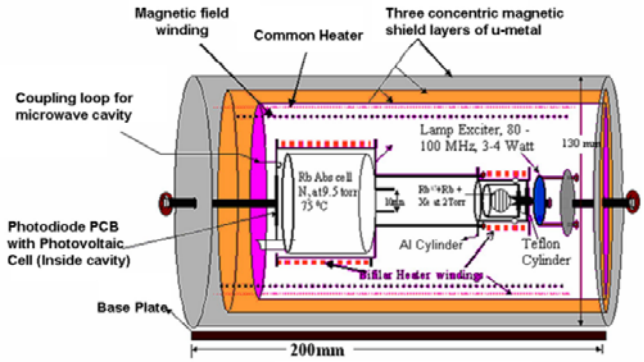

Fig. 1.133 Design of Physics Package of Rubidium Atomic Clock developed by CSIR-NPL

Classification and authentication of unknown water samples using machine learning algorithms

CSIR-CEERI developed water sample classification and authentication, in real life which is based on machine learning algorithms. The proposed techniques used experimental measurements from a pulse voltametry method which is based on an electronic tongue (E-tongue) instrumentation system with silver and platinum electrodes. E-tongue include arrays of solid state ion sensors, transducers even of

different types, data collectors and data analysis tools, all oriented to the classification of liquid samples and authentication of unknown liquid samples. The time series signal and the corresponding raw data represent the measurement from a multi-sensor system. The E-tongue system, implemented in a laboratory environment for 6 different BSI (Bureau of Indian standard) certified water samples (Aquafina, Bisleri, Kingfisher, Oasis, Dolphin, and McDowell) was the data source for developing two types of machine learning algorithms like classification and regression. A water data set consisting of 6 numbers of sample classes containing 4402 numbers of features were considered. In this study, a PCA (principal component analysis) based classification and authentication tool was developed as the machine learning component of the E-tongue system. A proposed partial least squares (PLS) based classifier, which was dedicated as well; to authenticate a specific category of water sample evolved out as an integral part of the E-tongue instrumentation system. The developed PCA and PLS based E-tongue system emancipated overall encouraging authentication percentage accuracy with their excellent performances for the aforesaid categories of water samples.

42 GHz, 200 kW Gyrotron

CSIR-CEERI has developed indigenously design technology of low power and high power Gyrotron has further implemented in the other high frequency gyrotrons like 95 GHz, 120 GHz, 170 GHz.

The design of a triode-type magnetically tunable magnetron injection gun (MT-MIG) is presented for 1-MW 110-, 120-, and 127.5-GHz-frequency gyrotrons with the various operating modes. Some basic equations relevant to the problem available in the literature have been used to obtain the preliminary design. Computer simulation has been performed by using the commercially available code EGUN. The triode-type MT-MIG with the accelerating voltage of 80 kV, the beam current of 40 A, the average transverse-to-axial velocity ratio of the electron beam of 1.26–1.35, and the maximum transverse velocity spread of less than 5% has been designed.

System for detection of synthetic adulteration in raw milk

CSIR-CEERI has developed a system for detection of adulteration in raw milk (KSHEER-SCANNER). It will help in on-line testing of the spurious milk. The developed system is far better than the presently available equipments in the Indian market. The system has capability to detect urea, salt, detergent, liquid soap, caustic soda, boric acid, hydrogen peroxide and sodium bicarbonate. On-line detection and checking has become necessary in the recent times because of the serious problem of adulteration. With the deployment of the adulteration detection system at the village milk collection centers across the country, would help in quality check of the milk.

On-line Surface Inspection Module for Hot Rolled Steel Strips

In collaboration with R&D centre for Iron and Steel, SAIL, (RDCIS, Ranchi), CSIR-CEERI has developed an online surface inspection module for inspection of hot rolled steel strips. The surface inspection module illuminates the surface of fast-moving steel strip with stroboscopic lighting, captures images of a portion of the strip

Fig. 1.134 Online surface inspection module for hot rolled steel strips

width in synchronization with the strip movement, preprocesses and analyzes the images, detects surface abnormalities, identifies real defects like scratch, blister, rolled-in-scale and pseudo-defects like water droplets, and provides results under real-time constraints. The module and its functionality have been successfully demonstrated at Bokaro Steel Plant. The collaborating agency, RDCIS, is taking steps to utilize the developed technology towards a complete surface inspection system for hot-rolled steel strips. The novelty of the development includes (i) high-speed imaging of fast-moving, red-hot steel strips moving at speeds up to 20 meter/second, (ii) efficient algorithms for image pre-processing, defect detection and defect identification, (iii) image acquisition and analysis software implemented using multi-threading on advanced vision processor hardware to provide real-time performance.

NIRS Based On-line Instrument for Quality Assessment in Edible Oil Industry

Fig. 1.135 NIRS based on-line instrument for quality assessment in edible oil industry

CSIR-CEERI and CSIR-CFTRI alongwith an industrial partner M/s Kaleesuwari Refinery Pvt. Ltd. Chennai have developed a Near InfraRed Spectroscopy (NIRS) based on-line instrument for quality assessment in edible oil industry. They investigated the relationship between NIRS and quality parameters such as Free Fatty Acids (FFA) & Peroxide Value (PV) and the development of a measuring system for on-line monitoring of these parameters in selective edible oils through chemometric techniques. The developed system was calibrated against samples collected from the industry and with analytical data derived from these samples by the CSIR-CFTRI. The technique is non-destructive, rapid and the system can accurately monitor even very low levels of free fatty acids (less than 0.25%). The system was tested in real time at the refinery and was demonstrated with all the features to the industry. The system will be a great boon to the edible oil industry that is looking towards optimizing the production with greater product quality in order to comply with food safety act.

Grading and Sorting machine for Mangoes

A machine vision based system has been developed by CSIR-CEERI for grading and sorting of mangoes based on electronic weighing and external features such as colour and size. The system inspects the weights and the external features of mangoes moving on a conveyor, and grades and sorts them as per customer specifications. The developed system uses an electronic load cell for fruit weighing and an embedded ARM7 microcontroller based sub-system for dynamic weight measurements and fruit sorting. The external features are assessed using a colour camera based machine vision sub-system. The system provides a user-friendly graphical user interface for various settings and report generation. The system measures the fruit weights with an accuracy of ±5gms with throughput of 2 fruits/second.

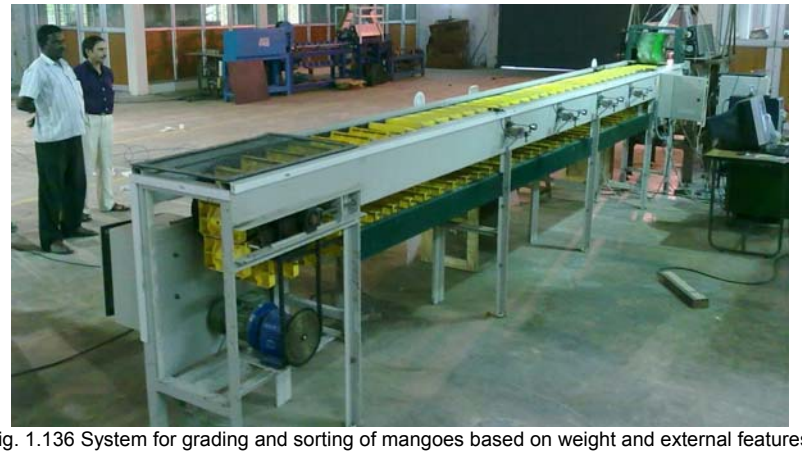

Fig. 1.136 System for grading and sorting of mangoes based on weight and external features

Immobilization of enzyme on long period grating fibers for sensitive glucose detection

Routine, yet sensitive, diagnosis of glucose in blood is a critical parameter in healthcare. Most of the glucose biosensors approved by US Food & Drug Administration (FDA) are based on electrochemical techniques. Long period grating (LPG) fibers have been proved as versatile sensors for temperature, axial strain structural health monitoring and index of refraction measurements. Despite some significant advantages of these fiber grating based sensors, such as high sensitivity and low noise, little efforts have been made on their utilization for clinical analysis. CSIR-CSIO has proposed glucose oxidase (GOD) immobilized LPG fibers for the specific and sensitive detection of glucose. The treatment of LPG fibers with aminopropyl triethoxysilane has induced biding sites for the subsequent GOD immobilization. Field emission scanning electron microscopy, confocal laser scanning microscopy, infrared spectroscopy and Raman spectroscopy have provided detailed evidences about the effectiveness of the adopted biofunctionalization methodology. The enzyme activity is conserved during the immobilization step. Fabricated LPG sensor was tested on different glucose solutions to record the transmission spectra on an optical spectrum analyzer. The wavelength shifts in the transmission spectra are linearly correlated with the glucose concentration in the range of 10–300 mg dl^{-1}. The fabricated sensor gives fast response and is demonstrated to be of practical utility by determining glucose contents in blood samples. Proposed technique can

further be extended to develop LPG fiber based novel, sensitive and label free nanosensors for disease diagnosis and clinical analysis. Application of long period grating fiber for disease sensing offers highly sensitive detections. The developed technology may be utilized for routine and early screening of diabetes. The technique can further be extended for other immunodiagnostic applications.

Recovery of pure ZnO nanoparticles from spent Zn-MnO_2 alkaline batteries

Effective recycling of spent batteries has become a matter of global concern as most of the existing technologies generate low-value products. CSIR-CSIO has attempted to recover pure ZnO (zinc oxide) nanoparticles from spent Zn-Mn dry alkaline batteries. Spent batteries were dismantled to separate the contained valuable metals of the cell electrodes in the form of black powder. Selective and quantitative liquid-liquid extraction of Zn(II) was carried out in three counter current steps by using Cyanex 923 (0.10 mol L^{-1} in n-hexane). Zn(II) distributed in the organic phase as complex ZnCl(2)·2R (R = Cyanex 923 molecule). The metal loaded organic phase was subjected to combust at 600°C to yield pure ZnO nanoparticles (40-50 nm). Nanoparticles were investigated by field emission scanning electron microscopy (FESEM), energy dispersive X-ray spectroscopy (EDX), X-ray diffraction spectroscopy (XRD), and atomic force microscopy (AFM). The proposed technology of the economically beneficial recycling of the industrial waste may lead to better route of waste management. The recovered nanoproduct is pure and may find applications in several fields.

Sensors and Instrumentation for Pesticide Estimation

CSIR-CSIO has made an attempt to develop a rapid and sensitive fluorescence based enzymatic bio-sensor for specific and sensitive detection of organophosphorous pesticides in soil, food and water samples. Organophosphorus hydrolase (OPH) has been employed extensively for catalysis based biosensor synthesis with optical, potentiometric and amperometric based detection mechanism. Institute has determined the response of bioconjuagtes prepared by utilizing OPH and pH sensitive polyanionic fluorophore i.e. pyranine (8-hydroxypyrene-1,3,6-trisulfonic acid trisodium salt) in different molar ratios by the aid of electrostatic force. Two types of bioconjugates were prepared, one of them contained mature form of OPH obtained from *E. coli* cells expressing organophosphate degrading (opd) gene from a tac promoter, whereas the variant OPH6His, has 6x histidine tail at C terminus. The investigation was carried out utilizing the bioconjugates of different molar ratios prepared with both the enzymes and ratio showing maximum degree of labeling with pyranine was selected for the detection of organophosphates in standard samples. The lower limit of detection for paraoxon was ~20 ppb and for methyl parathion and coumaphos it was ~50 ppb under optimized conditions (55–60 °C) with the reaction time of 3 min. These features of the prepared conjugate make it a strong contender for the development of the field deployable biosensor for organophosphates estimation. The advantage of developing this analytical tool is to properly monitor and control the indiscriminate use of pesticides by the farmers.

Porous Conducting Carbon Paper For Fuel Cell

Carbon paper electrode has a critical role in the proper functioning of fuel cell. The carbon paper technology has been successfully developed by CSIR-NPL and the process know how has been transferred to M/s. HEG, Bhopal. Following CSIR-NPL technology M/s HEG has now come up with the carbon paper equivalent in performance with the commercial standard Toray paper of Japan and meeting the requirement of carbon paper for India's fuel cell program.

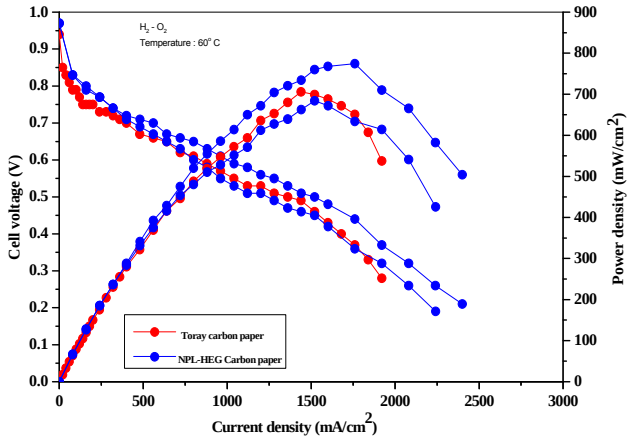

Fig: 1.137 Comparative performance of PEMFC with HEG and Toray carbon paper

Certified Reference Material preparation of elemental solutions

Five new elemental aqueous certified reference materials (CRM) i.e. Bharatiya Nirdeshak Dravyas (BNDs/ or CRMs) namely Pb (50 mg/kg and 100 mg/kg), Cr (110 mg/kg), Ca (100 mg/kg) and SO4 (50 mg/kg) have been prepared by CSIR-NPL and certified according to quality management system based on ISO/IEC-17025 and Guide 34. Certified values are assigned by gravimetric primary method (traceable to SI through CSIR-NPLI mass).

Quality System and International Peer-review on CRM activity

Quality management system (ISO/IEC-17025) in aqueous elemental solution analytical capability after their preparation (as per ISO Guide 34) under inorganic analysis CRM activity has been implemented by CSIR-NPL. An international peer-review on elemental aqueous solution (CRM) preparation activity was successfully completed for 13 no CMCs proposals during February 21-23, 2012 by the technical expert from BAM Germany.

Unique Major Facilities

Automatic Weather Station (AWS) on RV Sindhu Sanklap

An AWS on RV Sindhu Sankalp has been linked to INSAT-C which provides an hourly update of meteorological parameters (True wind speed & direction, air-temperature, air-pressure, humidity, solar radiation (SW, LW), ship heading, & rainfall along with Latitude, Longitude). Although AWS provides Latitude and Longitude, same is not being displayed in view of piracy and safety of the vessel. System has

been tested for couple of months for its consistency and stability. Data from AWS are transmitted to the Ground Receiving Station at INCOIS and from there is it linked to the CSIR-NIO server. At CSIR-NIO, server based application script running keeps track of incoming data and update plots as and when new data arrives.

Mobile Laboratory for Ballast Water Management

For data collection on the coastline, a mobile laboratory by CSIR-NIO has been commissioned especially for the Ballast Water Management Program of India (BAMPI). The main aim of the mobile laboratory is to routinely collect data at least for the next 5 years at the major ports of India where the ballast water is released by the cargo vessels along with microorganisms that have likelihood of threatening our rich biodiversity. The mobile laboratory contains wet and dry laboratories wherein seawater and sediment samples can be analyzed for chemical and microbiological parameters as soon as they are collected.

Programmable Josephson Voltage Standard at CSIR-NPL

Recently, state-of- the-art Programmable Josephson Voltage Standard (PJVS) at 10 V level has been installed at CSIR-NPL with the support of 'National Institute of Standards and Technology' (NIST), USA. Very few such facilities exist in the world.

This forms the basis for standard of the unit of 'Volt' in India at par with the international level. The uncertainty in measurement of Zener Reference Standards is ± 350 nV at k=2 (inclusive of noise of a typical Zener) at 10V level as per the ISO/IEC 17025:2005. This is used for the dissemination of unit 'volt' at par to international level to various industries, governments, defence and strategic sectors laboratories in India and in SAARC regions.

Chemical Metrology at CSIR-NPL

CSIR-NPL provides national traceability for ambient ozone measurements by UV-absorption photometry method (0.2 - 1000 nmol/mol) through CSIR-NPL's primary ozone standard facility under the MiC activity. CSIR-NPL's ozone calibration & measurement capability (CMC) is already listed at BIPM Paris key comparison database (KCDB) under MiC. Thus reliability of Indian ozone measurement data now have been established through this CSIR-NPL calibration service which is of global equivalence among the best for better quality of life. It is open to all users monitoring ambient ozone by UV-photometry.