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Transforming industrial estates in India

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Traditional herbal flocculants for waste water purification

Water scarcity is an acute problem in the developing countries. Water management has become a global phenomenon. However, we are fully aware of the consequence of rapid urbanization and population growth, which is invariably accompanied by adverse environmental problems.

Current research on renewable energy and development

A compilation of annotated bibliographies from different leading periodicals on current research on renewable energy and environment.

Technological developments

Some of the recent technological developments in the field of development are discussed.

Web updates

This section picks up some of the web resources available in the fields of renewable energy and environment.

Forthcoming events

Covering some of the major forthcoming events in the field of environment, renewable energy, and sustainable development…

Ministry of Environment and Forests, Government of India

The Energy and Resources Institute

Transforming industrial estates in India

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Introduction

There are about 1000 industrial estates in India today and many more are planned. These vary in composition from clusters of SSIs (small-scale industries) in single sectors (tanneries, textiles, foundries), to larger estates (also known as industrial areas or industrial belts) comprising a mix of small, medium, and large enterprises, and a mix of enterprises in different industrial sectors. The recent addition to these are the SEZs (special economic zones), envisaged under the SEZ Act, 2005, to serve as engines of economic growth, attract larger foreign investment, and generate employment.

Typically, the industrial estates consume large amounts of resources, and generate wastes. Many collective approaches to tackle environmental issues with respect to these have therefore evolved over time, including CETPs (common effluent treatment plants), common hazardous waste disposal facilities (TSDFs), formation of WMCs (waste minimization circles), CP (cleaner production) initiatives, zoning atlas for siting new industries, and more recently, IE (industrial ecology) approaches to optimize material and energy flows among a set of industries through waste exchanges and networking.

Historically, the efforts have focused on sector-specific studies, or on a subset of the industry, that is, the SMEs (small and medium enterprises). Although co-location may offer significant opportunities for sharing resources and wastes, relatively few examples of symbiosis (or interdependence) within industrial estates are actually found. There is also no single compilation nationally or state-wise of their environmental profile in terms of pollution loads, resource and energy intensity, current environmental management practices, networking successes or failures, environmental information and technology needs, and overall, a comprehensive policy for industrial estate management and planning which integrates the several innovative approaches that have been put forth to conserve energy and resources, and prevent and abate pollution from industrial clusters.

A much neglected aspect is also the social and institutional dimension which is integral to any industrial estate management, including for environmental purposes. Studies in the past have demonstrated the success of a certain environmental management approach in one instance and its failure in another, purely due to different social structures.

It may therefore be worth taking a fresh look at industrial estates in India from an environmental networking perspective and look for ways to transform these into sustainable, eco-friendly entities based on principles of industrial ecology, with a view to material and energy conservation, waste minimization, and cleaner production, and state-of-the-art residuals management. The approach would integrate technical with social and institutional aspects, and policy and regulatory instruments, to arrive at a comprehensive environmental management framework, which could be tested and replicated in existing industrial estates around the country, as well as applied to new ones being planned.

Before doing so, it is imperative also to review the past efforts and build any future work on these attempts.

Collective approaches to industrial pollution management

Common effluent treatment plants The idea of CETPs (common effluent treatment plants) was first conceived in the mid 1980s to deal with the unique waste water problems of the SSIs, which traditionally lack funds, space, know-how, and so on to set up individual effluent treatment plants, but create significant pollution when located in clusters. The first CETP that was set up for a cluster of tanneries in Tamil Nadu, later became a model for similar initiatives in many other parts of the country. The MoEF (Ministry of Environment and Forests) undertook a centrally sponsored scheme by which CETPs could be set up for

clusters of SSIs, with 25% financing from the CPCB (Central Pollution Control Board), 25% from the respective SPCBs (state pollution control board), 30% soft loans, and 20% SSI contribution. In addition to waste water treatment, the CETPs were required to have a sludge management plan, recycle/reuse plan for treated effluent, and environmental management and monitoring plan. The focus of this approach was on end-of-the-pipe pollution control.

Common treatment, storage, and disposal facilities for hazardous wastes Setting up of common TSDF (treatment, storage, and disposal facilities) for hazardous wastes was envisaged after the Hazardous Waste (Handling and Management) Rules were notified by the MoEF in 1989, and amended in 2000 and 2003 (and more recently in 2008). During the Tenth Five-year Plan the central government made a provision for financing Rs 2 crore per TSDF, provided the states would make available an equal grant for setting up such a facility. The approach was not designed for industries located in clusters per se, but for groups of industries generating hazardous waste. Three states – Andhra Pradesh, Gujarat, and Maharashtra – now operate common TSDFs, whereas several others are in the process of doing so. According to a Supreme Court ruling, the state governments are required to compile and publish periodically an inventory of hazardous waste disposal sites and facilities within their jurisdiction. The SPCBs prepare an inventory of hazardous wastes within their jurisdiction based on returns filed by occupiers and operators of hazardous waste facilities. The SPCBs/PCCs (pollution control committees of the union territories) are also required to carry out inventory on hazardous waste dump sites and make an assessment with regard to the extent of soil and groundwater contamination in and around such dumpsites and prepare and submit rehabilitation plans.

Waste minimization circles During the late 1980s, a mass movement on 'pollution prevention' (rather than end-of-the-pipe treatment) was started in the country, following which the Government of India adopted a Policy Statement for Abatement of Pollution through Preventive Approaches in 1992. In 1995/96, the MoEF conceived the idea of WMCs and initiated the Phase I Project on Waste Minimization in Small and Medium Scale Industry – WMCs – under the World Bank assisted Industrial Pollution Prevention Project. A WMC was defined as, 'A small group of entrepreneurs in the small-scale sector whose units manufacture similar products and employ the same processes, meeting periodically and regularly in the premises of each member unit one after another, to analyse the operation of the host unit to identify sources of waste generation and implement waste minimization options, leading to an increase in individual profitability and reduction in pollution load from the units'. The main objective of the project was to promote group efforts for demonstrating waste minimization/cleaner production techniques, which could be replicated in similar cases. The project led to the establishment of 118 WMCs in 41 sectors in 17 locations, and sector specific technical manuals were prepared, along with a compendium of success stories. According to the NPC (National Productivity Council), the nodal agency for the project, the SSIs benefited from the project in many ways. The industries introduced systematic measuring and manufacturing procedures and implemented a number of waste minimization options, resulting in economic as well as environmental gains.

Cleaner production To supplement ongoing waste minimization efforts, the MoEF started a grant scheme on clean technologies in 1994, under which studies have been undertaken through the IITs (Indian Institutes of Technology), CSIR (Council of Scientific and Industrial Research), and NPC on LCAs (life cycle assessments) in key industrial sectors, carrying capacity studies in selected geographical locations, and pollution prevention studies in important locations. The MoEF has also established a National Clearing House for Clean Technology at the ministry in order to promote the development, diffusion, and transfer of technologies with environmental benefits for the industrial sector.

NGOs in India have also been actively involved in inducing improved environmental performance in industry. In the mid-1990s, the CSE (Centre for Science and Environment) launched the GRP (Green Rating Project), which rated

environmental performance of a company on the basis of theoretical best practice. Based on the assessment, GRP proposed concrete recommendations for the selected industry sectors. The project lead to visible environmental gains, in the form of reduced water consumption and introduction of chlorine free bleaching in the pulp and paper sector, greening of the supply chain in the automobile sector, and introduction of membrane technology and regulations for input mercury in the chlor-alkali sector.

Zoning atlas for siting of industries The zoning atlas programme was initiated by the CPCB in 1996 to serve as a planning tool for development projects, particularly new industrial estates. The programme identified possible alternate sites for location of industries based on an evaluation of the prominent environmental conditions and pollution receiving potential of an area. The land classification thus generated was presented through easy to read maps, which identified the potential industrial sites in relation to any environmentally sensitive zones, suggested waste water disposal points, and provided recommendations on surrounding land uses. Subsequently, the Environment (Siting for Industrial Projects) Rules, 1999, were notified, which lay down the provisions for siting of industries, precautionary measures to be taken for site selection as also the aspects of environmental protection which should be incorporated during the implementation of the industrial development project.

Eco-industrial networking While the waste minimization and cleaner production measures focused on single sectors, an effort to address the environmental management needs of a mixed set of industries through an eco-industrial networking approach was first started by the CII (Confederation of Indian Industry) at the Naroda Industrial Estate in Gujarat in 1998–2000. This approach looked at the potential for networking material flows of a cluster of industries, such that the wastes of one unit could be utilized as an input to another. To operationalize the concept, a baseline survey focusing on material, water and energy usage was conducted for 477 industrial units within the estate. Common environmental problems and networking solutions were then identified to reduce wastes. Project teams were set up to implement these measures. Subjects of the first four projects were recycling of spent acid, recycling of chemical gypsum, recycling of chemical iron sludge, and reuse/recycling of biodegradable waste. The initiative at Naroda demonstrated the utility of a collaborative approach in improving industrial environmental and financial performance.

Industrial ecology By far the most comprehensive approach that has been promoted lately is that of Industrial Ecology, which analyses material and energy flows in a given system and aims to optimize their use. Although IE has come with many convoluted definitions and advanced analytical tools[1], it provides a most holistic approach towards the analysis of industrial clusters, encompassing the entire industrial ecosystem, including the industries, the concerned communities, and the resources (land, water and energy) on which these are dependent. It incorporates the various preventive approaches to industrial pollution (waste minimization, cleaner production) which have been tried and tested over time, while also optimizing water, materials and energy use by networking these flows among the components of an industrial ecosystem.

The approach has been applied to existing as well as new industrial estates. TERI initiated work on industrial estate planning in India using the IE approach some years ago and suggested co-location of combinations of industries on this basis. The ROI (Resource Optimization Initiative), Bangalore, has reported a number of interesting case studies – such as for the textile industry in Tirupur, foundries in Howrah, leather industry in Tamil Nadu, industrial belt in the Damodar valley region, and paper-sugar complex in Tamil Nadu – demonstrating the value of a resource flow analysis in understanding the environmental issues pertaining to industrial clusters and their broader policy implications for resource use within a region.

[1]Such as MFA (materials flow analysis), RFA (Resource Flow Analysis), LCA (life cycle assessment), DfE (design for environment), integrated assessment, systems analysis/modeling, scenario analysis, information systems, and I-O (input-output) analysis

Development of a model environmental management framework

Evidently, there has been a transition from end-of-the-pipe pollution control in industry, to preventive intervention in specific sectors, to recent initiatives on more heterogeneous networking using IE methods. This has had a major technology focus so far, with a vast amount of technical information generated over the years on waste minimization options, by-product exchange opportunities, water saving and recycling techniques, and energy efficiency measures.

To test and replicate the newer approaches on a wider scale, and to assure sustainability, it is necessary to study not only the technical, but also the economic, social and institutional factors that may play a role in successful implementation. It is also important that the environmental policy for industry should have appropriate instruments and institutional mechanisms conducive to any such collective efforts in industrial pollution management.

Development of a model environmental management framework for industrial estates based on IE principles could be a concrete step in this direction. The development of such a framework would involve the following.

- Evaluating IE options for selected industrial estates (including technology and information needs) in terms of opportunities for closing the materials loops and minimizing emissions, using alternative resources, increasing resource productivity, and managing residuals in an environmentally sound manner.
- Benchmarking the environmental performance of these industrial estates to assess pollution loads and resource intensity at current operating levels; if present regulations were fully met; and if IE were implemented.
- Setting environmental goals for the industrial estates, which would go beyond meeting present emission regulations and include targets (guidelines) for raw material use, energy consumption, water consumption, and waste generation.
- Estimating the costs of meeting these goals and comparing with current approaches.
- Carrying out a stakeholder analysis to define roles and responsibilities of the various partners involved in the process, and developing an institutional framework to implement the environmental management system.
- Identifying appropriate regulatory and fiscal measures to support the environmental management framework.

Conclusion

Given the backlog of environmental problems associated with industry, the impetus being provided to establishment of SEZs, and the recent development of innovative industrial ecology tools, there is a need to come up with a new environmental management model to deal with industrial clusters. While economics would be the major driving force for real life acceptance and implementation, this should also become the focus of future government policy.

Bibliography

CPCB (Central Pollution Control Board). 1996
Zoning Atlas for Siting of Industries (Based on Environmental Considerations): the conceptual framework
New Delhi: CPCB

CPCB (Central Pollution Control Board). 2006
Performance Status of Common Effluent Treatment Plants
New Delhi: CPCB

CSE (Centre for Science and Environment). 1995
Industry and Environment [Green Rating Project]
Details available at, www.cseindia.org/programme/industry/green_rating.htm, last accessed on 12 May 2008

Michael von H and Martin Z W. 2000
Eco-Industrial Networking: a practicable approach for sustainable development in developing countries
Helsinki Symposium on Industrial Ecology and Material Flows, 31 August—3 September, Helsinki
Details available at www-vwl2.wiwi.uni-kl.de/mitarbeiter/wilderer/Helsinki-Paper-Wilderer-000704.PDF, last accessed on 12 May 2008

MoEF (Ministry of Environment and Forests). 1994
Grant-in-Aid Scheme on Clean Technology
Details available at, envfor.nic.in/funding/chap2.pdf, last accessed on 12 May 2008

Ramaswamy R. 2004
Industrial Ecology: a new platform for planning sustainable societies
In *Governance for Industrial Transformation*, edited by K Jacob, M Binder, and A Wieczorek, New Delhi: Environmental Policy Research Centre

Shaleen S and Kapur A. 2002
Industrial Estate Planning and Management in India
Journal of Environmental Management **66**(1): 19–29

World Bank. 2007
India: Industrial Pollution Prevention Project [Project Performance Assessment Report]
Washington, DC: The World Bank

Traditional herbal flocculants for waste water purification

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Introduction

Water scarcity is an acute problem in the developing countries. Water management has become a global phenomenon. However, we are fully aware of the consequence of rapid urbanization and population growth, which is invariably accompanied by adverse environmental problems.

Botanicals are unique products with special concerns regarding sourcing, consistency, safety, and efficacy. Botanicals or phyto-medicines have always been a major component of the traditional systems of healing in India. Before the study of the crude drugs was systematized, the crude drugs of vegetable, animal, and mineral origin were commonly described as independent units and for ease of reference were arranged alphabetically under the division of minerals, plants, and animals. The earliest books containing these descriptions were known as *Herbals*.

The present paper aims at investigating how a common plant *Moringa oleifera* (drumstick) of our country could be easily cultivated for various purposes with special references to its anticoagulant properties. The work is based on studies of literature, both primary and secondary information, correspondence with scientists, and laboratory and field research on traditional water coagulation on different parts of Indian villages.

The use of herbal materials to reduce turbidity, or muddiness in the water and to remove the harmful biological material that can lead to illness is an age-old concept. The seeds of drumstick (*Moringa oleifera)* containing basic polypeptides are an alternative and possibly cheaper water purification opportunity for rural communities in third world countries. In the tropical developing countries, the clarification of turbid waters from rivers, lakes, and wells is an old household method, and using simple equipment villagers in many countries purify water for their households with *Moringa* tree seeds.

These seeds were detected by Sudanese village women at the beginning of the 20th century as substitute for less efficient beans and groundnuts. India's ancient tradition of Ayurveda says that the leaves of the *Moringa* tree prevent 300 diseases. The oil is obtained from the seed of the *M. oleifera* tree and is called *ben* or horse-radish tree.

Though it is native to India, the tree is now also growing in the West Indies. Scientific research has proven that these leaves are in fact a powerhouse of nutritional value. Modern science confirms the basic idea. Several organizations have isolated the active polyelectrolyte to facilitate its use in water treatment plants as well as in algae farms and other industries using flocculation—wineries, paper manufactures, mines, and so on. Now that research and application at the pilot scale have been achieved, the production and use of *Moringa* flocculent in real economic conditions is being developed 11,12. Unfortunately, even while science sings the praise of *Moringa* leaves, this vital information has not reached the people who need it most.

Historical background

The *Moringa* plant is native to Northern India, where it was first described around 2000 BC as a medicinal herb. The oral traditions may go back several centuries BC, but no written documentation exists before the beginning of the first century AD. It has been reported that in China, attempts were taken at water clarification since the 2nd century AD and the Chinese were involved in the transfer of the technology and knowledge. It is thus believed that the Chinese have contribution to new developments.

The oldest records of a precursor of *Moringa oleifera* seeds are from ancient India (Ist century AD). European eyewitnesses reported related water clarification methods in Egypt at the end of the 16th century and while in China at the end of the 17th century. There is a striking similarity between the Indian and Egyptian methods of

applying a flocculating plant material. Moringa was featured in an early chapter of Bible. The first Hindu practice of clarifying water with plant 'coagulants' and mineral materials is mentioned in the *Sushruta Samhita*— the famous treatise, written by Sushruta. It is believed to be based on the divine teaching revealed to the Holy Dhanvantari, the greatest of all healers who offers three ambrosia of immortality to the gods.

Interestingly, it is found that between AD 680 and 750, the famous thinker Samkara and his contemporaries such as Suresvara and Mandana Misra while giving philosophical interpretation of Vedic scriptures in the *Advaita Vedanta*, mentioned the use of the seeds of *Strychnos potatorum* for water clarification. They were obviously impressed by the remarkable ability of ground *kataka* 'nuts' in the process of removing dirt from dirty water by disappearing itself in the process.

Ancient Indian Buddhists were also in favour of using herbal seeds like *Strychnos potatorum* for water coagulation. In the *Samantapasadika*, a comment in Pali compiled about AD 500, it is found that the water mixed with *kataka* nut is legally acceptable since the nuts remain separated from the water after clarification. Apart from this plant coagulant, the *Samantapasadika* told us about the use of another plant material that is, *Kapittha* fruits (*Ferronia elephantum* Correa, (rose apple tree) for purifying water which does not appear in any other texts. According to some, Buddhists were allowed to drink water treated with *Strychnos potatorum* seeds at any time, whereas water treated with *Ferronia elephantum* fruits could be consumed only before 12 p.m.

The ancient Egyptian used to use *Moringa* oil as cure for skin ravages of desert weather. Later, the Greeks found many other uses for *Moringa* and introduced it to the Romans. Over the centuries, the *Moringa* plant has been carried to all the tropical parts of the world, where it readily takes root. It is commonly used for food, medicinal purposes, as a wind-break in fields, and so on. The *Moringa* plants spread eastward from India to the lower parts of China, Southeast Asia, and the Philippines. From India it also spreads over westward to Egypt, the Horn of Africa, around the Mediterranean, and finally to West Indies in America.

The identification of most of these materials has been rather controversial. But in the *Manu Smriti* or *Manu Samhita*, (about AD 100–300), the use of seeds of *Strychnos potatorum* or *Kataka* seeds for traditional water clarification had been mentioned as a philosophical hint, 'Though the *kataka* tree's fruit makes water clear, water does not become limpid merely by the mention of its name'.

Household water purification method

River water taken for household use can be full of suspended matter, particularly in the rainy season. The water carries silt particles, solids, bacteria, and other microorganisms (some of which can carry disease). It is very important to remove as much as possible of this material before people use the water. Using natural minerals to clarify water is a technique that has been practiced for centuries and of all the materials that have used, seeds of *Moringa* have been found good. Large water treatment centres do this by adding chemical coagulants to the water. These cause the particles to stick together (coagulate) and sink. The clean water can then be poured off. The correct chemicals, however, may be unavailable or too expensive. An alternative is to use a natural coagulant, usually made from plants. In certain parts of the world, this has been done for centuries on a small scale.

According to Yongabi (2005) an integral part of two natural water purification technologies (Biocoagulant–sand filter drum) could be a panacea for treatment of all types of contaminated water for potable and non-potable uses. Turbid water after treating with *Moringa* seeds can be used in agro forestry also.

Purification of water by Strychnos potatorum

In the *Sushruta Samhita,* Sushruta described how the qualities of the 'ambrosial rainwater' after pouring on the surface of earth (rivers, tanks, ponds or fountains), got contaminated by soil and plants (probably by algae and microbes) and how it could be purified by using different methods of purifying water. According to him, there are seven different ways by which one can clean their drinking water. He mentioned the names of the *Kataka* seed (*Strychnos potatorum* L), roots of lotus plants, aquatic mosses, and also a piece of linen or gems known as *Gomedha*, pearl, or a crystal in a pitcher containing water.

Purification of water by Moringa oleifera

Indians have been using *Moringa oleifera* as a natural coagulant since time immemorial. The Maasai of Eastern Africa are a nomadic tribe of cattle-herders who rely on access to dependable water sources to survive. However, the Maasai, like many residents of the Third World, are facing a growing global problem—a lack of safe drinking water. But recently a small group of students from the University of Idaho is trying to make a difference through their Clearwater-Aid project with the help of *Moringa* seeds. Recently Holmes *et al.* 1993 have showed that the water treated with *Moringa* seed can be easily used for irrigation purpose in the developing country where water crisis is one of the major problems.

About 50–150 mg of ground *Moringa* seed treats one litre of water, depending on how clear the water is. First, allow the *Moringa* seed pods to dry naturally on the tree before harvesting them. Seed husks are removed, leaving a whitish kernel, which is then crushed to a powder with a stone or mortar. This crushed powder is then mixed with a small quantity of clean water in a small cup. The mixture is sieved through a tea strainer into a cup. The whole milky fluid is then added up to the turbid and dirty water, stir properly but slowly and regularly for five minutes. After covering the water pot, it is then allowed to stand undisturbed for at least one hour. All dirt settles down gradually and then clean water may be siphoned or poured off. *Moringa* seeds contain a cationic polyelectrolyte that has proved efficient in water treatment, as a substitute to aluminium sulphate and other flocculents. There is a dual advantage to this property.

- It can be used as a locally produced substitute for imported flocculent, thus reducing expenditure of foreign currency reserves by third world countries;
- *Moringa* flocculent, unlike aluminium sulphate, is completely biodegradable. This aspect may be particularly interesting to developed countries.

Purification of water by other plants

According to Yongabi (2004), *Allium sativum*, *Moringa oleifera*, and *Occimum gratissimum* could be used as phytohygienic plants at home for cleaning gutters/channels where waste water exists. The coagulative and disinfective ability of seeds of *Moringa oleifera*, *Jatropha curcas* seeds, calyx of *Hibiscus sabdarifa*, sclerotium of *Pleurotus tuberregium*, and alum on waste water samples was tested. Varying weights (0.5 to 59) of dried pulverized plant materials and alum were placed in 200 ml each of the three waste water samples and left for 24 hours. The results showed well above 90% reduction in bacterial load of the water samples by *Moringa oleifera*. All the plant materials exhibited appreciable coagulative effect comparable to alum. *Moringa oleifera* seeds, *Jatropha curcas* seeds, and *Hibiscus sabdarifa* calyx reduced the bacterial load drastically and inhibited *Escherichia coli* in vitro using the agar diffusion method. The turbidity of both plant and alum treated water samples drastically reduced. But the pH of alum treated water was observed to decrease from neutral to acidic as opposed to a constant pH of 7.0 for plant treated waste water samples.

Pharmaceutical factory waste water purification

Pharmaceutical factory waste water (herbal nature) poses pollution problem due to its high COD and BOD. Moreover the characteristics of waste water depict wide variation due to different types of medicines manufactured and raw materials required. Further addition of solvents and oil as per requirement also increases the pollution load. Because of this acute problem the conventional treatment units which employ ASP (activated sludge process) and trickling filter for the pharmaceutical factory (herbal) effluent treatment usually malfunctions. It was thus proposed to subject the waste water to physico-chemical treatment, using different coagulants and coagulants aids. Commonly available coagulants like lime, alum, ferrous sulphate, ferric chloride, PAC (poly-aluminium chloride), and also polyelectrolyte were studied. Results indicated that this waste water is amenable to physico-chemical treatment and can be applied as a pre-treatment technology as well as a polishing treatment. Lime:Alum:Polyelectrolyte resulted in good and most economical removals of SS, COD, and BOD of 69.75%, 82.72%, and 86.72% respectively at a dose of 300:100:0.1 mg/l respectively.

Discussion

Moringa is a tropical tree with multiple uses, and which is resistant to drought. Among the 13 species known, *Moringa oleifera* is particularly easy to reproduce and its growth is very fast. The numerous economic uses of *Moringa oleifera* together with its easy propagation have raised growing international interest for this tree which originated from India and which is found in most tropical countries (Africa, Asia, and America). *Moringa stenopetala* and other species from Eastern Africa and Madagascar also have potential even though they have been less exploited so far.

The seeds of the tropical tree *Moringa oleifera* contain a natural coagulant. Pushpa *et al.* 2006 explores the unexploited sorption property of the shelled *Moringa oleifera* seeds for decontamination of arsenic for water bodies. The coagulation efficiency of *Moringa oleifera* was found to be dependent on initial turbidity of water samples. Highest turbidity removals were obtained for water with very high initial turbidity. Actually the coagulation efficiency of *Moringa oleifera* was found independent of storage temperature and container. however, coagulation efficiency of *Moringa oleifera* decreased as storage duration increased. In addition, *Moringa oleifera* can be used as a potential coagulant especially for very high turbidity water.

The fact that a natural water treatment material can be extracted from the seeds (and press cake obtained following oil extraction) has perhaps been one of the most significant findings that have driven the development of *Moringa* as a whole. But the development of a commercial product based on this finding is not an easy task. Firstly, to use seeds as the raw material on a water treatment works would require changes to the dosing systems used for conventional chemical coagulants. This would require additional investment for the water companies. Secondly, the crude extract may contain a wide range of organic compounds, which could have a negative impact on the quality of the final treated water. By producing an extracted and concentrated product both of these obstacles can be overcome but the constraints to development that still need to be overcome are its cost effective processing, marketing awareness (that is, one should remain aware of the coagulant/flocculant market which is a highly competitive one), and the regulation for bringing the product into the market.

The testing conducted on single chemical entities may also not be appropriate for botanicals because of their heterogeneous nature. However, botanicals may offer novel therapeutic potential not achievable with mainstream therapeutic interventions alone. Currently, there is an urgent need for international collaboration in the development and promotion of operational methodologies that should include variety of standard operating procedures addressing the nomenclature, quality, safety, and efficacy of these products when used as phytomedicines. In addition, there is a need for coordination and harmonization of regulations related to research and development of natural products as both pharmaceuticals and food supplements.

References

Barzilay J I, Weinberg W G and Eley J W. 1999
The Water We Drink: water quality and its effects on health
New Brunswick, NJ: Rutgers University Press

Singh R. 2006
Psychoactive Medicinal Plants: hallucinogenic and narcotic drugs
New Delhi: Global Vision Publishing House

Wallis T E. 1985
Text Book of Pharmacognosy
Delhi: CBS Publishers and Distributors

Adinolfi M and Corsaro M M. 1994
Composition of the coagulant polysaccharide fraction from *Strychnos potatorum* seed
Carbohydrate Research **26**(1): 103–110

Sutherland J P, Folkard G K, Mtawali M A, Grant G D. 1994
Affordable Water Supply and Sanitation
Proceedings of the 20th WEDC Conference, *Moringa oleifera as a natural coagulant* 22-26 August, 1994, Colombo, Sri Lanka, WEDC Publications, pp 298-299

Quick R E.and Venczel L V. 1996
Narrow-mouthed water storage vessels and in situ chlorination in a Bolivian community: a simple method to improve drinking water quality
American Journal of Tropical Hygiene and Medicine **54**(5): 511–516

Jahn S A. 2006
Personal communication

Magness J R, Markle G M, and Compton C C. 1971
***Ben Moringa seed oil*: food and feed crops of the United States**
[Inter-Regional Research Project] New Jersey

Verma S C, Banerji R, Misra G, Nigam, S K. 1976
Nutritional value of moringa
Current Science **45**(21): 769–770

Folkard G K and Sutherland J P. 1996
***Moringa oleifera*: a tree and a litany of potential**
Agroforestry Today **8**(3): 5–8

Berger M R, Habs M, Jahn S A, Schmahl D. 1984
Toxicological assessment of seeds from *Moringa oleifera* and *Moringa stenopetala*, to raw water
East African Medical Journal **61**: 712–716

Okuda C K. 1999
Improvement of extraction method of coagulation active components from *Moringa oleifera* seed
In *Water Research*
Amsterdam: Elsevier Science Publishers

Baker M N. 1948
The Quest for Pure Water
New York: The American Water Works Association

Maliga L. 2006
***Moringa oleifera*: the *Moringa* tree**
Details available at http://searchwarp.com/swa32107.htm

Bishagratna K K. 1963
The Sushruta Samhita: the Chowkhamba Sanskrit Studies
Varanasi: Vedic Books Publishers

Potter K H. 1981
Encyclopaedia of Indian Philosophies: Advaita Vedanta up to Sankara and his pupil
Princeton, New Jersey: Princeton University Press

Apte V S. 1957
Sanskrit-English Dictionary
Pune: Prasad Prakashan

Bendahmane D B. (ed.) 1993
Lessons Learned in Water, Sanitation, and Highly Efficient Primary Coagulants for Domestic Water Treatment of Tropical Health: thirteen years of experience in developing countries.
Washington, DC: Water and Sanitation for Health Project

Travis V E, Folkard G K, and Sutherland J P. 1993
Preliminary investigations into the use of seeds from the tree Moringa oleifera as a treatment for waste waters
[Leicester University Engineering Research Report]
UK: Leicester University

Ndabigengesere N K. 1995
Active agents and mechanism of coagulation of turbid waters using *Moringa oleifera*
In *Water Research*
Amsterdam: Elsevier Science Publishers

Holmes R G H, Travis V E, Sutherland J P, Folkard G K. 1994
The use of natural coagulants to treat wastewaters for agricultural re-use
Science, Technology & Development **12**(2): 15–23

Folkard G K, Sutherland J P, and Jahn S A. 1986
Water clarification with natural coagulants and dissolved air flotation
Waterlines **5**(2): 23–26

Youngabi K A. 2005
The role of medicinal plants in environmental biotechnology and integrated biosystems
E-Seminar on Medicinal plants in environmental biotechnology and IBS held between 18 and 22 March 2005

Kaviraj K L B. 2006
The Sushruta Samhita: an English translation based on original Sanskrit texts
New Delhi: Cosmo Publishers

Sutherland J P, Folkard G K, Mtawali M A, Young R J. 1993
Performance of a natural coagulant at pilot and full scale in Malawi
Proceedings of the First Southern Africa Water and Wastewater Conference*Southern Africa after the drought,* 21–24 September 1993, Johannesburg, South Africa, pp. 87-92

Holmes R G H, Travis V E, Sutherland J P, Folkard G K. 1993
The use of natural coagulants to treat wastewaters for agricultural re-use in developing countries
Paper presented at International Conference on Science and Technology in Third World Development, University of Strathclyde, 5–7 April, 1993 Glasgow, pp. 39–47

Folkard G K, Sutherland J P, Travis V E, Holmes R G H. 1993
Innovative water and wastewater treatment for developing countries
Journ. Ind. Wat. Soc, **September**: 29-32

Desa D. 1985
Water Purification with *Moringa oleifera*
Waterline **3**(4): 22–23

Kenneth A Y. 2004
Studies on the potential use of medicinal and microfungi (lower plants) in water and waste water purification
IOBB E-Seminar, 14–25 June 2004

Oo K N and Aung K S. 1993
Effectiveness of potash alum in decontaminating household water
Diarrhoeal Disease Research **11**(3): 172–174

Jain G, Satyanarayan S, Nawghare P, Kaul S N. 2001
Treatment of pharmaceutical waste water (herbal) by a coagulation/flocculation process
Int. J. Environ. Stud. **58**(3): 313–330

Broin M, Santaella C, Cuine S, Kokou K, Peltier G, Joet T. 2002
Flocculant activity of a recombinant protein from *Moringa oleifera* Lam seeds
Applied Microbiology and Biotechnology **1**(2): 114–119

Kumari P, Sharma P, Srivastava S, Srivastava M M. 2006
Biosorption studies on shelled *Moringa oleifera* Lamarck seed powder: Removal and recovery of arsenic from aqueous systems.
International Journal of Mineral Processing **78**(3): 131–139

Katayon S, Mohd Noor M J, Asma M, Ghani L A, Thamer A M, Azni I, Ahmad J, Khor B C, Suleyman A M. 2006
Effects of storage conditions of *Moringa oleifera* seeds on its performance in coagulation
Bioresource Technology 97(13): 1455–1460

Sutherland J P, Folkard G K, and Poirier Y L. 2001
Moringa oleifera: the constraints to commercialization.
Proceedings of the Seminar on Development Potential for Moringa Products, 29 October–2 November 2001, Dar-es-Salaam, Tanzania

Current research on renewable energy and development

Forstmeier M, Feichter W, and Mayer O. 2008. **Photovoltaic powered water purification: challenges and opportunities.** *Desalination* **221**(3): 23–28
Hybrid and Renewable Energy Systems, GE Global Research, Freisinger Landstrasse 50

PV (photovoltaic)-powered water purification suggests itself to be one of the solutions in areas with high sun radiation like India or the MENA (Middle East and North Africa) region. The paper presents a concept of combining a membrane filtration plant with PV power supply only. As PV is a fluctuating energy source and the conventional membrane process needs a constant power input to maintain pressure and flow on the membranes to guarantee their lifetime, some challenges in the system design need to be addressed. Mere coupling of off-the-shelf components does not do the job. A full-scale system for sustainable water purification has been designed and tested in the lab and a pilot location. The results indicate that beyond the environmental benefits, the system also competes with standard systems on the market. Based on the experimental results, a cost model has been derived, the main cost factors for the system will be established and a design strategy for a small-scale PV-powered system, able to supply a farm or village with safe potable water, is presented. (3 figures, 7 references)

Nouni M R, Mullick S C, Kandpal T C. 2008. **Providing electricity access to remote areas in India: an approach towards identifying potential areas for decentralized electricity supply.** *Renewable and Sustainable Energy Reviews* **12**(5): 1187–1220

This study presents the results of a preliminary attempt towards identifying potential areas in India where provision of electricity through renewable energy-based decentralized generation options can be financially more attractive as compared to extending the grid. The cost of generation of electricity from coal, hydro, and nuclear power plants, and also cost of transmission and distribution of electricity in the country have been estimated. The delivered cost of electricity (generated in a coal thermal power plant) in remote areas, located in the distance range of 5–25 km is found to vary in a wide range varying from Rs 13.18 to 231.14/kWh depending on peak electrical load and load factor. The study indicates that renewable-energy-based decentralized electricity supply options (such as micro hydro, dual fuel biomass gasifier systems, small wind electric generators, and photovoltaics) could be financially attractive as compared to grid extension for providing access to electricity in small remote villages. (10 figures, 3 tables, 37 references)

Jörg P and Sascha T. 2008. **Promoting biofuels: implications for developing countries.** *Energy Policy* **36**(4): 1538–1544

Interest in biofuels is growing worldwide as concerns about the security of energy supply and climate change are moving into the focus of policy-makers. However, production costs of biofuels are typically much higher than those of fossil fuels. As a result, promotion measures such as tax exemptions or blending quotas are indispensable for ascertaining substantial biofuel demand. With particular focus on developing countries, this paper discusses the economic justification of biofuel promotion instruments and investigates their implications. Based on data from India and Tanzania, we find that substantial biofuel usage induces significant financial costs. Furthermore, acreage availability is a binding natural limitation that could also lead to conflicts with food production. Yet, if carefully implemented under the appropriate conditions, biofuel programmes might present opportunities for certain developing countries. (4 tables, 31 references)

Khanna R K, Rathore R S, and Sharma C. 2008. **Solar still an appropriate technology for potable water need of remote villages of desert state of India: Rajasthan.** *Desalination* **220**(1–3): 645–653

Rajasthan has two-third of its area as desert and it faces scanty rainfall, recurring droughts. This paper studies present status of drinking water, detailing about 237 blocks in Rajasthan and found that only 49 are safe in terms of ground water while 101 are critical and semi critical and 86 are over exploited. About 21 190 villages/ habitations suffer from the problem of excessive salinity, 23 297 villages/habitations suffer from excess fluoride problem and 20 659 villages/ habitations suffer from excess nitrate problem. Therefore, based on the WHO guidelines for drinking-water quality about 56% of the water sources are un-potable. The authors suggested that part of solar energy may be utilized to meet out drinking water need of remote area dwellers. Solar distillation and desalination unit is most appropriate for remote area dwellers because it is economical, easy to construct and maintain. Most parts of Rajasthan have enough solar radiation available, which is the prime input for the system. A low-cost, high-efficiency solar still with porous evaporating surface is fabricated for the purpose and cost analysis is done to calculate the cost of water in this paper. Water samples are collected from a remote village of state and analysed to find the quality of drinking water. The working habits and medical history of the villagers is also investigated to work out cost analysis more realistically. (6 figures, 3 tables, 8 references)

Carolin M M and Fernandez E. 2008. **Analysis of wind power generation and prediction using ANN: a case study.** *Renewable Energy* 33(5): 986–992

Many developing nations, such as India have embarked upon wind energy programmes for areas experiencing high average wind speeds throughout the year. The present paper attempts to apply artificial intelligence techniques concept for assessment of the wind energy output of wind farms in Muppandal, Tamil Nadu (India). Field data are collected from seven wind farms at this site over a period of three years and used for the analysis and prediction of power generation from wind farms. The model has been developed with the help of neural network methodology. It involves three input variables – wind speed, relative humidity, and generation hours – and one output variable, energy output of wind farms. The modelling is done using MATLAB toolbox. The model accuracy is evaluated by comparing the simulated results with the actual measured values at the wind farms and is found to be in good agreement. (12 figures, 2 tables, 19 references)

Bhave A G, Vyas D K, and Patel J B. 2008. **A wet-packed bed scrubber-based producer gas cooling–cleaning system.** *Renewable Energy* 33(7): 1716–1720

Biomass gasifiers are playing an increasing role as decentralized energy sources in the rural areas of India. When used for power generation through internal combustion engines, or for certain thermal applications requiring a clean flue gas, it is necessary to cool biomass-based producer gas to ambient temperature, and clean it of tar and particulates before it can be used as a fuel. This paper describes the development and evaluation of a compact, wet-packed bed scrubber-based producer gas cooling and cleaning system, suited for small-scale applications. (6 figures, 1 table, 6 references)

Umamaheswaran K and Batra V S. 2008. **Physico-chemical characterization of Indian biomass ashes.** *Fuel* **87**(6): 628–638

India stands fourth in biomass utilization for various purposes like domestic, commercial, and industrial applications. While extensive studies have been made for coal ash characterization and utilization, studies on characterization of biomass ash and its utilization has not been addressed. In this paper, biomass ash from five sources, that is rice husk, bagasse, groundnut shell, cashewnut

shell, and arecanut shell have been characterized. Chemical composition analysis, particle size analysis, thermal analysis, and microstructure analysis were carried out. Results show that among all ashes, silica is the major compound with particle size ranging from 15 mm to 30 μm and having irregular shape. Ash powders originating from cashewnut shell, arecanut shell, and groundnut shell also have compounds of calcium, magnesium, and potassium. Bagasse and cashewnut shell ashes have high loss on ignition due to presence of unburnt carbon, P_2O_5 and other volatiles. (2 figures, 6 tables, 12 references)

Swider D J, Beurskens L, Davidson S, Twidell J, Pyrko J, Prüggler W, Auer H, Vertin K, Skema R. 2008. **Conditions and costs for renewables electricity grid connection: examples in Europe.** *Renewable Energy* **33**(8): 1832–1842

This paper compares conditions and costs for RES-E grid connection in selected European countries. These are Germany, the Netherlands, the UK (United Kingdom), Sweden, Austria, Lithuania, and Slovenia. Country specific case studies are presented for wind onshore and offshore, biomass and photovoltaic power systems, as based on literature reviews and stakeholder interviews. It is shown that, especially for wind offshore, the allocation of grid connection costs can form a significant barrier for the installation of new RES-E generation if the developer has to bear all such costs. If energy policy makers want to reduce the barriers for new large-scale RES-E deployment, then it is concluded that the grid-connection costs should be covered by the respective grid operator. These costs may then be recouped by increasing consumer tariffs for the use of the grid. (3 figures, 6 tables, 26 references)

Barthelmie R J, Murray F, and Pryor S C. 2008. **The economic benefit of short-term forecasting for wind energy in the UK electricity market.** *Energy Policy* **36**(5): 1687–1696

In the UK market, the total price of renewable electricity is made up of the Renewables Obligation Certificate and the price achieved for the electricity. Accurate forecasting improves the price if electricity is traded via the power exchange. In order to understand the size of wind farm for which short-term forecasting becomes economically viable, the authors have developed a model for wind energy. Simulations were carried out for 2003 electricity prices for different forecast accuracies and strategies. The results indicate that it is possible to increase the price obtained by around £5/MWh which is about 14% of the electricity price in 2003 and about 6% of the total price. The authors have also shown that the economic benefit of using short-term forecasting is also dependant on the accuracy and cost of purchasing the forecast. As the amount of wind energy requiring integration into the grid increases, short-term forecasting becomes more important to both wind farm owners and the transmission/distribution operators. (5 figures and 36 references)

Beccali M, Brunone S, Cellura M, Franzitta V. 2008. **Energy, economic and environmental analysis on RET-hydrogen systems in residential buildings.** *Renewable Energy* **33**(3): 366–382

The aim of this study was to analyse energy, economic, and environmental performances of a set of scenarios dealing with the production and the use of hydrogen as energy carriers in residential applications in combination with renewable energy. The authors also made an investigation into the required economic conditions necessary for making H_2–RE residential systems competitive with conventional ones, which are based on the use of grid electricity and natural gas. A case study was enacted in a small residential district in Palermo (Italy). Many energy systems have been considered according to several fuel-device combinations (electric grid, fuel cell, PV panels, wind turbines, boiler, and so on). The software HOMER (hybrid optimization model for electric renewables) was used, in order to study the

energy balance of the system and its components. Moreover, it was possible to simulate the hourly operation of each system and to calculate technical, economic, and environmental performance parameters. The net present cost and the cost of energy were used to compare economic performances of the systems with both actual and expected costs in the medium term. Besides, a sensitivity analysis was carried out in order to appreciate the most important parameters influencing the economic performances of the systems and to define possible future scenarios of competitiveness between technologies. Emissions of CO_2 (the most important greenhouse gas) and other pollutants have been considered for an environmental benefits analysis. The data were found to be quite satisfactory in terms energy conservation using RE-H2 systems in residential buildings. (25 figures, 13 tables, 14 references)

Technological developments

Recycling plastics into gas

A company in the US (United States) has developed recycling technology of plastic into the oil and gas. The process requires a finely tuned microwave that uses 1200 different frequencies within the microwave range, to act on specific hydrocarbon materials and a mix of materials made from oil to reduce the product back into oil, a fuel gas and some residues. As the material is microwaved at the appropriate wavelength, part of the hydrocarbons that make up the plastic and rubber in the material are broken down into diesel oil and combustible gas. The sample analysis have shown that running 9.1 kg of ground-up tyres through this machine produces 4.54 litres of diesel oil, 1.42 cubic metres of combustible gas, 1 kg of steel, and 3.40 kg of carbon black.
www.environment.newscientist.com, 25 March 2008

Biofuels from grasses and biomass

Biofuels Research Laboratory at Cornell will convert perennial grasses and woody biomass into cellulosic ethanol and other biofuels by January 2009. The $6 million lab is being constructed and will include analytical equipment, incubators, fermentors, and other state-of-the-art biotechnology equipment. The department plans to offer a master's of engineering programme focused on biofuels in fall 2008 because demand for trained biofuel engineers is high. The new lab will be shared by faculty and students across campus. Five separate labs will be equipped to focus on different aspects of biofuels research, including two growth chambers for specialty plants 'biomolecular farming' that express different proteins. Researchers are working to overcome the physical, chemical and biological barriers to liberating sugars from such alternative energy crops as switchgrass, biomass sorghum and other perennial grasses as well as woody biomass, and to biologically convert these sugars into such biofuels as ethanol, butanol, or hydrogen.
http://www.enn.com, 14 March 2008

Hydrogen from methane using microwaves

Latest research in a US-based company showed a new application to recover hydrogen from methane gas at an extremely high rate. The propriety process, made possible with company's AtmoPlas microwave atmospheric plasma technology is unique because the hydrogen recovery rate could potentially exceed 95%. These results make the AtmoPlas technology suitable for fuel-cell applications that may require on-demand production capability. Potentially, this process could eliminate some of the hydrogen storage issues in mobile fuel-cell applications. The overall energy efficiency of the process is currently being optimized. The AtmoPlas technology generates and sustains plasma at atmospheric pressure without costly vacuum equipment to effectively harness microwave energy. AtmoPlas can exceed plasma temperatures of 1200 °C within seconds, and there is no known practical upper temperature limit. This reduces cycle times and

can lead to lower energy use. Other key benefits include lower operating and maintenance costs and an overall reduction in capital investment.
http://www.evworld.com, 14 March 2008

New discovery could improve fuel cell efficiency

The efficiency of polymer electrolyte fuel cells could be increased with new technology, scientists have claimed. Scientists from Berkeley claim that a polymer membrane that becomes wetter as the temperature in the surrounding air increases can improve the efficiency of polymer electrolyte fuel cells. A scientist from the Berkeley Lab's Materials Sciences Division said that the fuel cells can be used to power cars as the membrane is the first of its kind. The technology has been developed over several years since this simple technology could keep water in the polymer membranes.
www.fuelcelltoday.com, 14 February 2008

Bacteria and nano-filters: the future of clean water technology

Bacteria often get bad press, with those found in water often linked to illness and disease. Researchers at the University of Nottingham are using bacteria alongside the very latest membrane filtration techniques to improve and refine water-cleaning technology. These one-celled organisms eat the contaminants present in water — whether it is being treated prior to industrial use or even for drinking — in a process called bioremediation. The water is then filtered through porous membranes, which function like a sieve. However, the holes in these sieves are microscopic, and some are so small they can only be seen at the nano-scale. Pore size in these filters can range from ten microns — ten-thousandths of a millimetre — to one nanometre — a millionth of a millimetre. These technologies can be developed into processes that optimize the use of water, whether in an industrial system or to provide drinking water in areas where it is a scarce resource.
www.physorg.com, 12 February 2008

Dyed solar cells may offer unique installation opportunities

Researchers at the Fraunhofer Institute of Solar Energy Systems have developed a new solar module that uses organic dyes in combination with nanoparticles to produce electricity. The key component of the new modules is an organic dye which in combination with nanoparticles converts sunlight into electricity. Due to the small size of the nanoparticles, the modules are semi-transparent. This aspect makes them well suited for façade integration. The solar module prototype manufactured by the researchers at Fraunhofer ISE is amber in colour. It is possible, however, to produce the modules in other colours, or even to print images or text on the module so that it serves as a decorative element. These design options open up an entirely new range of possible applications. Instead of mounting the solar module on the roof of a building, the electricity producer could be integrated in the glass façade. Used in this way, the new technology not only prohibits direct sunlight from entering the building interior but also generates electricity at the same time.
www.renewableenergyaccess.com, 4 February 2008

Nano-structured thin film for efficient solar energy conversion

New nano-structured thin film shows promise for efficient solar energy conversion. Two nanotech methods for engineering solar cell materials have shown particular promise. One uses thin films of metal oxide nano-particles, such as titanium dioxide, doped with other elements, such as nitrogen. Another strategy employs quantum dots—nanosize crystals—that strongly absorb visible light. These tiny semiconductors inject electrons into a metal oxide film, or 'sensitize' it, to increase solar energy conversion. Both doping and quantum dot sensitization extend the visible light absorption of the metal oxide materials. Combining these two approaches appears to yield better solar cell materials than either one alone does. Researchers at Berkeley created a thin film doped with nitrogen and sensitized with quantum dots. When tested, the new nano-composite material performed better than predicted—as if the functioning of the whole material was greater

than the sum of its two individual components. The researchers have demonstrated highly efficient thermoelectric behaviour from arrays of silicon nano-wires grown onto a silicon wafer. The technology is compatible with fabrication processes used in the large-scale silicon processing industry. A low-cost thermoelectric system could be used to generate electricity from heat lost from fossil-fuel-based energy generation.
www.energytech-today.com, 8 January 2008

Bio-diesel from chicken fat

Chemical engineering researchers at the University of Arkansas have investigated supercritical methanol as a method of converting chicken fat into biodiesel fuel. The new study also successfully converted tall oil fatty acid, a major by-product of the wood-pulping process, into biodiesel at a yield of greater than 90%, significantly advancing efforts to develop commercially viable fuel out of plentiful, accessible, and low-cost feedstocks and other agricultural by-products. The low-grade chicken fat was subjected to experimentation through a chemical process known as supercritical methanol treatment. Supercritical methanol treatment dissolves and causes a reaction between components of a product — in this case, chicken fat and tall oil — by subjecting the product to high temperature and pressure. Substances become 'supercritical' when they are heated and pressurized to a critical point, the highest temperature and pressure at which the substance can exist in equilibrium as a vapour and liquid. The simple, one-step process does not require a catalyst.
www.renewableenergyaccess.com, 3 January 2008

3-D solar cells enhance the absorption of sunlight

Researchers at The Georgia Technological Research Institute, US has developed a 3-D solar cell to boost photovoltaic efficiency and reduce in size, weight and mechanical complexities of existing systems. Design-wise, the new cell can harness sunlight from any angle. It can absorb virtually all the light striking them, enabling more photons to be converted into electric current. Besides, the new cell uses much smaller photovoltaic arrays, as it captures more light. The cell traps light between tower structures arrays of about 100µ tall, 40µ squares, and 10µ apart millions of vertically aligned carbon nano-tubes. A likely use for the cells would be in spacecraft and satellites, which use large and heavy solar arrays to produce onboard electricity.
Invention Intelligence **42**(6): 33

eNREE invites contributions

eNREE is meant for ENVIS members and all stakeholders interested in advancing, promoting, and sharing the knowledge in renewable energy and environment in India and abroad. We sincerely welcome your help in enriching this newsletter by sending us articles, case studies, etc. and also welcome feedback on the contents of the newsletter to help us make it more informative and rich in content.

Please send in your contributions to

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Web updates

Karnataka Renewable Energy Development Ltd

http://www.kredl.kar.nic.in/

KREDL (Karnataka Renewable Energy Development Ltd) is an organization devoted entirely to the promotion of non-conventional energy sources in Karnataka. The company advises the Government of Karnataka on policies to be adopted for ensuring a systematic and balanced growth of projects for harnessing renewable energy sources. This website provides general information on different forms of renewable energy, state-level energy conservation awards, progress report of grid-connected projects, events, tenders, links, and articles.

Solar energy in India

http://www.indiasolar.com/

This website provides information about renewable energy with focus on solar energy in India. It provides statistical information on solar photovoltaics, solar water heating systems, solar cookers, suppliers and manufacturers, biomass and wind energy use in India, useful links, and events.

Energy Conservation Mission

http://www.save-today-survive-tomorrow.com/

The Institution of Engineers (India), having recognized the need for enhancing awareness on energy conservation measures in various sectors, authorized Andhra Pradesh state centre to constitute an ECM (Energy Conservation Mission). The website of ECM provides information on ECM activities and initiatives. It also provides links to presentations and write-ups to enhance further learning on energy conservation concepts, and technologies.

Green-energy website

http://www.nef.org.uk/greenenergy/index.htm

The NEF (National Energy Foundation) is working actively to promote renewable energy and sustainable development to a wide audience. This section of the NEF website is providing information on renewable energy technologies and relevant links.

Forthcoming events

14–15 August 2008, Kuala Lumpur, **Malaysia**

Clean Power Generation 2008
Avail Corporation
31A SS 19/6C , 47500 Subang Jaya, Selangor, Malaysia
Tel. +603 5637 2531
Fax +603 5632 2318
E-mail info@availcorp.com
Web http://www.availcorp.com/english/events_list.php?eventsid=142&backurl=upcomingevents_list.php

19–25 July 2008, Scotland, **UK**

World Renewable Energy Congress X
World Renewable Energy Congress X, Secretariat, P O Box 362, Brighton, BN2 1YH, United Kingdom
Tel. +44 (0)1273 625643
Fax +44 (0)1273 625768
E-mail asayigh@netcomuk.co.uk
Web www.wrenuk.co.uk

30 June–4 July 2008, Lucerne, **Switzerland**

International Fuel Cell Conference with Exhibition: eighth European SOFC Forum
European Fuel Cell Forum
P O Box 99, orgenacherstrasse 2F
CH-5452 Oberrohrdorf / Switzerland
Tel. +41 56 496 7292
Fax +41 56 496 4412
E-mail forum@efcf.com
Web www.efcf.com

15–19 June 2008, Brisbane, Queensland, **Australia**

17th World Hydrogen Energy Conference, Brisbane, Australia
ICMS Pty Ltd
88 Merivale Street, South Bank
Queensland 4101, Australia
Tel. +61 73 307 4000
Fax +61 73 844 0909
Web www.whec2008.com

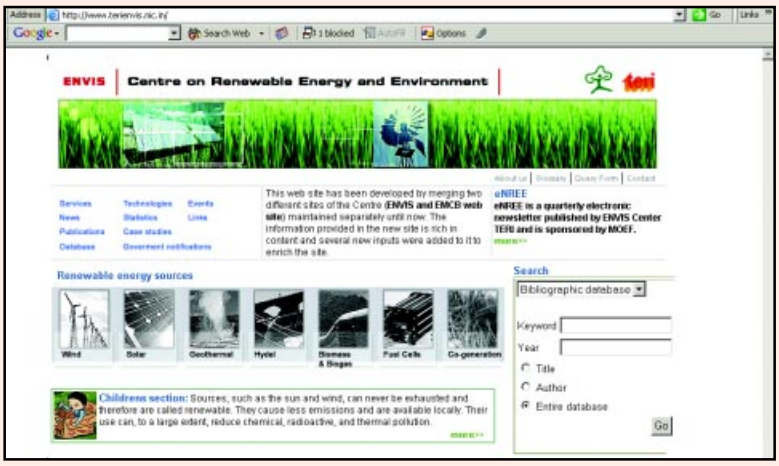
27–29 May 2008, **Sweden**

World Bioenergy 2008: conference and exhibition on biomass for energy
P O Box 6066, SE-550 06 J™NK™PING, Sweden
Tel. +46 (0)36 15 20 00
Fax +46 (0)36 16 46 92
E-mail bioenergy@elmia.se
Web www.worldbioenergy.se

ENVIS Centre on Renewable Energy and Environment

A knowledge gateway

To work towards saving the environment by understanding its myriad facets, the ENVIS (Environmental Information System) network was established under the MoEF (Ministry of Environment and Forests), Government of India, in December 1982. The objective was clear and urgent: work towards bridging the data gaps by developing an environmental information system that will help disseminate information to decision-makers, scientists, and other stakeholders.



<http://www.terienvis.nic.in>

The ministry selected certain institutions/ organizations, universities, academic/research bodies in state governments, corporate houses, and NGOs as ENVIS centres, based on their excellence in research activities. Each centre would work on a specialized subject from the vast expanse of environmental studies available.

TERI became the host to the ENVIS Centre on Renewable Energy and Environment in July 1984. The mandate for the TERI centre is to collect, collate, store, retrieve, and disseminate information on renewable energy and environment as well as to support and promote research and development. The Institute has also hosted the EMCB (Environment Management Capacity Building) Node on Renewable Energy and Environment since 2000/01, a sub-component of ENVIS that aims to build capacity through the development and maintenance of a web site that serves as an information clearing house.

This new-look, revamped website has helped achieve just what the centre set out to do display a world of information at a glance. TERI's ENVIS Centre and the EMCB Node have been actively engaged in resource generation, data collection, problem recognition and provision of solutions, capacity building, and information dissemination. Rich in content that is constantly updated, the site does an impressive job of plugging information gaps that existed in the renewable energy and environmental sectors. Besides, it draws the attention of the Indian scientific community, a fact that becomes evident from the hundreds of technical queries received through the website. Here's a snapshot of some of the main features of the site.

- Regular sections – news, events, statistics, etc. – provide updates on the environmental impact of power, renewable energy, transport, pollution control technologies, hazardous waste management, and other related subjects spanning local and national boundaries.
- Recently developed renewable energy technologies and case studies are added attractions.
- Review articles from the Centre's premier publication *TIDEE* (*TERI's Information Digest on Energy and environment*) enrich the knowledge base of the scientific community by providing information on the latest developments in energy and environment.
- *eNREE* (*E-Newsletter on Renewable Energy and Environment*), a quarterly, non-priced, electronic newsletter (also uploaded on the site) highlights recent issues in the sector.
- The search function for the bibliographic database and the directory of experts can further be screened through categories such as title, author, etc. The online bibliographic database includes bibliographic records of selected fields from 1991 onwards, covering over 11 000 records. The centre is also building up an exhaustive Directory of Experts on Renewable Energy and Environment.
- The colourful and lively children's section, *Edugreen*, lives up to its tag line—'making environmental learning fun for the young'.

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