ENVIRONMENTAL BIOTECHNOLOGY

(Abstract January 2000 onwards)

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C O N T E N T S

BACKGROUND

Environmental Information System (ENVIS) is established in the year 1984 as a network of

Information Centre. It is planned by the Ministry of Environment and Forest. Aim of this centre is to provide descriptive data and environmental subject related numerical data. Now 35 centres are working under this network on various subjects area in the country. The focal point of this network is at the Ministry of Environmental and Forest, Government of India, New Delhi.

EMCB-ENVIS Centre (27) is established for studies on Environmental Biotechnology as Pollutant Degradation at the University of Kalyani, Department of Environmental Science, Nadia-741235, West Bengal.

The objective of this centre is to collect data, related to the above mentioned subject, from different major libraries in Kolkata with different journals, Annual reviews, Internet and to generate a database and to create a website with this database. View point of this journal abstract is to help the interested research workers, scientist, administrator and the public.

This is the first publication of this ENVIS Centre. This contains the abstract of research papers collected in the area of Environmental Biotechnology from various journal published during January 2000 onwards. Here various topics like Bio-engineering, Bio-degradation, Bio-remediation, Bio-transformation etc. are covered. We are grateful to the various libraries and their staff for their extended cooperation in the collection of the articles.

Abstract Format

The format of the abstract is as follows:

Abstract : The abstracts were arranged in alphabetic orders different subheads.

Author: Name of the authors are given in the order in which they appear in the original document. These names are given in succession.

Address of Authors: Address of the author is given in parenthesis at the end of the author name. When the address of any other author is found, it is written after wards delimited by stop(.).

Locus: The name of the journal are followed by the volume number, the issue number, the year of publication and the page no.

GENERAL INFORMATION

Abstract have been taken directly from source document like research report, journals, Internet, seminars, proceedings, standards and patents. All the resources published within the year 2000-2002.

Abstract are broadly classified and arranged under the following heads:

Bioaccumulation: It studies address the buildup of bioaccumulative compounds through biomagnification and/or bioconcentration. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. Understanding the dynamic process of bioaccumulation is very important in protecting human beings and other organisms from the adverse effects of chemical exposure, and it has become a critical consideration in the regulation of chemicals.

Bioremediation: It is a clean-up technology that uses naturally occurring microorganisms to degrade hazardous substances into less toxic or nontoxic compounds. These microorganisms may:

1. Ingest and degrade organic substances as their food and energy source,

2. Degrade organic substances, such as chlorinated solvents or petroleum products, that are hazardous to living organisms, including humans, anddegrade the organic contaminants into inert products.

Because the microorganisms already occur naturally in the environment they pose no contamination risk.

Bio-Transformation: This is a process of Biological changes of complex compound to simpler toxic to non-toxic or vice-versa. Several microorganism are capable of transforming a varity of compound founding nature but generally with respect to synthetic compound they are unable to show any appropriate action. Biotransfer appears to be one of the major detoxication method known so far.

Biomarker: It is a biological response to a chemical that gives a measure of exposure and, sometimes, of toxic effect.Biological markers found in crude oils and source rock extracts can provide molecular evidence of the correlation among oils and their sources.

Bioenergy: In recent decades, efforts were made for evolving were non-polluting bioenergy sources or energy generation from organic waste or biomass. These are all ecofreindly solution. Biomass energy supply demand balances have become a component of energy sector analysis and planning and assumed greater importance in countries. These are variety of biological energy sources. Biomass, Biogas, Hydrogen are the example of Bioenergy.

Biofertilizer: To reduce the impact of excess chemical fertilizers in the field of agriculture the biofertilizer is a potential tool, biologically fixed nitrogen is such a source which can supply an adequate amount of Nitrogen to plants and other nutrients to some extent. Many free living and symbiotic bacteria which fix atmospheric Nitrogen were used as biofertiliser material as a substitute for Nitrogen fertilizer. In general two types of biofertiliser are used

1. Bacterial Biofertilizer
2. Algal Biofertilizer

Biocomposting: It involves combining organic materials under conditions that enables them to decompose more quickly than they would in nature. Think about logs and leaves on the ground in a forest. The leaves will break down and disappear within a year. Logs of course will take much longer to crumble away. Composting involves combining organic materials under conditions that enables them to decompose more quickly than they would in nature.

Biopesticide: pest control by biological antagonism appears to be very useful tool in recent years. Bacterial pesticides are being developed. Heliothis complex, which lives in close association with plant roots, consists of two major crop pests budworm and ball warm. Biological insecticides against both these insects are being prepared by transfer of a gene from *Bacillus thuringiensis*

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Biodegradation: It is nature's way of recycling wastes, breaking down organic matter into nutrients that can be used by other organisms. "Degradation" means decay, and the "bio-" prefix means that the decay is carried out by a huge assortment of bacteria, fungi, maggots, worms, and other organisms that eat dead material and recycle it into new forms.

In nature, there is no waste because everything gets recycled. The waste products from one organism become the food for others, providing nutrients and energy while breaking down the waste organic matter. Some organic materials will break down much faster than others, but all will eventually decay.

By harnessing these natural forces of biodegradation, people can reduce wastes and clean up some types of environmental contaminants. Through **composting**, we accelerate natural biodegradation and convert organic wastes to a valuable resource.

Biosensor: Biosensor represents biophysical devices which will detect the presence and measure the quantities of specific substances in a varity of environments. These specific substances may include sugars, proteins, or humas and varity of toxins in the industrial effluents. In designing a biosensor an enzyme or an antibody or even microbial cells are associated with microchip devices which are used for quantitative estimate of a substance.

Bioengineering: It is a developing speciality featuring a multidisciplinary approach to the solution of problems in medicine and biology, based on the application of advances in science, engineering and technology. A major focus for bioengineering is to improve the quality of life of people with medical conditions that restrict independent living and integration within the community.

Pollen-Biotechnology: This is a new field of science delaying with the pollen chemistry allerginicity of aerospora. This subject also covers genetic manipulation of pollen development of haploid culture. Such haploid plant have remains values in genetic research.

Biotechnology Policy Issue: Biotechnology appears to be a emerging science in present decades. Genetic manipulation and development of genetically modified organism in human welfare is now showed a potential prospect and risk. Thus researches and application of Biotechnology in diverse field is a major policy issue in the present decades.

Agricultural Biotechnology: Over the years tremendous success was made in diverse field of agriculture by applying Biotechnology. It includes development of genetically modified crops, genetically improvement in sericulture practices, improvement in Biofertilizer development and similar other aspects. Crop production against pest and disease stress resistance of crops also considered to be emerging area of Agricultural Biotechnology.

ABBREVIATIONS USED IN ADDRESSES AND CITED JOURNALS

Acad	Academy	Chem	Chemistry
Adm	Administration	Chemi	Chemical
Admn	Administrative	Clini	Clinical
Adv	Advance	Co	Company
Agric	Agriculture	Coil	College
Agrici	Agricultural	Comm	Committee
Amer,	American	Commn	Commission
An	Annual	Comp	Comparative
Analyt	Analytical	Conf	Conference
Anat	Anatomy	Conv	Convention
Anim	Animal	Conserv	Conservation
Ann	Annals	Conti	Control
Appt	Applied	Contam	Contamination
Arch	Archives	Corpn	Corporation
Archaeo	Archaeology	Coun	Council
Archaeol	Archaeological	Cult	Culture
Architect	Architecture	Cultl	Cultural
Assoc	Association	Curr	Current
Asst	Assistant	Dept	Department
Atom	Atomic	Dev	Development
Bacterio	Bacteriology	Develop	Developmental
Bacteriol	Bacteriological	Dig	Digest
Bd	Board	Div	Division
Bio	Biology	Divl	Divisional
Biochem	Biochemistry	Dte	Directorate
Biochemi	Biochemical	Dy	Deputy
Bioengng	Bioengineering	Eco	Ecology
Biol	Biological	Ecol	Ecological
BiometeO	Biometeorology	Econ	Economics
Biophys	Biophysics	Ecosys	Ecosystem
Biometeol	Biometeorological	Exotoxico	Ecotoxicology
Biotech	Biotechnique(s)	Endocrinol	Endocrinological
Biotechno	Biotechnology	Engng	Engineering
Biotechnol	Bitechnological	Engrs	Engineers
Bidg	Building	Env	Environment
Bot	Botany	Environ	Environmental
Boti	Botanical	Epidemic	Epidemiology
Br	Branch	Epidemiol	Epidemiological
Bull	Bulletin	Estb	Establishment
Cent	Centre	Ethnopharmaco	Ethnopharmacology
Centl	Central	Exot	Experiment

Expti	Experimental	Microbiol	Microbiological
Fac	Faculty	Min	Ministry
Fd	Food	Monit	Monitoring
Fedn	Federation	Myco	Mycology
Fert	Fertiliser	Mycol	Mycological
Fmg	Farming	Nat	Natural
Gaz	Gazette	Natl	National
Genet	Genetics	N-E	North Eastern
Geo	Geology	Nut	Nutrition
Geogr	Geography	No	Number
Geogri	Geographical	Occ	Occassional
Geol	Geological	Occupl	Occupational
Geosci	Geoscience	Oceanogr	Oceanogoraphy
Govt	Government	Org	Organic
Hist	History	Orgn	Organisation
Hlth	Health	Pharmaco	Pharmacology
Hort	Horticulture	Pharmacol	Pharmacological
Hosp	Hospital	Phyl	Physical
Hydro	Hydrology	Patho	Pathology
Hydrol	Hydrological	Pathol	Pathological
Immuno	Immunology	Petrochemi	Petrochemical
Immunol	Immunlogical	Petro	Petrology
Ind	Industry	PG	Post Graduate
Inf	Information	Phys	Physics
Inst	Institute	Physio	Physiology
Instn	Institution	Phytopath	Phytopathology
Int	International	Phytopathol	Phytopathological
Irrig	Irrigation	Plang	Planning
J	Journal	Polln	Pollution
Lab	Laboratory	Proc	Proceedings
Lett	Letter(s)	Prot	Protection
Ltd	Limited	Pub	Publication
Malario	Malariology	Pvt	Private
Malariol	Malariological	Qlty	Quality
Manag	Management	Qr	Quarter
Med	Medicine	Rad	Radiation
Medl	Medical	Radio	Radiology
Metab	Metabolism	Radiol	Radiological
Metall	Metallurgy	Rd	Road
Metallurg	Metallurgical	Recd	Received
Meteo	Meteorology	Reg	Region
Meteol	Meteorological	Regl	Regional
Microbio	Microbiology		
Rep	Report	Stud	Studies
Reptr	Reporter	Surv	Survey
Res	Research	Syst	System
Rev	Review	Tax	Taxonomy
Sch	School(s)	Techi	Technical
Sci	Sciences(s)	Techno	Technology
Scient	Scientific	Technol	Technological
S-E	South East	Toxico	Toxicology
Sec	Section	Toxicol	Toxicological
Sect	Sector	Trans	Transcations

Semin	Seminar	Trans	Transportation
Ser	Services	Tmg	Training
Soc	Society	Trop	Tropical
Sod	Social	Univ	University
Stat	Statistics	Util	Utilisation
Stati	Statistical	Vet	Veterinary
Stand	Standard(s)	Zoo	Zoology
Std	Study	Zool	Zoological

Bioaccumulation

Chinmoy Chatterjee. (Department of Zoology Raniganj Girls' College (Burdwan University, Raniganj-713347, W.B., India). **Bioaccumulation of Lead In Blood of Traffic Police Personnel Employed In Traffic Dense Areas of G.T. Road Between Asansol And Durgapur, India**. Poll Res. 20 (2) (2001),183-185.

Traffic police personnel working in the traffic dense areas are exposed to heavy traffic for long periods. Experiments were conducted to determine the blood lead concentrations of the traffic policemen exposed to lead emitted by the automobiles. Blood samples of the traffic police personnel employed in the traffic dense areas on G.T. Road between Asansol and Durgapur industrial cities, were taken for determination of blood levels and haematological tests. The results showed that concentration of lead in blood was very high among the traffic policemen as compared to that of the control group. However, no significant abnormality in haematological parameters was detected.

Kazutoshi Saeki, Hiroyuki Sakakibara, Haruya Sakai, Takashi Kunito, Shinsuke Tanabe. (Oita University, Dannoharu 700, Oita, 870–1192, Japan.Department of Environment Conservation, Ehime University, Tarumi 3-5-7, Matsuyama 790 8566, Japan. Department of Environment Conservation, Ehime University, Tarumi 3-5-7, Matsuyama 790 8566, Japan. Center for Marine Environmental Studies (CMES), Ehime University, Tarumi 3-5-7, Matsuyama 790 8566, Japan Present addresses: Faculty Agriculture of Kobe University, Kobe, Japan. Center for Marine Environmental Studies (CMES), Ehime University, Tarumi 3-5-7, Matsuyama 790 8566, Japan Present addresses: Faculty Agriculture of Kobe University, Kobe, Japan). **Arsenic accumulation in three species of sea turtles**. BioMetals, 13 (3) (2000), 241-250.

Arsenic in the liver, kidney and muscle of three species of sea turtles, e.g., green turtles (*Chelonia mydas*), loggerhead turtles (*Caretta caretta*) and hawksbill turtles (*Eretmochelys imbricata*), were determined using HG-AAS, followed by arsenic speciation analysis using HPLC-ICP-MS. The order of arsenic concentration in tissues was muscle > kidney > liver. Unexpectedly, the arsenic concentrations in the hawksbill turtles feeding mainly on sponges were higher than the two other turtles primarily eating algae and mollusk, which accumulate a large amount of arsenic. Especially, the muscles of the hawksbill turtles contained remarkably high arsenic concentrations averaging 153 mg kg-1 dry weight with the range of 23.1–205 mg kg-1 (n=4), even in comparison with the data from other organisms. The arsenic concentrations in the tissues of the green turtles were significantly decreased with standard carapace length as an indicator of growth. In arsenic compounds, arsenobetaine was mostly detected in the tissues of all the turtles. Besides arsenobetaine, a small amount of dimethylarsinic acid was also observed in the hawksbill turtles.

M Balaji, K Satyanarayana Rao. **Size dependent bioaccumulation of heavy metals by *Mytiiopsis satlei* (Recluz) at Visakhapatnam harbour**. India Journal of Experimental Biology, 38(4) (2000), 405-407.

Relationship between body size and bioaccumulation of copper, zinc, lead and cadmium in the fouling bivalve, *M. satlei* (Recluz) in Visakhapatnam harbour was studied: While concentration of copper, zinc and lead decrease with increasing size, no such relationship is observed for cadmium.

Monica Bhatnagar, Ashish Bhatnagar, Sapna Jha. (Department of Microbiology, Maharshi Dayanand Saraswati University, Ajmer 305 001, Rajasthan, India .Department of Microbiology, Maharshi Dayanand Saraswati University, Ajmer 305 001, Rajasthan, India). **Interactive biosorption by microalgal biomass as a tool for fluoride removal**. Biotechnology Letters, 24(13) (2002), 1079-1081.

Maximum biosorption of Ca2+ was at 50 mg Ca2+ l-1 with both *Anabaena fertilissima* (2.8 mg Ca2+ g-1 dry wt) and *Chlorococcum humicola* (4.4 mg g-1). Such Ca2+-treated biomasses, accumulated, respectively, 7 mg F g-1 DW from an aqueous solution of 10 mg F l-1 and 4.5 mg F g-1 DW from 15 mg F l-1. Data for both Ca2+ and F- biosorption fitted the Langmuir adsorption isotherm indicating monolayer adsorption at a constant energy.

P.S. Dhami, R. Kannan, P.W. Naik, V. Gopalakrishnan, A. Ramanujam, N.A. Salvi, S. Chattopadhyay. (Process Development Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India. Bio-Organic Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India). **Biosorption of americium using biomasses of various *Rhizopus* species**. Biotechnology Letters, 24(11) (2002), 885-889.

Biomasses from eight different *Rhizopus* species were tested for the sorption of americium from nitric acid medium. *Rhizopus arrhizus* NCIM 997 showed maximum sorption at pH 2. Laboratory scale experiments were carried out using this biomass in packed columns for the sorption of a-activity from an americium spiked low level waste stream of PUREX process. The biomass was found to be an excellent sorbent for remediation of low level waste streams on once through basis.

Pinaki Sar, Stanislaus F. D'Souza. (Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India). **Biosorption of thorium (IV) by a *Pseudomonas* biomass**. Biotechnology Letters, 24(3) (2002), 239-243.

Lyophilized biomass of a *Pseudomonas* soil isolate adsorbed thorium (IV) (430 mg g-1 dry wt) optimally at pH 4, with 91% of equilibrium loading being reached in 1 min. Equilibrium metal sorption showing conformity to Langmuir isotherm model suggested a monolayered thorium binding. Thorium binding remained unaffected or slightly affected (< 20% inhibition) in presence of equimolar (430 µM) concentration of several interfering ions except Fe3+ (40% inhibition). More than 90% of loaded thorium could be recovered using 1 M $CaCO_3$, though mineral acids and Na_2CO_3 were also effective.

R.S. Sindhu, Reeta Sharma. (Regional Institute of Education, Bhopal - 462 013). **Bioaccumulation of lead, cadmium and mercury by *Gallium tricorne***. Poll Res. 18(4) (1999), 395-397.

Bioaccumulation of lead, cadmium and mercury by *Gallium tricorne* was investigated by performing pot experiments. The plants were treated with different concentrations of the metals in the form of their metal nitrates, through soil. In each case the investigation period was four weeks. The order of accumulation was Pb > Cd > Hg. While lethal dose for Pb and Cd was 1000 ug/ml, for Hg it was 800 ug/ml.

Subhashree Pradhan, L.C. Rai. (Laboratory of Algal Biology, Department of Botany, Banaras Hindu University, Varanasi- 221 005, INDIA. Laboratory of Algal Biology, Department of Botany, Banaras Hindu University, Varanasi- 221 005, INDIA). **Biotechnological potential of *Microcystis* sp. in Cu, Zn and Cd biosorption from single and multimetallic systems**. BioMetals, 14(1) (2001), 67-74.

This paper provides information on biosorption of Cu, Zn and Cd by *Microcystis* sp. in single, bi and trimetallic combination. Highest biosorption of Cu followed by Zn and Cd in single as well as in mixtures containing two or three metals was noticed. The order of inhibition of Cu, Zn and Cd biosorption in bi and trimetallic combinations was suggestive of screening or competition for the binding sites on the cell surface. This observation was reconfirmed by Freundlich adsorption isotherm. Kf values were maximum for Cu (Kf=45.18), followed by Zn (Kf=16.71), and Cd (Kf=15.63) in single metallic system. The Kf values for each test metal was reduced in solution containing more than one metal. Further, the reduction in biosorption of each metal ion due to presence of other metal ion was of greater magnitude at relatively higher concentrations of interfering metal ion. The biosorption of Cu at saturation was less affected when secondary metal (Cd or Zn) was added in the medium. Above results suggest that *Microcystis* holds great potential for metal biosorption from mixture.

Biocomposting

Habib, F.M., M.A.Negm, and M.M.Hassan. (1-Soils and Agric.Chem.Dept.,Faculty of Agric.,Moshtohor,Zagazic Univ.,Egypt. 2-Soils,Water and Environment Research Institute, Agric.Res.Centre,Giza,Egypt). **Composting of sugerbeet residues (1) A study on condition and period of composting**. The Egyptan Journal of Agriculture Research, 79(2) (2001).

A laboratory work was conducted to monitor two composting systems, aerobic and anaerobic for 9 months. Sugarbeet residues whether resulted from haulms, preparation the roots in field and before squeezing to obtain sugar were collected, air dried and chopped into pieces one inch long. The whole quantity was divided into two portions. One of them was composted under aerobic and the other under anaerobic conditions. Samples of each system were taken after 0, 7, 15 days then monthly Lip to 9 months. Results showed that organic matter content decreased with time of composting in a rate higher in case of aerobic compost than in anaerobic one. Humus and organic acids increased with time of composting. Their concentrations under anaerobic conditions were higher than those under aerobic when the period of composting was longer than 6 months. Total nitrogen increased. In the same time, C/N ratio narrowed gradually by time of composting. That ratio was more wide in anaerobic than in aerobic compost. Ammonification process was active through time and produced more ammonia in anaerobic case. Nitrification activity was detected only in aerobic conditions. Total phosphorus and total potassium followed the same trend of total nitrogen. Ratios of C/P and C/K were almost similar to those of C/N. As percent of decomposed material increased. pH of compost decreased slowly in aerobic case but under anaerobic condition.It was more acidic after 9 months. Total soluble salts in the mixture at 0 time was about 2.1%. That percentage increased gradually recording more high salinity in compost of anaerobic condition up to times of its eginning. Soluble sodium and potassium behaved in similar trend of total soluble salts. The increases in total soluble salts resulted from more soluble Ca++. Water holding capacity in composting samples revealed gradual increases under two composting systems up to 15 days in aerobic versus 60 days in anaerobic system followed by a decrease in both cases. As for moisture content, it gradually increased with

time of composting under both systems, but it was higher under anaerobic Conditions.

Biodegradation

A. Philippoussis, G. Zervakis, P. Diamantopoulou. (National Agricultural Research Foundation, Institute of Agricultural Engineering, Edible Fungi Research Laboratory, 61 Democratias St., 135 61 Ag. Anargyri, Athens, Greece. National Agricultural Research Foundation, Institute of Kalamata, 85 Lakonikis St., 241 00 Kalamata, Greece. National Agricultural Research Foundation, Institute of Agricultural Engineering, Edible Fungi Research Laboratory, 61 Democratias St., 135 61 Ag. Anargyri, Athens, Greece). **Bioconversion of agricultural lignocellulosic wastes through the cultivation of the edible mushrooms *Agrocybe aegerita, Volvariella volvacea* and *Pleurotus* spp**. World Journal of Microbiology and Biotechnology, 17(2) (2001), 191-200.

Ten selected wild and commercial strains of *Pleurotus ostreatus*, *Pleurotus eryngii*, *Pleurotus pulmonarius*, *Agrocybe aegerita* and *Volvariella volvacea* were cultivated on three agricultural wastes, i.e. wheat straw (WS), cotton waste (CW) and peanut shells (PS). All species demonstrated significantly higher colonization rates on WS and CW than on PS. WS supported faster growth of *A. aegerita* and *Pleurotus* spp., whereas *V. volvacea* performed better on CW. Comparison of growth rates on composted and non-composted WS and CW substrates revealed that in the latter case faster colonization was achieved, particularly for *Pleurotus* spp. However, one commercial strain of *V. volvacea* presented higher growth rates when the composted CW medium was used. Furthermore, earliness in the fructification of *P. ostreatus*, *P. pulmonarius* and *V. volvacea* strains was promoted in CW substrates, while WS favoured earliness of *P. eryngii* and *A. aegerita*. Similarly, high sporophore yields were obtained by *P. ostreatus* and *P. pulmonarius* on both wastes, whereas WS enhanced yield and basidioma size of *P. eryngii* and *A. aegerita* strains and CW production of *V. volvacea*. The substrates cellulose:lignin ratios were found to be positively correlated to mycelial growth rates and to mushroom yield of *P. ostreatus* and *P. pulmonarius*; in addition, positive correlation was also detected for carbon:nitrogen ratio and mushroom yield in *P. eryngii* and *A. aegerita* and between cellulose content and mushroom yield for *V. volvacea* strains.

A.A. Leontievsky , N.M. Myasoedova, B.P. Baskunov, C.S. Evans, L.A. Golovleva. (Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, 142292 Pushchino Moscow region, Russia. Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, 142292 Pushchino Moscow region, Russia. Fungal Biotechnology Group, University of Westminster, London W1M 8JS, U.K. Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, 142292 Pushchino Moscow region, Russia. Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, 142292 Pushchino Moscow region, Russia). **Transformation of 2,4,6-trichlorophenol by the white rot fungi *Panus tigrinus* and *Coriolus versicolor***. Biodegradation, 11(5) (2000), 331-340.

The toxicity of thirteen isomers of mono-, di-, tri- and pentachlorophenols was tested in potato-dextrose agar cultures of the white rot fungi *Panus tigrinus* and *Coriolus versicolor*. 2,4,6-Trichlorophenol (2,4,6-TCP) was chosen for further study of its toxicity and transformation in liquid cultures of these fungi. Two schemes of 2,4,6-TCP addition were tested to minimize its toxic effect to fungal cultures: stepwise addition from the moment of inoculation and single addition after five days of growth. In both cases the ligninolytic enzyme systems of both fungi were found to be responsible for 2,4,6-TCP transformation. 2,6-Dichloro-1,4-hydroquinol and 2,6-dichloro-1,4-benzoquinone were found as products of

primary oxidation of 2,4,6-TCP by intact fungal cultures and purified ligninolytic enzymes, Mn-peroxidases and laccases of both fungi. However, primary attack of 2,4,6-TCP in *P. tigrinus* culture was conducted mainly by Mn-peroxidase, while in *C. versicolor* it was catalyzed predominantly by laccase, suggesting a different mode of regulation of these enzymes in the two fungi.

Abd El-Rahman Mansy, Ebtesam El-Bestawy. (Agricultural Research Center at Sabahia, Central Laboratory of Pesticides, Alexandria, Egypt. Department of Environmental Studies, Institute of Graduate Studies and Research, Alexandria University, Alexandria, Egypt). **Toxicity and biodegradation of fluometuron by selected cyanobacterial species**. World Journal of Microbiology and Biotechnology, 18(2) (2002), 125-131.

The Biodegradation capabilities of six selected cyanobacterial species for fluometuron, a phenylurea herbicide, as well as its inhibitory effect on chlorophyll a content were investigated. The selected species (three strains of *Microcystis aeruginosa, Anabaena cylindrica*, *A. flos-aquae* and *A. spiroides*) were subjected to three elevated concentrations of fluometuron (0.14, 0.7 and 1.4 mg/ml) for different exposure times (1–5 days). Results revealed that biodegradation of fluometuron is species-dependent and positively correlated with the exposure time, reaching maximum efficiency after 5 days at all the investigated concentrations. All the species tested showed generally great ability to degrade the compound even at the highest concentration with specific variations among them. Biodegradation efficiencies of fluometuron by the selected species were in the following ranges; 39.2–99.9; 87.5–100; and 93.2–100 at 0.14; 0.7 and 1.4 mg fluometuron/ml respectively. It was noticed that the gradual increase in the pesticide concentration enhances its biodegradability by the selected algal species. Variations according to species as well as exposure time were discussed. The highest fluometuron concentration (1.4 mg/l) showed the highest inhibition of chlorophyll a content in the tested species and toxicity was also species and time-dependent.

Albert L. Juhasz * and Ravendra Naidu. (CSIRO Land and Water, PMB 2, Glen Osmond, Adelaide, SA 5064, Australia). **Bioremediation of high molecular weight polycyclic aromatic hydrocarbons: a review of the microbial degradation of benzo[a]pyrene**. International Biodeterioration & Biodegradation, 45(1-2) (2000), 57-88.

Over the past 30 years, research on the microbial degradation of polycyclic aromatic hydrocarbons (PAHs) has resulted in the isolation of numerous genera of bacteria, fungi and algae capable of degrading low molecular weight PAHs (compounds containing three or less fused benzene rings). High molecular weight PAHs (compounds containing four or more fused benzene rings) are generally recalcitrant to microbial attack, although some fungi and, algae are capable of transforming these compounds. Until recently, only a few genera of bacteria have been isolated with the ability to utilise four-ring PAHs as sole carbon and energy sources while cometabolism of five-ring compounds has been reported. The focuss of this review is on the high molecular weight PAH benzo[a]pyrene (BaP). There is concern about the presence of BaP in the environment because of its carcinogenicity, teratogenicity and toxicity. BaP has been observed to accumulate in marine organisms and plants, which could indirectly cause human exposure through food consumption. This review provides an outline of the occurrence of BaP in the environment and the ability of bacteria, fungi and algae to degrade the compound, including pathways for BaP degradation by these organisms. In addition, approaches for improving microbial degradation of BaP are discussed.

Anita Singh a, 0m P. Sharma a * and Sudarshan Ojha b (Biochemistry Laboratory, Indian Veterinary Research Institute, Regional Station, Kangra Valley, Palampur 176061, Himachal Pradesh, India, Department of Biochemistry, Punjab University, Chandigarh 160014, India). **Biodegradation of lantadene A, the hepatotoxin of Lantana plant**. International Biodeterioration & Biodegradation, 46 (2) (2000), 107-110.

A bacterial strain, *Alcaligenes odorans*, has been isolated, by enrichment from soil, using lantadene A (LA), the pentacyclic triterpenoid from lantana plant, as the sole carbon source. The strain is Gram negative, motile, catalase positive and is capable of utilizing LA. The utilization of LA was less when glucose was used as cosubstrate. The isolate did not utilize lantadene B, a congener of lantadene A.

Alfred M. Spormann, Friedrich Widdel. (Departments of Civil and Environmental Engineering, and of Biological Sciences, Stanford University, Stanford, CA 94305-4020, USA. Max-Planck-Institut für Marine Mikrobiologie, Celsiusstrasse 1, D-28359 Bremen, Germany). **Metabolism of alkylbenzenes, alkanes, and other hydrocarbons in anaerobic bacteria**. Biodegradation, 11(2-3) (2000), 85-105.

Aromatic and aliphatic hydrocarbons are the main constituents of petroleum and its refined products. Whereas degradation of hydrocarbons by oxygen-respiring microorganisms has been known for about a century, utilization of hydrocarbons under anoxic conditions has been investigated only during the past decade. Diverse strains of anaerobic bacteria have been isolated that degrade toluene anaerobically, using nitrate, iron(III), or sulfate as electron acceptors. Also, other alkylbenzenes such as m-xylene or ethylbenzene are utilized by a number of strains. The capacity for anaerobic utilization of alkylbenzenes has been observed in members of the a-, ß-, ?- and d-subclasses of the Proteobacteria. Furthermore, denitrifying bacteria and sulfate-reducing bacteria with the capacity for anaerobic alkane degradation have been isolated, which are members of the ß- and d-subclass, respectively. The mechanism of the activation of hydrocarbons as apolar molecules in the absence of oxygen is of particular interest. The biochemistry of anaerobic toluene degradation has been studied in detail. Toluene is activated by addition to fumarate to yield benzylsuccinate, which is then further metabolized via benzoyl-CoA. The toluene-activating enzyme presents a novel type of glycine radical protein. Another principle of anaerobic alkylbenzene activation has been observed in the anaerobic degradation of ethylbenzene. Ethylbenzene in denitrifying bacteria is dehydrogenated to 1-phenylethanol and further to acetophenone; the latter is also metabolized to benzoyl-CoA. Naphthalene is presumably activated under anoxic conditions by a carboxylation reaction. Investigations into the pathway of anaerobic alkane degradation are only at the beginning. The saturated hydrocarbons are most likely activated by addition of a carbon compound rather than by desaturation and hydration, as speculated about in some early studies. An anaerobic oxidation of methane with sulfate as electron acceptor has been documented in aquatic sediments. The process is assumed to involve a reversal of methanogenesis catalyzed by Archaea, and scavenge of an electron-carrying metabolite by sulfate-reducing bacteria. Among unsaturated non-aromatic hydrocarbons, anaerobic bacterial degradation has been demonstrated and investigated with n-alkenes, alkenoic terpenes and the alkyne, acetylene.

Alwell U. Nwankwoala, Kafui Nyavor. (Environmental Engineering Program, Department of Chemical Engineering. Tuskegee University, Tuskegee, AL 36088, USA. Environmental Engineering Program, Department of Chemical Engineering. Tuskegee University, Tuskegee, AL 36088, USA). **Enhanced biodegradation of methylhydrazine and hydrazine contaminated NASA wastewater in fixed-**

film bioreactor. Biodegradation, 12(1) (2001), 1-10.

The aerobic biodegradation of National Aeronautics and Space Administration (NASA) wastewater that contains mixtures of highly concentrated methylhydrazine/hydrazine, citric acid and their reaction product was studied on a laboratory-scale fixed film trickle-bed reactor. The degrading organisms, *Achromobacter* sp., *Rhodococcus* B30 and *Rhodococcus* J10, were immobilized on coarse sand grains used as support-media in the columns. Under continuous flow operation, *Rhodococcus* sp. degraded the methylhydrazine content of the wastewater from a concentration of 10 to 2.5 mg/mL within 12 days and the hydrazine from ~0.8 to 0.1 mg/mL in 7 days. The *Achromobacter* sp. was equally efficient in degrading the organics present in the wastewater, reducing the concentration of the methylhydrazine from 10 to ~5 mg/mL within 12 days and that of the hydrazine from ~0.8 to 0.2 mg/mL in 7 days. The pseudo first-order rate constants of 0.137 day-1 and 0.232 day-1 were obtained for the removal of methylhydrazine and hydrazine, respectively, in wastewater in the reactor column. In the batch cultures, rate constants for the degradation were 0.046 and 0.079 day-1 for methylhydrazine and hydrazine respectively. These results demonstrate that the continuous flow bioreactor afford greater degradation efficiencies than those obtained when the wastewater was incubated with the microbes in growth-limited batch experiments. They also show that wastewater containing hydrazine is more amenable to microbial degradation than one that is predominant in methylhydrazine, in spite of the longer lag period observed for hydrazine containing wastewater. The influence of substrate concentration and recycle rate on the degradation efficiency is reported. The major advantages of the trickle-bed reactor over the batch system include very high substrate volumetric rate of turnover, higher rates of degradation and tolerance of the 100% concentrated NASA wastewater. The results of the present laboratory scale study will be of great importance in the design and operation of an industrial immobilized biofilm reactor for the treatment of methylhydrazine and hydrazine contaminated NASA wastewater.

Ana C. Morán, Nelda Olivera, Marta Commendatore, José L. Esteves, Faustino Siñeriz. (lanta Piloto de Procesos Industriales Microbiológicos (PROIMI), Belgrano y Caseros, (4000) Tucumán, Argentina. Centro Nacional Patagónico (CENPAT), Bv. Brown s/n, (9120) Pto. Madryn, Chubut, Argentina. Centro Nacional Patagónico (CENPAT), Bv. Brown s/n, (9120) Pto. Madryn, Chubut, Argentina. Centro Nacional Patagónico (CENPAT), Bv. Brown s/n, (9120) Pto. Madryn, Chubut, Argentina. Cátedra de Microbiología Superior, Facultad de Bioquímica, Química y Farmacia, Universidad Nacional de Tucumán, Belgrano y Caseros, (4000) Tucumán, Argentina). **Enhancement of hydrocarbon waste biodegradation by addition of a biosurfactant from *Bacillus subtilis O9***. Biodegradation, 11(1) (2000), 65-71.

A non-sterile biosurfactant preparation (surfactin) was obtained from a 24-h culture of *Bacillus subtilis O9* grown on sucrose and used to study its effect on the biodegradation of hydrocarbon wastes by an indigenous microbial community at the Erlenmeyer-flask scale. Crude biosurfactant was added to the cultures to obtain concentrations above and below the critical micelle concentration (CMC). Lower concentration affected neither biodegradation nor microbial growth. Higher concentration gave higher cell concentrations. Biodegradation of aliphatic hydrocarbons increased from 20.9 to 35.5% and in the case of aromatic hydrocarbons from nil to 41%, compared to the culture without biosurfactant. The enhancement effect of biosurfactant addition was more noticeable in the case of long chain alkanes. Pristane and phytane isoprenoids were degraded to the same extent as n-C17 and n-C18 alkanes and, consequently, no decrease in the ratios

n-C17/pri and n-C18/phy was observed. Rapid production of surfactin crude preparation could make it practical for bioremediation of ship bilge wastes.

Ana Elías, Astrid Barona, F. Javier Ríos, Anje Arreguy, Miguel Munguira, Javier Peñas, J. Luis Sanz. (Department of Chemical and Environmental Engineering, Engineering School, University of the Basque Country, Alda Urquijo s/n. 48013 Bilbao, Spain. Department of Chemical and Environmental Engineering, Engineering School, University of the Basque Country, Alda Urquijo s/n. 48013 Bilbao, Spain. Department of Chemical and Environmental Engineering, Engineering School, University of the Basque Country, Alda Urquijo s/n. 48013 Bilbao, Spain. Department of Chemical and Environmental Engineering, Engineering School, University of the Basque Country, Alda Urquijo s/n. 48013 Bilbao, Spain. Department of Chemical and Environmental Engineering, Engineering School, University of the Basque Country, Alda Urquijo s/n. 48013 Bilbao, Spain. Department of Chemistry and Edaphology, Faculty of Science, University of Navarra, Spain. Department of Molecular Biology, Universidad Autónoma Madrid, 28049 Madrid, Spain). **Application of biofiltration to the degradation of hydrogen sulfide in gas effluents**. Biodegradation, 11(6) (2000), 423-427.

A laboratory scale bioreactor has been designed and set up in order to degrade hydrogen sulfide from an air stream. The reactor is a vertical column of 7 litre capacity and 1 meter in height. It is divided into three modules and each module is filled with pellets of agricultural residues as packing bed material. The gas stream fed into the reactor through the upper inlet consists of a mixture of hydrogen sulfide and humidified air. The hydrogen sulfide content in the inlet gas stream was increased in stages until the degradation efficiency was below 90%. The parameters to be controlled in order to reach continuous and stable operation were temperature, moisture content and the percentage of the compound to be degraded at the inlet and outlet gas streams (removal or elimination efficiency). When the H2S mass loading rate was between 10 and 40 g m-3h-1, the removal efficiency was greater than 90%. The support material had a good physical performance throughout operation time, which is evidence that this material is suitable for biofiltration purposes.

André Ferraz, Jaime Rodríguez, Juanita Freer, Jaime Baeza. (Departamento de Biotecnologia, Faculdade de Engenharia Química de Lorena, CP 116, 12600-000 Lorena, SP, Brazil. Renewable Resources Laboratory, Universidad de Concepción, Casilla 160-C, Concepción, Chile). **Biodegradation of *Pinus radiata* softwood by white-and brown-rot fungi**. World Journal of Microbiology and Biotechnology, 17(1) (2001), 31-34.

The weight and component losses of *Pinus radiata* wood after decay by six species of white-rot and two species of brown-rot fungi for periods varying from 30 to 360 days were evaluated. Three groups of decayed wood samples were identified based on the principal component analysis (PCA) of the data on their weight and component losses. Selective lignin degradation was produced by *Ceriporiopsis subvermispora* and *Punctularia atropurpurascens* within different periods, the longest one lasting 90 days, and also by *Merulius tremellosus* after 90 days of biodegradation. Comparing the data on biodegradation of *P. radiata* by *Trametes versicolor* with the ones reported for biodegradation of *Eucalyptus globulus* and *E. grandis* indicated that *P. radiata* is as susceptible to wood decay by this white-rot fungus as the two types of hardwood.

Andrew J. Stocking, Rula A. Deeb, Amparo E. Flores, William Stringfellow, Jeffrey Talley, Richard Brownell, Michael C. Kavanaugh. (Malcolm Pirnie, Inc., 180 Grand Ave. Suite 1000, Oakland, California 94612-3754, USA. Department of Civil and Environmental Engineering, 631 Davis Hall, MC 1710, University of California, Berkeley, California 94720-1710, USA. Malcolm Pirnie, Inc. Oakland, California 94612. Malcolm Pirnie, Inc., 180 Grand Ave. Suite 1000, Oakland, California 94612-3754, USA. Lawrence Berkeley National Laboratory, One Cyclotron Road, MS: 70A-3317, Bldg. 70A, Room

3317 Berkeley, California 94720, USA. Environmental Laboratory, US Army Corp of Engineers, Engineer Research and Development Center (ERDC), MS: CEWES-EF-R, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180, USA. Malcolm Pirnie, Inc., 104 Corporate Park Drive, Box 751, White Plains, New York 10602-0751, USA. Malcolm Pirnie, Inc., 180 Grand Ave. Suite 1000, Oakland, California 94612-3754, USA*).* **Bioremediation of MTBE: a review from a practical perspective**. Biodegradation, 11(2-3) (2000), 187-201.

The addition of methyl tert-butyl ether (MTBE) to gasoline has resulted in public uncertainty regarding the continued reliance on biological processes for gasoline remediation. Despite this concern, researchers have shown that MTBE can be effectively degraded in the laboratory under aerobic conditions using pure and mixed cultures with half-lives ranging from 0.04 to 29 days. Ex-situ aerobic fixed-film and aerobic suspended growth bioreactor studies have demonstrated decreases in MTBE concentrations of 83% and 96% with hydraulic residence times of 0.3 hrs and 3 days, respectively. In microcosm and field studies, aerobic biodegradation half-lives range from 2 to 693 days. These half-lives have been shown to decrease with increasing dissolved oxygen concentrations and, in some cases, with the addition of exogenous MTBE-degraders. MTBE concentrations have also been observed to decrease under anaerobic conditions; however, these rates are not as well defined. Several detailed field case studies describing the use of ex-situ reactors, natural attenuation, and bioaugmentation are presented in this paper and demonstrate the potential for successful remediation of MTBE-contaminated aquifers. In conclusion, a substantial amount of literature is available which demonstrates that the in-situ biodegradation of MTBE is contingent on achieving aerobic conditions in the contaminated aquifer.

Aran Incharoensakdi, Rungaroon Waditee. **Degradation of Glycinebetaine by Betaine-Homocysteine Methyltransferase in Aphanothece halophytica: Effect of Salt Downshock and Starvation**. Curr Microbiol 41 (2000), 227-231.

We have investigated conditions leading to the degradation of glycinebetaine in Aphanothece halophytica and have shown the activity of betaine-homocysteine methyltransferase (BHMT). The intracellular glycinebetaine level was decreased approximately 50% after 36 h salt downshock from 2.0 m NaCl medium to 0.5 m NaCl medium. A slight additional decrease of glycinebetaine occurred when salt downshock was combined with dark treatment. The omission of carbon and nitrogen sources in the growth medium further decreased intracellular glycinebetaine. The activity of BHMT increased from 0 to 460 nmol h-1mg-1 after 3 h salt downshock. Higher strength of salt downshock resulted in higher activity of the enzyme. Small increase of the enzyme activity was also observed when A. halophytica was deprived of carbon and nitrogen sources in the growth medium.

Atuk K. Johri, Meenakshi Dua, D.M. Saxena, N. Sethunathan. **Enhanced Degradation of Hexachlorocyclohexane Isomers by *Sphingomonas paucimobilis***. Curr Microbiol 41 (2000), 309-311.

Hexachlorocyclohexane (HCH) has been banned for use in technologically advanced countries; however, it is still in use in tropical countries like India. Earlier we reported the degradation of HCH isomers by *Sphingomonas paucimobilis* within 12 days of incubation. Here we report the role of different factors that could enhance the degradation rate of HCH isomers. We found that an increase in the cell number from 102 to 108 cells/ml resulted in an increased degradation rate of HCH isomers viz. alpha, beta, gamma, and delta-HCH. While

alpha-HCH and gamma-HCH disappeared completely from the medium within 3 days of incubation, a maximum of only 90% and 85% degradation was observed for beta and delta-HCH, respectively. We have also observed that adapted cultures degraded HCH isomers more efficiently than did the normal cultures.

Bernard O. Ejechi. (Department of Microbiology, Delta State University, Abraska, Nigeria). **Wood biodeterioration control potential of *Acalypha hispida* leaf phenolic extract in combination with Trichoderma viride culture filtrate**. World Journal of Microbiology and Biotechnology, 17(6) (2001), 561-565.

The phenolic extract of *Acalypha* leaves inhibited growth of *Gloeophyllum sepiarium* and *Pleurotus* sp. (test wood-rot fungi) in potato dextrose agar, starch agar, starch glucose agar, carboxyl methyl cellulose agar and carboxyl methyl cellulose glucose agar. Fungicidal or fungistatic concentration of the extract (10–14 mg/ml) depended on the medium. However a lower concentration of the extract (8–10 mg/ml) in combination with *Trichoderma viride* culture filtrate caused a similar inhibitory pattern. Degradation of obeche (*Triplochiton scleroxylon*), mahogany (*Khaya ivorensis*) and walnut (*Lovoa trichilioides*) by the test fungi was limited or prevented by extract treatment of 8–10 mg/g wood. A similar inhibitory effect again occurred when a combination of T. viride filtrate and lower extract concentration (6–8 mg extract per gram of wood) was used. On-going wood decay was limited or halted by a combined treatment involving 8–12 mg extract per gram of wood depending on the fungal residence period. Treated stakes exposed to 6 months of tropical wet season retained resistance to fungal attack including soft rot. The phenolic extract of *A. hispida* may prove useful in an integrated chemical and biological approach to wood treatment.

Bruce E. Rittmann, Patarapol Tularak, Kuan-Chun Lee, Thomas W. Federle, Nina R. Itrich, Sandra K. Kaiser, Jay Shi, Drew C. McAvoy. (Departments of Civil and Chemical Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208-3109, USA. Departments of Civil and Chemical Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208-3109, USA. Departments of Civil and Chemical Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208-3109, USA. Pollution Control Department, Ministry of Science, Technology and Environment, Bangkok 10400, Thailand. Environmental Research, The Procter and Gamble Co., Cincinnati, OH 45217-1087, USA. Environmental Research, The Procter and Gamble Co., Cincinnati, OH 45217-1087, USA. Environmental Research, The Procter and Gamble Co., Cincinnati, OH 45217-1087, USA. Environmental Research, The Procter and Gamble Co., Cincinnati, OH 45217-1087, USA. Environmental Research, The Procter and Gamble Co., Cincinnati, OH 45217-1087, USA). **How adaptation and mass transfer control the biodegradation of linear alkylbenzene sulfonate by activated sludge**. Biodegradation, 12(1) (2001), 31-37.

We use a nonsteady-state model to evaluate the effects of community adaptation and sorption kinetics on the fate of linear alkylbenzene sulfonate (LAS) in batch experiments conducted with activated sludge that was continuously fed different concentrations of LAS. We observed a sharp decrease in the biodegradation rate between 30 and 60 minutes and the presence of an LAS residual at the end of the batch experiments. The modeling analysis indicates that these phenomena were caused by relatively slow inter-phase mass transport of LAS. The modeling analyses also showed that the amount of LAS-degrading biomass increased when the continuous activated sludge was fed a higher LAS concentration. Although community adaptation to LAS involved accumulation of more LAS degraders, the increase was not proportional to the feed concentration of LAS, which supports the concept that LAS degraders also utilized portions of the general biochemical oxygen demand (BOD) fed to the continuous activated sludge systems.

C.M. Kamanavalli, H.Z. Ninnekar. (Department of Biochemistry, Karnatak University, Dharwad – 580 003, India). **Biodegradation of propoxur by *Pseudomonas* species**. World Journal of Microbiology and Biotechnology, 16(4) (2000), 329-331.

A bacterium capable of degrading propoxur (2-isopropoxyphenyl-N-methylcarbamate) was isolated from soil by enrichment cultures and was identified as a *Pseudomonas* species. The organism grew on propoxur at 2 g/l as sole source of carbon and nitrogen, and accumulated 2-isopropoxyphenol as metabolite in the culture medium. The cell free extract of *Pseudomonas* sp. grown on propoxur contained the activity of propoxur hydrolase. The results suggest that the organism degraded propoxur by hydrolysis to yield 2-isopropoxyphenol and methylamine, which was further utilized as carbon source.

C.S. Kedari, S.K. Das, S. Ghosh. (Process Development Division, Bhabha Atomic Research Centre, Trombay, Mumbai – 400 085, India. Food Technology Division, Bhabha Atomic Research Centre, Trombay, Mumbai – 400 085, India. **Biosorption of long lived radionuclides using immobilized cells of *Saccharomyces cerevisiae***. World Journal of Microbiology and Biotechnology, 17 (8) (2001), 789-793.

The efficacy of immobilized *Saccharomyces cerevisiae* (biomatrix) for the sorption of different metal ions and its potential applications in nuclear waste treatment were investigated. The sorption of radionuclides such as 233U, 241Am, 144Ce, 137Cs and 90Sr was studied under different experimental conditions. More than 95% sorption of UO22+, Pu4+, Am3+ and Ce3+ could be obtained in the pH range 1 to 2 of the aqueous solutions. However the sorption of Cs+ and Sr2+ were negligible under the similar experimental conditions. The infrared spectra and scanning electron microscopic images of the control and uranium-bearing biomatrix were studied to understand the chemistry of metal uptake by this biomatrix.

Christopher Juneson, Owen P. Ward, Ajay Singh. (Microbial Biotechnology Laboratory, Department of Biology, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1. Microbial Biotechnology Laboratory, Department of Biology, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1. Microbial Biotechnology Laboratory, Department of Biology, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1). **Biodegradation of dimethyl phthalate with high removal rates in a packed-bed reactor**. World Journal of Microbiology and Biotechnology, 18(1) (2002), 7-10.

Biological treatment of a dimethyl phthalate (DMP)-containing waste stream was evaluated in packed-bed bioreactors using an acclimated mixed bacterial culture. The passive immobilization start-up strategy was successful in the development of a stable biofilm on the packing material in the reactor. Nutrient supplementation significantly improved the removal efficiency. High removal rates with 100% efficiencies of DMP removal were achieved up to the phthalate-loading rate of 560 g/m3 h.

Cleotilde Juárez-Ramírez, Nora Ruiz-Ordaz, Eliseo Cristiani-Urbina, Juvencio Galíndez-Mayer. (Departamento de Ingeniería Bioquímica, Escuela Nacional de Ciencias Biológicas, del I.P.N. Prolongación de Carpio y Plan de Ayala S/N, Col. Santo Tomas, México, D.F. C.P. 11340 México. Departamento de Ingeniería Bioquímica, Escuela Nacional de Ciencias Biológicas, del I.P.N. Prolongación de Carpio y Plan de Ayala S/N, Col. Santo Tomas, México, D.F. C.P. 11340 México. **Degradation kinetics of phenol by immobilized cells of *Candida tropicalis* in a fluidized bed reactor**. World Journal of Microbiology and Biotechnology, 17(7) (2001), 697-705.

Degradation kinetics of phenol by free and agar-entrapped cells of *Candida tropicalis* was studied in batch cultures. The initial phenol degradation rate achieved with free cells was higher than that obtained with immobilized cells, when phenol concentrations up to 1000 mg l-1 were used. However, at higher phenol concentrations, the behaviour was quite different. The initial degradation rate of the immobilized yeast cells was about 10 times higher than that of the free cells, at a phenol concentration of 3500 mg l-1. The semicontinuous and continuous degradation of phenol by immobilized yeast cells was also investigated in a multi-stage fluidized bed reactor. The highest phenol removal efficiencies and degradation rates as well as the lowest values of residual phenol and chemical oxygen demand were obtained in the semicontinuous culture when phenol concentrations up to 1560 mg l-1 were used.

D. Hoffmann, S. Kleinsteuber, R.H. Müller, W. Babel. (UFZ - Umweltforschungszentrum Leipzig-Halle GmbH, Sektion Umweltmikrobiologie, Permoserstraße 15, 04318 Leipzig, Germany). **Development and Application of PCR Primers for the Detection of the *tfd* Genes in *Delftia acidovorans* P4a Involved in the Degradation of 2,4-D** . Acta Biotechnologica, 21(4) (2001), 321-331.

Primers specific for the genes *tfdD*, *tfdE* and *tfdF*, derived from conserved amino acid sequence motifs of the corresponding homologous enzymes, and primers specific for the genes *tfdA* and *tfdB* as well as *tfdC* taken from the literature were applied in PCR reactions using the genomic DNA of *Delftia acidovorans* P4a as the template. PCR products were obtained with all primer pairs that were similar in size to those found with the genomic DNA of strains harbouring plasmid pJP4 as the carrier of *tfd* genes. The nucleotide sequences and the corresponding amino acid sequences of the PCR products obtained with Strain P4a were compared with the sequence databases. According to BLAST analyses, the partial sequences of *tfdA* and *tfdB* exhibited a 94-99% degree of identity with the homologous sequences of the 2,4-D-degrading strains *Achromobacter xylosoxidans* subsp. *denitrificans* EST4002 (pEST4011), *Burkholderia* sp. RASC, *Variovorax paradoxus* TV1 (pTV1) and *Burkholderia cepacia 2a* (pIJB1), whereas the partial sequences of the *tfdC*, *tfdD*, *tfdE* and *tfdF* genes revealed a 96-100% degree of identity with the homologous sequences of the chlorobenzene-utilizing strains *Ralstonia eutropha* NH9 (pENH91), *Pseudomonas chlororaphis* RW71 and *Pseudomonas* sp. P51 (pP51).

D.Y. Bojinova, R.G. Velkova. (University of Chemical Technology and Metallurgy, 8 Kliment Ohridski Blvd, 1756 Sofia, Bulgaria). **Bioleaching of Metals from Mineral Waste Product**. Acta Biotechnologica, 21(3) (2001), 275-282.

The possibility of bioleaching Al, K, Na, Ca and Mg using microorganisms of the *Thiobacillus thiooxidans* group from industrial waste product (IWP) of copper ore flotation from the company MEDET was studied. The aim of the investigations was to establish the possible application of a combined method for processing IWP. The preliminary mechanical activation in combination with bioleaching resulted in a high extent of extraction of useful components. It was established that the removal of useful components from mechanically activated IWP is improved compared to non-activated IWP. The effect of the concentration of Al-containing waste product, of incubation time and time of preliminary mechanical activation on the extraction degree () [% w/w] of useful elements was investigated. The maximum degree of extraction of Al was achieved on Day 28 and its value reached 71% for industrial waste product mechanically activated for 4 hours. The maximum degrees of extraction of K and Na in the case of industrial waste

product mechanically activated for 4 hours were achieved on Day 7 of the incubation period and their values were 78% and 91%, respectively. Under the conditions of bioleaching only Si had a low degree of extraction, accounting for 2.5%. The ability of microorganisms to leach aluminium could be used for the extraction of metals from nonbauxite raw materials and Al-containing waste product not treatable by means of the BAYER method.

Dácio Roberto Matheus, Vera Lúcia Ramos Bononi, Kátia Maria Gomes Machado. (Mycology and Lichenology Section – Instituto de Botânica, Caixa Postal 4005, São Paulo 01061-970, Brazil. Secretary for the Environment of the State of São Paulo, São Paulo, Brazil. Fundação Centro Tecnológico de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil). **Biodegradation of hexachlorobenzene by basidiomycetes in soil contaminated with industrial residues**. World Journal of Microbiology and Biotechnology, 16(5) (2000), 415-421.

Hexachlorobenzene (HCB), one of twelve compounds classified as 'persistent organic pollutants' (POP), is a byproduct of the manufacture of organochlorine compounds, and is a cause of environmental contamination in several parts of the world. Its degradation by *Brazilian basidiomycetes* was studied through chromatographic analyses and monitoring of the production of 14CO2 from [14C]HCB in the soil. Nineteen strains of basidiomycetes were found to be capable of tolerating concentrations of 5000 to 50,000 mg of HCB kg-1 of soil. In spite of the low rates of production of 14CO2, *Psilocybe cf. castanella* CCB444 and *Lentinus cf. zeyheri* CCB274 were capable of removing nearly 3150 and 1400 mg of HCB kg-1 from respective soil samples, during a 65-day study period.

Daniel J. Arp, Chris M. Yeager, Michael R. Hyman. (Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331, USA. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331, USA. Department of Microbiology, North Carolina State University, Raleigh, NC 27695, USA). **Molecular and cellular fundamentals of aerobic cometabolism of trichloroethylene**. Biodegradation, 12(2) (2001), 81-103 .

Cometabolism recognizes that microorganisms can transform non-growth-supporting substrates. The term "cometabolism'' was first introduced over 30 years ago and has been redefined, criticized, and used widely ever since. In this review we have examined the aerobic cometabolism of chlorinated solvents, with a particular emphasis on the cometabolism of trichloroethylene. Monooxygenases or dioxygenases with relaxed substrate ranges initiate these transformations. The physiological role of the oxygenases is to initiate the metabolism of growth-supporting substrates (e.g., methane, propane, butane, toluene, ethylene, and ammonia). Diverse enzymes catalyze these oxidative reactions with chlorinated solvents. Synthesis of most of these enzymes is induced by the presence of the growth-supporting substrate and is largely regulated at the level of gene transcription. The genes that code for a given oxygenase are usually clustered together in a single operon and often share homology with counterparts that code for the subunits of related oxygenases in other bacteria. During cometabolism the growth-supporting and non-growth-supporting substrates can both bind to the oxygenase. Transformation of chlorinated solvents by these enzymes presents the cell with a new set of compounds. Some of these compounds are toxic to the cells, others are stable products that are expelled from the cell, and in a few cases the cells utilize the products. The combined effects of cometabolism can have a profound influence on a cell.

Debbie-Ann P. Bramwell, Shonali Laha. (Department of Civil & Environmental Engineering and

Drinking Water Research Center, Florida International University, University Park Campus EAS 3685, Miami, Florida 33199, USA. Department of Civil & Environmental Engineering and Drinking Water Research Center, Florida International University, University Park Campus EAS 3685, Miami, Florida 33199, USA). **Effects of surfactant addition on the biomineralization and microbial toxicity of phenanthrene**. Biodegradation, 11(4) (2000), 263-277.

Surfactants are known to increase the apparent aqueous solubility of polycyclic aromatic hydrocarbons and may thereby enhance their bioavailability. In this study the effects of four surfactants on the mineralization of phenanthrene by *Pseudomonas aeruginosa* in liquid culture and in soil-water suspensions was studied in batch reactors over a 15-week study period. In the absence of surfactant, liquid cultures mineralized approximately 50% of the phenanthrene added within seven weeks following a one-week lag period and an initial mineralization rate of 0.04 mg/d. Mineralization in soil-water suspensions proceeded without any measurable lag period. The initial mineralization rate was lower (0.006 mg/d), but mineralization continued to >70% over the fifteen week period. In general, the addition of very low concentrations of surfactant (=0.001%) to liquid cultures did not impact mineralization significantly. At higher surfactant concentrations (=CMC) all surfactants were seen to be inhibitory. In soil-water systems, the rate of phenanthrene mineralization was decreased even at surfactant doses that did not produce significant solubilization. In summary, none of the surfactants enhanced the mineralization of phenanthrene by *P. aeruginosa* in liquid culture or in soil-water suspensions. In order to rank surfactant toxicity, microbial toxicity tests were performed measuring the light output of bioluminescent bacteria as affected by the presence of surfactants. Additional toxicity testing indicated that the presence of solubilized phenanthrene increased the toxicity of the surfactant by a 100-fold suggesting that the toxicity of solubilized substrate needs also to be considered in the application of surfactant-amended remediation.

Derek R. Lovley. (Department of Microbiology, University of Massachusetts, Amherst, MA 01003, USA). **Anaerobic benzene degradation**. Biodegradation, 11(2-3) (2000), 107-116.

Although many studies have indicated that benzene persists under anaerobic conditions in petroleum-contaminated environments, it has recently been documented that benzene can be anaerobically oxidized with most commonly considered electron acceptors for anaerobic respiration. These include: Fe(III), sulfate, nitrate, and possibly humic substances. Benzene can also be converted to methane and carbon dioxide under methanogenic conditions. There is evidence that benzene can be degraded under in situ conditions in petroleum-contaminated aquifers in which either Fe(III) reduction or methane production is the predominant terminal electron-accepting process. Furthermore, evidence from laboratory studies suggests that benzene may be anaerobically degraded in petroleum-contaminated marine sediments under sulfate-reducing conditions. Laboratory studies have suggested that within the Fe(III) reduction zone of petroleum-contaminated aquifers, benzene degradation can be stimulated with the addition of synthetic chelators which make Fe(III) more available for microbial reduction. The addition of humic substances and other compounds that contain quinone moieties can also stimulate anaerobic benzene degradation in laboratory incubations of Fe(III) reducing aquifer sediments by providing an electron shuttle between Fe(III) reducing microorganisms and insoluble Fe(III) oxides. Anaerobic benzene degradation in aquifer sediments can be stimulated with the addition of sulfate, but in some instances an inoculum of benzene-oxidizing, sulfate-reducing microorganisms must also be added. In a field trial,

sulfate addition to the methanogenic zone of a petroleum-contaminated aquifer stimulated the growth and activity of sulfate-reducing microorganisms and enhanced benzene removal. Molecular phylogenetic studies have provided indications of what microorganisms might be involved in anaerobic benzene degradation in aquifers. The major factor limiting further understanding of anaerobic benzene degradation is the lack of a pure culture of an organism capable of anaerobic benzene degradation.

E. Seklemova, A. Pavlova, K. Kovacheva. (Research and Development Institute, LUKoil Neftochim Bourgas AD, 8104 Bourgas, Bulgaria). **Biostimulation-based bioremediation of diesel fuel: field demonstration**. Biodegradation, 12(5) (2001), 311-316.

Ex-situ bioremediation of leached cynamonic forest soil at initial diesel oil contamination of 6000 mg kg^{-1}, 4000 mg kg^{-1} and 2000 mg kg^{-1} was investigated after biostimulation with inorganic fertilizers. It was found that the added nutrients had no effect on the decontamination of polluted soils. A precise and reliable approach for evaluation of the biodegradation process is proposed. It comprises application of sensitive and easily accessible diagnostic parameters and relations, calculated on the basis of n-alkanes and isoprenoids – pristane (2.6.10.14-tetramethylpentadecane, i-$C_{19}H_{40}$) and phytane (2.6.10.14-tetramethylhexadecane, i-$C_{20}H_{42}$) distribution.

E.I. Atuanya, H.J. Purohit, T. Chakrabarti. (Department of Microbiology, University of Benin, P.M.B. 1154, Benin city, Nigeria. National Environmental Engineering Research Institute Nagpur 440020, India). **Anaerobic and aerobic biodegradation of chlorophenols using UASB and ASG bioreactors**. World Journal of Microbiology and Biotechnology, 16(1) (2000), 95-98.

Chlorophenol degradation was studied by combined anaerobic–aerobic treatments as a single or multi-substrate system. 2,4-Dichlorophenol (2,4-DCP) was degraded to the extent of 52 and 78% in up-flow anaerobic sludge blanket (UASB) and aerobic suspended growth (ASG) reactors respectively, at organic loading rates of 0.18 kg/m3/day and hydraulic retention time of 26.4 h in the presence of glucose. The UASB represents the dominating facultative anaerobic microbial population. When the effluent from the anaerobic reactor (UASB) was subjected to aerobic treatment on the ASG reactor, 2,4-DCP and COD removals of 86 and 95% respectively were achieved. Aerobic degradation of chlorophenol by acclimated mixed bacterial isolates was found to be sequential: 2-Chlorophenol (2-CP) and 4-CP were degraded first, followed by 2,4-DCP and 2,4,6-Trichlorophenol (2,4,6-TCP) while the contrary was obtained in anaerobic degradation. In anaerobic degradation by acclimated mixed bacterial cells, 2,4-DCP and 2,4,6-TCP were degraded first followed by mono-chlorophenols. The anaerobic/aerobic bioreactors were most efficient when operated in sequence (series) rather than in parallel.

Egbert Schwartz, Kate M. Scow. (Graduate Group in Ecology and Department of Land, Air and Water Resources, One Shields Ave. University of California at Davis, Davis, CA 95616-8627, USA Author for correspondence: 151 Hilgard Hall, University of California, Berkeley CA 94720-3110, USA. Graduate Group in Ecology and Department of Land, Air and Water Resources, One Shields Ave. University of California at Davis, Davis, CA 95616-8627, USA). **Repeated inoculation as a strategy for the remediation of low concentrations of phenanthrene in soil**. Biodegradation, 12(3) (2001), 201-207.

Phenanthrene, a polycyclic aromatic hydrocarbon, becomes increasingly unavailable to microorganisms for degradation as it ages in soil. Consequently, many bioaugmentation efforts to remediate polycyclic aromatic hydrocarbons in soil have failed. We studied the effect of repeatedly inoculating a soil with a phenanthrene-degrading *Arthrobacter* sp. on the mineralization kinetics of low concentrations of phenanthrene. After the first inoculation, the initial mineralization rate of 50 ng/g phenanthrene declined in a biphasic exponential pattern. By three hundred hours after inoculation, there was no difference in mineralization rates between the inoculated and uninoculated treatments even though a large fraction of the phenanthrene had not yet been mineralized. A second and third inoculation significantly increased the mineralization rate, suggesting that, though the mineralization rate declined, phenanthrene remained bioavailable. Restirring the soil, without inoculation, did not produce similar increases in mineralization rates, suggesting absence of contact between cells and phenanthrene on a larger spatial scale (>mm) is not the cause of the mineralization decline. Bacteria inoculated into soil 280 hours before the phenanthrene was added could not maintain phenanthrene degradation activity. We suggest sorption lowered bioavailability of phenanthrene below an induction threshold concentration for metabolic activity of phenanthrene-degrading bacteria.

Egbert Schwartz, Kate M. Scow. (Graduate Group in Ecology and Department of Land, Air and Water Resources, One Shields Ave. University of California at Davis, Davis, CA 95616-8627, USA Author for correspondence: 151 Hilgard Hall, University of California, Berkeley CA 94720-3110, USA). **Repeated inoculation as a strategy for the remediation of low concentrations of phenanthrene in soil**. Biodegradation, 12(3) (2001), 201-207.

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Floriane Solano-Serena, Rémy Marchal, Jean-Michel Lebeault, Jean-Paul Vandecasteele. (Institut Français du Pétrole, Division Chimie et Physico-chimie appliquées, Département Microbiologie, 1 et 4 avenue de Bois-Préau, 92852 Rueil-Malmaison Cedex, France. Institut Français du Pétrole, Division Chimie et Physico-chimie appliquées, Département Microbiologie, 1 et 4 avenue de Bois-Préau, 92852 Rueil-Malmaison Cedex, France. Université de Technologie de Compiégne, Centre de Recherches de Royallieu, BP 20529, 60205 Compiégne Cedex, France. Institut Français du Pétrole, Division Chimie et Physico-chimie appliquées, Département Microbiologie, 1 et 4 avenue de Bois-Préau, 92852 Rueil-

Malmaison Cedex, France). **Distribution in the environment of degradative capacities for gasoline attenuation**. Biodegradation, 11(1) (2000), 29-35.

A methodology allowing the detailed assessment of the capacities of microflorae to degrade gasoline in aerobic conditions has been developed. It consisted in the determination of the degradation of a gasoline model mixture in liquid cultures in optimal conditions. The gasoline model mixture contained 23 representative hydrocarbons of gasoline (GM23). The kinetics and extent of biodegradation were evaluated by continuous overall monitoring of CO2 production and final chromatographic analysis (usually after about 30 days) of the consumption of each hydrocarbon. The methodology was used with soil and water samples from polluted and non polluted sites. The experimentation aimed at assessing the distribution of the degradative capacities in the environment and the prospects for natural attenuation of gasoline. Nine microflorae were tested. The intrinsic biodegradability (existence of mechanisms of biodegradation) appeared total for GM23 as shown by the results obtained with several microflorae. The degradative capacities of microflorae from non polluted samples were high (total degradation rates at least 85%). Incomplete degradation was observed essentially for trimethylalkanes (2,2,4-trimethylpentane and 2,3,4-trimethylpentane) and for cyclohexane. In several cases, samples from polluted sites exhibited more extensive degradative capacities, with total degradation of all hydrocarbons being observed for three out of the six samples.

G. Emtiazi, N. Naghavi, A. Bordbar. (Biology Department, Isfahan University P.O. Box 117, Isfahan 81745, Iran. Biology Department, Isfahan University P.O. Box 117, Isfahan 81745, Iran. Biology Department, Isfahan University P.O. Box 117, Isfahan 81745, Iran). **Biodegradation of lignocellulosic waste by *Aspergillus terreus***. Biodegradation, 12(4) (2001), 257-261.

Biodegradation of lignocellulosic waste by *Aspergillus terreus* is reported for the first time. This isolate produced 250 CMCase (carboxymethyl cellulase or endoglucanase) U.ml-1 and biodegraded hay and straw during 3 days and the biomass production on straw was 5g.L-1dry weight from 0.25 cm2 inoculated mycellium. This strain secreted endocellulases and exocellulases in the culture medium, but some of the enzymes produced, remained cell membrane bound. Cell bound enzymes were released by various treatments. The highest amount of endoglucanase and exoglucanase was released when the cells were treated with sonication. *Aspergillus terreus* was added to two tanks containing sugar wastewater and pulp manufacturing waste, as a seed for COD removal. This fungus reduced the COD by 40-80 percent, also, ammonia was reduced from 14.5 mM to 5.6 mM in sugar beet wastewater. The effects of crude enzyme of this fungus for COD removal was studied.

G. Emtiazi. (Biology Department, University of Esfahan, Iran, P. 0. Box 81745-117). **Decolorization and Biodegradation of Dyes by *Aspergillus terreus* grown on wheat straw with Mn peroxidase activity**. Poll Ress., 19(1) (2000), 31-35.

Aspergillus terreus isolated from rotten wood decolorized several dyes used in textile industries including Solamine blue, Solamine yellow, Salaminc red. Solanrine scarlet, Terter direct orange, Terter direct blue and Anilin blue. Decolorization was favoured when the *Aspergillus terreus* was grown on wheat straw with cellulase and Mn peroxidase activities. This fungus could biodegrade these dyes and utilize them as the only source of carbon, nitrogen and energy.

The COD removal and production of ammonia during biodegradation of dyes by the isolated fungi were investigated.

Gary T. Howard *. (Department of Biological Sciences, Southeastern Louisiana University, SLU 10736, Hammond, LA 70402, USA). **Biodegradation of polyurethane: a review**. International Biodeterioration & Biodegradation, 49(4) (2002), 245-252.

Lack of degradability and the closing of landfill sites as well as growing water and land pollution problems have led to concern about plastics. Increasingly, raw materials such as *crude* oil are in short supply for the synthesis of plastics, and the recycling of waste plastics is becoming more important. As the importance of recycling increases, so do studies on elucidation of the biodegradability of polyurethanes.Polyurethanes are an important and versatile class of man-made polymers used in a wide variety of products in the medical, automotive and industrial fields. Polyurethane is a general term used for a class of polymers derived from the condensation of polyisocyanates and polyalcohols. Despite its xenobiotic origins, polyurethane has been found to be susceptible to biodegradation by naturally occurring microorganisms. Microbial degradation of polyurethanes is dependent on the many properties of the polymer such as molecular orientation, crystallinity, cross-linking and chemical groups present in the molecular chains, which determine the accessibility to degrading-enzyme systems. Esterase activity (both membrane-bound and extracellular) has been noted in microbes, which allow them to utilize polyurethane. Microbial degradation of polyester polyurethane is hypothesized to be mainly due to the hydrolysis of ester bonds by these esterase enzymes.

Gijs D. Breedveld, Magnus Sparrevik. (Norwegian Geotechnical Institute, P.O. Box 3930, Ullevaal Stadion, N-0806 Oslo, Norway; Department of Geology, University of Oslo, P.O. Box 1047 Blindern, N-0316 Oslo, . Norwegian Geotechnical Institute, P.O. Box 3930, Ullevaal Stadion, N-0806 Oslo, Norway*).* **Nutrient-limited biodegradation of PAH in various soil strata at a creosote contaminated site**. Biodegradation, 11(6) (2000), 391-399.

The effects of nutrient addition on the *in situ* biodegradation of polycyclic aromatic hydrocarbons in creosote contaminated soil were studied in soil columns taken from various soil strata at a wood preserving plant in Norway. Three samples were used: one from the topsoil (0–0.5 m), one from an organic rich layer (2–2.5 m) and one from the sandy aquifer (4.5–5 m). The addition of inorganic nitrogen and phosphorous stimulated the degradation of polycyclic aromatic hydrocarbons (PAHs) in the top soil and the aquifer sand. These two soils, which differed strongly in contamination levels, responded similarly to nutrient addition with the corresponding degradation of 4-ring PAHs. The ratio between available nitrogen (N) and phosphorous (P) might explain the degree of degradation observed for the 4-ring PAHs. However, the degree of degradation of 3-ring PAHs did not significantly increase after nutrient addition. An increase in the respiration rate, after nutrient addition, could only be observed in the topsoil. In the aquifer sand, 4-ring PAH degradation was not accompanied by an increase in the respiration rate or the number of heterotrophic micro-organisms. PAH degradation in the organic layer did not respond to nutrient addition. This was probably due to the low availability of the contaminants for micro-organisms, as a result of sorption to the soil organic matter. Our data illustrate the need for a better understanding of the role of nutrients in the degradation of high molecular weight hydrocarbons for the successful application of bioremediation at PAH contaminated sites.

Göran Bengtsson, Christel Carlsson. (Department of Ecology, Lund University, Sölvegatan 37, SE-223 62 Lund, Sweden). **Degradation of dissolved and sorbed 2,4-dichlorophenol in soil columns by suspended and sorbed bacteria**. Biodegradation, 12(6) (2001), 419-432.

The influence of absorption of bacteria, as well as 2,4-dichlorophenol (2,4-DCP), on the mineralization of 100 µg l^{-1} of the organic compound was examined in an aquifer material under advective flow conditions (column displacement technique). The study was designed to distinguish the rates and extent of biodegradation of the sorbed and the dissolved trace organic and the contribution of sorbed and suspended bacteria to the degradation. The degradation of dissolved 2,4-DCP was significantly faster than the degradation of the same compound sorbed to the solids, and suspended bacteria degraded the dissolved compound at a higher rate than sorbed bacteria, also on a per cell basis. The suspended bacteria degraded 8–12% of the added dissolved 2,4-DCP, while sorbed bacteria made a smaller contribution by degrading about 5% of sorbed 2,4-DCP. No degradation was seen with sorbed 2,4-DCP and suspended bacteria, and a marginal contribution was made by sorbed bacteria on the degradation of dissolved 2,4-DCP (<0.4%).

H. Moormann [1], P. Kuschk [2], U. Stottmeister [2]. ([1]Universität Bremen, Zentrum für Umweltforschung (UFT) und Umwelttechnologie, Institut für Umweltverfahrenstechnik, Leobener Straße, 28359 Bremen, Germany. [2]UFZ - Umweltforschungszentrum Leipzig - Halle GmbH, Sektion Sanierungsforschung, Permoserstraße 15, 04318 Leipzig, Germany). **The Effect of Rhizodeposition from Helophytes on Bacterial Degradation of Phenolic Compounds**. Acta Biotechnologica , 22(1-2) (2002), 107-112.

The effect of rhizodeposition from helophytes (aquatic plants) on the bacterial degradation of toxic compounds such as phenolic substances was tested. Investigations were carried out as batch experiments with rhizodeposition products obtained from helophytes. DOC concentrations, which were used as points of reference for rhizodeposition, were between 2.5 and 12 mg per litre. Rhizodeposition was found to advance the biodegradation of 4-chlorophenol when using a mixed bacterial culture and pure cultures of bacteria previously isolated from *Phalaris arundinacea* roots. This stimulation is a result of rhizodeposition products serving as growth substrates for the bacteria. Investigations with *Ralstonia eutropha* (DSMZ Braunschweig, strain 5536) confirmed the function of rhizodeposition products as growth substrates. Degradation by *Acinetobacter baumannii* and *Ralstonia* sp. obtained from *Phalaris arundinacea* was accompanied by the dechlorination of 4-chlorophenol. There was no enhancing impact on the degradation of the substances phenol and 2,6-dimethylphenol by rhizodeposition products.

H. Seidel [1], J. Mattusch [2], R. Wennrich [2], P. Morgenstern [2], J. Ondruschka [3]. ([1]UFZ - Umweltforschungszentrum Leipzig - Halle GmbH, Sektion Sanierungsforschung, Permoserstraße 15, 04318 Leipzig, Germany. [2]UFZ - Umweltforschungszentrum Leipzig - Halle GmbH, Sektion Analytik, Permoserstraße 15, 04318 Leipzig, Germany. [3]SIAB - Sächsisches Institut für Angewandte Biotechnologie an der Universität Leipzig, Permoserstraße 15, 04318 Leipzig, Germany). **Mobilization of Arsenic and Heavy Metals from Contaminated Sediments by Changing the Environmental Conditions**. Acta Biotechnologica, 22(1-2) (2002), 153-160.

The solubility of arsenic (As) and heavy metals (Me) from two sediments with differing chemical characteristics and degrees of contamination was quantified by suspension leaching under both aerobic and anoxic conditions. Elemental sulphur (S°) was added as a substrate for the indigenous *Thiobacillus* spp. The objective

of this study was to examine the effects of measures, which attempted to stimulateor to prevent the mobilization of the pollutants in the source material. By stimulating aerobic bioleaching with S°, up to 80% (660 mg/kg) of the As became soluble in a highly polluted lake sediment (Suesser See) in the form of arsenite and arsenate. Without the addition of S°, the As solubility ranged between 0.6 and 3.5 mg/kg. No toxic effects of As (III) on bacterial growth and microbial activity of the indige nous *Thiobacillus* spp. were observed. By comparison, the As solubility in an oxic sediment from the river Weisse Elster was low (max. 0.5 mg/kg), while the total Me solubility reached 60% (3.7 g/kg). The anaerobic leaching tests were performed under the conditions of a nitrogen atmosphere in a special vessel allowing the redox potential and the pH of the solution to be continuously recorded. In the lake sediment without adding S°, the As solubility increased temporarily; up to 9% of the total As became soluble, and As (III) was the dominant As soluble species (20 mg/kg). In the late leaching phase (- 300 mV), the total soluble As decreased, and As (V) became the major soluble species (3.9 mg/kg). In the presence of S°, soluble As and Me were immobilized. The inhibition of As and Me release can be explained by fixation as insoluble sulphides, suggesting that immobilization was driven by dissimilatory sulphur reduction. The data indicatethat the availability of oxidizable sulphur and the oxidation state of the polluted material play an important role in assessing the release of arsenic and heavy metals, including anaerobic conditions. Attention has to be paid to the maintaining of strong anaerobic conditions in sulphur-rich materials in order to prevent the mobilization of pollutants.

Haibo Yu, Byung J. Kim, Bruce E. Rittmann. (McKinsey & Company, Inc., 600 Campus Drive, Florham Park, NJ 07932, USA. US Army Engineer Research and Development Center, Champaign, IL 61821, USA. Department of Civil Engineering, Northwestern University, Evanston, IL 60208-3109, USA). **The roles of intermediates in biodegradation of benzene, toluene, and *p*-xylene by *Pseudomonas putida* F1**. Biodegradation, 12(6) (2001), 455-463.

Several types of biodegradation experiments with benzene, toluene, or *p*-xylene show accumulation of intermediates by *Pseudomonas putida* F1. Under aerobic conditions, the major intermediates identified for benzene, toluene, and *p*-xylene are catechol, 3-methylcatechol, and 3,6-dimethylcatechol, respectively. Oxidations of catechol and 3-methylcatechol are linked to biomass synthesis. When oxygen is limited in the system, phenol (from benzene) and *m*-cresol and *o*-cresol (from toluene) accumulate.

Haibo Yu, Byung J. Kim, Bruce E. Rittmann. (McKinsey & Company, Inc., 600 Campus Drive, Florham Park, NJ 07932, USA. US Army Engineer Research and Development Center, Champaign, IL 61821, USA. Department of Civil and Environmental Engineering, Northwestern University, Evanston, IL 60208-3109 USA). **A two-step model for the kinetics of BTX degradation and intermediate formation by *Pseudomonas putida* F1**. Biodegradation, 12(6) (2001), 465-475.

A two-step model is developed for the aerobic biodegradation of benzene, toluene, and p-xylene (BTX) by *Pseudomonas putida* F1. The model contains three unique features. First, an initial dioxygenation step transforms BTX into their catechol intermediates, but does not support biomass growth. Second, the benzene or toluene intermediates are mineralized, which supports biomass synthesis. Third, BTX exhibit competitive inhibition on each other's transformation, while toluene and benzene noncompetitively inhibit the mineralization of their catechol intermediate. A suite of batch and chemostat

experiments is used to systematically measure the kinetic parameters for the two-step transformations and the substrate interactions.

Hanumanthanaik P. Doddamani, Harichandra Z. Ninnekar. **Biodegradation of Carbaryl by a *Micrococcus* Species**. Curr Microbiol 43 (2001), 69-73.

A bacterium capable of utilizing carbaryl as sole source of carbon was isolated from garden soil and identified as a *Micrococcus* species. The organism also utilized carbofuran, naphthalene, 1-naphthol, and several other aromatic compounds as growth substrates. The organism degraded carbaryl by hydrolysis to yield 1-naphthol and methylamine. 1-Naphthol was further metabolized via salicylate by a gentisate pathway, as evidenced by oxygen uptake and enzymatic studies.

Hanumanthanaik P. Doddamani, Harichandra Z. Ninnekar. **Biodegradation of Phenanthrene by a *Bacillus* Species**. Curr Microbiol 41(2000), 11-14.

A bacterial strain capable of utilizing phenanthrene as sole source of carbon was isolated from soil and identified as a *Bacillus* sp. The organism also utilized naphthalene, biphenyl, anthracene, and other aromatic compounds as growth substrates. The organism degraded phenanthrene through the intermediate formation of 1-hydroxy-2-naphthoic acid, which was further metabolized via o-phthalate by a protocatechuate pathway, as evidenced by oxygen uptake and enzymatic studies.

Harald J. Ruijssenaars, Francesca Stingele, Sybe Hartmans. **Biodegradability of Food-Associated Extracellular Polysaccharides**. Curr Microbiol 40 (2000), 194-199.

Exopolysaccharides (EPSs) produced by lactic acid bacteria, which are common in fermented foods, are claimed to have various beneficial physiological effects on humans. Although the biodegradability of EPSs is important in relation to the bioactive properties, knowledge on this topic is limited. Therefore, the biodegradability of eight EPSs, six of which were produced by lactic acid bacteria, was compared with microorganisms from human feces or soil. EPS-degradation was determined from the decrease in polysaccharide-sugar concentration and by high-performance size exclusion chromatography (HPSEC). Xanthan, clavan, and the EPSs produced by Streptococcus thermophilus SFi 39 and SFi 12 were readily degraded, in contrast to the EPSs produced by Lactococcus lactis ssp. cremoris B40, Lactobacillus sakei 0-1, S. thermophilus SFi20, and Lactobacillus helveticus Lh59. Clearly, the susceptibility of exopolysaccharides to biological breakdown can differ greatly, implying that the physiological effects of these compounds may also vary a lot.

Harry R. Beller (Lawrence Livermore National Laboratory, P.O. Box 808, L-542, Livermore, CA 94551, USA). **Metabolic indicators for detecting *in situ* anaerobic alkylbenzene degradation**. Biodegradation, 11(2-3) (2000), 125-139.

Monitoring programs for intrinsic bioremediation of fuel hydrocarbons require indicators that can convincingly demonstrate *in situ* metabolism. In this

evaluation of potential indicators of *in situ* anaerobic alkylbenzene metabolism, laboratory and field data are reviewed for two classes of aromatic acids: (i) benzylsuccinate, *E*-phenylitaconate, and their methyl homologs, and (ii) benzoate, and methyl-, dimethyl-, and trimethylbenzoates. The review includes previously unpublished field data from a hydrocarbon-contaminated site in Fallon (Nevada), at which both classes of metabolites were detected in groundwater. The two classes of compounds were evaluated with respect to specificity (i.e., unique biochemical relationship to a specific alkylbenzene), stability, and generation as degradation intermediates versus dead-end products; recent developments in the biochemistry of anaerobic toluene and xylene degradation were incorporated in this evaluation. In general, benzylsuccinates/*E*-phenylitaconates are superior to benzoates in terms of their very high specificity to their parent hydrocarbons and their lack of commercial and industrial sources. They are also uniquely indicative of anaerobic conditions. All of the benzoates, benzylsuccinates, and *E*-phenylitaconates are relatively stable chemically and (with the exception of benzoate) biologically under anaerobic conditions, based on the limited data available. Although benzoate, benzylsuccinate, and *E*-phenylitaconate are intermediates of anaerobic toluene mineralization to carbon dioxide, their methyl homologs can be either mineralization intermediates or cometabolic dead-end products of alkylbenzenes, depending on the bacteria involved. Benzoates are far more commonly reported in field studies of hydrocarbon-contaminated aquifers than are benzylsuccinates and *E*-phenylitaconates, although it is not clear whether this is an accurate representation of the relative occurrence of these metabolites at contaminated sites, or whether it instead reflects the limited range of target analytes used in most field studies to date.

Hubert H. Attaway, Michael G. Schmidt . **Tandem Biodegradation of BTEX Components by two *Pseudomonas* sp**. Curr Microbiol, 45 (2002), 30-36.

A co-culture of two *Pseudomonas putida* isolates was enriched from sediment on a mixture of benzene, toluene, ethylbenzene, m-xylene, p-xylene, and o-xylene. The co-culture readily degraded each of the compounds present. Benzene, toluene, and ethylbenzene were used as growth substrates by one isolate, while toluene, m-xylene, and p-xylene were used as growth substrates by the other. Neither isolate could grow on o-xylene, but it was removed in the presence of the other compounds presumably by co-metabolism. The findings presented here support other reports in which constructed communities were effectively used to degrade blends of between two and four of the components of BTEX. However, here the co-culture of two P. putida isolates effectively degraded a complete BTEX stream containing all six of the components.

I. Angelidaki, A.S. Mogensen, B.K. Ahring. (Department of Biotechnology, Building 227, The Technical University of Denmark, 2800 Lyngby, Denmark. Department of Biotechnology, Building 227, The Technical University of Denmark, 2800 Lyngby, Denmark. Department of Biotechnology, Building 227, The Technical University of Denmark, 2800 Lyngby, Denmark. School of Engineering and Applied Science, Department of Civil and Environmental Engineering, University of California, USA*).* **Degradation of organic contaminants found in organic waste**. Biodegradation, 11(6) (2000), 377-383.

In recent years, great interest has arisen in recycling of the waste created by modern society. A common way of recycling the organic fraction is amendment on farmland. However, these wastes may contain possible hazardous components in

small amounts, which may prevent their use in farming. The objective of our study has been to develop biological methods by which selected organic xenobiotic compounds can be biotransformed by anaerobic or aerobic treatment. Screening tests assessed the capability of various inocula to degrade two phthalates di-n-butylphthalate, and di(2-ethylhexyl)phthalate, five polycyclic aromatic hydrocarbons, linear alkylbenzene sulfonates and three nonylphenol ethoxylates under aerobic and anaerobic conditions. Under aerobic conditions, by selecting the appropriate inoculum most of the selected xenobiotics could be degraded. Aerobic degradation of di(2-ethylhexyl)phthalate was only possible with leachate from a landfill as inoculum. Anaerobic degradation of some of the compounds was also detected. Leachate showed capability of degrading phthalates, and anaerobic sludge showed potential for degrading, polycyclic aromatic hydrocarbons, linear alkylbenzene sulfonates and nonyl phenol ethoxylates. The results are promising as they indicate that a great potential for biological degradation is present, though the inoculum containing the microorganisms capable of transforming the recalcitrant xenobiotics has to be chosen carefully.

Ian R. Ramsay, Pratap C. Pullammanappallil. (Advanced Wastewater Management Centre, The University of Queensland, Brisbane Qld 4072, Australia. Advanced Wastewater Management Centre, The University of Queensland, Brisbane Qld 4072, Australia School of Environmental Science, Murdoch University, Perth WA 6150). **Protein degradation during anaerobic wastewater treatment: derivation of stoichiometry**. Biodegradation, 12(4) (2001), 247-256.

The stoichiometry of reactions that describe protein degradation in anaerobic treatment systems were investigated. A methodology was developed to describe protein degradation to organic acids using a single reaction step. The reactions for individual amino acid fermentation and their mediating organisms were reviewed. The dominant fermentation pathways were selected based on a number of assumptions. Using the amino acid content of a model protein, it was then possible to determine stoichiometric coefficients for each major organic acid product in the overall degradation of the protein. The theoretical coefficients were then compared to those determined from two experimental runs on a continuously-fed, well-mixed, laboratory-scale anaerobic wastewater treatment system. In general, the coefficients compared well thus validating the use of a single reaction step for the overall catabolic reaction of protein degradation to organic acids. Furthermore, even when the protein concentration in feed or the feed flow rate was doubled, the amino acid fermentation pathways were found to occur predominantly by only one pathway. Although the choice of Stickland reactions over uncoupled degradation provided good comparisons, an electron balance showed that only about 40% of the amino acids could have proceeded coupled to other amino acid reactions. Uncoupled degradation of the remaining amino acids must have relied on the uptake of hydrogen produced from these reactions by hydrogen-consuming methane bacteria.

Ivana Eichlerová, Ladislav Homolka, Františ:ek Nerud, Františ:ek Zadrazil, Petr Baldrian, Jirí Gabriel. (Institute of Microbiology AS CR, Víden:ská 1083, 142 20 Prague 4, Czech Republic. Institute of Microbiology AS CR, Víden:ská 1083, 142 20 Prague 4, Czech Republic. Institute of Microbiology AS CR, Víden:ská 1083, 142 20 Prague 4, Czech Republic. Institute of Plant Nutrition and Soil Science, FAL, Bundesallee 50, D-38116 Braunschweig, Germany. Institute of Microbiology AS CR, Víden:ská 1083, 142 20 Prague 4, Czech Republic. Institute of Microbiology AS CR, Víden:ská 1083, 142 20 Prague 4, Czech Republic). **Screening of *Pleurotus ostreatus* isolates for their ligninolytic properties during cultivation on natural substrates**. Biodegradation, 11(5) (2000), 279-287.

Thirteen basidiospore-derived isolates of *Pleurotus ostreatus* f6 strain differing in the level of ligninolytic enzyme production and other characteristics (mycelium extension rate, colony morphology) from the parental strain were cultivated on natural substrates. Under these conditions ligninolytic enzyme activity, loss of organic mass, polycyclic aromatic hydrocarbons (PAHs) degradation and colonization of sterile and nonsterile soil were studied. The activity of ligninolytic enzymes was substantially higher in straw than in liquid culture, although the differences between the isolates were less pronounced on this substrate. Some of the isolates showed a very good ability to decompose the lignocellulosic substrate (straw) and a relatively high loss of organic mass was found after 50 days of cultivation in these strains. The original strain f6 and isolates B13 and B26 successfully degraded all seven tested PAH compounds present in experimental soil samples, but the higher or lower ligninolytic enzyme production of isolates tested had no substantial effect on the extent of the degradation. In our screening, six basidiospore-derived isolates growing well in nonsterile soil were found, which could be suitable for the prospective biotechnological exploitation.

J. Mitra, P.K. Mukherjee, S.P. Kale, N.B.K. Murthy. (Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Mumbai - 400085, India). **Bioremediation of DDT in soil by genetically improved strains of soil fungus *Fusarium solani***. Biodegradation, 12 (4) (2001), 235-245.

Bioremediation of DDT in soil by genetically improved recombinants of the soil fungus *Fusarium solani* was studied. The parent strains were isolated from soil enriched with DDD or DDE (immediate anaerobic and aerobic degradation products of DDT), as further degradation of these products are slow processes compared to the parent compound. These naturally occurring strains isolated from soil, however, are poor degraders of DDT and differed in their capability to degrade its metabolites such as DDD, DDE, DDOH and DBP and other organochlorine pesticides viz. kelthane and lindane. Synergistic effect was shown by some of these strains, when grown together in the medium containing DDD and kelthane under mixed culture condition. No synergism in DDE degradation was observed with the strains isolated from enriched soil. DDD-induced proteins extracted from individual culture filtrate (exo-enzyme) when subjected to SDS-Polyacrylamide Gel Electrophoresis (SDS-PAGE) showed complementary polypeptide bands in these strains i.e., each strain produced distinct DDD degrading polypeptide bands and the recombinant or hybrid strains produced all of the bands of the two parents and degraded DDD better than the parental strains. Recombinant hybrid strains with improved dehalogenase activity were raised by parasexual hybridisation of two such complementary isolates viz. isolate 1(P-1) and 4(P-2) showing highest complementation and are compatible for hyphal fusion inducing heterokaryosis. These strains are genetically characterised as Kel+BenRDBP-Lin- and Kel-BenrDBP+Lin+ respectively. Recombinants with mixed genotype, i.e., Kel+BenRDBP+Lin+ showing superior degradation quality for DDT were selected for bioremediation study. Recombination was confirmed by polypeptide band analysis of DDD induced exo-proteins from culture filtrate using SDS-Polyacrylamide Gel Electrophoresis (PAGE) and RAPD (Random Amplified Polymorphic DNA) of genomic DNA using PCR (Polymerase Chain Reaction) technique. SDS-PAGE showed combination of DDD induced polypeptide bands characteristic of both the parents in the recombinants or the hybrids. PCR study showed the parent specific bands in the recombinant strains confirming gene transformation.

J. Musarrat, N. Bano, R.A.K. Rao. (Department of Agricultural Microbiology, Institute of Agriculture, AMU, Aligarh 202002, India). **Isolation and characterization of 2,4-dichlorophenoxyacetic acid-catabolizing bacteria and their biodegradation efficiency in soil**. World Journal of Microbiology and Biotechnology, 16(5) (2000), 495-497.

Bacterial isolates (NJ 10 and NJ 15) capable of degrading the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) were isolated from agricultural soil by enrichment culture technique. The isolates exhibited substantial growth in mineral salt medium supplemented with 0.1–0.5% of 2,4-D as a sole source of carbon and energy. Based on their morphological, cultural and biochemical characteristics, the isolates NJ 10 and NJ 15 have been identified as Pseudomonas species and Pseudomonas aeruginosa, respectively. Biodegradation studies in a soil microcosm enriched with pure cultures of the isolates demonstrated a time-dependent disappearance of 2,4-D from the 100 mg/kg herbicide-amended soil. The HPLC data analysis revealed 96.6 and 99.8% degradation in the soil inoculated with the pure cultures of isolates NJ 10 and NJ 15, respectively with in 20 days of incubation at 30 °C. Both the isolates showed significant solubilization of inorganic phosphate [Ca3(PO4)2] on the specific Pikovskaya's medium.

J.F. Batista, R.F.C. Pereira, J.M. Lopes, M.F.M. Carvalho, M.J. Feio, M.A.M. Reis. (Chemistry Department-CQFB, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2825-114 Caparica, Portugal. Chemistry Department-CQFB, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2825-114 Caparica, Portugal. Instituto de Tecnologia Química e Biológica, Rua da Quinta Grande 6, Apartado 127, 2780 Oeiras, Portugal. Chemistry Department-CQFB, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2825-114 Caparica, Portugal. Microbiology Research Laboratory, School of Pharmacy, Physical and Biomedical Sciences, University of Portsmouth, St. Michaels' Building, White Swan Road, Portsmouth, PO1 2DT, UK. Chemistry Department-CQFB, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2825-114 Caparica, Portugal). **In situ corrosion control in industrial water systems**. Biodegradation, 11(6) (2000), 441-448.

The main objective of this study was to evaluate the efficacy of a biocide and a corrosion inhibitor against the corrosion of a circulating pipe in a cooling tower. Isothiazolone was tested as the industrial biocide. The results showed that the biocide by itself or combined with a dispersant was not efficient to control corrosion in the industrial system. Corrosion rates of 0.324 mm/year were recorded in both the presence and absence of the biocide. Corrosion control was successfully accomplished by using a corrosion inhibitor. In the latter case the maximum corrosion rate of 0.024 mm/year were obtained.

Jacob G. Bundy, David G. Durham, Graeme I. Paton, Colin D. Campbell. (Department of Plant and Soil Science, University of Aberdeen, Aberdeen AB24 3UU, UK. School of Pharmacy, Robert Gordon University, Schoolhill, Aberdeen AB10 1FE, UK. Department of Plant and Soil Science, University of Aberdeen, Aberdeen AB24 3UU, UK. Soil Science Group, Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen AB15 8QH, UK). **Investigating the specificity of regulators of degradation of hydrocarbons and hydrocarbon-based compounds using structure-activity relationships**. Biodegradation, 11(1) (2000), 37-47.

Microbial biosensors, which have genes for bioluminescence, coupled to genes that control hydrocarbon degradation pathways could be used as reporters on the specificity of regulation of those pathways. Structure-activity relationships can be used to discover what governs that specificity, and can also be used to separate compounds into different groups depending on mode of action. Published data for four different bioluminescent biosensors, reporting on toluene (two separate

biosensors), isopropylbenzene, and octane, were analyzed to develop structure-activity relationships between biological response and physical/chemical properties. Good QSARs (quantitative structure-activity relationships) were developed for three out of the four biosensors, with between 88 and 100 per cent of the variance explained. Parameters found to be important in controlling regulator specificity were hydrophobicity, lowest unoccupied molecular orbital energies, and molar volume. For one of the biosensors, it was possible to show that the biological response to chemicals tested fell into three separate classes (non-hydrocarbons, aliphatic hydrocarbons, and aromatic hydrocarbons). A statistically significant QSAR based on hydrophobicity was developed for the fourth biosensor, but was poor in comparison to the other three (44 per cent variance explained).

Jagjit S. Yadav, David L. Lawrence, Barbara A. Nuck, Thomas W. Federle, C. Adinarayana Reddy. (Department of Environmental Health, Division of Molecular Toxicology, University of Cincinnati, Cincinnati, OH 45267-0056, USA. Environmental Science Department, The Procter & Gamble Company, P.O. Box 538707 , Cincinnati, OH 45253-8707, USA. Department of Microbiology and the NSF Center for Microbial Ecology, Michigan State University, East Lansing, MI 48824-1101, USA Author for correspondence). **Biotransformation of linear alkylbenzene sulfonate (LAS) by *Phanerochaete chrysosporium* : oxidation of alkyl side-chain**. Biodegradation, 12(6) (2001), 443-453.

The white rot fungus *Phanerochaete chrysosporium*, which generally mineralizes substituted aromatics to CO_2, transformed linear alkylbenzene sulfonate (LAS) surfactants mainly at their alkyl side chain. Degradation of LAS was evidenced by a zone of clearing on LAS-containing agar plates and colorimetric analysis of liquid cultures. Disappearance of LAS was virtually complete within 10 days in low nitrogen (2.4 mM N), high nitrogen (24 mM N) and malt extract (ME) liquid media. After 5 days of incubation in ME medium, transformation of LAS was complete at concentrations ≤4 mg l^{-1}, but decreased at higher concentrations. The LAS degradation was not dependent on lignin peroxidases (LiPs) and manganese-dependent peroxidases (MnPs). Mineralization of ^{14}C-ring-LAS to $^{14}CO_2$ by *P. chrysosporium* was <1% regardless of the culture conditions used. Thin layer chromatography and mass spectral analyses indicated that *P. chrysosporium* transformed LAS to sulfophenyl carboxylates (SPCs) through oxidative shortening of the alkyl side-chains. While LAS disappearance in the cultures was not dependent on LiPs and MnPs, transformation of the parent LAS moieties to SPCs was more extensive in low N medium that favors expression of these enzymes. The SPCs produced in LN cultures were shorter in chain- length than those produced in ME cultures. Also there was a notable shift in the relative abundance of odd and even chain length metabolites compared to the starting LAS particularly in the low N cultures suggesting the possible involvement of processes other than or in addition to β-oxidation in the chain-shortening process.

Jan Weijma, Look W. Hulshoff Pol, Alfons J.M. Stams, Gatze Lettinga. (Wageningen University, Department of Agrotechnology and Food Sciences, Subdepartment of Environmental Technology, P.O. Box 8129, 6700 EV, Wageningen. Wageningen University, Department of Agrotechnology and Food Sciences, Subdepartment of Environmental Technology, P.O. Box 8129, 6700 EV, Wageningen. Laboratory of Microbiology, Hesselink van Suchtelenweg 4, 6703 CT, Wageningen, The Netherlands. Wageningen University, Department of Agrotechnology and Food Sciences, Subdepartment of Environmental Technology, P.O. Box 8129, 6700 EV, Wageningen). **Performance of a thermophilic sulfate and sulfite reducing high rate anaerobic reactor fed with methanol**. Biodegradation, 11(6) (2000), 429-439.

Thermophilic sulfate and sulfite reduction was studied in lab-scale Expanded Granular Sludge Bed (EGSB) reactors operated at 65°C and pH 7.5 with methanol as the sole carbon and energy source for the sulfate- and sulfite-reducing bacteria. At a hydraulic retention time (HRT) of 10 h, maximum sulfite and sulfate elimination rates of 5.5 gSO32- L-1 day-1 (100 % elimination) and 5.7 gSO42- -1 day-1 (55% elimination) were achieved, resulting in an effluent sulfide concentration of approximately 1800 mgS L-1. Sulfate elimination was limited by the sulfide concentration, as stripping of H2S from the reactor with nitrogen gas was found to increase the sulfate elimination rate to 9.9 gSO42- L-1 day-1 (100 % elimination). At a HRT of 3 h, maximum achievable sulfite and sulfate elimination rates were even 18 gSO32- L-1 day-1 (100% elimination) and 11 gSO42- L-1 day-1 (50% elimination). At a HRT of 3 h, the elimination rate was limited by the biomass retention of the system. 5.5 ± 1.8% of the consumed methanol was converted to acetate, which was not further degraded by sulfate reducing bacteria present in the sludge. The acetotrophic activity of the sludge could not be stimulated by cultivating the sludge for 30 days under methanol-limiting conditions. Omitting cobalt as trace element from the influent resulted in a lower acetate production rate, but it also led to a lower sulfate reduction rate. Sulfate degradation in the reactor could be described by zeroth order kinetics down to a threshold concentration of 0.05 g L-1, while methanol degradation followed Michaelis-Menten kinetics with a Km of 0.037 gCOD L-1.

Jason C. Stolworthy, Andrzej Paszczynski, Roger Korus, Ronald L. Crawford. (Department of Chemical Engineering, University of Idaho, Moscow, ID 83844-1021, USA. Environmental Biotechnology Institute, University of Idaho, Moscow, ID 83844-1052, USA Department of Microbiology, Molecular Biology & Biochemistry, University of Idaho, Moscow, ID 83844-3052, USA Author for correspondence. Department of Chemical Engineering, University of Idaho, Moscow, ID 83844-1021, USA. Environmental Biotechnology Institute, University of Idaho, Moscow, ID 83844-1052, USA Department of Microbiology, Molecular Biology & Biochemistry, University of Idaho, Moscow, ID 83844-3052, USA). **Metal binding by pyridine-2,6-bis(monothiocarboxylic acid), a biochelator produced by *Pseudomonas stutzeri* and *Pseudomonas putida*.** Biodegradation, 12(6) (2001), 411-418.

Pyridine-2,6-bis(monothiocarboxylic acid) (pdtc), a natural metal chelator produced by *Pseudomonas stutzeri* and *Pseudomonas putida* that promotes the degradation of carbon tetrachloride, was synthesized and studied by potentiometric and spectrophotometric techniques. The first two stepwise protonation constants (pK) for successive proton addition to pdtc were found to be 5.48 and 2.58. The third stepwise protonation constant was estimated to be 1.3. The stability (affinity) constants for iron(III), nickel(II), and cobalt(III) were determined by potentiometric or spectrophotometric titration. The results show that pdtc has strong affinity for Fe(III) and comparable affinities for various other metals. The stability constants (log K) are 33.93 for $Co(pdtc)_2^{1-}$; 33.36 for $Fe(pdtc)_2^{1-}$; and 33.28 for $Ni(pdtc)_2^{2-}$. These protonation constants and high affinity constants show that over a physiological pH range the ferric pdtc complex has one of the highest effective stability constants for iron binding among known bacterial chelators.

Jeanne M. VanBriesen. (Department of Civil and Environmental Engineering, Carnegie Mellon University, Pittsburgh, PA 15213-3890, USA). **Thermodynamic yield predictions for biodegradation through oxygenase activation reactions**. Biodegradation, 12 (4) (2001), 263-279.

Activation reactions involve modification of recalcitrant substrates to forms that are more readily degradable. These reactions require specialized enzymes and cosubstrates, including molecular oxygen and reduced electron carriers. In these reactions, microorganisms invest electrons and cannot capture energy or carbon for synthesis. The subsequent degradation of the intermediates formed in activation reactions releases electrons, energy, and carbon that the organisms use for growth. The overall yield is reduced due to the required activation investments. A mathematical method to predict cell yields of oxygenase activation reactions is developed using electron and energy balances. Predicted yields are compared with experimental yields for methane, organic chelating agents, and aromatic hydrocarbons.

Jeffrey A. Cunningham, Gary D. Hopkins, Carmen A. Lebron, Martin Reinhard. (Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA. Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA. Restoration Development Branch, Naval Facilities Engineering Service Center, 1100 23rd Ave., ESC-411, Port Hueneme, CA 93043, USA. Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA*).* **Enhanced anaerobic bioremediation of groundwater contaminated by fuel hydrocarbons at Seal Beach, California**. Biodegradation, 11(2-3) (2000), 159-170.

Enhanced anaerobic biodegradation of groundwater contaminated by fuel hydrocarbons has been evaluated at a field experiment conducted at the Naval Weapons Station, Seal Beach, California. This experiment included the establishment of three different remediation zones in situ: one zone was augmented with sulfate, one was augmented with sulfate and nitrate, and the third was unaugmented. This enables a comparison of hydrocarbon biodegradation under sulfate-reducing, sequential denitrifying/sulfate-reducing, and methanogenic conditions, respectively. In general, the results from the field experiment are: (1) Certain fuel hydrocarbons were removed preferentially over others, but the order of preference is dependent upon the geochemical conditions; and (2) In the zones that were augmented with sulfate and/or nitrate, the added electron acceptors were consumed quickly, indicating that enhancement via electron acceptor injection accelerates the biodegradation process. More specifically, in the sulfate-reducing zone, sulfate was utilized with an apparent first-order rate coefficient of approximately 0.1 day-1. In the combined denitrifying/sulfate-reducing zone, nitrate was utilized preferentially over sulfate, with an apparent first-order rate coefficient of 0.1–0.6 day-1. However, the data suggest that slow sulfate utilization does occur in the presence of nitrate, i.e. the two processes are not strictly sequential. With regard to the aromatic BTEX hydrocarbons, toluene was preferentially removed under intrinsic conditions; biodegradation of benzene was slow if it occurred at all; augmentation with sulfate preferentially stimulated biodegradation of *o*-xylene; and ethylbenzene appeared recalcitrant under sulfate-reducing conditions but readily degradable under denitrifying conditions.

Jens Aamand, Sebastian R. Sørensen.(Department of Geochemistry. Geological Survey of Denmark and Greenland (GEUS), Thoravej 8, DK-2400 Copenhagen, Denmark. Department of Geochemistry. Geological Survey of Denmark and Greenland (GEUS), Thoravej 8, DK-2400 Copenhagen, Denmark). **Biodegradation of the Phenylurea Herbicide Isoproturon and its Metabolites in Agricultural Soils**. Biodegradation, 12(1) (2001), 69-77.

Degradation of the phenylurea herbicide isoproturon (3-(4-isopropylphenyl)-1,1-dimethylurea) and several phenylurea and aniline metabolites was studied in

agricultural soils previously exposed to isoproturon. The potential for degradation of the demethylated metabolite 3-(4-isopropylphenyl)-1-methylurea in the soils was much higher compared to isoproturon. In the most active soil only 6% of added 14C-labelled isoproturon was mineralised to 14C2 within 20 days while in the same period 45% of added 14C-labelled 3-(4-isopropylphenyl)-1-methylurea was mineralized. This indicates that the initial N-demethylation may be a limiting step in the complete mineralization of isoproturon. Repeated addition of 3-(4-isopropylphenyl)-1-methylurea to the soil and further subculturing in mineral medium led to a highly enriched mixed bacterial culture with the ability to mineralize 3-(4-isopropylphenyl)-1-methylurea. The culture did not degrade either isoproturon or the didemethylated metabolite 3-(4-isopropylphenyl)-urea when provided as sole source of carbon and energy. The metabolite 4-isopropyl-aniline was also degraded and utilised for growth, thus indicating that 3-(4-isopropylphenyl)-1-methylurea is degraded by an initial cleavage of the methylurea-group followed by mineralization of the phenyl-moiety. Several attempts were made to isolate pure bacterial cultures degrading 3-(4-isopropylphenyl)-1-methylurea or 4-isopropyl-aniline, but they were not successful.

Jens Harder. (Department of Microbiology, Max-Planck-Institute for Marine Microbiology, Celsiusstr. 1, D-28359 Bremen). **Anaerobic utilization of essential oils by denitrifying bacteria**. Biodegradation, 11(1) (2000), 55-63.

Plant volatile organic compounds are a major carbon source in nature. We studied the degradability of these substances by anaerobic microorganisms in enrichment cultures with representative essential oils as organic substrates and nitrate as electron acceptor. Lemon and pine needle oil supported microbial growth in the presence of pure oil, whereas parsley seed, camphor, sage, fennel, and mint oil supported growth only when the essential oils were dissolved in an overlying phase of 2,2,4,4,6,8,8-heptamethylnonane. Thyme oil did not support denitrification. Analyses of the microbially degraded oils revealed the disappearance of monoterpenes, of several monoterpenoids, and of methoxy-propenyl-benzenes, including apiole and myristicin. Most-probable-number determinations for denitrifying communities in sewage sludge and forest soil yielded 106 to 107 monoterpene-utilizing cells ml-1, representing 0.7 to 100% of the total cultivable nitrate-reducing microorganisms. The utilization of essential oils together with the common occurrence of this metabolic trait are indications for an environmentally important, but currently unexplored anaerobic turnover of plant volatile organic compounds in soil.

Juan-Pedro Elissetche, André Ferraz, Carolina Parra, Juanita Freer, Jaime Baeza, Jaime Rodríguez. (Renewable Resources Laboratory, Casilla 160-C, Universidad de Concepción, Concepción, Chile. Departamento de Biotecnologia, Faculdade de Engenharia Química de Lorena, CP 116, 12600-000 Lorena, SP, Brazil. Renewable Resources Laboratory, Casilla 160-C, Universidad de Concepción, Concepción, Chile. Renewable Resources Laboratory, Casilla 160-C, Universidad de Concepción, Concepción). **Biodegradation of Chilean native wood species, *Drimys winteri* and *Nothofagus dombeyi*, by *Ganoderma australe***. World Journal of Microbiology and Biotechnology, 17(6) (2001), 577-581.

Drimys winteri and *Nothofagus dombeyi*, two native Chilean wood species with high potential for pulp production, were biodegraded by *Ganoderma australe*. This fungus is known to provoke extensive and selective biodelignification of these wood species in the field. Under laboratory conditions, *N. dombeyi* underwent higher weight and component losses than *D. winteri*. In neither case was the

lignin removal selective, because glucan loss was almost simultaneous with lignin degradation. The decayed wood chips became progressively discoloured throughout the biodegradation time. The brightness increase was only partly reversed in thermal reversion assays. *Nothofagus dombey* solubility in 1% NaOH increased by 13.7% after 9 weeks of biodegradation, while *D. winteri* solubility increased by 14.2% in a shorter period (6 weeks). In both cases, the solubility increase was proportional to the liquor absorbance increase at 272 nm, which indicates that the wood solubility in 1% NaOH was dependent of lignin solubilization.

K. Leeming a, C.P. Moore a and S.P. Denyer b*. (Kodak European *R&D,* Kodak Ltd, Headstone Drive, Harrow, Middlesex HA I 4TY, UK. School of Pharmacy and Biomolecular Sciences, University of Brighton, Lewes Road, Brighton, E. Sussex BN2 4GJ, UK). **The use of immobilised biocides for process water decontamination**. International Biodeterioration & Biodegradation, 49(1) (2002), 39-43.

Photoprocessing solutions offer an ideal environment for microbial growth and require biocide protection. In this study, isothiazolin-3-one biocidal agents immobilized on hydrophobic beads have been shown to provide significant antimicrobial control in a recirculating system. Proposed mechanisms of action include direct donation of biocide from the supporting resin to the target cell and sustained delivery into solution; both require an optimum balance between biocide and support hydrophobicites to achieve the 72 day biogrowth control seen in practice.

Keith A. Strevett, Br. Angela Vanegas, Gang Chen. (Bioenvironmental Engineering & Environmental Science Laboratory, School of Civil Engineering & Environmental Science, University of Oklahoma, OK 73019, USA). **Naphthalene, phenanthrene and surfactant biodegradation.** Biodegradation, 12 (6) (2001), 433-442.

The impact of surfactants on naphthalene and phenanthrene biodegradation and vice versa after surfactant flushing were evaluated using two anionic surfactants: sodium dodecyl sulfate (SDS) and sodium dodecyl benzene sulfonate (SDBS); and two nonionic surfactants: POE (20) sorbitan monooleate (T-maz-80) and octylphenol poly(ethyleneoxy) ethanol (CA-620). Naphthalene and phenanthrene biodegradation varied differently in the presence of different surfactants. Naphthalene biodegradation was not impacted by the presence of SDS. In the presence of T-maz-80 and CA-620, naphthalene biodegradation occurred at a lower rate (0.14 d^{-1} for T-maz-80 and 0.19 d^{-1} for CA-620) as compared to un-amended control (0.29 d^{-1}). Naphthalene biodegradation was inhibited by the presence of SDBS. In the presence of SDS, phenanthrene biodegradation occurred at a lower rate (0.10 d^{-1} as compared to un-amended control of 0.17 d^{-1}) and the presence of SDBS, CA-620 and T-maz-80 inhibited phenanthrene biodegradation. The surfactants also responded differently to the presence of naphthalene and phenanthrene. In the presence of naphthalene, SDS biodegradation was inhibited; SDBS and T-maz-80 depleted at a lower rate (0.41d^{-1} and 0.12 d^{-1} as compared to 0.48 d^{-1} and 0.22 d^{-1}). In the absence of naphthalene, CA-620 was not degradable, while in the presence of naphthalene, CA-620 began to degrade at a comparatively low rate (0.12 d^{-1}). In the presence of phenanthrene, SDS biodegradation occurred at a lower rate (1.2 d^{-1} as compared to 1.68 d^{-1}) and a similar trend was observed for T-maz-80. The depletion of SDBS and CA-620 did not change significantly. The choice of SDS for naphthalene-contaminated sites would not adversely affect the natural

attenuation of naphthalene, in addition, naphthalene was preferentially utilized to SDS by naphthalene-acclimated microorganisms. Therefore, SDS was the best choice. T-maz-80 was also found to be usable in naphthalene-contaminated sites. For phenanthrene contaminated sites, SDS was the only choice.

L.A. Launen, L.J. Pinto, P.W. Percival, S.F.S. Lam, M.M. Moore. (Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6 Canada. Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6 Canada. Department of Chemistry, Simon Fraser University, Burnaby, BC V5A 1S6 Canada. Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6 Canada. Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6 Canada). **Pyrene is metabolized to bound residues by *Penicillium janthinellum* SFU403**. Biodegradation, 11(5) (2000), 305-312.

We have previously shown that the filamentous fungus, *Penicillium janthinellum* SFU403 (SFU403) oxidizes pyrene to pyrene 1,6- and 1,8-quinones and that the level of pyrenequinones (PQs) subsequently declines suggesting that PQs are not terminal metabolites. The purpose of this study was to determine the fate of PQs in SFU403. First, we compared the fate of 14C-pyrene in SFU403 and a non-pyrene-oxidizing fungus, a *Paecilomyces* sp.. After 7 days of incubation, more than 80% of the radioactivity was cell-associated in both fungi; however, while 90% of the 14C could be extracted from the *Paecilomyces* sp. as unmetabolized pyrene, 65–80% of the bound radioactivity remained inextractable from SFU403. Further evidence that pyrene oxidation to PQs was required for irreversible binding was obtained by comparing the extent of 14C bound to SFU403 when it was grown for 21 days under conditions that resulted in differing amounts of 14C-pyrene oxidation. The results showed that ˜40% of the inextractable products were bound residues derived from pyrene metabolites. The balance (60%) could be attributed to strong sorption of unreacted pyrene. We used electron paramagnetic resonance spectroscopy and oxygen consumption studies to demonstrate that both NADPH and glutathione can reduce PQs by one electron to their corresponding semiquinone anion radicals *in vitro*. These studies demonstrate that PQs are metabolized by SFU403 to bound residues, possibly via semiquinone intermediates.

Lal B, Mishra S, Bhattacharya D, Sarma P M. **Biotechnological approach to manage oily sludge**. In Proceedings of the 4th International Petroleum Conference and Exhibition (PETROTECH-2001), edited by AK Bhatnagar Faridabad: R&D Centre, Indian Oil Corporation Ltd, Biodegradation (2001), 195-196.

An indigenous bacterial consortium was developed by combining the cultures of five bacterial strains, which could biodegrade crude oil and oily sludge. This indigenous bacterial consortium was designated as 'Oilzapper'. Crude oil and oily sludge degrading efficiency of Oilzapper was tested under laboratory and field conditions. A full-scale study on in situ bioremediation of oily sludge was conducted at an oil refinery. The indigenous population of hydrocarbon degrading bacteria in soil at full-scale bioremediation site was only 1000-10000 cfu/g soil. Treatment plots Al, A2 and A3 of block A were treated with Oilzapper and nutrients, resulted in 96.2%, 90.6% and 90.3% biodegradation of TPH respectively in one year as compared to only 14.3% biodegradation of TPH in control block. Similarly the plots B1, B2 and B3 of block B were also treated with Oilzapper and nutrients, which revealed 90.6%, 89.6% and 87.8% biodegradation of TPH in soil in one year. The population of Acinetobacter baumannii strains (constituent of Oilzapper) was stable in soil at bioremediation site even after one year of its application. Physical and chemical properties of soil

of bioremediation site improved significantly in one year. A similar study on bioremediation of oily sludge with application of Oilzapper was also conducted at various oil refineries and the results are highly encouraging.

Laleh Yerushalmi, Jean-Francois Lascourreges, Chakib Rhofir, Serge R. Guiot. (Biotechnology Research Institute, National Research Council Canada 6100 Royalmount Avenue, Montreal, Canada, H4P 2R2). **Detection of intermediate metabolites of benzene biodegradation under microaerophilic conditions**. Biodegradation, 12(6) (2001), 379-391.

The intermediate metabolites of benzene transformation by a microaerophilic bacterial consortium, adapted to degrade gasoline and benzene at low concentrations of dissolved oxygen (<1 mg l^{-1}), were identified. The examined range of initial DO concentration, 0.05 to 1 mg l^{-1}, was considerably lower than the previously reported values believed to be necessary to initiate benzene biodegradation. An extensive transformation of benzene, higher than the theoretical predictions for its aerobic oxidation, was observed. Phenol was identified as the most stable and the major intermediate metabolite, which was subsequently transformed into catechol and benzoate. The use of ^{13}C-labeled compounds identified benzene as the source of phenol, and phenol as the source of catechol and benzoate, suggesting the involvement of a monooxygenase enzymatic system in biodegradation of benzene at low DO concentrations. A metabolic sequence was proposed to describe the simultaneous detection of catechol and benzoate during the microaerophilic transformation of benzene. The results of this work demonstrate that it is possible to transform benzene, a highly carcinogenic hydrocarbon and a major contaminant of groundwater, to more easily biodegradable compounds in the presence of very small amounts of oxygen.

Lenita E. Lindberg, Bjarne R. Holmbom, Outi M. Väisänen, Assi M-L. Weber, Mirja S. Salkinoja-Salonen. (Aring;bo Akademi Process Chemistry Group, c/o Laboratory of Forest Products Chemistry, Porthansgatan 3, FIN-20500 Turkuåb. Aring;bo Akademi Process Chemistry Group, c/o Laboratory of Forest Products Chemistry, Porthansgatan 3, FIN-20500 Turkuåbo, Finland. University of Helsinki, Department of Applied Chemistry and Microbiology, P.O. Box 56, FIN-00014 University of Helsinki, Finland Present address: Leiras Oy, P. O. Box 415, FIN-20101 Turkuåbo, Finland. Metsä-Serla Group, Corporate R & D, P.O. Box 44, FIN-08701 Virkkala, Finland. University of Helsinki, Department of Applied Chemistry and Microbiology, P.O. Box 56, FIN-00014 University of Helsinki, Finland). **Degradation of paper mill water components in laboratory tests with pure cultures of bacteria**. Biodegradation, 12(3) (2001), 141-148.

The degradation of dissolved and colloidal substances from thermomechanical pulp (TMP) by bacteria isolated from a paper mill was studied in a laboratory slide culture system. *Burkholderia cepacia* strains hydrolysed triglycerides to free fatty acids, and the liberated unsaturated fatty acids were then degraded to some extent. Saturated fatty acids were not notably degraded. However, the branched anteiso-heptadecanoic fatty acid was degraded almost like the unsaturated fatty acids. About 30% of the steryl esters were degraded during 11 days, increasing the concentrations of free sterols. Approximately 25% of the dehydroabietic, and 45% of the abietic and isopimaric resin acids were degraded during 11 days. The degree of unsaturation seemed to be of greater importance for the degradation of fatty acids than the molar mass. No degradation of dissolved hemicelluloses could be observed with any of the nine bacterial strains studied. *Burkholderia cepacia* strains and one *Bacillus coagulans* strain degraded monomeric fructose and glucose in winter TMP water, but in summer TMP water, with much lower sugar concentrations, also other *Bacillus* strains degraded monomeric sugars. .

Lenita E. Lindberg, Bjarne R. Holmbom, Outi M. Väisänen, Assi M-L. Weber, Mirja S. Salkinoja-Salonen. (Aring;bo Akademi Process Chemistry Group, c/o Laboratory of Forest Products Chemistry, Porthansgatan 3, FIN-20500 Turkuåbo, Finland. University of Helsinki, Department of Applied Chemistry and Microbiology, P.O. Box 56, FIN-00014 University of Helsinki, Finland Present address: Leiras Oy, P. O. Box 415, FIN-20101 Turkuåbo, Finland. Metsä-Serla Group, Corporate R & D, P.O. Box 44, FIN-08701 Virkkala, Finland). **Degradation of paper mill water components in laboratory tests with pure cultures of bacteria**. Biodegradation, 12(3) (2001), 141-148.

The degradation of dissolved and colloidal substances from thermomechanical pulp (TMP) by bacteria isolated from a paper mill was studied in a laboratory slide culture system. *Burkholderia cepacia* strains hydrolysed triglycerides to free fatty acids, and the liberated unsaturated fatty acids were then degraded to some extent. Saturated fatty acids were not notably degraded. However, the branched anteiso-heptadecanoic fatty acid was degraded almost like the unsaturated fatty acids. About 30% of the steryl esters were degraded during 11 days, increasing the concentrations of free sterols. Approximately 25% of the dehydroabietic, and 45% of the abietic and isopimaric resin acids were degraded during 11 days. The degree of unsaturation seemed to be of greater importance for the degradation of fatty acids than the molar mass. No degradation of dissolved hemicelluloses could be observed with any of the nine bacterial strains studied. *Burkholderia cepacia* strains and one *Bacillus coagulans* strain degraded monomeric fructose and glucose in winter TMP water, but in summer TMP water, with much lower sugar concentrations, also other *Bacillus* strains degraded monomeric sugars.

Linda Gordon, Alan D.W. Dobson. (Department of Microbiology, National University of Ireland, University College, Cork, Ireland). **Fluoranthene degradation in *Pseudomonas alcaligenes* PA-10**. Biodegradation, 12(6) (2001), 393-400.

Pseudomonas alcaligenes strain PA-10 degrades the four-ring polycyclic aromatic hydrocarbon fluoranthene, co-metabolically. HPLC analysis of the growth medium identified four intermediates, 9-fluorenone-1-carboxylic acid; 9-hydroxy-1-fluorene carboxylic acid; 9-fluorenone and 9-fluorenol, formed during fluoranthene degradation. Pre-exposure of PA-10 to 9-fluorenone-1-carboxylic acid and 9-hydroxy-1-fluorene-carboxylic acid resulted in increases in fluoranthene removal, while pre-exposure to 9-fluorenone and 9-fluorenol resulted in a decrease in fluoranthene degradation. The rate of indole transformation was similarly affected by pre-exposure to these metabolic intermediates, indicating a link between fluoranthene degradation and indigo formation in this strain.

Lisa Alvarez-Cohen, Gerald E. Speitel Jr. (Department of Civil and Environmental Engineering, University of California, Berkeley, CA 94720-1710, U.S.A. Department of Civil Engineering, ECJ 8.6, University of Texas at Austin, TX 78712, U.S.A). **Kinetics of aerobic cometabolism of chlorinated solvents**. Biodegradation, 12(2) (2001), 105-126.

The objectives of this paper are to review the wide range of kinetic models that have been introduced to describe the cometabolic oxidation of chlorinated solvents, to compare modeling approaches and associated experimental data, and to discuss knowledge gaps in the general topic of cometabolism kinetics. To begin, a brief description of the mechanism of oxygenase enzyme metabolism and its qualitative effects on cometabolic degradation kinetics is given. Next, a variety of kinetic expressions that have been used to describe cometabolism, ranging from adaptations of simple metabolic relationships to the development of

complex equations that account for intracellular concentrations of key reaction species, are presented. A large number of kinetic coefficients published for a variety of oxygenase populations degrading a broad range of chlorinated solvents are categorized and compared. The discussion section of the paper contains an exploration of knowledge gaps that exist in our understanding of the kinetics of aerobic chlorinated solvent cometabolism. Specific topics covered include: [the use of half saturation constants (Ksc and Ksg) as estimates for inhibition constants (Kisc and Kisg) in saturation modeling expressions, &bull] [the specific nature of chlorinated solvent induced product toxicity and the capability for cells to recover from toxic effects, and &bull] & methods for incorporating reducing energy limitations into cometabolism models. Finally, the applicability of the broad range of kinetic modeling approaches to scale-up and field applications for *in situ* bioremediation of chlorinated solvents is discussed.

Li-Tse Ou, John E. Thomas, Keun-Yook Chung, Andrew V. Ogram. (Soil and Water Science Department, P.O. Box 110290, University of Florida, Gainesville, FL 32611-0290, USA. Soil and Water Science Department, P.O. Box 110290, University of Florida, Gainesville, FL 32611-0290, USA. Soil and Water Science Department, P.O. Box 110290, University of Florida, Gainesville, FL 32611-0290, USA. Soil and Water Science Department, P.O. Box 110290, University of Florida, Gainesville, FL 32611-0290, USA). **Degradation of 1,3-dichloropropene by a soil bacterial consortium and *Rhodococcus* sp. AS2C isolated from the consortium**. Biodegradation, 12(1) (2001), 39-47.

A bacterial consortium capable of degrading the fumigant 1,3-D ((Z)- and (E)-1,3-dichloropropene) was enriched from an enhanced soil. This mixed culture degraded (Z)- and (E)-1,3-D only in the presence of a suitable biodegradable organic substrate, such as tryptone, tryptophan, or alanine. After 8 months of subculturing at 2- to 3-week intervals, a strain of *Rhodococcus* sp. (AS2C) that was capable of degrading 1,3-D cometabolically in the presence of a suitable second substrate was isolated. (Z)-3-chloroallyl alcohol (3-CAA) and (Z)-3-chloroacrylic acid (3-CAAC), and (E)-3-CAA and (E)-3-CAAC were the metabolites of (Z)- and (E)-1,3-D, respectively. (E)-1,3-D was degraded faster than (Z)-1,3-D by the strain AS2C and the consortium. AS2C also degraded (E)-3-CAA faster than (Z)-3-CAA. Isomerization of (E)-1,3-D to (Z)-1,3-D or the (Z) form to the (E) form did not occur.

Lorenz Adrian, Ulrich Szewzyk, Helmut Görisch. (Fachgebiet Technische Biochemie, Sekr. GG1, Technische Universität Berlin, Seestraße 13, D-13353 Berlin, Germany. Fachgebiet Ökologie der Mikroorganismen, Sekr. OE5, Technische Universität Berlin, Franklinstraße 29, D-10587 Berlin, Germany. Fachgebiet Technische Biochemie, Sekr. GG1, Technische Universität Berlin, Seestraße 13, D-13353 Berlin, Germany). **Bacterial growth based on reductive dechlorination of trichlorobenzenes**. Biodegradation, 11(1) (2000), 73-81.

An anaerobic mixed bacterial culture was enriched for bacteria dechlorinating 1,2,3- and 1,2,4-trichlorobenzene (TCB) to dichlorobenzenes by exclusive use of non-fermentable substrates and the application of vancomycin. Growth and dechlorination occurred in a purely synthetic medium with formate or hydrogen, acetate, and TCB. Neither acetogenesis nor methanogenesis was detected in the culture. Repeated subculturing maintaining high dechlorinating activities was also achieved when only hydrogen and TCB were supplied. This indicated that reductive dechlorination of TCB was the primary energy conservating process. The number of dechlorinating bacteria was strictly limited by the amount of TCB supplied in the medium. In addition, the dechlorinating activity could be maintained only in the presence of TCB. A most probable number analysis showed that the dechlorinating species amounted to at least 6 105 cells per ml at a total

cell number of about 2 106 cells per ml. Vitamin B12 significantly stimulated the dechlorinating activity.

Luisa M. Freitas dos Santos, Arnaud Spicq, Anthony P. New, Jean-Claude Wolff, Andrew Edwards. (Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK). **Aerobic biotransformation of 4-fluorocinnamic acid to 4-fluorobenzoic acid**. Biodegradation, 12(1) (2001), 23-29.

The biotransformation of 4-fluorocinnamic acid (FCA) using non-acclimated industrial activated sludge was investigated. FCA is a common intermediate in organic synthesis, and it is often present in aqueous waste streams. Hence, the biotransformation reactions this compound undergoes when exposed to activated sludge micro-organisms should be understood before waste streams are sent to biological wastewater treatment plants (WWTPs). FCA biotransformation was monitored using a wide range of analytical techniques. These techniques were used to monitor not only FCA disappearance, but also the formation of degradation products, in order to propose the metabolic pathway. FCA was biotransformed to 4-fluorobenzoic acid via the formation of 4-fluoroacetophenone. The removal of FCA up to 200 mg L-1 followed first order kinetics. The half-lives for removal of FCA from the test solutions supplied with 200 mg L-1, 100 mg L-1, and 50 mg L-1 were 53, 18, and 5 hours respectively.

M. Hutnan, M. Drtil, L. Mrafkova. (Department of Environmental Science, Faculty of Chemical Technology, Slovak University of Technology, Radlinskeho 9, 812 37 Bratislava, Slovak Republic. Department of Environmental Science, Faculty of Chemical Technology, Slovak University of Technology, Radlinskeho 9, 812 37 Bratislava, Slovak Republic. Department of Environmental Science, Faculty of Chemical Technology, Slovak University of Technology, Radlinskeho 9, 812 37 Bratislava, Slovak Republic*).* **Anaerobic biodegradation of sugar beet pulp**. Biodegradation, 11(4) (2000), 203-211.

Sugar beet pulp is a by-product of sugar production and consists mainly of cellulose, hemicellulose and pectin. Its composition is suitable for biological degradation. A possible alternative for the utilization of this material (besides cattle feeding) can be anaerobic methanogenic degradation. It has an additional advantage – biogas production. Beet pulp was treated by a two-step anaerobic process. The first step consisted of hydrolysis and acidification. The second step was methanogenesis. In this paper, observation of the process of anaerobic degradation and determination of optimal parameters is discussed. A laboratory-scale model for sugar beet pulp anaerobic biodegradation was operated. Results of model performance have shown very good pulp digestion characteristics. In addition, high efficiency removal of organic matter was achieved. Methane yield was over 0.360 m3 kg-1 dried pulp and excess sludge production was 0.094 g per gram COD added.

M.D. Zwolinski, R.F. Harris, W.J. Hickey. (Environmental Toxicology Center, University of Wisconsin-Madison, Madison, WI 53706-1299, USA. Environmental Toxicology Center and Department of Soil

Science, University of Wisconsin-Madison, Madison, WI 53706-1299, USA. Environmental Toxicology Center and Department of Soil Science, University of Wisconsin-Madison, Madison, WI 53706-1299, USA.). **Microbial consortia involved in the anaerobic degradation of hydrocarbons**. Biodegradation, 11(2-3) (2000), 141-158.

In this review, we examine the energetics of well-characterized biodegradation pathways and explore the possibilities for these to support growth of multiple organisms interacting in consortia. The relevant phenotypic and/or phylogenetic characteristics of isolates and consortia mediating hydrocarbon degradation coupled with different terminal electron-accepting processes (TEAP) are also reviewed. While the information on metabolic pathways has been gained from the analysis of individual isolates, the energetic framework presented here demonstrates that microbial consortia could be readily postulated for hydrocarbon degradation coupled to any TEAP. Several specialized reactions occur within these pathways, and the organisms mediating these are likely to play a key role in defining the hydrocarbon degradation characteristics of the community under a given TEAP. Comparing these processes within and between TEAPs reveals biological unity in that divergent phylotypes display similar degradation mechanisms and biological diversity in that hydrocarbon-degraders closely related as phylotypes differ in the type and variety of hydrocarbon degradation pathways they possess. Analysis of microcosms and of field samples suggests that we have only begun to reveal the diversity of organisms mediating anaerobic hydrocarbon degradation. Advancements in the understanding of how hydrocarbon-degrading communities function will be significantly affected by the extent to which organisms mediating specialized reactions can be identified, and tools developed to allow their study in situ.

Manuel Hernández, María J. Hernández-Coronado, Andrew S. Ball, María E. Arias. (Departamento de Microbiologia y Parasitologia, Universidad de Alcala, 28871 Alcalá de Henares, Spain. Departamento de Microbiologia y Parasitologia, Universidad de Alcala, 28871 Alcalá de Henares, Spain. Department of Biological Sciences. University of Essex, Wivenhoe Park, Colchester C04 3SQ, U.K. Departamento de Microbiologia y Parasitologia, Universidad de Alcala, 28871 Alcalá de Henares, Spain Author for correspondence). **Degradation of alkali-lignin residues from solid-state fermentation of wheat straw by *streptomycetes***. Biodegradation, 12(4) (2001), 219-223.

The ability of three *Streptomyces* strains to degrade alkali-lignin, produced from the treatment of wheat straw by the same organisms, was examined. Decolourisation and loss of alkali-lignin was only detected in cultures supplemented with ammonium as an inorganic N source. The pH of cultures supplemented with inorganic N reached lower pH than in those supplemented with yeast extract. From FT-IR spectra corresponding to the alkali-lignin obtained from the same cultures, a degradation of carbohydrate component concomitant with a modification in the aromatic moiety of lignin could be inferred. The results indicate that streptomycetes are suitable for use in the treatment of alkali-lignin effluents from the biological treatment of wheat straw by the same organisms and therefore support the role for these organisms in the development of clean technologies in pulp and paper industry.

Maria Eugenia Corbella, Amando Garrido-Pertierra, Antonio Puyet. (Departamento de Bioquímica y Biología Molecular IV, Facultad de Veterinaria, Universidad Complutense de Madrid, 28040 Madrid, Spain. Departamento de Bioquímica y Biología Molecular IV, Facultad de Veterinaria, Universidad Complutense de Madrid, 28040 Madrid, Spain. Departamento de Bioquímica y Biología Molecular IV, Facultad de Veterinaria, Universidad Complutense de Madrid, 28040 Madrid). **Induction of the halobenzoate catabolic pathway and cometabolism of ortho-chlorobenzoates in *Pseudomonas aeruginosa* 142 grown on glucose-supplemented media**. Biodegradation, 12(3)

(2001), 149-157.

The aerobic cometabolism of *ortho*-substituted chlorobenzoates by *Pseudomonas aeruginosa* strain 142 growing on glucose-supplemented medium was analyzed. The strain, which can use 2-chlorobenzoate (2-CBA) and 2,4-dichlorobenzoate (2,4-DCBA) as sole carbon and energy sources, showed high rates of 2-CBA metabolism in glucose-fed cells. In contrast, 2,4-DCBA was metabolized only after extended incubation of the full grown culture and depletion of glucose. In addition to the *ortho*-dehalogenation (*ohb*142) genes encoding the a and ß subunits of the oxygenase component of a 2-halobenzoate dioxygenase, strain 142 harbours a closely related *ohbABCDFG* gene cluster previously identified in *P. aeruginosa* JB2 (*ohb*JB2). The genes for the chlorocatechol *ortho*-catabolic pathway were identified and sequenced in this strain, showing a near complete identity with the *clc*ABD operon of the pAC27 plasmid. Relative quantification of mRNA by RT-PCR shows a preferential induction of *ohb*142 by 2-CBA, which is abolished in glucose-grown cultures. The alternate *ohb*JB2 and *clc* genes were expressed preferentially in 2,4-DCBA grown cultures. Only *ohb*JB2 appears to be expressed in the presence of the carbohydrate. Detection of chlorocatechol-1,2-dioxygenase activity in 2,4-DCBA plus glucose grown cultures suggests the presence of an alternate system for the *ortho*-cleavage of chlorobenzoates. The recruitment of elements from two halobenzoate dioxygenase systems with different induction patterns, together with a chlorocatechol degradative pathway not repressed by carbon catabolite, may allow *P. aeruginosa* 142 to cometabolize haloaromatics in carbohydrate grown cultures.

Matilde Gil, Ali Haïdour, Juan L. Ramos. (Fábrica Nacional de la Marañosa, Madrid, Spain. NMR Service Department, University of Granada, Granada, Spain. Department of Plant Biochemistry and Molecular and Cellular Biology of Plants, Estación Experimental del Zaidïn, Consejo Superior de Investigaciones Cientïficas, Apdo Correos 419, E18008 Granada, Spain). **Degradation of o-methoxybenzoate by a two-member consortium made up of a gram-positive *Arthrobacter* strain and a gram-negative *Pantotea* strain**. Biodegradation, 11(1) (2000), 49-53.

Aromatic carboxylic acids substituted with methoxylated groups are among the most abundant products in "alpechin", the wastes resulting from pressing olives to obtain olive oil. Degradation of o-methoxybenzoate by a stable consortium made of a gram positive bacterium, *Arthrobacter oxydans*, and gram negative one, *Pantotea agglomerans*, was shown to mineralize this compound efficiently. he concerted action of both microorganisms was needed for the two first steps n the process, namely, the conversion of o-methoxybenzoate into salycilate, and the hydroxylation of the latter to gentisate. Gentisate was further degraded by the *Arthrobacter* strain.

Matthew J. Zenker, Robert C. Borden, Morton A. Barlaz. (Department of Civil Engineering, North Carolina State University, Raleigh, NC 27695-7908, USA). **Mineralization of 1,4-dioxane in the presence of a structural analog**. Biodegradation, 11(4) (2000), 239-246.

A mixed culture with the ability to aerobically biodegrade 1,4-dioxane in the presence of tetrahydrofuran (THF) was enriched from a 1,4-dioxane contaminated aquifer. This consortium contained 3–4 morphologically different types of colonies and was grown in mineral salts media. Biodegradation of 1,4- dioxane began when THF concentrations in batch experiments became relatively low. No biodegradation of 1,4-dioxane was observed in the absence of THF and the

measured cell yield was similar during degradation of 1,4-dioxane with THF or with THF alone. However, when the consortium was grown in the presence of 14C-1,4-dioxane plus THF, 2.1% of the radiolabeled 1,4-dioxane was present in the particulate fraction. The majority of the 14C (78.1%) was recovered as 14CO2, while 5.8% remained in the liquid fraction. This activity is interesting since the non-growth substrate is mineralized, yet only minimally assimilated into biomass. Using THF as the growth substrate, 1,3-dioxane, methyl t-butyl ether, ethyl t-butyl ether and t-amyl methyl ether.

Minna K. Männistö, Marja A. Tiirola, Jaakko A. Puhakka. (Tampere University of Technology, Institute Environmental Engineering and Biotechnology, P.O. Box 541, FIN-33101 Tampere, Finland. University of Jyväskylä, Department of Biological and Environmental Sciences, P.O. Box 35, FIN-40351 Jyväskylä, Finland. Tampere University of Technology, Institute Environmental Engineering and Biotechnology, P.O. Box 541, FIN-33101 Tampere, Finland). **Degradation of 2,3,4,6-tetrachlorophenol at low temperature and low dioxygen concentrations by phylogenetically different groundwater and bioreactor bacteria**. Biodegradation, 12(5) (2001), 291-301.

Effects of low temperature and low oxygen partial pressure on the occurrence and activity of 2,3,4,6-tetrachlorophenol degrading bacteria in a boreal chlorophenol contaminated groundwater and a full-scale fluidized-bed bioreactor were studied using four polychlorophenol degrading bacterial isolates of different phylogenetic backgrounds. These included an α-proteobacterial *Sphingomonas* sp. strain MT1 isolated from the full-scale bioreactor and three isolates from the contaminated groundwater which were identified as β-proteobacterial *Herbaspirillum* sp. K1, a Gram-positive bacterium with high G + C content *Nocardioides* sp. K44 and an α-proteobacterial *Sphingomonas* sp. K74. The *Sphingomonas* strains K74 and MT1 and *Nocardioides* sp. K44 degraded 2,4,6-trichlorophenol and 2,3,4,6-tetrachlorophenol as the sole carbon and energy sources. Close to stoichiometric inorganic chloride release with the 2,3,4,6-tetrachlorophenol removal and the absence of methylation products indicated mineralization. Tetrachlorophenol degradation by the *Herbaspirillum* sp. K1 was enhanced by yeast extract, malate, glutamate, pyruvate, peptone and casitone. At 8 °C, *Sphingomonas* sp. K74 had the highest specific degradation rate (μ_{max} = 4.9 × 10^{-12} mg h^{-1} $cell^{-1}$) for 2,3,4,6-tetrachlorophenol. The *Nocardioides* strain K44 had the highest affinity (K_s = 0.46 mg l^{-1}) for tetrachlorophenol. K1 and MT1 grew microaerophilically in semisolid glucose medium. Furthermore, the growth of MT1 was inhibited in liquid glucose medium at high oxygen partial pressure indicating sensitivity to accumulating toxic oxygen species. On the other hand, trichlorophenol degradation was not affected by oxygen concentration (2–21%). The isolates K44, K74 and MT1, with optimum growth temperatures between 23 and 25 °C, degraded tetrachlorophenol faster at 8 °C than at room temperature indicating distinctly different temperature optima for chlorophenol degradation and growth on complex media. These results show efficient polychlorophenol degradation by the isolates at the boreal groundwater conditions, i.e., at low temperature and low oxygen concentrations. Differences in chlorophenol degradation and sensitivities to chlorophenols and oxygen among the isolates indicate that the phylogenetically different chlorophenol degraders have found different niches in the contaminated groundwater and thus potential for contaminant degradation under a variety of saturated subsurface conditions.

N.V. Balashova, A. Stolz, H-J. Knackmuss, I.A. Kosheleva, A.V. Naumov, A.M. Boronin. (Pushchino State University, 142290, Pushchino, Moscow region, Russia. Institut für Mikrobiologie der Universität Stuttgart, Allmandring 31,D-70569 Stuttgart, Germany. Laboratory of Plasmid Biology, Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, 142290, Pushchino, Moscow region, Russia). **Purification and characterization of a salicylate hydroxylase involved**

in 1-hydroxy-2-naphthoic acid hydroxylation from the naphthalene and phenanthrene-degrading bacterial strain *Pseudomonas putida* BS202-P1. Biodegradation, 12(3) (2001), 179-188.

1-Hydroxy-2-naphthoate is formed as an intermediate in the bacterial degradation of phenanthrene. A monooxygenase which catalyzed the oxidation of 1-hydroxy-2-naphthoate to 1,2-dihydroxynaphthalene was purified from the phenanthrene- and naphthalene-degrading *Pseudomonas putida* strain BS202-P1. The purified protein had a molecular weight of 45 kDa and required NAD(P)H and FAD as cofactors. The purified enzyme also catalysed the oxidation of salicylate and various substituted salicylates. The comparison of the K_m and V_{max} values for 1-hydroxy-2-naphthoate and salicylate demonstrated a higher catalytic efficiency of the enzyme for salicylate as a substrate. A significant substrate-inhibition was detected with higher concentrations of 1-hydroxy-2-naphthoate. The aminoterminal amino acid sequence of the purified enzyme showed significant homologies to salicylate 1-monooxygenases from other Gram negative bacteria. It was therefore concluded that during the degradation of phenanthrene the conversion of 1-hydroxy-2-naphthoate to 1,2-dihydroxynaphthalene is catalysed by a salicylate 1-monooxygenase. Together with previous studies, this suggested that the enzymes of the naphthalene pathway are sufficient to catalyse also the mineralization of phenanthrene.

Najat Amellal, Jean-M. Portal, Timothy Vogel, Jacques Berthelin. (Centre de Pédologie-Biologique, UPR 6831 du C.N.R.S. associée á l'Université Henri Poincaré-Nancy I, B.P. 5, 54501 Vandœuvre-lés-Nancy, France. Centre de Pédologie-Biologique, UPR 6831 du C.N.R.S. associée á l'Université Henri Poincaré-Nancy I, B.P. 5, 54501 Vandœuvre-lés-Nancy, France. Rhodia Eco services/ATE, 69330 Meyzieu, Franc. Centre de Pédologie-Biologique, UPR 6831 du C.N.R.S. associée á l'Université Henri Poincaré-Nancy I, B.P. 5, 54501 Vandœuvre-lés-Nancy, France*).* **Distribution and location of polycyclic aromatic hydrocarbons (PAHs) and PAH-degrading bacteria within polluted soil aggregates**. Biodegradation, 12(1) (2001), 49-57.

A study was conducted to determine the location and distribution of PAH and PAH-degrading bacteria in different aggregate size fractions of an industrially polluted soil. The estimation of PAH-degrading bacteria using an MPN microplate technique indicated that these bacteria are most numerous in the aggregate size fractions corresponding to fine silt (2–20µm) and clay (<2µm) compared to larger fractions or unfractionated soil. PAH concentrations were also highest in the aggregate size fraction corresponding to fine silt. Similar results were found in a spiked soil (incubated for 6 months) with similar carbonated minerals. Transmission electron microscopy observations showed that the autochtonous PAH-degrading bacteria were embedded in the aggregates where PAHs were abundant. In spite of this extensive co-localisation PAH degradation was limited during 6 months incubation. This indicates that factors other than spatial distribution and PAH degrading ability control degradation rates. The fine silt fraction of the industrial soil had an elevated C/N ratio (35) compared to the clay fraction (C/N: 16). Thus the fraction, which assumably had the highest specific surface area, contained less PAH but similar numbers of PAH-degraders. N thus seem to play an important role in the long term, but as PAH degradation was low in fine size fractions, other sources/factors were probably limiting (easily degradable C, P org, O2 etc.). Based on these findings, soil particle organization and structure of soil aggregates appear to be important for the characterization of a polluted soil (localization and sequestration). Manipulations that modify aggregation in polluted soils could thus potentially influence the accessibility and biodegradability of PAHs.

P. Traverso, P. Pavan, D. Bolzonella, L. Innocenti, F. Cecchi, J. Mata-Alvarez. (Department of Environmental Sciences, University of Venice, Calle Larga S. Marta 2137, 30123 Venice, Italy . Department of Environmental Sciences, University of Venice, Calle Larga S. Marta 2137, 30123 Venice, Italy. Department of Science and Technology, University of Verona, Strada Le Grazie, 37134 Verona, Italy. Department of Environmental Sciences, University of Venice, Calle Larga S. Marta 2137, 30123 Venice, Italy. Department of Science and Technology, University of Verona, Strada Le Grazie, 37134 Verona, Italy. Department of Chemical Engineering, University of Barcelona, P.ta Marti y Franquez, Barcelona, Spain). **Acidogenic fermentation of source separated mixtures of vegetables and fruits wasted from supermarkets**. Biodegradation, 11(6) (2000), 407-414.

A pilot scale mesophilic anaerobic acidogenic fermenter was fed with mixtures of vegetables and fruits shredded by a hammer mill and mixed in a stock tank, in order to produce a liquid phase suitable as RBCOD source in denitrification and EBPR processes. Different operative conditions were studied working with a HRT in the range 1–:12 days. The effluent coming from the fermenter was screw pressed, and the solid phase was recycled adopting different ratios to the fermenter, in order to define its effect on the final liquid phase composition. The variations of the VFA, lactate, methyl and ethyl alcohol concentrations, TCOD, SCOD and pH during more than one year were analysed and discussed both with reference to the fresh feed, and to the content of the fermenter. It was found that almost all the organic matter in the liquid phase inside the fermenter was represented by VFA (mainly acetate), lactate (in particular) and methyl and ethyl alcohols when HRT was longer than 6 days.

P.D. Franzmann, W.J. Robertson, L.R. Zappia, G.B. Davis. (CSIRO Land and Water, Underwood Ave, Floreat Park, WA 6014, Australia). **The role of microbial populations in the containment of aromatic hydrocarbons in the subsurface**. Biodegradation, 13(1) (2002), 65-78.

A survey of soil gases associated with gasoline stations on the Swan Coastal Plain of Western Australia has shown that 20% leak detectable amounts of petroleum. The fates of volatile hydrocarbons in the vadose zone at one contaminated site, and dissolved hydrocarbons in groundwater at another site were followed in a number of studies which are herein reviewed. Geochemical evidence from a plume of hydrocarbon-contaminated groundwater has shown that sulfate reduction rapidly developed as the terminal electron accepting process. Toluene degradation but not benzene degradation was linked to sulfate reduction. The sulfate-reducing bacteria isolated from the plume represented a new species, *Desulfosporosinus meridiei*. Strains of the species do not mineralise ^{14}C-toluene in pure culture. The addition of large numbers of cells and sulfate to microcosms did stimulate toluene mineralisation but not benzene mineralisation. Attempts to follow populations of sulfate-reducing bacteria by phospholipid signatures, or *Desulfosporosinus meridiei* by FISH in the plume were unsuccessful, but fluorescently-labeled polyclonal antibodies were successfully used. In the vadose zone at a different site, volatile hydrocarbons were consumed in the top 0.5 m of the soil profile. The fastest measured rate of mineralisation of ^{14}C-benzene in soils collected from the most active zone (6.5 mg kg^{-1} day^{-1}) could account for the majority of the flux of hydrocarbon vapour towards the surface. The studies concluded that intrinsic remediation by subsurface microbial populations in groundwater on the Swan Coastal Plain can control transport of aromatic hydrocarbon contamination, except for the transport of benzene in groundwater. In the vadose zone, intrinsic remediation by the microbial populations in the soil profile can contain the transport of aromatic hydrocarbons, provided the physical transport of gases, in particular oxygen from the atmosphere, is not impeded by structures.

Pardi Jitnuyanont, Luis A. Sayavedra-Soto, Lewis Semprini. (Department of Civil, Construction, and Environmental Engineering, Oregon State University, Corvallis, OR,97331, USA. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR, 97331, USA. Department of Civil, Construction, and Environmental Engineering, Oregon State University, Corvallis, OR,97331, USA). **Bioaugmentation of butane-utilizing microorganisms to promote cometabolism of 1,1,1-trichloroethane in groundwater microcosms**. Biodegradation, 12(1) (2001), 11-22.

The transformation of 1,1,1-trichloroethane (1,1,1-TCA) in ioaugmented and non-augmented microcosms was evaluated. The microcosms contained roundwater and aquifer materials from a test site at Moffett Field, Sunnyvale, CA. The initial inoculum for bioaugmentation was a butane-utilizing enrichment from the subsurface of the Hanford DOE site. The non-augmented microcosm required 80 days of incubation before butane-utilization was observed while the augmented microcosms required 3 days. Initially the augmented microcosms were effective in transforming 1,1,1-TCA, but their transformation ability decreased after prolonged incubation. The non-augmented microcosms initially showed limited 1,1,1-TCA transformation but improved with time. After 440 days, both the non-augmented and augmented microcosms had similar transformation yields (0.04 mg 1,1,1-TCA/mg butane) and had similar microbial composition (DNA fingerprints). Subsequent microcosms, when bioaugmented with a Hanford enrichment that was repeatedly grown in 100% mineral media, did not effectively grow or transform 1,1,1-TCA under groundwater nutrient conditions. Microcosm tests to study the effect of mineral media on transformation ability were performed with the Hanford enrichment. Microcosms with 50% mineral media in groundwater most effectively utilized butane and transformed 1,1,1-TCA, while microcosms with groundwater only and microcosms with 5% mineral media in groundwater lost their 1,1,1-TCA transformation ability. DNA fingerprinting indicated shifts in the microbial composition with the different mineral media combinations. Successful bioaugmentation was achieved by enriching butane-utilizers from Moffett Field microcosms that were effective in groundwater with no mineral media added. The results suggest that successful in-situ bioaugmentation might be achieved through the addition of enriched cultures that perform well under subsurface nutrient conditions.

Paweł Kaszycki, Małgorzata Tyszka, Przemysław Malec, Henryk Kołoczek. (University of Agriculture, Biochemistry Department, Faculty of Horticulture, Al. 29 Listopada 54, 31-425 Kraków, Poland. Jagiellonian University, Institute of Molecular Biology, Department of Plant Physiology and Biochemistry, Al. Mickiewicza 3, 31-120 Kraków, Poland). **Formaldehyde and methanol biodegradation with the methylotrophic yeast *Hansenula polymorpha*. An application to real wastewater treatment**. Biodegradation, 12(3) (2001), 169-177.

The application of methylotrophic yeast *Hansenula polymorpha* to the treatment of methanol and formaldehyde-containing wastewater was experimentally verified. A variety of real wastewater samples originating from chemical industry effluent were examined. The yeast cell culture could grow in the wastewater environment, revealing low trophic requirements and a very high adaptation potential to poor cultivation conditions. The proliferation of cells was accompanied by a concomitant xenobiotic biodegradation. Grown, preadapted cellular suspension at a density of about 1×10^7 cells/ml proved to be able to utilize formaldehyde present in wastewater at concentrations up to 1750 mg/l, levels toxic to most microorganisms. The biological waste treatment method presented shows the enhanced potential by means of specific enzymatic activities of monocarbonic compound oxidations through methylotrophic pathway reactions. The need to obtain mutants highly resistant to formaldehyde has also been rationalized.

Peng Chen, Michael A. Pickard, Murray R. Gray. (Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta T6G 2G6, Canada. Department of Biological Sciences, University of Alberta, Edmonton Alberta T6G 2E9, Canada. Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta T6G 2G6, Canada*).* **Surfactant inhibition of bacterial growth on solid anthracene**. Biodegradation, 11(5) (2000), 341-347.

Surfactants have been proposed as a promising method to enhance bioremediation of hydrophobic compounds in contaminated soils. However, the results of effects of surfactants on bioremediation are not consistent. This study showed that Triton X-100 at low concentration (0.024 mM or 0.09 CMC) inhibited the rate of growth of either a *Mycobacterium* sp. or a *Pseudomonas* sp. on solid anthracene as sole carbon source. Recovery of microbial growth rate could be achieved by dilution of surfactants, while addition of more surfactant gave an immediate decrease in growth rate. No inhibition of growth by Triton X-100 was observed with growth on glucose. The surfactant sorbed onto the surfaces of both the cells and the anthracene particles, which could inhibit uptake of anthracene. The results were consistent with the hypothesis that inhibition of microbial adhesion of cells to anthracene was responsible for the inhibition of growth by Triton X-100.

Peter W. Milligan, Max M. Häggblom. (Biotechnology Center for Agriculture and the Environment and Department of Biochemistry and Microbiology Rutgers, the State University of New Jersey New Brunswick, NJ 08901. Biotechnology Center for Agriculture and the Environment and Department of Biochemistry and Microbiology Rutgers, the State University of New Jersey New Brunswick, NJ 08901). **Anaerobic degradation and dehalogenation of chlorosalicylates and salicylate under four reducing conditions**. Biodegradation, 12(3) (2001), 159-167.

The anaerobic biodegradability and transformation of the mono-and dichlorinated salicylates (2-hydroxybenzoates) was examined under denitrifying, Fe (III) reducing, sulfate reducing and methanogenic conditions. 3,6-Dichlorosalicylate and 6-chlorosalicylate are anaerobic microbial metabolites of dicamba, a widely used herbicide. Anaerobic microcosms were established with dicamba treated soil from Wyoming, and golf course drainage stream sediments from New Jersey, which were each spiked with salicylate, 3,6-dichlorosalicylate or one of the four monochlorosalicylate isomers. Salicylate was degraded under denitrifying, sulfidogenic and methanogenic conditions. In methanogenic enrichments 5-chlorosalicylate and 3-chlorosalicylate were reductively dehalogenated to salicylate, which was then utilized. Dehalogenation of monochlorinated salicylates to salicylate was also observed in denitrifying chlorosalicylate degrading cultures. The study revealed that the position of the chlorine substituent as well as the predominant electron accepting process affect the rate and extent of chlorosalicylate degradation in anoxic environments.

Peter Weiland. (Institute of Technology and Biosystems Engineering, Federal Agricultural Research Centre (FAL), Bundesallee 50, D-38116 Braunschweig, Germany*).* **Anaerobic waste digestion in Germany Status and recent developments**. Biodegradation, 11(6) (2000), 415-421.

Anaerobic treatment processes are especially suited for the utilization of wet organic wastes from agriculture and industry as well as for the organic part of source-separated household wastes. The anaerobic degradation is a very cost-effective method for treating biogenic wastes because the formed biogas can be used for heat and electricity production and the digester residues can be recycled to agriculture as a secondary fertilizer. The anaerobic technology will be used

today also for the common treatment of wastes together with renewable energy crops in order to reduce the CO2-emissions according the Kyoto protocol. Various process types are applied in Germany, which differ in material, reaction conditions and in the form of the used reactor systems. The widespread introduction of anaerobic digestion in Germany has shown that biogenic organic wastes are a valuable source for energy and nutrients. Anaerobic waste treatment is done today in approx. 850 biogas plants on small farm scale as well as on large industrial scale with the best beneficial and economic outcome. Due to some new environmental protection acts which promote the recycling of wastes and their utilization for renewable energy formation it can be expected that several hundreds new biogas plants will be built per year in Germany. For using the synergetic effects of a combined fermentation of wastes and energy crops new process types must be developed in order to optimize the substrate combinations and the process conditions for maximum biodegradation.

Richard Gattin, Alain Copinet *, Celine Bertrand and Yves Couturier. (Materials and Packaging Research Centre (CERME), UMR INRA/URCA FARE, Ecole d'Ingenieurs en Emballage, Esplanade Roland Garros, PB 1029, 51686 Reims Cedex 2, France). **Biodegradation study of a starch and poly (lactic acid) co-extruded material in liquid, composting and inert mineral media**. International Biodeterioration & Biodegradation, 50(1) (2002), 25-31.

The biodegradation of a co-extruded starch/poly (lactic acid) polymeric film was studied in liquid, inert solid and composting media. Main mechanical properties of this film Young's modulus: 2340MPa, elongation at break: 50%, contact angle: 118°. Mineralization of the material's carbon content was followed using the appropriate experimental methods of the International Standard Organization. Whatever be the biodegradation medium used, the percentage of mineralization was better than the required 60% value for the definition of a biodegradable material. Moreover, repartitioning of the material's carbon between the various degradation products produce was quantified throughout the duration of experimental runs. The presence of starch was found to facilitate biodegradation of the polylactic component, especially in liquid media.

Roswitha Schepp, Thomas Jahns. (Fachrichtung 8.3 Mikrobiologie, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken, F.R.G.). **Isobutylidenediurea degradation by Rhodococcus erythropolis**. Biodegradation, 12(5) (2001), 317-323.

A new enzyme (isobutylidenediurea amidinohydrolase) catalyzing the hydrolysis of isobutylidenediurea (a condensation product of urea and isobutyraldehyde widely used as a slow-release nitrogeneous fertilizer) was characterized from a strain of *Rhodococcus erythropolis*. The enzyme was purified 1250-fold to apparent homogeneity and shown to hydrolyze the fertilizer to urea and isobutyraldehyde at a molar ratio of 2 : 1. No activity was observed with ureido- or other structurally related compounds. Its molecular mass was determined by native polyacrylamide gelelectrophoresis and matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry to be 15 kDa (±2 kDa) and 16.4 kDa, respectively. Growth of the bacterium in the presence of isobutylidenediurea led to an increased expression of the constitutively synthetized enzyme.

Rula A. Deeb, Kate M. Scow, Lisa Alvarez-Cohen. (Department of Civil and Environmental Engineering, 631 Davis Hall, MC 1710, University of California, Berkeley, CA 94720-1710, U.S.A. Malcolm Pirnie, Inc.,180 Grand Ave.,Ste. 1000,Oakland, CA 94612, USA. Department of Land, Air and

Water Resources, One Shields Avenue, University of California, Davis, CA 95616-8627, USA. Department of Civil and Environmental Engineering, 631 Davis Hall, MC 1710, University of California, Berkeley, CA 94720-1710, U.S.A.). **Aerobic MTBE biodegradation: an examination of past studies, current challenges and future research directions**. Biodegradation, 11(2-3) (2000), 171-185.

With the current practice of amending gasoline with up to 15% by volume MTBE, the contamination of groundwater by MTBE has become widespread. As a result, the bioremediation of MTBE-impacted aquifers has become an active area of research. A review of the current literature on the aerobic biodegradation of MTBE reveals that a number of cultures from diverse environments can either partially degrade or completely mineralize MTBE. MTBE is either utilized as a sole carbon and energy source or is degraded cometabolically by cultures grown on alkanes. Reported degradation rates range from 0.3 to 50 mg MTBE/g cells/h while growth rates (0.01–0.05 g MTBE/g cells/d) and cellular yields (0.1–0.2 g cells/g MTBE) are generally low. Studies on the mechanisms of MTBE degradation indicate that a monooxygenase enzyme cleaves the ether bond yielding *tert*-butyl alcohol (TBA) and formaldehyde as the dominant detectable intermediates. TBA is further degraded to 2-methyl-2-hydroxy-1-propanol, 2-hydroxyisobutyric acid, 2-propanol, acetone, hydroxyacteone and eventually, carbon dioxide. The majority of these intermediates are also common to mammalian MTBE metabolism. Laboratory studies on the degradation of MTBE in the presence of gasoline aromatics reveal that while degradation rates of other gasoline components are generally not inhibited by MTBE, MTBE degradation could be inhibited in the presence of more easily biodegradable compounds. Controlled field studies are clearly needed to elucidate MTBE degradation potential in co-contaminant plumes. Based on the reviewed studies, it is likely that a bioremediation strategy involving direct metabolism, cometabolism, bioaugmentation, or some combination thereof, could be applied as a feasible and cost-effective treatment method for MTBE contamination.

S. L. Sharma, A. Pant. (Division of Biochemical ,Sciences, National Chemical Laboratory , , Pune 411 008, India .Division of Biochemical ,Sciences, National Chemical Laboratory , , Pune 411 008, India) . **Biodegradation and conversion of alkanes and crude oil by a marine *Rhodococcus***. Biodegradation, 11(5) (2000), 289-294.

A hydrocarbon degrader isolated from a chronically oil-polluted marine site was identified as *Rhodococcus* sp. on the basis of morphology, fatty acid methyl ester pattern, cell wall analysis, biochemical tests and G + C content of DNA. It degraded upto 50% of the aliphatic fraction of Assam crude oil, in seawater supplemented with 35 mM nitrogen as urea and 0.1 mM phosphorus as dipotassium hydrogen orthophosphate, after 72 h at 30 ° and 150 revolutions per minute. The relative percentage of intracellular fatty acid was higher in hydrocarbon-grown cells compared to fructose-grown cells. The fatty acids C16 , C1616 :1 C18 and C18 : 1 were constitutively present regardless of the growth substrate. In addition to these constitutive acids, other intracellular fatty acids varied in correlation to the hydrocarbon chain length supplied as a substrate. When grown on odd carbon number alkanes, the isolate released only monocarboxylic acids into the growth medium. On even carbon number alkanes only dicarboxylic acids were produced.

S. Rajarathnam, M.N. Shashirekha, Zakia Bano. (Fruit and Vegetable Technology, Central Food Technological Research Institute, Mysore – 570 013, India.). **Biodegradation of gossypol by the white oyster mushroom, *Pleurotus florida*, during culturing on rice straw growth substrate,**

supplemented with cottonseed powder. World Journal of Microbiology and Biotechnology, 17(3) (2001), 221-227.

The capacity of the white oyster mushroom, Pleurotus florida to biodegrade gossypol was studied, when grown on rice straw supplemented with cottonseed powder. The mushroom fruiting bodies did not contain any residues of gossypol at concentrations of cottonseed powder =0.15–0.60% nitrogen contents of rice straw at the end of mycelial ramification. However, the cottonseed supplementation (at 0.30% N level itself) caused a doubling in the mushroom yield and its protein content, per unit weight straw substrate. The mushroom mycelium when grown on synthetic medium in liquid cultures was able to biodegrade gossypol. A pre-incubation period of 5 days before the addition of gossypol into the culture medium, an inoculum load =10 mg and an incubation period of 10 days at 25 °C caused the biodegradation of 100 µg gossypol. Increased concentrations of gossypol required increased duration and increased inoculum levels to effect biodegradation. However, the effect was more pronounced with an increase in inoculum density. The fungal monoculture when grown in rice straw (powder) (5%) + glucose (1%) liquid culture medium, showed an increase in hexosamine content and laccase activity that produced an increased degradation of gossypol over an incubation period from 5 to 25 days. Enzymic extracts of the mycelial monoculture raised on the chopped rice straw substrate when incubated with 100 µg of gossypol demonstrated its biodegradability; the increase in enzyme concentration showed enhanced gossypol degradation. This study adds to the world list of organic compounds that *Pleurotus* is able to biodegrade, and explains the cause of non-yellowing of the white oyster mushroom (*P. florida*) fruiting bodies, during culture on rice straw with supplementation of cottonseed powder for enhancing the mushroom yields.

S.S. Radwan *, R.H. AI-Hasan, S. Salamah and S. Al-Dabbous. (Department of Biological Sciences, Faculty of Science, Kuwait University, P.O. Box 5969, Safat 13060, Kuwait). **Bioremediation of oily sea water by bacteria immobilized in biofilms coating macroalgae**. International Biodeterioration & Biodegradation, 50(1) (2002), 55-59.

Using the standard plate method and a solid mineral medium containing crude oil as a sole source of carbon and energy, 10 different macroalgae from the Arabian Gulf were found associated with large numbers of oil-utilizing bacteria. Each gram fresh alga was associated with about two to about 30 million cells of bacteria predominantly belonging to the nocardioforms and the genus *Acinetobacter*. Shaking macroalgal samples in sea water batches containing known amounts of individual hydrocarbons led to considerable attenuation of these compounds as measured by GLC. Thus, bacteria associated with macroalgae consumed about 64-98% of n-octadecane and about 38-56% phenanthrene from medium aliquots containing 0.03% of the test hydrocarbon after 2 weeks. Meanwhile, the oil-utilizing bacteria, especially the nocardioforms, associated with the macroalgae increased in number by about 32-490 fold, depending on the macroalgae and hydrocarbons studied. On the other hand, relatively negligible numbers of bacteria were released into the seawater compared with the numbers immobilized on the macroalgal surfaces. Individual bacterial isolates could grow on a wide range of pure alkanes and aromatic hydrocarbons as sole sources of carbon and energy. It was concluded that macroalgae submerged in the seawaters are coated with biofilms rich in oil-utilizing bacteria, that contribute to hydrocarbon attenuation in water. These natural biological consortia represent valuable tools that could be of high potential for phytoremediation of oily seawater.

Safia Ahmed, M. Afzal Javed, Shazia Tanvir, Abdul Hameed. (Department of Biological Sciences, Quaid-i-Azam University, Islamabad, Pakistan). **Isolation and characterization of a *Pseudomonas* strain that degrades 4-acetamidophenol and 4-aminophenol**. Biodegradation, 12(5) (2001), 303-309.

Though many microorganisms that are capable of using phenol as sole source of carbon have been isolated and characterized, only a few organisms degrading substituted phenols have been described to date. In this study, one strain of microorganism that is capable of using phenol (3000 ppm), 4-aminophenol (4000 ppm) and 4-acetamidophenol (4000 ppm) as sole source of carbon and energy was isolated and characterized. This strain was obtained by enrichment culture from a site contaminated with compounds like 4-acetamidophenol, 4-aminophenol and phenol in Pakistan at Bhai Pheru. The contaminated site is able to support large bacterial community as indicated by the viable cell counts (2 × 104-5 × 108) per gram of soil. Detailed taxonomic studies identified the organisms as *Pseudomonas* species designated as strain STI. The isolate also showed growth on other organic compounds like aniline, benzene, benzyl alcohol, benzyl bromide, toluene, *ℬ*-cresol, trichloroethylene and *o*-xylene. Optimum growth temperature and pH were found to be 30 °C and 7, respectively, while growth at 4, 25 and 35 °C and at pH 8 and 9 was also observed. Non growing suspended cells of strain ST1 degraded 68, 96 and 76.8% of 4-aminophenol (1000 ppm), phenol (500 ppm) and 4-acetamidophenol (1000 ppm), respectively, in 72 hrs. The isolation and characterization of *Pseudomonas* species strain ST1, may contribute to efforts on phenolic bioremediation, particularly in an environment with very high levels of 4-acetamidophenol and 4-aminophenol.

Sandeep Pareek, Jun-Ichi Azuma, Yoshihisa Shimizu, Saburo Matsui. (Research Center for Environmental Quality Control, Kyoto University, 1–2 Yumihama, Otsu, Shiga, 520-0811, Japan. Laboratory of Recycle System of Biomass, Division of Environmental Science and Technology, Department of Bio-environmental Science, Graduate School of Agricultural Science, Kyoto University, Kitashirakawa Oiwake-Cho, Kyoto 606-8502, Japan. Research Center for Environmental Quality Control, Kyoto University, 1–2 Yumihama, Otsu, Shiga, 520-0811, Japan. Research Center for Environmental Quality Control, Kyoto University, 1–2 Yumihama, Otsu, Shiga, 520-0811, Japan). **Hydrolysis of newspaper polysaccharides under sulfate reducing and methane producing conditions**. Biodegradation, 11(4) (2000), 229-237.

The initial decomposition rates of cellulose and hemicellulose were measured using toluene to specifically inhibit the microbial uptake of hydrolysis products during the degradation of newspaper under sulfate reducing and methane producing conditions. The amount of glucose and xylose accumulation in the first 2 weeks of incubation period was higher in the sulfate reducing condition compared to the methane producing condition. It was estimated that 28 and 6% of initially loaded cellulose in the sulfate reducing condition and the methane producing condition was hydrolyzed, respectively. Accordingly, the newspaper-cellulose hydrolysis rate constant was estimated to be 6.7 times higher in sulfate reducing condition than in methane producing condition. Based on the glucose accumulation patterns, when sulfate reducing bacteria (SRB) were inhibited by anthraquinone and molybdate (Na2MoO4), it may be suggested that SRB might have contributed to the hydrolysis of cellulose, while their effect on the hydrolysis of hemicellulose could not be elucidated.

Seung H. Woo, Bruce E. Rittmann. (School of Environmental Engineering, Pohang University of Science and Technology, San 31, Hyoja-Dong, Pohang 790-784, Korea.Department of Civil Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208-3109, USA*).* **Microbial energetics and stoichiometry for biodegradation of aromatic compounds involving**

oxygenation reactions. Biodegradation, 11(4) (2000), 213-227.

Oxygenation reactions significantly alter the energy and electron flows and, consequently, the overall stoichiometry for the microbial utilization of aromatic compounds. Oxygenation reactions do not yield a net release of electrons, but require an input of electrons to reduce oxygen molecules. The biodegradation pathway of phenanthrene as a model compound was analyzed to determine the impact of oxygenation reactions on overall stoichiometry using the half-reaction method. For individual oxygenation reactions, the half-reaction method for analyzing the electron and energy flows must be modified, because the reactions do not release electrons for synthesis or energy generation. Coupling the oxygenation reaction to subsequent reaction steps provides a net electron release for the coupled reactions. Modeling results indicate that oxygenation reactions increase the oxygen requirement and reduce the cell yield, compared to the conventional mineralization represented by hydroxylation reactions in place of oxygenations. The computed yields considering oxygenation reactions conform better to empirical yields reported in the literature than do yields computed by the hydroxylation single-step methods. The coupled-reaction model also is consistent with information about the ways in which micro-organisms that degrade aromatics accumulate intermediates, regulate degradation genes, and organize enzyme clusters.

Si-Jing Wang, Kai-Chee Loh. (Department of Chemical and Environmental Engineering, The National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260). **Biotransformation kinetics of *Pseudomonas putida* for cometabolism of phenol and 4-chlorophenol in the presence of sodium glutamate.** Biodegradation, 12(3) (2001), 189-199.

A kinetic model to describe the degradation of phenol and cometabolic transformation of 4-chlorophenol (4-cp) in the presence of sodium glutamate (SG) has been developed and validated experimentally. The integrated model accounts for cell growth, toxicity of 4-cp, cross-inhibitions among the three substrates, and the different roles of the specific growth substrate (phenol) and the conventional carbon source (SG) in the cometabolism of 4-cp. In this ternary substrate system, the overall phenol degradation and 4-cp transformation rates are greatly enhanced by the addition of SG since SG is able to attenuate the toxicity of 4-cp and therefore increase the cell growth rate. Model analysis indicates that the maximum specific degradation rate of phenol (0.819 mg $(mg.h)^{-1}$) is lowered by SG by up to 46% whereas the specific transformation rate of 4-cp is not directly affected by the presence of SG. The competitive inhibition coefficient of 4-cp to phenol degradation ($K_{i,cp}$) and that of phenol to 4-cp transformation ($K_{i,ph}$) were determined to be 6.49 mg l^{-1} and 0.193 mg l^{-1}, respectively, indicating that phenol imposes much larger competitive inhibition to 4-cp transformation than the converse. The model developed can simultaneously predict phenol degradation and 4-cp transformation, and is useful for dealing with cometabolism involving multiple substrates.

Swapna Thomas, Sami Sarfaraz, L.C. Mishra, Leela Iyengar. (Biotechnology Laboratory, Department of Chemistry, Indian Institute of Technology, Kanpur 208016, India. Biotechnology Laboratory, Department of Chemistry, Indian Institute of Technology, Kanpur 208016, India. Department of Life Sciences, C.S.J.M University, Kanpur 208016, India. Biotechnology Laboratory, Department of Chemistry, Indian Institute of Technology, Kanpur 208016, India). **Degradation of phenol and phenolic compounds by a defined denitrifying bacterial culture**. World Journal of Microbiology and Biotechnology, 18(1) (2002), 57-63.

Phenol, a major pollutant in several industrial waste waters is often used as a model compound for studies on biodegradation. This study investigated the anoxic degradation of phenol and other phenolic compounds by a defined mixed culture of Alcaligenes faecalis and Enterobacter species. The culture was capable of degrading high concentrations of phenol (up to 600 mg/l) under anoxic conditions in a simple minimal mineral medium at an initial cell mass of 8 mg/l. However, the lag phase in growth and phenol removal increased with increase in phenol concentration. Dissolved CO2 was an absolute requirement for phenol degradation. In addition to nitrate, nitrite and oxygen could be used as electron acceptors. The kinetic constants, maximum specific growth rate μmax; inhibition constant, Ki and saturation constant, Ks were determined to be 0.206 h-1, 113 and 15 mg phenol/l respectively. p-Hydroxybenzoic acid was identified as an intermediate during phenol degradation. Apart from phenol, the culture utilized few other monocyclic aromatic compounds as growth substrates. The defined culture has remained stable with consistent phenol-degrading ability for more than 3 years and thus shows promise for its application in anoxic treatment of industrial waste waters containing phenolic compounds.

T. Komang Ralebitso, Eric Senior, Henk W. van Verseveld. (International Centre for Waste Technology (Africa), School of Applied Environmental Sciences, University of Natal, P/B X01, Scottsville, 3209, South Africa. International Centre for Waste Technology (Africa), School of Applied Environmental Sciences, University of Natal, P/B X01, Scottsville, 3209, South Africa. Department of Molecular Cell Physiology, Vrije Uni-versiteit, De Boelelaan 1087, NL-1081 HV Amsterdam, The Netherlands). **Microbial aspects of atrazine degradation in natural environments**. Biodegradation, 13(1) (2002), 11-19.

The potential toxicity of the *s*-triazine herbicide atrazine motivates continuous bioremediation-directed research. Several indigenous soil atrazine-catabolizing microbial associations and monocultures have been enriched/isolated from compromised sites. Of these, *Pseudomonas* sp. strain ADP has become a reference strain and has been used to elucidate sequences of the catabolic enzymes *atz*A, *atz*B, *atz*C and *atz*D involved in one aerobic degradation pathway and develop probes for the genes which encode these enzymes. Despite this, hitherto unknown or novel microorganisms, with unique sequences and different enzyme-mediated operative pathways, warrant continued investigations for effective site bioremediation. Also, the sustained effectiveness of natural attenuation must be demonstrated continually so regular site evaluations and results analyses, despite the limitations of chemical extraction methodologies, are crucial practices. For both directed and intrinsic bioremediation monitoring, traditional microbial association studies must be complemented by more advanced physiological and molecular approaches. The occurrence of catabolic plasmids, in particular, should be probed with DNA hybridization techniques. Also, PCR-DGGE and subsequent new sequence elucidation should be used prior to developing new primers for DNA sequences encoding novel catabolic enzymes, and for hybridization probe development, to establish the degradative potential of a compromised site, or adoption of FISH to, for example, monitor bioaugmented remediation.

T. Schoenberg, S. Veltman, M. Switzenbaum. (Department of Civil and Environmental Engineering, University of Massachusetts, Amherst, MA, USA. Olver, Inc., Blacksburg, VA, USA. Olver, Inc., Blacksburg, VA, USA). **Kinetics of anaerobic degradation of glycol-based Type I aircraft deicing fluids**. Biodegradation, 12(1) (2001), 59-67.

The kinetics of anaerobic degradation of glycol-based Type I aircraft deicing fluids (ADFs) were characterized using suspended-growth fill-and-draw reactors. Both Type I ADFs tested showed near-complete anaerobic degradability. First-order degradation rate constants of 3.5 d-1 for the propylene glycol-based Type I ADF and 5.2 d-1 for the ethylene glycol-based Type I ADF were obtained through continuous-culture means under mesophilic conditions (35 °C). Fill-and-draw operation at lower temperatures affected anaerobic degradability only minimally down to 25 °C but substantially below 25 °C. High Type I ADF feed concentrations substantially affected degradability. Batch testing of fill-and-draw reactors resulted in first-order degradation rate constants of 1.9 d-1 for propylene glycol-based Type I ADF and 3.5 d-1 for ethylene glycol-based Type I ADF.

Thayumanavan, Tha., K.S.M. Rahman and P. Lakshmanaperumalsamy*. (Department of Environmental Sciences, Bharathiar University, Coimbatore-641 046, Tamil Nadu, India). **Biodegradation of** P**etroleum Refinery Waste Oil Sludge**. Poll Res, 20(2) (2001), 155-161.

Oil contamination of soil and water is a widespread problem in recent years. Microbiological clean ups of this type of contamination can be advantageous, when compared to other remediation techniques. Bacterial consortium prepared with *Pseudomonas* sp., *Corynebacterium* sp*., Flavobacterium* sp., *Bacillus* sp. and *Micrococcus* sp. was tested for the degradation of petroleum refinery effluent treatment plant sludge applied to sterile and non-sterile red soil. The maximum rate of oil degradation (71.23%) was observed in treatment E which is amended with non-sterile red soil, non-sterile sludge and mixed consortium. Among the various amendments, non-sterile red soil contained fewer fungal populations, which have also Involved in the degradation process. It is concluded that the mixed consortium can be applied in large-scale sludge degradation, as this process is an economically feasible.

Theresia K. Ralebitso, Wilfred F. M. Röling, Martin Braster, Eric Senior, Henk W. van Verseveld. (Molecular Microbial Ecology Section, Department of Molecular Cell Physiology, Biology Faculty, Vrije Universiteit, De Boelelaan 1087, NL-1081 HV Amsterdam. Molecular Microbial Ecology Section, Department of Molecular Cell Physiology, Biology Faculty, Vrije Universiteit, De Boelelaan 1087, NL-1081 HV Amsterdam. Molecular Microbial Ecology Section, Department of Molecular Cell Physiology, Biology Faculty, Vrije Universiteit, De Boelelaan 1087, NL-1081 HV Amsterdam. International Centre for Waste Technology (Africa), School of Applied Environmental Sciences, University of Natal, P/B X01, Scottsville, 3209, South Africa. Molecular Microbial Ecology Section, Department of Molecular Cell Physiology, Biology Faculty, Vrije Universiteit, De Boelelaan 1087, NL-1081 HV Amsterdam). **16S rDNA-based characterization of BTX-catabolizing microbial associations isolated from a South African sandy soil**. Biodegradation, 11(6) (2000), 351-357.

In the presence of different selection pressures, particularly pH and electron donor concentration, indigenous microbial associations which catabolize selected petroleum hydrocarbon components (benzene, toluene and o-, m- and p-xylene (BTX)) were enriched and isolated from a petroleum hydrocarbon-contaminated KwaZulu-Natal sandy soil. Electron microscopy revealed that, numerically, rods constituted the majority of the populations responsible for BTX catabolism. Molecular techniques (polymerase chain reaction (PCR) and 16S rDNA fingerprinting by denaturing-gradient gel electrophoresis (DGGE)) were employed to explore the diversities and analyze the structures of the isolated microbial associations. Pearson product-moment correlation indicated that the different, but chemically similar, petroleum hydrocarbon molecules, effected the isolation of different associations. However, some similar numerically-dominant bands characterized the associations. A 30% similarity was evident between them and

o-xylene-catabolizing associations regardless of the molecule concentration and the enrichment pH. PCR-DGGE was also used to complement conventional culture-based microbiological procedures for environmental parameter optimization. Band pattern differences indicated profile variations of the isolated associations which possibly accounted for the growth rate changes recorded in response to pH and temperature perturbations.

Tom Tanghe, Willem Dhooge, Willy Verstraete. (Laboratory of Microbial Ecology and Technology (LabMET), Coupure L 653, B-9000 Ghent, Belgium. Laboratory of Andrology, University Hospital, Ghent University, B-9000 Ghent, Belgium. Laboratory of Microbial Ecology and Technology (LabMET), Coupure L 653, B-9000 Ghent, Belgium). **Formation of the metabolic intermediate 2,4,4-trimethyl-2-pentanol during incubation of a shape *Sphingomonas* sp. strain with the xeno-estrogenic octylphenol**. Biodegradation, 11(1) (2000), 11-19.

Degradation of branched octylphenol was studied in a bacterial culture of a Sphingomonas sp. strain. Octylphenol is considered to be the most stable degradation intermediate formed from the corresponding nonionic octylphenol polyethoxylates surfactants during biological wastewater treatment. Since octylphenol can exert estrogenic effects in wildlife, a detailed study of its biodegradation is warranted. The aerobic microbiological transformation of octylphenol was examined with and without the addition of the easily assimilable sodium acetate. In both cases the formation of the metabolite 2,4,4-trimethyl-2-pentanol, representing the intact alkyl chain as a tertiary alcohol, was observed. Since the octylphenol degradation rate was not affected by the presence of acetate, this strain did not show any diauxic metabolic behaviour when incubated with octylphenol and sodium acetate as the sources of carbon and energy. As a result of the biotransformation of octylphenol, its estrogenic potency was removed because it is the phenolic moiety that interacts with the estrogen receptors. This feature opens perspectives for the use of this strain in the framework of an adequate treatment of wastewater with high levels of alkylphenol polyethoxylates.

U. Sharanagouda, T.B. Karegoudar. (Department of Biochemistry, Gulbarga University, Gulbarga 585 106, India. Department of Biochemistry, Gulbarga University, Gulbarga 585 106, India). **Degradation of 2-methylnaphthalene by free and immobilized cells of Pseudomonas sp. strain NGK1**. World Journal of Microbiology and Biotechnology, 18(3) (2002), 225-230.

A *Pseudomonas* sp. strain NGK1 (NCIM 5120) capable of utilizing 2-methylnaphthalene (2-MN) was immobilized in various matrices namely, polyurethane foam (PUF), alginate, agar and polyvinyl alcohol (PVA) (1.5 × 1012 c.f.u. g-1 beads). The degradation rates of 25 and 50 mM 2-MN by freely suspended cells (2 × 1011 c.f.u. ml-1) and immobilized cells in batches, semi-continuous with shaken culture and continuous degradation in a packed-bed reactor were compared. The PUF-immobilized cells achieved higher degradation of 25 and 50 mM of 2-MN than freely suspended cells and the cells immobilized in alginate, agar or PVA. The PVA- and PUF-immobilized cells could be reused for more than 30 and 20 cycles respectively, without losing any degradation capacity. The effect of dilution rates on the rate of degradation of 25 and 50 mM 2-MN with freely suspended and immobilized cells were compared in the continuous system. Increase in dilution rate increased the degradation rate only up to 1 h-1 in free cells with 25 mM 2-MN and no significant increase was observed with 50 mM 2-MN. With immobilized cells, the degradation rate increased with increase in dilution rate up to 1.5 h-1 for 25 mM and 1 h-1 for 50 mM 2-MN. These results

revealed that the immobilized cell systems are more efficient than freely suspended cells for biodegradation of 2-MN.

Valentina Murygina, Mikhail Arinbasarov, Sergey Kalyuzhnyi. (Department of Chemical Enzymology, Chemistry Faculty, Moscow State University, 119899 Moscow, Russia. All-Russian Research Institute of Oil and Gas, 125422, Dmitrovskiy proyezd, 10, Moscow, Russia. Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, 142292, Pushchino, Moscow Region, Russia. Department of Chemical Enzymology, Chemistry Faculty, Moscow State University, 119899 Moscow, Russia*).* **Bioremediation of oil polluted aquatic systems and soils with novel preparation 'Rhoder'**. Biodegradation, 11(6) (2000), 385-389.

This paper summarises the experience accumulated during the field application of biopreparation `Rhoder' (solely or in a combination with preliminary mechanical collection of free oil) for remediation of oil polluted aquatic systems and soils in the Moscow region and Western Siberia during 1994–1999. It was demonstrated that `Rhoder' had a very high efficiency (>99%) for bioremediation of the open aquatic surfaces (100 m2 bay of the River Chernaya, two 5,000 m2 lakes in Vyngayakha) at initial level of oil pollution of 0.4–19.1 g/l. During remediation of the wetland (2,000 m2) in Urai (initial level of oil pollution of 10.5 g/l), a preliminary mechanical collection of oil was applied (75% removal) followed by a triple treatment with `Rhoder'. It resulted in an overall treatment efficiency of 94%. Relatively inferior results of bioremediation of the 10,000 m2 wetland in Vyngayakha (65% removal) and the 1,000 m2 marshy peat soil in Nizhnevartovsk (19% removal) can be attributed to the very high initial level of oil pollution (24.3 g/l and >750 g/g dry matter, respectively) aggravated by the fact that it was impossible to apply a preliminary mechanical collection of oil on these sites. A possible strategy for remediation of such heavily polluted sitesis discussed.

Venkat Hamde and M.S. Andhale*. (Department of Microbiology, Yogeshwari Mahavidyalaya, AmbejogCli -431 517. India), **Bioconversion of Propionitrile into Propionic acid**. Poll Res.,18(2) (1999), 173-176.

A bacterium utilizing propionitrile as a sole source of carbon and nitrogen was isolated from soil and identified as *Corynebacterium* sp. YM-1. the strain could assimilate acetonitrile and acrylonitrile. A metabolite of propionitrile was identified as ammonia And propionic acid. The strain grow best in presence of 0.3 % (w/v) propionitrile concentration and pH 7.0.

Vyacheslav Fedorovich, Martine Greben, Sergey Kalyuzhnyi, Piet Lens, Look Hulshoff Pol (Department of Chemical Enzymology, Chemistry Faculty, Moscow State University, 119899 Moscow, Russia. Sub-Department of Environmental. Technology, Wageningen Agriculture University, 6700 EV Wageningen, The Netherlands. Department of Chemical Enzymology, Chemistry Faculty, Moscow State University, 119899 Moscow, Russia. Sub-Department of Environmental Technology, Wageningen Agriculture University, 6700 EV Wageningen, The Netherlands. Sub-Department of Environmental Technology, Wageningen Agriculture University, 6700 EV Wageningen, The Netherlands*).* **Use of hydrophobic membranes to supply hydrogen to sulphate reducing bioreactors.** Biodegradation, 11(5) (2000), 295-303.

This paper reports on the application of hydrophobic membranes to supply the gaseous substrates hydrogen/carbon dioxide (H2/CO2)to a sulphate reducing bioreactor. For this, two flat 0.016m2 sheets of flouroplast microporous (0.45µm) membranes were inserted in a 3.6 dm016m3 bioreactor for the supply of H

H2/CO2 gas as small gas bubbles. The bioreactor was operated at 30 °C and pH 7.0 and was also equipped with an external ultra filtration module for biomass retention. At a sulphate loading rate (SLR) of 1.32 g SO42- dm-3 day-1 and a hydraulic retention time (HRT) of 61 h, a sulphate reduction rate (SRR) of 0.90 g SO42- dm-3 day-1 was achieved. When the influent sulphate concentration was reduced from 3.36 to 0.75 g SO42- dm-3 by lowering the HRT to 10.3 h (SLR of 1.75 g SO42- dm-3 day -1), the SRR dropped to 0.22 g SO42- dm-3 day -1. The lower sulphate reduction efficiency was most probably caused by a too short biomass-substrate contact time or by irreversible sulphide inhibition. Mass transfer limitation of H2 and improper mixing of the reactor liquid were shown not to contribute to the low sulphate reduction efficiency.

Xiaoming Zhang, Elise R. Sullivan, L. Y. Young. (Biotechnology Center for agriculture and the Environment, Cook College, Rutgers, the State University of New Jersey, New Brunswick, NJ 08901, USA. Biotechnology Center for Agriculture and the Environment, Cook College, Rutgers, the State University of New Jersey, New Brunswick, NJ 08901, USA. Biotechnology Center for Agriculture and the Environment,and Department of Environmental Sciences, Cook College, Rutgers, the State University of New Jersey, New Brunswick, NJ 08901, USA*).* **Evidence for aromatic ring reduction in the biodegradation pathway of carboxylated naphthalene by a sulfate reducing consortium.** Biodegradation, 11(2-3) (2000), 117-124.

Naphthalene was used as a model compound in order to study the anaerobic pathway of polycyclic aromatic hydrocarbon degradation. Previously we had determined that carboxylation is an initial step for anaerobic metabolism of naphthalene, but no other intermediate metabolites were identified (Zhang & Young 1997). In the present study we further elucidate the pathway with the identification of six novel naphthalene metabolites detected when cultures were fed naphthalene in the presence of its analog 1-fluoronaphthalene. Results from cultures supplemented with either deuterated naphthalene or non-deuterated naphthalene plus [13C]bicarbonate confirm that the metabolites originated from naphthalene. Three of these metabolites were identified by comparison with the following standards: 2-naphthoic acid (2-NA), 5,6,7,8-tetrahydro-2-naphthoic acid, and decahydro-2-naphthoic acid. The presence of 5,6,7,8-tetrahydro-2-NA as a metabolite of naphthalene degradation indicates that the first reduction reaction occurs at the unsubstituted ring, rather than the carboxylated ring. The overall results suggest that after the initial carboxylation of naphthalene, 2-NA is sequentially reduced to decahydro-2-naphthoic acid through 5 hydrogenation reactions, each of which eliminated one double bond. Incorporation of deuterium atoms from D2O into 5,6,7,8-tetrahydro-2-naphthoic acid suggests that water is the proton source for hydrogenation.

Yuksel Orhan and Hanife Buyukgungor. (Environmental Engineering Department, Ondokuz mayis University, Kurupelit-55139, Samsun, Turkey). **Enhancement of biodegradability of disposable polyethylene in controlled biological soil**. International Biodeterioration & Biodegradation , 45(1-2) (2000), 49-55.

Plastics as polyethylene are widely used in packaging and other agricultural applications. They accumulate in the environment at a rate of 25 million tons per year. Thus, the development and use of degradable plastics was proposed as a solution for plastic waste problem. Because of the ever-increasing use of plastic films, nowadays, biodegradability has " become a useful characteristic for plastics. Conversely, the introduction of biodegradable plastics has generated a need for methods to evaluate the biodegradation of these polymers in landfills and solid waste treatment systems such as composting or anaerobic digestion

treatment plants. The purpose of this study was to investigate the biodegradation of disposable low-density polyethylene bags containing starch (12%), autoxidizable fatty acid ester and catalytic agents in soil. Structurally this work intended to evaluate the capacity of. Phanerochaete chrysosporium (ATCC 34541) to enhance polyethylene film biodegradation in soil microcosms. Soil samples inoculated with P. chrysosporium were mixed with LDPE/starch blend films and biological changes of the films and soil were monitored for 6months. The biodegradation of polyethylene starch blend film has been determined by the physical, chemical and biological properties of the samples such as pH, biomass, CO_2 formation, percentage elongation, relative viscosity and FTIR spectrum.

Bioenergy

A. J. Moffat, A. T. Armstrong and J. Ockleston. (A Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH, UK. b Thames Water Utilities Ltd, Spencer House, Manor Farm Road, Reading, Berkshire RG2 0JN, UK). **The optimization of sewage sludge and effluent disposal on energy crops of short rotation hybrid poplar**. Biomass and Bioenergy, 20(3) (2001), 161-169.

An experiment was set up to test the effect of sewage sludge application and waste water irrigation on the biomass production of two poplar varieties, Populus trichocarpa x P. deltoides "Beaupré", and Populus trichocarpa "Trichobel". Three sludge applications were examined factorially with two irrigation regimes (with and without), over the two final years of a three-year rotation. The effects of treatment on soil and soil water were monitored, and the amount of heavy metals removed in the biomass was quantified. Irrigation had a significant effect on biomass of both poplar varieties, with Beaupré yielding more than Trichobel. Sludge application was not effective in increasing biomass yield, but the experiment was valuable in identifying that modest amounts of sludge (approximately 100 m3 ha-1 yr-1) were acceptable environmentally and did not compromise biomass production. Cadmium uptake was detected in the poplar biomass, but the amounts were small and insufficient for poplar to be used in phytoremediation of metal-contaminated land.

G. D. P. S. Augustus, M. Jayabalan and G. J. Seiler. (A Research Centre in Botany, V.H.N.S.N. College, Virudhunagar, 626 001, India. b USDA––ARS, Northern Crop Science Laboratory, P.O. Box 5677, Fargo, ND 58105, USA). **Evaluation and bioinduction of energy components of *Jatropha curcas***. Biomass and Bioenergy, 23(3) (2002), 161-164.

Jatropha curcas is a multipurpose species with many attributes and considerable potential. The oil from the seeds is potentially the most valuable end product. Nearly 40% of the land area in India is wasteland. However, a large number of latex bearing and oil yielding plants can grow under such unfavorable agroclimatic conditions. J. curcas, a Euphorbiaceae grows well under such adverse climatic conditions because of its low moisture demands, fertility requirements, and tolerance to high temperatures. The seed contains 19.0% oil, 4.7% polyphenol, and 3.9% hydrocarbon. This semi-drying oil could be an efficient substitute for diesel fuel. The gross heat value for the seed (0% moisture content) was 4980.3 cal/g (20.85 MJ/kg), oil was 9036.1 cal/g (37.83 MJ/kg), and hydrocarbon was 9704.4 cal/g (40.63 MJ/kg). The oil fraction consists of both saturated fatty acids, palmitic acid (14.1%), stearic acid (6.7%) and unsaturated fatty acids, oleic acid (47.0%), and linoleic acid (31.6%). Treatment of plants with growth regulators significantly influenced the production of hydrocarbons. Among the treatments, ethephon and morphactin induced the maximum production of hydrocarbon with

5.0% and 5.4%, respectively.

G. S. Haripriya. (Environmental Economics Unit, Department of Economics, University of Göteborg, Gotebörg, SE - 405 30, Sweden). **Estimates of biomass in Indian forests**. Biomass and Bioenergy, 19(4) (2000), 245-258.

Forest volume inventories are valuable source of data for estimating above-ground biomass density and the carbon stored in biomass of forests. In view of the importance of biomass estimates in the global carbon (C) cycle, the present study estimates the biomass and the C contained in biomass of Indian forests for the year 1993, using species-wise volume inventories for all forest strata in various states. The above-ground biomass densities ranged from 14 to 210 Mgha-1, with a mean of 67.4 Mgha-1, which equals around 34 MgCha-1. As most of the biomass is concentrated in lower diameter classes of potentially large species, the low biomass estimates in Indian forests implies that there is a large potential to sequester carbon over several decades to continue if left undisturbed.

Günther Fischer and Leo Schrattenholzer. (International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg, Austria). **Global bioenergy potentials through 2050**. Biomass and Bioenergy, 20(3) (2001), 151-159.

Estimates of world regional potentials of the sustainable use of biomass for energy uses through the year 2050 are presented. The estimated potentials are consistent with scenarios of agricultural production and land use developed at the International Institute for Applied Systems Analysis, Austria. They thus avoid inconsistent land use, in particular conflicts between the agricultural and bioenergy land use. As an illustration of the circumstances under which a large part of this potential could be used in practice, a global energy scenario with high economic growth and low greenhouse gas emissions, developed by IIASA and the World Energy Council is summarised. In that scenario, bioenergy supplies 15% of global primary energy by 2050. Our estimation method is transparent and reproducible. A computer program to repeat the calculation of the estimates with possibly changed assumptions is available on request.

H. Yokoi, R. Maki, J. Hirose and S. Hayashi. (Department of Applied Chemistry, Faculty of Engineering, Miyazaki University, Miyazaki 889-2192, Japan). **Microbial production of hydrogen from starch-manufacturing wastes**. Biomass and Bioenergy, 22(5), (2002), 389-395.

Effective hydrogen production from starch-manufacturing wastes by microorganisms was investigated. Continuous hydrogen production in high yield of 2.7 mol H2 mol-1 glucose was attained by a mixed culture of Clostridium butyricum and Enterobacter aerogenes HO-39 in the starch waste medium consisting of sweet potato starch residue as a carbon source and corn steep liquor as a nitrogen source in a repeated batch culture. Rhodobacter sp. M-19 could produce hydrogen from the supernatant of the culture broth obtained in the repeated batch culture of C. butyricum and E. aerogenes HO-39. Hydrogen yield of 4.5 mol H2 mol-1 glucose was obtained by culturing Rhodobacter sp. M-19 in the supernatant supplemented with 20 μgl-1 Na2MoO4·2H2O and 10 mgl-1 EDTA in a repeated batch culture with pH control at 7.5. Therefore, continuous hydrogen production with total hydrogen yield of 7.2 mol H2 mol-1 glucose from the starch remaining in the starch residue was attained by the repeated batch

culture with C. butyricum and E. aerogenes HO-39 and by the successive repeated batch culture with Rhodobacter sp. M-19.

Keith Openshaw. (Alternative Energy Development Inc., Silver Spring, MD, USA). **A review of *Jatropha curcas*: an oil plant of unfulfilled promise**. Biomass and Bioenergy, 19(1) (2000), 1-15.

Jatropha curcas is a multipurpose plant with many attributes and considerable potential. It is a tropical plant that can be grown in low to high rainfall areas and can be used to reclaim land, as a hedge and/or as a commercial crop. Thus, growing it could provide employment, improve the environment and enhance the quality of rural life. The establishment, management and productivity of jatropha under various climatic conditions are not fully documented. This is discussed and the gaps in the knowledge elucidated, especially its fertilizer requirements. The plant produces many useful products, especially the seed, from which oil can be extracted; this oil has similar properties to palm oil. The costs and returns of growing the plant and producing the plant oil are discussed and tabulated. Because it can be used in place of kerosene and diesel and as a substitute for fuelwood, it has been promoted to make rural areas self sufficient in fuels for cooking, lighting and motive power. This strategy is examined and found not viable. Oil for soap making is the most profitable use. It is concluded that all markets for jatropha products should be investigated. If the full potential of the plant is to be realized, much more research is required into the growing and management of Jatropha curcas and more information is needed on the actual and potential markets for all its products.

Kiran L. Kadam, Loyd H. Forrest and W. Alan Jacobson. (a National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, CO 80401, USA. b TSS Consultants, 2890 Kilgore Road, Rancho Cordova, CA 95670, USA). **Rice straw as a lignocellulosic resource: collection, processing, transportation, and environmental aspects**. Biomass and Bioenergy, 18(5) (2000), 369-389.

As open-field burning of rice straw is being phased out in California, rice growers and government agencies are looking for new rice straw uses. The amount of rice straw that may be available as a feedstock ranges from 1.0 to 1.4 million t yr-1. Irrespective of its actual use as a source of raw material for liquid fuel, fiber, or power generation, a study of issues dealing with its harvest is needed. This paper reviews possible harvesting systems and provides an analysis of operating parameters such as straw moisture, density, storage, and optimal number of transport units. A case study of rice straw production in the Sacramento Valley was conducted, which illustrates that 550 t d-1 of straw can be accessed at an estimated net delivered cost of about US $20/t (dry), which is generally considered attractive for an ethanol feedstock. Gainfully utilizing this residue can ease the disposal problem facing agricultural operations in the State. Furthermore, the potential environmental benefits of diverting rice straw from open-field burning will be to significantly reduce criteria air pollutants such as VOC, SOx, NOx, and PM10, and also silica emissions, which are not specifically monitored but can be a health hazard.

M. H. El Jalil, M. Faid and M. Elyachioui. (a Microbiology and Biotechnology Laboratory, Biology Department, Faculty of Sciences, P.O. Box 133 Kénitra, Morocco b Food Microbiology and Biotechnology Department, Hassan II Institute of Agronomy and Veterinary Medicine, P.O. Box 6202 Rabat-Instituts, Morocco). **A biotechnological process for treatment and recycling poultry wastes manure as a feed ingredient**. Biomass and Bioenergy, 21(4) (2001), 301-309.

Poultry wastes manure was diluted by adding the same amount of water 50–50 (w/v). They were then mixed with 10% molasses. The mixture was inoculated with a starter culture of Lactobacillus plantarum and Pediococcus acidolactici, and incubated at 30°C for 10 days. Changes in nutritional quality and biochemical properties (pH, total nitrogen, total volatile nitrogen, non protein nitrogen, carbohydrates and ash) were determined for the raw and the transformed product. In parallel, microbiological analyses, including standard plate count, enterobacteria and enterococci, were performed. Results indicated that the product obtained from the wastes fermentation showed low counts of enterobacteria and enterococci. Chemical determinations showed a net decrease of the pH to around 4.0 and the growth curve of the lactic acid bacteria showed the success of the acidification process. The total nitrogen was conserved in the product and the total volatile nitrogen was totally eliminated. The product was used for substituting some protein sources in a conventional formula used in laying feeding of three lots. Two formulae containing, respectively, 20% and 40% of the product were compared to the control (0%). The food consumption and laying performances were monitored for 30 days. The nutritional test indicated that the incorporation of the poultry manure silage at a rate of up to 40% gave laying performances similar to those obtained with the conventional formula. These results show that it is possible to transform poultry manure by controlled fermentation and that the product has an added value as a feed ingredient.

Martijn Ie Clercq, Tadafumi Adschiri and Kunio Arai. (Department of Chemical Engineering, Tohoku University, Aoba-ku, Aramaki Aza Aoba-07 Sendai 980-77 Japan). **Hydrothermal processing of nickel containing biomining or bioremediation biomass**. Biomass and Bioenergy, 21(1) (2001), 73-80.

The feasibility of recovering nickel and producing biofuels from nickel containing biomining or bioremediation biomass by a hydrothermal process has been investigated. Experiments were concerned with the reactions of nickel and biomass containing solutions (model solutions and an extract of *Berkheya coddii*) in hot compressed water between 200 and 375°C at 25 MPa. We found that in this temperature range nickel is soluble in aqueous solutions containing histidine, an amino acid present in high concentrations in nickel accumulators. The thermal decomposition products of the biomass reduce the histidine complexed nickel ions to metallic nickel. This reduction proceeds on metallic surfaces, and the nickel is deposited on the surface of the metal as a nickel or nickel/char layer. No added reducing agent such as hydrogen is required. An extract of the nickel bioaccumulator *B. coddii* and total biomass of *B. coddii* behaved similar to our model solutions. Based on our results we propose a three-step hydrothermal process for the recovery of nickel and biofuel from nickel containing biomass.

R. Alcantara, J. Amores, L. Canoira, E. Fidalgo, M. J. Franco and A. Navarro. (Department of Chemical Engineering and Fuels, School of Mines, Polytechnic University of Madrid, Ríos Rosas 21, 28003 Madrid, Spain). **Catalytic production of biodiesel from soy-bean oil, used frying oil and tallow**. Biomass and Bioenergy, 18(6), (2000), 515-527.

Three fatty materials, soy-bean oil, used frying oil and tallow, were transformed into two different types of biodiesel, by transesterification and amidation reactions with methanol and diethylamine respectively. The ignition properties of these types of biodiesel were evaluated calculating the cetane index of the transesterification products, and the blending cetane number of the amide biodiesel blended with conventional diesel. Amide biodiesel enhances the ignition

properties of the petrochemical diesel fuel, and it could account for the 5% market share that should be secured to biofuels by 2005.

Ramamurthi-R, Kastury-S, Smith-WH, Ramamurthi-R (ed.), Kastury-S (ed.), Smith-WH. **Eco-Friendly Technologies for Biamass Conversion to Energy and industrial Chemicals, Tirupati, India. September 1996**. Bioenergy:-vision-for-the-new-millennium.-Eco-Friendly-Teechnologies-for-Biomass-Conversion-to-Energy-and-industrial-Chemicals,-Tirupati,-India,-September-1996. 8 (2000), 129.

This book contains the 14 papers presented at. the workshop on 'Eco-Friendly Technologies for- Biomass Conversion to Energy and, Industrial. Chemicals' - The papers deal with the industry perspective on eco-friendly technology for biomass conversion into energy, specific issues relating to bagasse usage, effective utilization of bagasse in cogeneration of power in. a sugar plant, biomass energy plants, thermal conversion of biomass, woody biomass production, value-added chemicals from the byproducts of the sugar industry, composting as an eco-friendly technology for waste management, eco-friendly technologies for environmental remediation/management, production of ethanol from biomass, and lending in the biomass energy sector.

Rupam Kataki and Dolon Konwer. (Department of Energy, Tezpur University, Napaam, Tezpur 784 028, India). **Fuelwood characteristics of some indigenous woody species of north-east India**. Biomass and Bioenergy, 20(1) (2001), 17-23.

Wood energy is identified as the major source of energy in rural India and this has necessitated the identification of suitable tree species that can be included in energy plantation programme. As a preliminary to a more detailed future study of wood energy plantation, four indigenous perennial tree species, viz. Albizzia lucida, Syzygium fruticosum, Pterospermum lanceaefolium and Premna bengalensis growing in their natural habitat of north-east India were collected for fuelwood characterization studies. Various physico-chemical properties, viz. moisture and ash content, density, solubility in cold water, hot water and alkali, cellulose, holocellulose, lignin and extractive contents of different parts of these species were determined on ash-free dry weight and extractive-free dry weight basis to find out relationship, if any, between ash and extractive content with the calorific value. In all the species, leaf component contained the highest calorific value presumably because of the presence of extractives in higher amount, followed by heartwood. Elimination of ash from the plant parts increased calorific value while extractive-free materials declined in net caloric content in all plant parts, indicating a possible relationship of these two parameters with the heat of combustion. This study concludes that A. lucida, S. fruticosum and P. lanceaefolium have better fuelwood properties and can be considered for inclusion in the energy plantation programme of north-east India.

Bioengineering

David McCaskill* and Rodney Croteau. (Institute of Biological Chemistry, Washington State University, Pullman, WA 99164-6340). **Strategies for bioengineering the development and metabolism of glandular tissues in plants.** Nature Biotechnology, 17(Jan) (1999), 31.

Glandular tissues in plants produce a wide variety of commercially important chemicals. We review specific model systems that can be exploited for bioengineering the development and metabolism of these specialized structures, and the economic considerations that must be satisfied to permit commercially viable bioengineering approaches to specific chemicals and that constrain the choice of production systems.

F. A. Banat, S. Al-Asheh. (Department of Chemical Engineering, Jordan University of Science and Technology, Irbid, 22110, Jordan). **Biosorption of phenol by chicken feathers**. Environmental Engineering and Policy, 2(2) (2000), 85-90.

This work aimed at exploring the potential use of chicken feathers as a biosorbent for the removal of phenol from aqueous solutions. Batch kinetics and isotherm studies were performed to evaluate the effects of process parameters such as pH, temperature, initial phenol concentration, and sorbent concentration. Complete adsorption of phenol was noticed under certain process conditions. The adsorption of phenol increased with increasing initial phenol concentration, solution pH, temperature, and sorbent concentration. The adsorption equilibrium was well represented by the Freundlich and Langmuir adsorption isotherm models. The thermodynamic parameters obtained by means of the Langmuir model showed that the adsorption process was endothermic.

Narciso Campos', Manuel Rodriguez-Concepcion, Susanna Sauret-Gueto, Francesca Gallego, Luisa-Mariaa LOIS and Albert Boronat (Denartment de BioouimiM i Biologia Molecular, Facultat de Quimica Universitat de Barcelona C/Marti 1 Franques 1 08028 Barcelona fioal -Luisa-Maria LOIS and Albert BORONAT. (Denartment de Bioquimica i Biologia Molecular, Facultat de Quimica, Universitat de Barcelona, C/Marti i Franques 1, 08028 Barcelona Spain) **Escherichia coli engineered to synthesize isopentenyl diphosphate and dimethylallyl diphosphate from mevalonate: a novel system for Fro the genetic analysis of the 2-C-methyl-D-erythritol 4-phosphate pathway for isoprenoid biosynthesis**. Journal of Biochemistry, 353 (2001), 59-67.

Isopentenyl diphosphate (IPP) and its isomer dimethylallyl diphosphate (DMAPP) constitute the basic building block of isoprenoids, a family of compounds that is extraordinarily diverse in structure and function. IPP and DMAPP can be synthesized by two independent pathways: the mevalonate pathway and the recently discovered 2-C-methyl-D-erythritol 4-phosphate (MEP) pathway. Although the MEP pathway is essential in most eubacteria, algae and plants and has enormous biotechnological interest, only some of its steps have been determined. We devised a system suitable for the genetic analysis of the MEP pathway in *Escherichia 0.* A synthetic operon coding for yeast 5-diphosphomevalonate decarboxylase, human 5-phosphomevalonate kinase, yeast mevalonate kinase and *E. coli* isopentenyl, diphosphate isomerase was incorporated in the chromosome of this bacterium. The expression of this operon allowed the synthesis of IPP and DMAPP from mevalonate added exogenously and complementation of lethal mutants of the MEP pathway. We used this system to show that the *ygbP.* y*chB* and *ygbB* genes are essential in *E. coli* and that the steps catalysed by the products of these genes belong to the trunk line of the MEP pathway.

Rajinder K. Jain, Sunita Jain. **Transgenic strategies for genetic improvement of Basmati rice**. Indian Journal of Experimental Biology, 38(1) (2000), 6-17.

Transgenic approach offers an attractive alternative to conventional techniques for the genetic improvement of Basmati rice because they enable the introduction of one or more genes into a leading cultivar without affecting its genetic background. During the last ten years, a rapid progress has been made towards the development of transformation methods in rice. Several transformation methods including Agrobacterium, biolistic, and DNA uptake by protoplasts have been employed to produce transgenic rice. An array of useful genes is now available and many of these have already been transferred in rice to improve the resistance against biotic and abiotic stresses. In Basmati rice, a beginning has already been made regarding the development of tissue culture protocols, transformation methods and production of useful transgenic plants. The application and future prospects of transformation technology to engineer the resistance against insect pests (stem borer, leaf folder, brown plant hopper, gall midge), fungal diseases (blast, bakanae/foot rot), bacterial diseases (bacterial leaf blight, sheath blight), abiotic stresses (salinity and drought) and improved nutritional quality (accumulation of provitamin A and essential amino acids in endosperm) in Basmati rice, have been addressed.

Tomoaki Matsuura1, Kouji Miyai1, Savitr Trakulnaleamsai1, Tetsuya Yomo1,2, Yasufumi Shima1,Snigeji Miki1, Keizo Yamamoto3, and Itaru Urabe1*. (1Department of Biotechnology, Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka 565-0871, lapan. 2Form and Function Project, PRESTO, JST. 2-1 Yamadaoka, Suita, Osaka 565-0871 Japan. 3Department of Chemistry, Nara Medical University, 810 Shijo, Kashihara. Nara 634-0813, Japan.). **Evolutionary molecular engineering by random_elongation mutagenesis**. Nature Biotechnology, 17 (Jan) (1999), 58.

We describe a new method of random mutagenesis that employs the addition of peptide tails with random sequences to the C-terminal of enzyme molecules. A mutant population of catalase I from Bacillus stearothermophilus prepared by this method has a diversity in thermostability and enzyme activity equal to that obtained after random point mutagenesis. When a triple mutant of catalase I (1108T/D130N/1222T)—the thermostability of which is much lower than that of the wild type—was subjected to random elongation mutagenesis, we generated a mutant population containing only mutants with higher thermostability than the triple mutant. Some had an even higher stability than the wild-type enzyme, whose thermostability is considered to be optimized. These results indicate that peptide addition expands the protein sequence space resulting in a new fitness landscape. The enzyme can then move along the routes of the new landscape until it reaches a new optimum. The combination of random elongation mutagenesis with random point mutagenesis should be a useful approach to the in vitro evolution of proteins with new properties.

Biofertilizer

Adhikary-SP, Redy-SM (ed.), Rao-D (ed.), **Vidyavati. Potentiality of cyanobacteria biofertilizer containing local isolates on the growth and yield of two different rice varieties**.Perapectives-in-biotechnolocly.-Proceedincra-Qf-a-natiQnal-svmposium.-Waranaal. -India. -26-27-Februarv-1999, (2001), 13-21.

In a study conducted during 1995-97, five species of cyanobacteria (*Anabaena variabilis* UU 147, *Nostoc* sp. UU 29130, *Cylindrospermum* sp. UU 245, *Aulosira* sp. 00 25118 and *Caiothrix* sp. 00 29139) from the 120 species of cyanobacterial germplasm of the rice fields in Orissa, India, maintained at Utkal University, were

selected on the basis of their wide occurrence, faster growth, higher nitrogen fixing capability to find out their potentiality on the growth and yield of two different rice varieties (Mashuri and CR 1009). These organisms were cultivated outdoors in galvanized iron trays and polybags for producing inocula for field application. Increase in grain yield by over 25% than control was obtained in plots algalized with fresh cyanobacteria inoculum containing regional isolates which was much higher than the yield of the plots inoculated with soil based culture. Most of the inoculated species competed successfully with the indigenous flora and established in the rice fields.

Araceli Pérez-Sanz, Ana Álvarez-Férnandez, Tomás Casero, Francisco Legaz, Juan José Lucena. (Dpto. Química Agrícola. Facultad de Ciencias C-VII. Universidad Autónoma de Madrid. E-28049 Madrid, Spain; ETSIA Avda Alcalde de Rovira Roure 177 E-25198 Lleida, Spain; IVIA Carretera de Moncada a Náquera Km 5. E-46113 Valencia. Spain). **Fe enriched biosolids as fertilizers for orange and peach trees grown in field conditions.** Plant and Soil, 241(1) (2002), 145-153.

Iron enriched biosolids (FEB) from water treatment facilities are being used as an alternative to synthetic chelates in order to improve Fe uptake. The impact of this type of products on iron nutrition is not fully understood. Plant response depends on FEB composition, soil and climatic conditions and crop response. In order to study the effectiveness of FEB as fertilisers, two field experiments have been carried out. Two different commercial formulations of FEB (unmodified u-FEB and modified m-FEB) produced as a by-product of a drinking water treatment facility in Tampa (Florida, USA) were used. An orange tree (*Citrus sinensis*, cv. Navelina) and a peach tree (*Prunus persica* cv. Sudanell) field experiments took place in different locations in Spain. Macro and micronutrients were evaluated to assess mineral status of orange and peach leaf samples. Yield and fruit size were also determined. Despite the large amount of Fe bound by the organic matter on FEB, these products were less effective than synthetic chelates to improve iron uptake. No differences were found in orange yield or size. Results show that the ferric treatments improve fruit calibre, but not yield in peaches.

Hashem-MA. **Problems and prospects of cyanobacterial biofertilizer for rice cultivation.Contributed papers from the 8th International Symposium on Nitrogen Fixation with Non-Legumes, Sydney, NSW, Australia, 3-7 December 2000**. Australian-Journal-of-Plant-Physiology, 28(9) (2001), 881-888.

Nitrogen (N2)-fixing cyanobacteria are a dominant microflora in rice fields and are currently being used sporadically as a supplement to chemical nitrogen fertilizers for rice cultivation in rice-growing countries, including India and Bangladesh. This technology suffers from serious drawbacks and its use at the farm level is not gaining universal acceptance due to some major problems, which include development of a suitable production technology of biofertilizer for field use, establishment of the applied biofertilizer in the rice field and the sustainability of the technology. In order to significantly improve the efficient use of cyanobacteria as a N-based biofertilizer for rice cultivation, experiments were carried out in different dimensions both in the laboratory and field. Cyanobacterial strains were isolated identified and quantified from a wide range of distinctively different types of soils, viz., acid, calcareous, saline, red and neutral soils under different agroecological zones (AEZ) of Bangladesh. The isolated strains were tested for their N2-fixing capacity and growth rate under various stress conditions prevailing in the rice field e.g. pH, combined N, pesticides, salinity and nutrient availability in order to select suitable strains for use as biofertilizer. Large-scale

cyanobacterial biofertilizer was produced with the strains showing high rates of growth and N2 fixation both in liquid cultures under laboratory conditions and in soils of their habitats and non-habitats under open air. To assess the effectiveness of the produced biofertilizer, field trials at the selected locations were carried out on rice. To assess the effectiveness of the produced biofertilizer. field trials at the selected locations were carried out on rice. Results of the field trials showed that cyanobacterial biofertilizer may reclaim the problem soils such as acid soils and saline soils, improve the fertility status and may supplement 215-35% N for rice cultivation in these soils. This biofertilizer may be used in improving the soil environment.

Seema-Bhadauria, Pahari-GK, Sudhir-Kumar. **Effect of Azospirillum biofertilizer on seedling growth and seed germination of Emblica officinalis**. Indian-Journal-of-Plant-Physiology, 5(2) (2000), 177-179.

Seeds of *E. officinalis* [*Phyllanthus emblica*] were treated with Azospirillum biofertilizer (Azogreen) for 24, 16, 8, and 0 h. During the second week after sowing, 30% germination was observed in the control, whereas biofertilizer coated seeds showed germination of 13-18%. Biofertilizer treatment subsequently enhanced seed germination, which was highest in the fourth week in the 24 h treatment (79% compared with 50% in the control). Seed inoculation with biofertilizer increased root and shoot length from 3.2 to 5.3 cm and 3.6 to 5.5 cm, respectively. Total length of 3-week-old seedlings was almost double in the 24 h treatment (10.98 cm) than in the control (4.8 cm).

Sharma-E, Rai-SC, Shanna-R. **Soil, water and nutrients conservation in mountain farming systems: case-study from the Sikkim Himalaya**. Journal-of-Environmental-Management, 61(2) (2001), 123-135.

Overland flow, and losses of soil and nutrients were assessed in the Khanikhola watershed, in Sikkim, India, in relation to land uses and farming practices, including: agricultural (cropped) fields; forests; large cardamom (*Amomum subulatum*) agro forestry; cultivation of broom grass (*Thysanolaena maxima*) on terrace risers; plantations of horticultural trees; use of the nitrogen-fixing tree Albizia in both agroforestry and croplands to improve soil fertility; and biocomposting of residues.

Tiwary-DK, Hasan-MA, Chattopadhyay-PK. **Studies on the effect of inoculation with Azotobacter and Azospirillum on growth, yield and quality of banana**. Indian-Agriculturist, 42(4) (1998), 235-240.

The experiment was conducted to study the effect of inoculation with Azotobacter and Azospirillum on growth, yield and quality of banana (cv. Giant), grown with different rates of N. Inoculation of sucker with Azospirillum twice (sucker + soil inoculation) resulted in maximum plant height and leaf size in plants receiving 50% of the recommended N dose. Inoculation of Azospirillum did not reduce the time required for shooting from planting. Azospirillum-inoculated plants produced a high number of hands/bunch, and the number of hands/bunch obtained was at par with double inoculation. Inoculation with Azospirillum produced highest yield of banana (69.15 t/ha). A fairly high T.S.S. and reducing sugar content were

recorded in Azotobacter-inoculated plants. However, the effect of biofertilizer on total sugar and acidity content of fruits was not consistent.

Wankhade-ST, Solanke-VM, Turkhede-AB, Malvi-SD, Katkar-RN. **Effect of biofertilizer on growth and yield of Arborium cotton (AKA-8401)**. Crop-Research-Hisar, 21(1) (2001), 38-40.

Cotton cv. AKA-8401 was grown at Akola in 1993-96 with 50, 75 or 100% of recommended N and soil or seed inoculation with Azotobacter or Azospirillum, or no inoculation. Seed cotton yield was not significantly affected by inoculation treatments, but increased with increasing N rate.

Zodape-ST. **Seaweeds as a biofertilizer**. Journal-of-Scientific-and-industrial-Research, 60(5) (2001), 378-382.

Seaweeds are large plants growing in the sea as marine algae like rockweeds, kelps, sea lettuce and dulses. Dried, fresh or liquid seaweed extracts are being used by horticulturists, gardeners, farmers and orchadists as fertilizers since they contain microelements and plant growth regulators like cytokinins. They are commercially available as Maxicrop, Seasol, SM3, Kelpak and Cytokin. Seaweed extracts enhance seed germination, increase plant nutrient uptake, increase plant resistance against frost and fungal diseases, are effective for ripening of fruits, increase shelf-life of produce, and are an excellent soil conditioner.

Biomarker

Brian K. Harper, Stephen A. Mabon, Staci M. Leffel, Matthew D. Halfhill, Harold A. Richards, Kari A. Moyer; and C. Neal Stewart, Jr. (Departmint of Biology, University of North Carolina, Greensboro, NC 27402-6174). **Green fluorescent protein as a marker for expression of a second gene in transgenic plants**. Nature Biotechnology, 17(Nov) (1999), 1125.

The use of transgenic crops has generated concerns about transgene movement to unintended hosts and the associated ecological consequences. Moreover, the in-field monitoring of transgene expression is of practical concern (e.g., the underexpression of an herbicide tolerance gene in crop plants that are due to be sprayed with herbicide). A solution to these potential problems is to monitor the presence and expression of an agronomically important gene by linking it to a marker gene, such as *GFP.* Here we show that GFP fluorescence can indicate expression of the *Bacillus thuringiensus cry1Ac* gene when co-introduced into tobacco and oilseed rape, as demonstrated by insect bioassays and western blot analysis. Furthermore we conducted two seasons of field experiments to characterize the performance of three different GFP genes in transgenic tobacco. The best gene tested was *mGFP5er,* a mutagenized GFP gene that is targeted to the endoplasmic reticulum. We also demonstrated that host plants synthesizing GFP in the field suffered no fitness costs.

Gupta –SK. **Neutral red retention by earthworm coelomocytes: a biomarker of cadmium contamination in soil**. Biomedical-and-Environmental-Sciences. 13(2) (2000), 117-121.

Coelomocytes from *Metaphire posthuma* were used as a model to assess the toxic potential of cadmium incorporated into soil through environmental or human activity. The retention period of neutral red in the lysosomes of the coelomocytes was used as a biomarker. The earthworms were used after 10 or 20 days of exposure to the test chemical (cadmium chloride). The viability of harvested coelomocytes was 93% and this was not altered by natural red staining during experimentation. The normal soil control and potassium chloride control coelomocytes retained dye for 119 and 121. min, respectively. A linear decline in retention -was seen with each increase in cadmium concentration (from neutral red retention for 98 min at 5ppm to 18 or 19 min at 80 ppm).

Biopesticide

Attila S. Csontos. **Lateral Movement of the Entomopathogenic Nematodes Steinemema glaseri and Heterorhabditis bacteriophora in Sand at Different Temperature in Response to Host Seeking**. Biocontrol Science and Technology, 12(1) 2002, 137-139.

Laboratory studies were conducted to determine the lateral movement of Steinemema gfaseri and Heterorhabditis bacteriophora in sand at 15,20, 25 and 30°C in response to Galleria mellonella larvae. Lateral movement was assessed in 42.5 * 5 cm PVC tubes, constructed from 17 individual sections, with G. mellonella larvae placed on one end and the nematodes in the center. The proportion of the nematodes moving towards or away from the larvae at different temperatures was quantified at 8 h intervals. Although both species are reported to be cruisers, only S. glaseri responded to the host cues. The movement of the infective juveniles of both species increased significantly as temperature rose. The extraction efficiency of both species decreased at all temperatures with time.

Dhawan-AK, Simwat-GS, Dhaliwal-GS (ed.), Arora-R (ed.), Randhawa-NS (ed.), Dhawan-AK. **Evaluation of different biopesticides against cotton boilworm, Helicoverpa armigera (Hubner)**. Ecological agriculture and sustainable development, Volume 2. Proceedings of International Conference on Ecological Agriculture: Towards Sustainable Development, Chandigarh, India. 15-17 November, 1997, (1998), 274-280.

The efficiency of commercially available formulations of Bacillus thuringiensis subsp. kurstaki (Dipel, Bioasp and Biolep), neem (*Azadirachta indica*) (Nimbecidine, Neemgold and Neemazal) and insect growth regulators (lufenuron, fiufenoxuron and RH-2485 a diacylhydriazne) were evaluated against *Helicoverpa armigera*. Ail the 3 formulations of *B. thuringiensis* @ 1.50 kg/litre/ha were as effective as quinalphos against the young larvae. These treatments were, however, significantly inferior to quinalphos against mature larvae. Neem based insecticides were significantly inferior to standards, quinalphos and chlorpyrifos against young and mature larvae except Neemazal which was as effective as quinalphos against young larvae. However, all the 3 insect growth regulators, lufenuron @ 75 g, fiufenoxuron @ 40g and RH-2485 @ 300 g a.i./ha were comparable to quinalphos against larvae. In another experiment, Dipel, Nimbecidine and lufenuron were evaluated against *H. armigera* populations collected from Ludhiana, Barnala and Bhatinda and the data showed variations in susceptibility to the pest. The Barnala population was comparatively more susceptible to all the 3 biopesticides. Similarly, the Bhatinda population was more susceptible to Nimbecidine and Dipel.

Ghayur-Alam, Alam-G. **A study of biopesticides and biofertilisers in Haryana, India**. Gatekeeper-Series-Sustainable-Agriculture-and-Rural-Livelihoods-Programme,-International-institute-for-Environment-and-Development, 93 (2000), 24.

The use of chemical pesticides and fertilizers in Indian agriculture has seen a sharp increase in recent years, and in some areas has reached alarming levels with grave implications for human health, the ecosystem and ground water. It is therefore increasingly urgent that environmentally friendly methods of improving soil fertility and pests and disease control are used. The potential of biopesticides and biofertilizers for promoting sustainable agriculture has been known for many years. A number of government agencies, including the Ministry of Agriculture and the Department of Biotechnology, are engaged in supporting research, production and application of these agents. However, in spite of these efforts, their use in India is small. The paper investigates the potential of and constraints in the use of biopeaticides and biofertilizers, taking the state of Haryana as a case study. It explores the factors responsible for the limited use of these agents, based on detailed discussions with a large number of farmers, various agencies engaged in the promotion of biopesticides and biofertilizers. State Agricultural Department officials, and shopkeepers. The study found that for the use of biopesticides, a key problem was that departments promoting Integrated Pest Management (IPM) have very little knowledge and experience of biopesticides. and most state agricultural universities, on whose recommendations pest control methods are promoted, do not tend to recommend biopesticides. In the absence of active promotion by the agriculture department, the demand for these products has not developed, and most private shops and dealers do not stock and sell biopesticides. The paper recommends that the agricultural departments and universities pay greater attention to the promotion of biopesticides that IPM training is improved, and that there is a greater focus on cropping techniques and varieties which do not require such a dependence on pesticides. In the case of biofertilizers, their poor quality and performance is a major factor in their limited uptake by farmers. This is primarily linked to inappropriate strains and inefficient production technology. As a result it is recommended that research and development to identify more suitable strains, to develop better production technology and quality control methods is greatly increased, and that in the meantime the various grants and subsidies on biofertilizers are diverted to support these R&D programmes.

Gupta-GP, Kirti-Sharma, Sharma-K. **Utilization of biopesticides in managing the cotton pest complex in India**. 1996 Proceedings Beltwide Cotton Conferences, Nashville, TO, USA, January 9-12, 1996, 2 (1996), 1135-1140.

Field trials were conducted with upland cotton during 1992-94 in New Delhi, India, to evaluate the bioefficacy of neem products and *Bacillus thuringiensis* formulations and their combinations with synthetic insecticides against cotton bollworms (Earias spp., *Pectinophora gossypiella* and *Heliothis armigera* [*Helicoverpa armigera*]). The application of neem products or *B. thuringiensis* alone, together or with synthetic insecticides failed to suppress the bollworm complex. However, neem or *B. thuringiensis* in combination with at least one spray of a synthetic pyrethroid in a 4-spray schedule gave effective control. Satisfactory control of the bollworm complex and an increase in cotton yield were also obtained by applying combinations of neem, *B. thuringiensis* and an 84% reduced rate of synthetic pyrethroid. No resurgence of aleyrodids was observed. The seed cotton yield with this spray schedule was more (1910 kg/ha) than conventional schedules (1370-1565 kg/ha).

J. Lawrie; M. P. Greaves; V. M. Down; B. Morales-Aza; J. M. Lewis. **Outdoor Studies of the Effeciency of *Altenaria altenata* in Controlling *Amaranthus retroflexus*.** Biocontrol Science and Technology, 12(1), 83-94.

Application of 250 L ha-1 containing 107 *Altenaria altenata* conidia ml-1 caused 61% reduction in dry weight and a 45% mortality in Amaranthus retroflexus plants growing in a wheat crop. However, only 10- 22% of the applied conidia were retained on the leaf. In one experiment, conidia remained viable for 4 days on the leaf surface until conditions were favorable for germination. Competition from the wheat crop, as well as its creation of a moist micro-climate, improved the control of *Am. retroflexus* by *A. altenata*. Total control of Am. retroflexus may be difficult to achieve with A. altemata, but suppression to reduce or eliminate its competitive effect on crops is possible.

M. G. Paoletti; D. Pimrntel. **Environmental Risks of Pesticides Versus Genetic Engineering for Agricultural Pest Control**. Journal of Agricultural and Environmental Ethics, 12(2002), 279-303.

Despite the application of 2.5 million tons of pesticides world wide, more than 40% of all potential food production is lost to insect, weed, and plant pathogen pests prior to harvest. After harvest, an additional 20% of food is lost to another group of pests. The use of pesticides for pest control results in an estimated 26 million human poisonings, with 220.000 fatalities, annually worldwide. In the United States, the environmental and public health costs for the recommended use of pesticides total approximately & dollar; 9 billion/yr. Thus, there is a need for alternative non-chemical pest controls, and genetic engineering (biotechnology) might help with this need. Disease and insect pest resistance to various pests has been slowly bred into crops for the past 12,000 year8; current techniques in biotechnology now offer opportunities to further and more rapidly improve the non-chemical control of disease and insect pests of crops. However, relying on a single factor, like the *Bacillus thuringiensis* toxin that has been inserted Into corn and a few other crops for Insect control, leads to various environmental problems, Including insect resistance and, in some cases, a threat to beneficial biological control insects and endangered insect species. A major environmental and economic cost associated with genetic engineering applications in agriculture relates to the use of herbicide resistant crops (HRC). In general, HRC technology results in increased herbicide use but no increase in crop yields. The heavy use of herbicides in HRC technology pollutes the environment and can lead to weed control costs for farmers that may be 2-Md greater than standard weed control costs. Therefore, pest control with both pesticides and biotechnology can be improved for effective, safe, economical pest control.

Marcia A. Shirakawa [a], Christine C. Gaylarde [b,c,*], Peter M. Gaylarde [c], Vanderley John [a], Walderez Gambale [d]. (Departmento de Engeharia de Construcdo Civil, Escola Poliecnica, Universidade de Saa Paulo, Saa Paulo, Brazil. Faculidade. Faculidade Biosciences, Departmento Biofisica, Universidade Federal do Rio Grande do Sul, Av. Bento Gancalves 9500, Porto Alegre-RS CEP 91501-970, Brazil. MIRCEN, Departmento Solos, C.P. 776, Porto Alegre-RS 91501-970, Brazil. Departmento De Microbiologia, Instituto de Clencias Biomedicas, Universidade de Sao Paulo, Sao Paulo, Brazil). **Fungal colonization and succession on newly painted buildings and the effect of biocide**. FEMS Microbiology Ecology 39(2002), 165-173.

This report describes the sequence of fungal colonization and the influence or biocide incorporation on paint films, determined using quantitative methods. Two buildings were painted with acrylic paint, with and without an experimental

biocide formulation containing a carbamate (carbendazin). N-octyl-2H-isolhiaitolin-3-one and N-(3,4-dichlorophenyl)N,N-dimethyl urea (total biocide concentration 0.25% w/w). One week after painting, the major groups of organisms detected were yeasts and Cladosportium. The yeast population fell to undetectable levels after the third week and this microbial group was not detected again until the 31st week, afler which they increased to high levels on the 42nd week. Awcobaridiumun1 showed a pattern similar to the yeasts. The main fungal genera detected over the 42 week period were *Alternaria*, *Curvularia*, *Epicoccum*, *Helminthosporium*, *Coelomycetes* (mainly *Pestalotial Pestalotiopsis*), *Monascus*, *Nigrospora*, *Aureobasidium* and *Cladosporium*. The latter was the main fungal genus detected at all times. The physiological factors controlling colonization are discussed. *Cladosporium*, *Aureobasidium*, Tripospermum and yeast on the painted surfaces were all able to grow on mineral salts agar containing 10% sodium chloride. This is the First lime that the genus Tripospermum has been reported on painted buildings. The fungal population on biocide-containing surfaces was significantly lower than on non-biocide-containing paint after 13 weeks and continued so to 42 weeks after painting, but there was no statistically significant difference in the level of fungal biodiversity.

Meshram-SU, Sonali-Joshi, Ramdas-Kamdi, Swati-Peshwe, Joshi-S, Kamdi-R, Peshwe-S. **In vitro interaction of microbial biopesticides with fish pathogens prevailing in aquaculture food industry**. Journai-of-Food-Science-and-Technology-Mysore, 35(2) (1998), 177-178.

Pathogens were isolated from the skin, gills, intestines, operculum, tail, and liver of diseased fish in the Vidarbha region, India, and identified as Klebsiella, Pseudomonas, *Escherichia coli* and *Salmonella*. 19 fungal cultures were also identified. Microbial biopesticides Bacillus thuringiensis (strains B-17, IPS-80 and H-14) and Streptomyces antibioticus were added to nutrient agar, previously plated with the pathogens, and the diameter of the zone of inhibition measured after incubation at 37°C for 48 h. Results are tabulated. In general, *B. thuringiensis* B-17 had a broad spectrum of inhibition against all pathogens, except *Saproiegnia* sp. Fingeriings of Labeo rohita were administered *B. thuringiensis* [dosage not given] and examined. No adverse effects were noted.

Nguya K. Maniania. **A Law-cost device for Infecting Adult tsetse fly, *Glossina* spp., with the *Entomopathogenic* Fungus *Metarhizium anisopliae* in the Field**. Biocontrol science and Technology, 12(1) 2002, 59-66.

A low-cost device for infecting adlitt tsetse fly, *Glossina fuscipes fuscipes*, with the entomopathogenic fungus *Metarhizium anisopliae* was designed and tested in the field. Tsetse flies that are attracted to the trap entered the contamination device and ultimately became infected with the fungus. Traps exposed to the sun attracted more flies than did the ones placed in the shade. The time spent by single flies in the contamination device varied between 5-186s, and the subsequent number of conidia collected varied between 1.6 * 105 conidia and 40.5 * 105 conidia per fly, and largely depended on the behavior of individual flies. Dry conidia of *M. anisopliae* in the device retained their viability for 31 days in the field, and efficacy against G.fuscipes was not affected.

Nina K. Zidack; Paul C. Quimby Jr. **Formulation of Bacteria for Biological Weed Control Using the Stabileze Method**. Biocontrol Science and Technolog,y 12(1) (2002), 67-74.

Two plant pathogenic *Pseudomonas* spp. were formulated using the 'Stebileze' method which involves the incorporation of bacteria in a water-absorbent starch matrix with oil and sucrose, then granulating the matrix with hydrated silica. In one experiment, *P. syringae* pv. tabaci formulated with the standard Stabileze formula was evaluated for storage viability at -15. 2 and 22°C. Bacteria stored for 1 year at -15 and 2°C lost only 0.2 and 0.5 log10, colony forming units (CFU) g-1 respectively compared to a loss of log10, 3.5 CPU at 22°C. In a second experiment, the same pathogen was evaluated using variations of the formula with and without oil, and with and without sucrose. *P.s*. pv. tabaci formulated with sucrose and oil in combination, and sucrose and oil alone survived better than the formulation without oil or sucrose. A third experiment tested the effect of four levels of oil and four level of sucrose (4 * 4 factorial) on survival of P.s. pv. tagetis over a 28 month period. Sucrose alone enhanced survival more than oil alone, and the beneficial effect of the sucrose was reduced when it was combined with oil. These experiments suggest that the Stabileze protocol is effective for stabilizing bacteria, but there are differences in response to different formulation components between species of bacteria.

P. V Krishnayyaand; P. S Grewal. **Effect of Neem and Selected Fungicides on Viability and Virulence of the Entomopathogenic Nematode *Steinemema feltiae***. Biocontrol Science and Technology, 12(2) 2002, 256-266.

Entomopathogenic nematodes are often used in conjunction with other pest management tactics and the lack of compatibility information is a major impediment in further expansion of their use. We evaluated the effects of different formulations of neem and selected fungicides commonly used in greenhouses on *Steinemema feltiae*, which is used for the control of fungus gnats. Neem as pure oil at the field recommended concentrations (5- 10 mLL-') had no effect on the viability and virulence of *S.feltiae* up to 120h incubation. However the neem formulation, Nimbecidine and neem oil when mixed with a bactericidal soap (commonly used as a surfactant with neem oil) caused 13- 25% mortality of S. feltiae. This toxic effect was entirely due to the soap that alone caused about 24% mortality. Neither neem oil, Nimbecidine or soap had any effect on nematode virulence. The fungicide cinnamaldehyde (Cinnamate) was highly toxic, resulting in 100% nematode mortality after 4h of incubation, followed by hydrogen dioxide/peroxyacetic acid mixture (ZeroTol) that caused 100% mortality after 120 h of incubation. Another fungicide, azoxystrobin (Abound) caused no nematode mortality. The investigation concludes that neem and the fungicide azoxystrobin (Abound) can be safely tank mixed at the field recommended concentrations with the infective juveniles of *S. feltiae* for application, but cinnamaldehyde (Cinnamate) and hydrogen dioxide/peroxyacetic mixture (ZeroTol), are incompatible. Also the surfactants that are usually recommended as 'tank-mix' applications can be toxic to the nematodes and should therefore be evaluated for compatibility prior to use.

R. J. Milner; P. R. Samson, G. K. Bullard. **A Profile of a Commercially Usefull Isolate of *Metarhizium anisopliae var anisopliae***. Biocontrol Science and Technology, 12(1) 2002, 43-58.

The isolate FI-1045 is the basis of a mycoinsecticide, BtoCane™ granules recently registered for the control of greyback canegrub, *Demnolepida albohirtum* (Coleoptera: Scarabaeidae: Melolonthinae) in Australian sugarcane Fields. The isolate was obtained from a naturally infected larva of 0. albohirtum collected

from Tully in north Queensland. The isolate can be distinguished from others infecting the same insect and also other species of canegrub by means of RAPD patterns and sequence data from the ITS region. A comparison of a stored FI-1045 isolate with three derived isolates, which had different histories of host-passage, showed no variation in RAPD pattern. All Isolates grew well at temperatures between 20 and 30°C but did not grow at 35°C and grew slowly at 15°C. However, on potato dextrose agar, the original FI-1045 grew more rapidly and did not produce as much pigment as the derived isolates. It is speculated that this difference was due to the storage method used with the original FI-1045 being stored at -70°C and the other isolates being freeze-dried. Bioassays against third instar greyback canegrubs gave a mean LC50, of 8.7 * 104 conidia g-1 peat substrate after 10 weeks. Using Tenebrio molitor a host, it was found that conidia taken directly from the infected insect were similar in virulence to the cultured Fl-1045. Using injection of culture filtrate as the assay method, it was found that Fl-1045 produced destruxins. In laboratory host range tests, a dose of 106 conidia g-1 peat killed 96% of southern oneyear canegrubs. *Antitrogus consanguineus*, 86% of *Lepidiota picticollis* and less than 30% of the other five species of canegrub tested.

Ramesh Arora, G.S. Battu and D.S. Bath. (Department of Entomology Punjab Agricultural University, Ludhiana - 141 004, India). **Management of insect pests of Cauliflower with Biopesticides**. Indian J. Ecol. 27(2) (2000), 156-162.

Dimondback moth *Plutella xylostella* (Linnaeus) is the key pest damaging cabbage and cauliflower crops in India. It has developed multiple resistance to all the important groups of conventional insecticides including organochlorines, organophosphates and synthetic pyrethroids. In a Field trial with commercially available *Bacillus thuringiensis* Berliner var. kurstaki based biopesticides, the pest was effectively controlled by two applications of Dipel 8L/Biolep/Biobit all ® 0.750 I or kg/ha or Dipel WP/Biotox @ 1.500 kg/ha. Based on these results and previous studies, an IPM system comprising intercropping of Indian mustard and need-based application of biopesticides (Bt and NPV) is proposed for managing the pest complex of cabbage and cauliflower crops.

Ramesh Arora, G.S. Battu And D.S. Bath. Department of Entomology, Punjab Agricultural University,Ludhiana 1410 04, India. **Management of Bihar hairy caterpillar, *Spilosoma oblique* walker with biopesticides**. Indian J. Ecol, 27(1) (2000), 92-94.

The Bihar hairy caterpillar *Spilosoma obliqua* Walker is a serious, sporadic, polyphagous, defoliating pest damaging a wide range of crops including oilseeds, pulses, vegetables and spices (Atwal and Dhaliwal, 1997). The young caterpillars can he easily killed by application of insecticides, while full-grown larvae are difficult to kill. Sole reliance on chemical pesticides also results in many undesirable ecological problems, Bacillus thuringiensis (Bt) based biopesticides are an environmentally benign alternative to chemical pesticides and effective against a wide range of lepidopterous and coleopterous pests (Arora et. al. 2000). In the present investigations, nine commercially available Bt-based biopesticides were evaluated for their efficacy against S. oblique larvae infesting castor crop in a field-cum-laboratory trial. Each of the nine Bt-based biopesticides (Halt, Dipel WP, Biotox, Bioasp, Delfin WG. Biobit, Biolep, Thuricide HPSC, Dipel 8L) were sprayed thoroughly at a concentration of O.I percent on five randomly selected plants of castor. 60 young (I, II instar) and an equal number of medium-sized (III instar) larvae were collected from each treatment, one hour after spray. These

larvae were reared in the laboratory in glass jars (10 cms * 15 cms) on treated castor foliage collected from respective treatments. Mortality data of larvae were recorded daily until pupation. Cent per0cent mortality of young larvae was recorded in Halt and Bioasp 48 h after spray (Table 1). However, all the treatments recorded 100 per cent mortality of young larvae 144 h after spray. In case of medium-sized larvae, mortality values varied from 16.67 per cent (Dipel WP) to 60 per cent (Bioasp) 48 h after spray. No medium-sized larvae survived in Halt, Biolox, Bioasp, Biolep and Dipel 8L at 144 h after spray. As many as 18 biotic agent.s including parasitic and predatory insect species and palhogenic microbes, responsible for the natural mortality of S. ohliqun have been reponed. Three of these, viz., nuclear polyhedrosis virus, a larval braconid parasitoid.

Roger N. Williams; Dan S. Fickle; Parwinder S. Grewal; John R. Meyer. **Assessing the Potential of Entomopathoghenic Nematodes to Control the Grape Root Borer *Vitacea poiistiformis* (Lepidoptera: Sesiidae) Through Laboratory and Greenhouse Bioassays**. Biocontrol Science and Technology 12(1), 35-42.

Seventeen entomopathogenic nematode species and strains were evaluated for virulence to the grape root borer, *Vitacea polistiformis* (Harris) in laboratory and greenhouse bioassays. Heterohabditis bacteriophora strain GPS11 and H. zealandica strain XI produced a larval mortality rate of over 85% of larvae embedded in the root cambium in laboratory bioassays. The nematode species H. marelata and *H. bacteriophora* strain Oswego produced mortality rates of over 75%. Of the Steinernema species tested, *S. carpocapsae* strain 'All' performed the best with a mortality rate of 69%. All other nematode species and strains tested, with the exception of *S. bicomutum*, produced some degree of larval mortality. In the greenhouse bioassays, 93% control was achieved with *H. zealandica* strain X1 applied at 4 * 109 infective juveniles (IJs) acre1-1 (9.88 * 109 IJs ha-1). *H. bacteriophora* strain GPS11 successfully reproduced in grape root borer larvae. The numbers of IJs produced within infected larvae were related to larval size. The survival rate of neonate larvae on grape root sections was 61 %, which thus provides a means to rear the neonate larvae for bioassays.

Sarode-SV, Sonalkar-VU. **Comparative performance of biopesticides and insecticides on pigeonpea crop**. Shashpa, 8(1) 2001, 85-87.

The use of biological control agents (BCA) and conventional chemical method to control *Helicoverpa armigera* was compared in a field experiment conducted with pigeon pea at 4 blocks, Dryland, Shivani, Gudadhi and Washim Road farm of the University, in Maharashtra, India, [date not given]. Trichoderma harzianum was applied as seed treatment at 4 g/kg seed, whereas 2 sprays of Ha nuclear polyhedrosis virus (NPV) at 250 LE/ha were given at flowering and pod formation stages of the crop at an interval of 15 days, except at Shivani where third spray was made. In the conventional plots, the seeds were untreated and 2 applications of 0.07% endosulfan were made at flowering and pod formation stages, except at Gudadhi where second spray was replaced with application of 0.05% quinalphos at pod formation. The observations were recorded on wilting, larval count, pod damage at harvest and yield. The average disease incidence was lowest (0.70%) in the plots treated with T. harzianum compared to 9.19% in untreated plots. Similarly, the pod damage caused by *H. armigera* was lowest (26.20%) in the plots sprayed with HaNPV compared to 29.00% in the plots treated with insecticides. Larval reduction in HaNPV-treated plots and insecticide-treated plots was 53.75 and 48.04%, respectively. Crop yield was also higher in BCA-treated

plots (7.46 q/ha) over the conventional plots (6.20 q/ha). An additional investment of Rs. 353.75/ha on BCA-treated plots increased net output, which resulted in higher cost benefit ratio of 1:2:40 compared to the conventional method (1:2:14). The incremental cost benefit cost ratio for BCA was 1:4:65 over the conventional method.

Seema-Mishra. **Baculoviruses as biopesticides**. Current-Science, 75(10) (1998), 1015-1022.

The development of baculoviruses as biological control agents is reviewed briefly. Screening, virus production, formulation, and application are discussed. The role of genetic engineering in improving baculoviruses is outlined. Field-testing of recombinant viruses and safety are also mentioned.

Sharma-AN. **Bioefficacy of Bacillus thuringiensis based biopesticides against *Spodoptera litura* (Fab.) and Spilarctia obliqua Walker feeding on soybean (Glycine max (L.) Merrill)**. Crop-Research-Hisar, 19(2) (2000), 373-375.

The effectiveness of 5 formulations of *Bacillus thuringiensis* was evaluated and compared with endosulfan against *Spodoptera litura* and *Spilarctia obliqua* under controlled conditions at 26±1°C and 75% RH. All the formulations were found to be effective against both the test insects, causing 66.66 to 100% mortality in 3-5 days. The effectiveness of some of the formulations was found to be on a par with that of endosulfan.

Singh-AP, Ramesh-Arora, Battu-GS, Arora-R. **Laboratory evaluation of three *Bacillus thuringiensis* Berliner - based biopesticides against the diamondback moth *Plutella xylostella* (Linnaeus)**. Pesticide-Research-Journal, 12(1) (2000), 54-62.

Three commercially available Bt-based biopesticides. viz., Dipel 8L Biolep and Halt, were evaluated in bioassay studies against third-instar larvae of *Plutella xylostella* (Linnaeus). The LC50 values for the three products calculated by using PCAT software package MSTAT were 0.013, 0.039 and 0.22%, respectively. The slope values for the probit-regression equation were 1.28, 1.49 and 1.43 for Dipel 8L, Biolep and Halt, respectively. Dipel 8L, found most promising in the bioassay studies, was used for further studies on food consumption and indices of growth of *P. xylosteila* larvae as affected by feeding on Bt-treated food. There was a concentration-dependent decrease in the amount of food consumed by the surviving larvae. The indices of growth (such as CI, AD, ECI and RGR) of these larvae were also adversely affected.

Sudhir U.Meshram*,G.B.Shinde, A.S Shanware AND R.R.Kamdi.(P.G. Department of Microbiology, L.I.T. Campus, Nagpur University, Nagpur - 440 010 (M.S.), India. **Bio-Control of fish pathogens associated with polluted aqua-culture**. Poll Res. 18 (4) (1999), 369-371.

In the quest of improving fish production for higher economic returns, there has been rapid expansion in agriculture using modern biotechnology in the past decade. This promising avenue has been vigorously explored through present investigation. An attempt is made to expose the possibility of use of biocontrol agents in the form of biopesticides i. e. *Bacillus thuringiensis* for controlling the

fish diseases in aqua-culture polluted water and also to reduce the application of recalcitrant pesticides. The antagonistic microbe has spelt out eco-friendly sustainable biocontrol measure, which has superseded other traditional approach with chemical posticides controlling the pathogens isolated from the infected parts of fishes. The investigations were carried out prominently *on* antagonistic effects and further interaction of *Bacillus thuringiensis* strains with isolated fish pathogens viz. *Pseudomonas* sp. and *Saprolegnia* sp. respectively; and thus revealed the possible mechanism through which *Bacillus thuringiensis* protects broad biopesticidal form to the fish from the infestation of dreadful diseases associated with common human enteric pathogens.

V.K. Gupta, Veena Khanna, V.K. Dilawari and H.S. Dhaliwal. (Department of Biotechnology, Punjab Agricultural University, Ludhiana-141004, India). **Certain strains of *Bacillus thuringiensis* and their evolution for control of yield damage by Po borer, Helicoverpa armigra**. India J. Ecol, 27(1) (2000), 76-81.

The delta endotoxin crystal yield from eight different strains belonging to three serotypes of *Bacillus thuringiensis* Berliner viz. aizaer, kurrtaki *k thuringiensis* ranged between 5.5 * 10^8 and 2.5 * 10^9/ml medium in liquid culture. Glucose salt yeast extract broth supporting high crystal forming efficiency and simple nutrient composition proved preferred medium to Luria broth containing expensive gradients, for mass production of endotoxin crystal. Using leaves from bioinsecticide sprayed chickpea fields as feed the toxicity symptoms in effective *H. armigera* larvae appeared within 48 hrs. maximum larvae mortality was observed in 144 hrs. which was 100% with strains HD-1, HD-73 and HD-263 following by HD-68 (87.5%) compared to 50% in case of strain HD-1 (Dipel)-an isolates from commercial Dipel 8L. In chickpea, fields the application of three different strains resulted in higher grain yield/plot than control (88g) being maximum with HD-1 (237 g) which was on a par with that in case of chemical insecticide endosulfan 0,07% (254g). A further and significant improvement in grain yield to 293g was achieved with the combined application of strain HD-1 with endosulfano 0.035% but other strain both individually as well as in combination with endosulfan were less effective in improving the overall grain yield through center of damage by *Hlecoverpa larvae*.

Bioremediation

A. Schäffner, B. Messner, C. Langebartels, H. Sandermann. (GSF - Forschungszentrum für Umwelt und Gesundheit, Institut für Biochemische Pflanzenpathologie, 85764 Neuherberg, Germany). **Genes and Enzymes for In-Planta Phytoremediation of Air, Water and Soil**. Acta Biotechnologica, 22(1-2) (2002), 141-151.

Plants harbour highly versatile enzymatic machineries to attack and detoxify pollutants. Similarities to the mammalian detoxification led to the coining of the term "green liver" for plant xenobiotic metabolism. Important enzyme classes such as cytochrome P450 monoxygenases, glutathione S-transferases, glycosyltransferases and transporters are involved in both kingdoms. The availability of the first whole plant genome sequence of Arabidopsis thaliana revealed an unforeseen complexity ofthese enzyme classes. Genetic and biochemical diversity, by far exceeding at least single microorganisms, seems to exist in plants. In agreement with previous investigations at the enzymatic level both terrestrial and aquatic plants possess an enormous potential for phytoremediation of soil, water and air iflimitations due to insufficient uptake into

plants can be overcome. This is exemplified by the detoxification of herbicides, halogenated phenols and anilines, and formaldehyde by the action of plant enzymes. Two examples are discussed at the biochemical and genetic level. Plants can detoxify airborne formaldehyde by a glutathione-dependent formaldehyde dehydrogenase. Recombinant expression of an Arabidopsis UDP-glucose dependent glucosyltransferase showed activity towards both endogenous and xenobiotic substrates by a single enzyme. Plants frequently do not completely degrade xenobiotics, but rather form conjugated metabolites and " bound" residues. However, these potential contaminants can be easily removed by harvesting. In order to exploit this enormous potential of plants, promising approaches extending their endogenous capacity have been initiated. Transgenic organisms that express heterologous enzymes in order to specifically degrade compounds or to increase the mobility and uptake ofrecalcitrant xenobiotics are being pursued to make phytoremediation procedures useful in practice.

Albert L. Juhasz * and Ravendra Naidu. (CSIRO Land and Water, PMB 2, Glen Osmond, Adelaide, SA 5064, Australia). **Bioremediation of high molecular weight polycyclic aromatic hydrocarbons: a review of the microbial degradation of benzo[a]pyrene**. International Biodeterioration & Biodegradation, 45(1-2) (2000), 57-88.

Over the past 30 years, research on the microbial degradation of polycyclic aromatic hydrocarbons (PAHs) has resulted in the isolation of numerous genera of bacteria, fungi and algae capable of degrading low molecular weight PAHs (compounds containing three or less fused benzene rings). High molecular weight PAHs (compounds containing four or more fused benzene rings) are generally recalcitrant to microbial attack, although some fungi and , algae are capable of transforming these compounds. Until recently, only a few genera of bacteria have been isolated with the ability to utilise four-ring PAHs as sole carbon and energy sources while cometabolism of five-ring compounds has been reported. The focuss of this review is on the high molecular weight PAH benzo[a]pyrene (BaP). There is concern about the presence of BaP in the environment because of its carcinogenicity, teratogenicity and toxicity. BaP has been observed to accumulate in marine organisms and plants, which could indirectly cause human exposure through food consumption. This review provides an outline of the occurrence of BaP in the environment and the ability of bacteria, fungi and algae to degrade the compound, including pathways for BaP degradation by these organisms. In addition, approaches for improving microbial degradation of BaP are discussed.

Andrew J. Stocking, Rula A. Deeb, Amparo E. Flores, William Stringfellow, Jeffrey Talley, Richard Brownell, Michael C. Kavanaugh. (Malcolm Pirnie, Inc., 180 Grand Ave. Suite 1000, Oakland, California 94612-3754, USA. Department of Civil and Environmental Engineering, 631 Davis Hall, MC 1710, University of California, Berkeley, California 94720-1710, USA. Malcolm Pirnie, Inc. Oakland, California 94612. Malcolm Pirnie, Inc., 180 Grand Ave. Suite 1000, Oakland, California 94612-3754, USA. Lawrence Berkeley National Laboratory, One Cyclotron Road, MS: 70A-3317, Bldg. 70A, Room 3317 Berkeley, California 94720, USA. Environmental Laboratory, US Army Corp of Engineers, Engineer Research and Development Center (ERDC), MS: CEWES-EF-R, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180, USA. Malcolm Pirnie, Inc., 104 Corporate Park Drive, Box 751, White Plains, New York 10602-0751, USA. Malcolm Pirnie, Inc., 180 Grand Ave. Suite 1000, Oakland, California 94612-3754, USA*).* **Bioremediation of MTBE: a review from a practical perspective.** Biodegradation, 11 (2-3) (2000), 187-201.

The addition of methyl *tert*-butyl ether (MTBE) to gasoline has resulted in public uncertainty regarding the continued reliance on biological processes for gasoline remediation. Despite this concern, researchers have shown that MTBE can be effectively degraded in the laboratory under aerobic conditions using pure and

mixed cultures with half-lives ranging from 0.04 to 29 days. Ex-situ aerobic fixed-film and aerobic suspended growth bioreactor studies have demonstrated decreases in MTBE concentrations of 83% and 96% with hydraulic residence times of 0.3 hrs and 3 days, respectively. In microcosm and field studies, aerobic biodegradation half-lives range from 2 to 693 days. These half-lives have been shown to decrease with increasing dissolved oxygen concentrations and, in some cases, with the addition of exogenous MTBE-degraders. MTBE concentrations have also been observed to decrease under anaerobic conditions; however, these rates are not as well defined. Several detailed field case studies describing the use of ex-situ reactors, natural attenuation, and bioaugmentation are presented in this paper and demonstrate the potential for successful remediation of MTBE-contaminated aquifers. In conclusion, a substantial amount of literature is available which demonstrates that the in-situ biodegradation of MTBE is contingent on achieving aerobic conditions in the contaminated aquifer.

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The plant-assisted removal of phenol, with special emphasis on the effects of this compound on some plant's physiological parameters, was investigated. Hydroponic cultures of alfalfa (*Medicago sativa* L., var. Romagnola) were employed as a model system. These cultures were exposed to two phenol concentrations: 100 and 500 mg/l. A first order kinetic approach was used to describe the removal of phenol from the solution. After 30 days of cultivation, the initial amount of phenol (100 mg/l) was reduced to non-detectable levels in the presence of plants. In the absence of plants, 20% of phenol remained in the solution. The half-life of phenol was reduced from 7.2 to 4.5 days in the presence of plants. After 25 days, the initial amount of 500 mg/l of phenol was reduced to non-detectable levels in the presence of plants not previously exposed to phenol and to approximately 20% with plants previously exposed to the contaminant. In the absence of plants, almost 40% remained in the solution. The presence of plants reduced the half-life of phenol from 18.3 days to 10.4 in the case of plants previously exposed and to 7.8 days in the case of plants without previous contact. Chlorophyll contents in alfalfa leaves of plants exposed to 100 mg/l of phenol were similar to those of control plants and a decrease in total chlorophyll content was observed when plants were exposed to 500 mg/l of phenol. The activity of soluble peroxidases of the roots increased in the presence of 100 mg/l of phenol but the amount of 500 mg/l had a negative effect on the peroxidase fraction. No changes were observed in the case of the ionically-bound cell wall fraction. The growth index of the plants exposed to 100 mg/l of phenol was comparable to that of non-exposed plants, while this parameter was negatively affected in the case of plants exposed to 500 mg/l of phenol. Although alfalfa plants were able to survive an exposure to 500 mg/l of phenol, their physiological parameters and their removal capacity were negatively affected.

C. Löser 1, A. Zehnsdorf 2. (1Technische Universität Dresden, Institut für Lebensmittel- und Bioverfahrenstechnik, Bergstraße 120, 01062 Dresden, Germany. 2UFZ - Umweltforschungszentrum Leipzig - Halle GmbH, Sektion Sanierungsforschung, Permoserstraße 15, 04318 Leipzig, Germany). **Conditioning of Freshly Dredged Heavy Metal-Polluted Aquatic Sediment with Reed Canary Grass (*Phalaris arundinacea* L)**. Acta Biotechnologica, 22(1-2) (2002), 81-89.

The remediation of heavy metal-polluted sediment by solid-bed bioleaching, using the percolation principle, requires a material well permeable to air and water. Freshly dredged sediment is nearly impermeable, unsuitable for solid-bed leaching, and therefore needs preliminary conditioning. During conditioning, the sediment underwent physicochemical changes such as oxidation and acidification, which were significantly accelerated by the presence of reed canary grass (*Phalaris arundinacea* L.) in comparison to the processes taking place in sediment without plant cover. *P. arundinacea* transpired large amounts of water followed by the formation of cavities in the sediment package which were then penetrated by atmospheric oxygen. Furthermore, *P. arundinacea* actively transported oxygen into the sediment via the roots. Oxygen and root exudates stimulated the growth of microbes, which together with hair roots made mineral sediment particles stick together, forming larger aggregates and changing the sediment structure from muddy-pasty to crumbly and soil-like. The structural changes markedly improved the permeability of the sediment to water by a factor of 5,000. Sediment conditioned with *P. arundinacea* consisted of larger and more stable particles and therefore it was twice as permeable as unplanted sediment. Comparative solid-bed bioleaching experiments on a pilot scale demonstrated that the removal of heavy metal occurred at nearly the same rate and efficiency with conditioned (for six months with *P. arundinacea*) and spontaneously ripened (stored for six years in the open) sediment.

Carol A. Fierke, Richard B. Thompson. (Departments of Chemistry and Biochemistry, University of Michigan, Ann Arbor, Michigan, USA. Department of Biochemistry and Molecular Biology, University of Maryland School of Medicine, Baltimore, Maryland, USA). **Fluorescence-based biosensing of zinc using carbonic anhydrase**. BioMetals, 14(3-4) (2001), 205-222.

Measurement of free zinc levels and imaging of zinc fluxes remains technically difficult due to low levels and the presence of interfering cations such as Mg and Ca. We have developed a series of fluorescent zinc indicators based on the superb sensitivity and selectivity of a protein, human apo-carbonic anhydrase II, for Zn(II). These indicators transduce the level of free zinc as changes in intensity, wavelength ratio, lifetime, and/or anisotropy; the latter three approaches permit quantitative imaging of zinc levels in the microscope. A unique attribute of sensors incorporating biological macromolecules as transducers is their capability for modification by site-directed mutagenesis. Thus we have produced variants of carbonic anhydrase with improved affinity for zinc, altered selectivity, and enhanced binding kinetics, all of which are difficult to modify in small molecule indicators.

G. Telysheva 1, T. Dizhbite 1, G. Lebedeva 1, G. Rossinskaja 1, V. Jurkjane 1, O. Treikale 1, U. Viesturs 1, M. Daugavietis 2. (1Latvian State Institute of Wood Chemistry, 27 Dzerbenes St., LV-1006, Riga, Latvia2Latvian Forest Research Institute Silava, 11 Rigas St., LV-2169, Salaspils, Latvia). **Lignin-Based Products Stimulating Soil Phytoremediation**. Acta Biotechnologica, 22(1-2) (2002), 167-173.

Chemical modification of lignin with Si- and N-containing compounds and immobilization of watersoluble, biologically active tree foliage extracts on lignin matrix are considered as tools for promoting different biological processes important for soil phytoremediation. With this aim, sorption properties of various solid lignins and radical scavenging activities of their soluble oligomeric and polymeric alkaline fractions were the focus of the investigation. It was shown that the sorption selectivity of lignin products could be purposefully changed by

chemical modification. The possibility of simultaneous sorption of an organic contaminant (phenol) and microorganisms (*Escherichia coli* bacteria) by lignin products was found. It was shown that the radical scavenger activity of lignin soluble fractions depends on the wood species, the method of lignin raw material production and the procedure of fraction isolation. The auxin-like effect of lignin oligomeric fractions was established and can be considered as evidence of a direct lignin effect on the plant physiological processes. Testing of the influence of the compositions tree foliage extract/lignin on the growth of winter wheat plant showed that tree foliage extract promoted the development of seedling green mass whereas the effect of lignin was revealed in the increase of root mass.

H. Koehler 1, J. Warrelmann 1, T. Frische 1, P. Behrend 1, U. Walter 2. (1Universität Bremen, Zentrum für Umweltforschung und Umwelttechnologie (UFT), Leobener Straße, 28359 Bremen, Germany. 2 Umweltschutz Nord GmbH & Co., 27777 Ganderkesee, Germany). **In-Situ Phytoremediation of TNT-Contaminated Soil**. Acta Biotechnologica, 22(1-2) (2002), 67-80.

Parts of the area of the derelict World-War-II ordnance plant "Werk Tanne" (Clausthal-Zellerfeld, Harz, Germany) are heavily contaminated by chemicals resulting from TNT production and particularly by TNT itself. High soil contamination has to be treated with ex-situ methods but for the extended contamination of surface soil, in-situ phytoremediation is appropriate. The TNT-degrading potential of the rhizosphere of the planted trees and shrubs themselves is augmented by highly active mycorrhiza and white-rot fungi.A phytoremediation measure was established to scale with heavy machinery (soil grader), including the incorporation of white-rot fungi into the soil and planting of mycorrhized trees and shrubs. The effects of site preparation, mycorrhized rhizosphere and white-rot fungi on the degradation of TNT were assessed over one year using a complex monitoring scheme, including a battery of five biotests and field investigations of selected indicators (soil mesofauna, decomposition). The results of the monitoring showed the great influence of the grading procedure for site preparation, a diversified sensitivity of the biotest battery and complex reactions of the field indicators. The grading procedure effectively reduced the contamination (almost 90% within the first six months regardless of the initial levels). The phytoremediation measure as a whole reduced hazards of transport of nitro-aromatics by dust or leachate, initiated a secondary succession of the soil ecosystem that could transform the remaining TNT and metabolites over a longer period of time, and thus proved to be an effective decontamination measure applicable in large-scale technology.

H. Wand [1], P. Kuschk [2], U. Soltmann [3], U. Stottmeister [2] . ([1]SIAB - Sächsisches Institut für Angewandte Biotechnologie an der Universität Leipzig, Permoserstraße 15, 04318 Leipzig, Germany. [2]UFZ - Umweltforschungszentrum Leipzig - Halle GmbH, Sektion Sanierungsforschung, Permoserstraße 15, 04318 Leipzig, Germany.[3]GMBU, Postfach 520165, Dresden). **Enhanced Removal of Xenobiotics by Helophytes**. Acta Biotechnologica, 22(1-2) (2002), 175-180.

The aromatic xenobiotics 2,6-dimethylphenol, 4-chlorophenol and naphthalene were removed using hydroponic cultures of *Carex gracilis* and *Juncus effusus* and using sand-bed reactors planted with *Carex gracilis* and *Juncus effusus*, respectively, under batch and flow-through conditions. Concentrations of 20 mg/l organic pollutant in the case of 4-chlorophenol, about 30 mg/l naphthalene and 50 mg/l 2,6-dimethylphenol were efficiently eliminated over periods of up to six months. Plant cultures were found to achieve a better removal rate than plant-less systems. In the systems investigated, organic xenobiotics are thought to be

mainly degraded by bacteria in the rhizosphere. The plants were not observed to suffer any damage when exposed to the above-mentioned pollutant concentrations. Indeed, plants responded to 2,6-dimethylphenol with better growth, implying that the plants benefited from the xenobiotic. However, whereas *Carex gracilis* plants exposed to more than 10 mg/l 4-chlorophenol initially died off, after a few weeks' of exposure up to 10 mg/l, they tolerated up to 30 mg/l 4-chlorophenol.

J. Bech [1], C. Poschenrieder [2], J. Barceló [2], A. Lansac [3]. ([1]University of Barcelona, Faculty of Biology, Chair of Soil Science, Avgd. Diagonal, 08028 Barcelona, Spain. [2]Autonomous University of Barcelona, Science Faculty, Plant Physiology Laboratory, 08193 Bellaterra, Spain. [3]UPC, Applied Physics Department, Manresa, Spain). **Plants from Mine Spoils in the South American Area as Potential Sources of Germplasm for Phytoremediation Technologies**. Acta Biotechnologica, 22 (1-2) (2002), 5-11.

The selection of adequate plant species is a prerequisite for cleaning-up contaminated soils by means of phytoextraction which is a time and cost-effective technology. Here first results of the screening of plant species from three different mining areas in South America are reported: A copper mine in Peru ("Mina Turmalina"), a silver mine in Ecuador ("Mina San Bartolomé") and a copper mine in Chile ("Mina El Teniente"). The accumulation of heavy metals and As in shoots as a function of extractable metal concentrations in the soils was analyzed in field samples.The different plant species collected on the severely polluted soils exhibited large differences in shoot accumulation of heavy metals and As. Among the grass species (Poaceae), the highest shoot As concentrations were found in *Paspalum* sp. (> 1.000 µg/g) and *Eriochloa ramosa* (460 µg/g) from the Cu mine in Peru, and in Holcus lanatus and Pennisetum clandestinum (> 200 µg/g) from the silver mine in Ecuador. *Paspalum racemosum* also accumulated considerable concentrations of Cu and Zn. The species from the genus *Bidens* (Asteraceae) were able not only to accumulate high shoot As concentrations (> 1000 µg/g in *B. cynapiifolia* from Peru), but also considerable amounts of Pb (*B. humilis* from Chile). The highest Cu shoot concentrations were found in Mullinum spinosum (870 µg/g) and in *B. cynapiifolia* (620 µg/g). The shoot accumulation of Zn was highest in Baccharis amdatensis (> 1900 µg/g) and in *Rumex crispus* (1300 µg/g) from the silver mine in Ecuador. The potential usefulness of these species for phytoremediation technologies is discussed.

J. Mitra, P.K. Mukherjee, S.P. Kale, N.B.K. Murthy. (Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Mumbai - 400085, India). **Bioremediation of DDT in soil by genetically improved strains of soil fungus *Fusarium solani***. Biodegradation, 12(4) (2001), 235-245.

Bioremediation of DDT in soil by genetically improved recombinants of the soil fungus *Fusarium solani* was studied. The parent strains were isolated from soil enriched with DDD or DDE (immediate anaerobic and aerobic degradation products of DDT), as further degradation of these products are slow processes compared to the parent compound. These naturally occurring strains isolated from soil, however, are poor degraders of DDT and differed in their capability to degrade its metabolites such as DDD, DDE, DDOH and DBP and other organochlorine pesticides viz. kelthane and lindane. Synergistic effect was shown by some of these strains, when grown together in the medium containing DDD and kelthane under mixed culture condition. No synergism in DDE degradation was observed with the strains isolated from enriched soil. DDD-induced proteins

extracted from individual culture filtrate (exo-enzyme) when subjected to SDS-Polyacrylamide Gel Electrophoresis (SDS-PAGE) showed complementary polypeptide bands in these strains i.e., each strain produced distinct DDD degrading polypeptide bands and the recombinant or hybrid strains produced all of the bands of the two parents and degraded DDD better than the parental strains. Recombinant hybrid strains with improved dehalogenase activity were raised by parasexual hybridisation of two such complementary isolates viz. isolate 1(P-1) and 4(P-2) showing highest complementation and are compatible for hyphal fusion inducing heterokaryosis. These strains are genetically characterised as Kel+BenRDBP-Lin- and Kel-BenrDBP+Lin+ respectively. Recombinants with mixed genotype, i.e., Kel+BenRDBP+Lin+ showing superior degradation quality for DDT were selected for bioremediation study. Recombination was confirmed by polypeptide band analysis of DDD induced exo-proteins from culture filtrate using SDS-Polyacrylamide Gel Electrophoresis (PAGE) and RAPD (Random Amplified Polymorphic DNA) of genomic DNA using PCR (Polymerase Chain Reaction) technique. SDS-PAGE showed combination of DDD induced polypeptide bands characteristic of both the parents in the recombinants or the hybrids. PCR study showed the parent specific bands in the recombinant strains confirming gene transformation.

Jeffrey A. Cunningham, Gary D. Hopkins, Carmen A. Lebron, Martin Reinhard. (Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA. Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA. Restoration Development Branch, Naval Facilities Engineering Service Center, 1100 23rd Ave., ESC-411, Port Hueneme, CA 93043, USA. Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, USA*).* **Enhanced anaerobic bioremediation of groundwater contaminated by fuel hydrocarbons at Seal Beach, California**. Biodegradation, 11(2-3) (2000), 159-170.

Enhanced anaerobic biodegradation of groundwater contaminated by fuel hydrocarbons has been evaluated at a field experiment conducted at the Naval Weapons Station, Seal Beach, California. This experiment included the establishment of three different remediation zones in situ: one zone was augmented with sulfate, one was augmented with sulfate and nitrate, and the third was unaugmented. This enables a comparison of hydrocarbon biodegradation under sulfate-reducing, sequential denitrifying/sulfate-reducing, and methanogenic conditions, respectively. In general, the results from the field experiment are: (1) Certain fuel hydrocarbons were removed preferentially over others, but the order of preference is dependent upon the geochemical conditions; and (2) In the zones that were augmented with sulfate and/or nitrate, the added electron acceptors were consumed quickly, indicating that enhancement via electron acceptor injection accelerates the biodegradation process. More specifically, in the sulfate-reducing zone, sulfate was utilized with an apparent first-order rate coefficient of approximately 0.1 day-1. In the combined denitrifying/sulfate-reducing zone, nitrate was utilized preferentially over sulfate, with an apparent first-order rate coefficient of 0.1–0.6 day-1. However, the data suggest that slow sulfate utilization does occur in the presence of nitrate, i.e., the two processes are not strictly sequential. With regard to the aromatic BTEX hydrocarbons, toluene was preferentially removed under intrinsic conditions; biodegradation of benzene was slow if it occurred at all; augmentation with sulfate preferentially stimulated biodegradation of *o*-xylene; and ethylbenzene appeared recalcitrant under sulfate-reducing conditions but readily degradable under denitrifying conditions.

K. R. Wang. (Chinese Academy of Sciences, Changsha Institute of Agricultural Modernization, 410125, Changsha, Hunan, P.R. China). **Tolerance of Cultivated Plants to Cadmium and their Utilization in Polluted Farmland Soils**. Acta Biotechnologica, 22(1-2) (2002), 189-198.

For the purpose of agro-ecological regulation and safe and efficient utilization of cadmium-polluted farmlands, a 7-year micro-plot experiment was conducted to evaluate the Cd tolerance of several main cultivated plants in Southern China. The study revealed that cereals such as Oryza sativa and Zea mays had a strong physiological tolerance of Cd toxicity. Nevertheless, their products (grains) are easily polluted and hence lose their edible value. As a consequence, they are inappropriate to be planted in the polluted soils. Other plants such as Brassica napus, *Arachis hypogaea* and *Saccharum officinarum* also had a strong physiological tolerance to Cd pollution. Meanwhile, Cd stocks in their products were very small. When soil Cd content was less than 50 mg/kg, Cd concentrations in vegetable oils and cane juice were less than 0.05 mg/kg and 0.15 mg/kg, respectively. This should have little effects on the edible quality. Therefore, these crops could be cultivated in some slightly Cd polluted farmlands, but the straw and dregs of oil crops, and sugarcane bagasse are not suitable to be used as manure or stock food as a result of their high Cd contents and should be properly treated as pollutants. Fibre crops like *Gossypium hirsutum*, Hibiscus cannabinus, *Boehmeria nivea* and *Morus alba* are tolerant towards soil Cd pollution to different degrees. Basically, soil Cd pollution has no unfavourable effects on the products of fibre crops. Moreover, there was scarcely any Cd entering the human food chain through these crops. Therefore, these fibre crops would be a good replacement for those sensitive crops in the polluted region.

Kyoungphile Nam, Jerome J. Kukor. (Biotechnology Center for Agriculture and the Environment, Cook College Campus, Rutgers University, 59 Dudley Road, New Brunswick, NJ 08901-8520, USAPresent address: School of Civil, Urban, and Geosystem Engineering, Seoul National University (Bldg 35, room 303), Seoul 151-742, Korea). **Combined ozonation and biodegradation for remediation of mixtures of polycyclic aromatic hydrocarbons in soil**. Biodegradation, 11 (1) (2000), 1-9.

A study was conducted to investigate the feasibility of a combined treatment (i.e., ozonation and biodegradation) to overcome the inherent bacterial bioavailability limitation, and hence bioremediation limitation, of polycyclic aromatic hydrocarbons in soil. Ozonation was very efficient in the removal of naphthalene, fluorene, phenanthrene, and anthracene, but not for pyrene, chrysene, and benzo(a)pyrene from soil freshly spiked with the hydrocarbons. A similar result was obtained from coal tar-contaminated soil. Elimination of polycyclic aromatic hydrocarbons increased appreciably in sand containing 0.03% organic carbon, indicating the adverse effect of organic carbon on the efficiency of ozone treatment. In spiked and coal tar-contaminated soils, ozonation followed by biodegradation significantly increased the degradation of various polycyclic aromatic hydrocarbons including chrysene and benzo(a)pyrene which were not degraded by the test bacterial consortium alone. In particular, the effect of the combined treatment was more pronounced in coal tar-contaminated soil than in sterile soil spiked with hydrocarbons, probably due to the augmented biological activity of the introduced consortium. The results suggest that a combined treatment including ozonation and biodegradation may be a promising bioremediation technology in soil contaminated with mixtures of polycyclic aromatic hydrocarbons such as former manufactured gas plant sites.

L. Chroma 1, M. Mackova 1, P. Kucerova 1, C. in der Wiesche 2, J. Burkhard 3, T. Macek 4. (1ICT, Faculty of Food and Biochemical Technology, Department of Biochemistry and Microbiology, Technicka 3, 16628 Prague, Czech Republic 2Institute of Plant Nutrition and Soil Science, FAL, Bundesallee 50, 38116 Braunschweig, Germany. 3ICT, Faculty of Chemical Technology, Department of Environmental Chemistry, Prague, Technicka 5, 16628 Prague, Czech Republic. 4Academy of Science of the Czech Republic, Institute of Organic Chemistry and Biochemistry, Flemingovo no. 2, 16610 Prague, Czech Republic). **Enzymes in Plant Metabolism of PCBs and PAHs**. Acta Biotechnologica, 22(1-2) (2002), 35-41.

Recently it has been shown that plants are able to transform polychlorinated biphenyls (PCBs) as well as polycyclic aromatic hydrocarbons (PAHs), but the knowledge of enzymes involved in these metabolic processes is limited. Plant peroxidases generally play an important role in plant metabolism. On the other hand, cytochrome P450 is involved in the detoxification of various xenobiotics in the cells of higher organisms. In this work, several in vitro cultures of different plant species were screened for their ability to transform PCBs or PAHs, and compared regarding their total extra- and intracellular peroxidase activity. Cultures with good transformation ability exhibited in the presence of xenobiotics the same or higher levels of peroxidases as the controls incubated without contaminants. Cultures with markedly lower peroxidase activity exhibited also lower PCB/PAH conversion in the presence of PCBs/PAHs. It was attempted to identify lignin peroxidase and Mn-peroxidase in plants, originally described in white rot fungi to be responsible for the degradation of PCBs and other environmental pollutants. In addition to different types of peroxidases, RBBR oxidase was also detected in plants. The decolourisation of RBBR during the growth on agar plates was used as a rough screening method for plant cells able to metabolise PCBs/PAHs efficiently. The exact type of transformation reaction (peroxidative or oxidative) was studied using various inhibitors and inducers of peroxidases and cytochrome P450. It was shown that both enzymatic systems are partially involved in the detoxification mechanism of chosen xenobiotics in plants.

Lal B, Mishra S, Ramesh K C. Jyot J. 2000. **An effective bioremediation tool**. In Proceedings of the international Seminar on Oily Sludge Management (2000), edited by R B Sing and A Jain New Delhi: Engineers India Ltd, (2000), 1-2.

Oil refineries generate large quantities of oily sludge, the safe disposal of which is major problem. The sludge is generated during clearing of storage tanks, cleaning and desilting of oil separator basins, distillation column residues, exchanger tube bundle sludge and sludge generated from effluent treatment plant (ETP). Conventional disposal method involves storing in sludge pits, which are expensive to construct and add to the already limited land resource at the refinery. Furthermore possible seepage of the constituents into groundwater can't be ruled out. An alternative method of lily sludge management involves use of microorganisms for in situ degradation in the soil. The process called Bioremediation is eco-friendly and more cost effective compared to conventional methods. Oilzapper, a consortium of oily sludge degrading bacteria, was developed in our laboratory to expedite the rate of bioremediation in contaminated soil. Extensive studies under laboratory conditions had established the potential of oilzapper to degrade oily sludge and crude oil. Field study was carried out in a refinery to evaluate the credibility of using Oilzapper to reclaim oily sludge contaminated land. A 4000 m^2 of land (site A) at Barauni refinery was taken up for the present study. The study was carried out for a period of one year from May 1998 to May 1999. A total of 900 tonnes of different types of oily sludge was loaded onto the site. Oilzapper at the rate of I kg/IO 2 of contaminated land was applied. Out of a total of 300 tonnes of ETP sludge added

from May 98-September 98 around 90.2-96% biodegradation was noted (adjacent figure shows the representative data). The figure clearly suggests the effectiveness of oilzapper for reclamation of the contaminated land. In September 98, 200 tonnes of tank bottom sludge was loaded. Total biodegradation between 37.7-66.4% was noted during the next 60 days. Residual oily sludge was added for the third (100 tonnes) and fourth (300 tonnes) sludge loading was added onto the site. Rates of biodegradation varied from 53.7-85.4% during the next 120 days till the end of the study. Initial results (May 98-December 98) encouraged us to take up another 2000m2 of land (site B). The study was carried out for 150 days till May 99. Around 1500 tonnes of tank bottom sludge was loaded onto this field and treated with oilzapper. An initial load of 24.9% sludge was calculated at the beginning of the study. At the end of the study the contamination load was 3.63%, which accounted for a reduction by 85.4%. In both the sites a small area was demarcated as control where oilzapper was not applied. The reduction of oily sludge in the untreated plots was found to be very less in comparison to the treated plots.The study established oilzapper as a potential bioremediation tool, which accounted for effective reduction of 2400 tonnes of oily sludge loaded onto both the sites.

Marjorie B. Medina. (U.S. Department of Agriculture, Agricultural Research Service, Eastern Regional Research Center, Wyndmoor, PA 19038, USA (Fax: 215-233-6559E). **Biosensor studies of the binding of extracellular matrix components with immobilized Escherichia coli O157:H7 and inhibition by polysulfated polysaccharides**. Biotechnology Letters, 24(1) (2002), 77-84.

Binding interactions of immobilized E. coli O157:H7 with collagen I, fibronectin, laminin and glucoaminoglycans were studied utilizing a surface plasmon resonance biosensor. A model system was developed to evaluate the inhibition of collagen-laminin binding on the E. coli sensor surface with polysulfated polysaccharides such as heparan sulfate and carrageenans. Results showed that carrageenans inhibited 71–99% while heparan sulfate inhibited 39–41% of collagen/laminin binding to E. coli sensor surface. These studies allowed a rapid assessment of compounds for carcass treatment to inhibit or detach pathogens from meat and poultry.

Mishra S, Jyot 3, Ramesh K C, Lal B. **Bioremediation soil contaminated with tank bottom sludge (tbs) by indigenous bacterial consortium**. In Proceedings of the Second International Conference on Contaminants in the Soil Environment in the Australasia-Pacific Region (1999), edited by B S Aggarwal, P Dureja and A K Dikshit, (1999), 149-150.

One of the sources of soil contamination around refineries is improper disposal of tank bottom sludge from storage tanks during the process of cleaning. Tank bottom sludge (TBS) contains considerable amount of petroleum hydrocarbons that are toxic and potent carcinogenic (Propst et al, 1999) Contamination of soil with TBS is a significant health hazard and threat to groundwater. Among the various approaches to treat the contaminated soil, bioremediation, utilizing indigenous microorganisms is one of the effective and economical processes (Korda et al, 1997, Dibble and Bartha 1979), Indigenous microorganisms can degrade a wide range of compounds and can tolerate high concentration of toxic contaminants (Fewson, 1988, Lal and Khanna, 1996). A field study was carried out in a refinery to reclaim land contaminated with tank bottom sludge, obtained after the cleaning of crude oil storage tanks, using bacterial consortium. The duration of the study was 60 days.

Mishra S, Lal B, Kuhad R C, Rajan S, Khanna S, Jyot J. **In situ bioremediation of oily sludge contaminated land using Oilzapper**. In Proceedings of the Mid-Atlantic Industrial and Hazardous Waste Conferenc, edited by D Bishop, Pennsylvania: Technomic Publishing Co. Inc, (2000), 174-183.

Bioremediation is a process that employs microorganisms capable of degrading toxic contaminants for reclamation of the polluted sites. It has the potential to treat the contaminants on-site in situ) thus confirming that the contaminant is not merely transformed from one medium to another. There are many contaminated sites currently under investigation utilizing this promising technique [1]. Several recent publications review the various aspects of bioremediation and its wide application [2,3]. Apart from the various factors like type and characteristic of the soil, nutrient and oxygen availability, various sampling and analytical techniques, a successful approach towards bioremediation involves the indigenous microorganisms, their survivability and response to toxic contaminants as well as nutrient enrichment. The reintroduction of indigenous microorganisms isolated from the contaminated sites after culturing seems to be a highly effective bioremediation approach, especially when the growth of the microorganism is supplemented by oxygen and fertilizers [4]. Oil refineries inevitably generate a huge volume of oily sludge contributing towards environmental pollution. Improper disposal and mishandling of oily sludge leads to soil contamination near refineries, posing a serious threat to groundwater [5,6]. In situ bioremediation employing microorganisms capable of degrading toxic hydrocarbon compounds in sludge is a potential means to reclaim these sites. Admixing of various agricultural by-products with petroleum products contaminated soil stimulate microbiological activity in both control and treated samples. Natural products provide a delivery medium for nutrients; moisture and physical support for increased aeration needed by microorganisms in degrading the petroleum pots [7]. Laboratory scale bioremediation studies was carried out using Hyponex (Hyponex Inc) and bark manure were added as basic nutrients for microorganisms and twelve kinds of materials like baked diatomite microporous glass, coconut charcoal, an oil-decomposing material mixture and eight kind of surfactants were tested to accelerate the biodegradation of hydrocarbons. Around 15-33% of the contaminated soil was reclaimed by application of these amendment materials. [8]. It has been reported that indigenous population of oil degrading microorganism increased rapidly when stimulating conditions (nutrient addition) were provided during bioremediation [9]. A preliminary study for six months was carried out in soil contaminated with oily sludge, generated during the process of petroleum refining, by using the approach of bioaugmentation. The bacterial inoculum was developed by enrichment method from microorganisms isolated from petroleum hydrocarbon contaminated soil. The consortium was applied in the form of "Oilzapper" a carrier based formulation for effective transfer of culture and nutrients to the contaminated sites. The main aim of this study was to find out the potential of microbial inoculation for bioremediation and the feasibility of a carrier based treatment method in field over other kinds of treatment. Along with application of Oilzapper other treatment methods include application of biostimulators and a combination of Oilzapper and biostimulators. A control block was also taken where no treatment was employed.

Monica Bhatnagar, Ashish Bhatnagar, Sapna Jha. (Department of Microbiology, Maharshi Dayanand Saraswati University, Ajmer 305 001, Rajasthan, India). **Interactive biosorption by microalgal biomass as a tool for fluoride removal**. Biotechnology Letters, 24 (13) (2002), 1079-108.

Maximum biosorption of Ca2+ was at 50 mg Ca2+ l-1 with both *Anabaena fertilissima* (2.8 mg Ca2+ g-1 dry wt) and *Chlorococcum humicola* (4.4 mg g-1).

Such Ca2+-treated biomasses, accumulated, respectively, 7 mg F g-1 DW from an aqueous solution of 10 mg F l-1 and 4.5 mg F g-1 DW from 15 mg F l-1. Data for both Ca2+ and F- biosorption fitted the Langmuir adsorption isotherm indicating monolayer adsorption at a constant energy.

Patrick Dabert, Jean-Philippe Delgenès, René Moletta, Jean-Jacques Godon. (Laboratoire de Biotechnologie de l'Environnement, Institut National de la Recherche Agronomique, Avenue des Etangs, 11100 Narbonne, France). **Contribution of molecular microbiology to the study in water pollution removal of microbial community dynamics**. Reviews in Environmental Science and Biotechnology, 1(1) (2002), 39-49.

Molecular tools based on 16S rRNA gene identification are revolutioning microbial ecology. After a short presentation of the advantages and drawbacks of these new tools, the paper gives a succinct review of their possibilities as they have been applied to the microbial ecology of water pollution removal. Examples of applications are presented in the fields of anaerobic digestion, nitrogen and phosphorus removal, filamentous bacteria and bioaugmentation. The data provided give some insights about microbial diversity, population dynamics, ecosystems stability and specific microbial population activity.

Pinaki Sar, Stanislaus F. D'Souza. (Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India). **Biosorption of thorium (IV) by a *Pseudomonas* biomass.** Biotechnology Letters, 24(3) (2002), 239-243.

Lyophilized biomass of a Pseudomonas soil isolate adsorbed thorium (IV) (430 mg g-1 dry wt) optimally at pH 4, with 91% of equilibrium loading being reached in 1 min. Equilibrium metal sorption showing conformity to Langmuir isotherm model suggested a monolayered thorium binding. Thorium binding remained unaffected or slightly affected (< 20% inhibition) in presence of equimolar (430 µM) concentration of several interfering ions except Fe3+ (40% inhibition). More than 90% of loaded thorium could be recovered using 1 M CaCO3, though mineral acids and Na2CO3 were also effective.

Q. Wang, Y. Cui, Y. Dong. (Chinese Academy of Sciences, Research Center for Eco-Environmental Sciences, P.O. Box: 2871, Beijing 100085, P. R. China). **Phytoremediation of Polluted Waters Potentials and Prospects of Wetland Plants**. Acta Biotechnologica, 22(1-2) (2002), 199-208.

To investigate the possible use of plants to remediate polluted waters, a pot experiment was carried out in the laboratory with five wetland plant species, i.e., sharp dock (*Polygonum amphibium* L.), duckweed (*Lemna minor* L.), water hyacinth (*Eichhornia crassipes*), water dropwort [Oenathe javanica (BL.) DC.] and calamus [*Lepironia articulata* (Retz.) Domin]. Nitrogen (N), phosphorus (P) and three heavy metals, cadmium (Cd), mercury (Hg) and lead (Pb), were the objects of remediation. Sharp dock was found to be a good accumulator of N and P. Indeed, on a dry weight basis the shoots of sharp dock accumulated up to 6.4% of N and 1.1% of P with BCF (bioconcentration factor) values of 2235 and 1568, respectively. Water hyacinth and duckweed strongly accumulated Cd with concentrations of 462 and 14200 mg/kg, respectively, and BCF values of 1225 and 2567, respectively. Water dropwort achieved the highest concentrations of Hg, i.e., 1.2 mg/kg with a BCF value of 807, whereas calamus achieved the highest concentrations of Pb, i.e., 512.4 mg/kg in its roots with a BCF value of

1217. Thus, it could be concluded that the above plant species are good candidates for phytoremediation of polluted waters, as follows: sharp dock through accumulation of N and P in its shoots, water hyacinth and duckweed as hyperaccumulators of Cd, water dropwort as an hyperaccumulator of Hg and calamus as an hyperaccumulator of Pb.

Ramesha N. (New Delhi: Indian Network for Soil Contamination Researc). **Biosurfactant production and biodegradation of endosulfan: a tool for bioremediation in the soil.** In Proceedings of the Second International Conference on Contaminants in the Soil Environment in the Australasia-Pacific Region, (1999), edited by B S Aggarwal, P Dureja, and A K Dikshit, (1999), 147-148.

Environmental pollution by organochlorine pesticides is well known. The health problems associated with dichlorodiphenyltrichloroethane (DDT), hexachloro cyclohexane (HCH), endosulfan, etc. are cancer (Guttes, et al. 1998, Zava et at. 1997), neurotoxicity (Tilson, 1998), mutation (Simon, 1997), reduction in immunity (Raszyk, et al. 1997), etc. Hence, there is a need to reduce the residues in our ecosystem to provide a cleaner environment. Realizing the potential danger of these chemicals, India banned/restricted the use of HCH and DDT. However, endosulfan is used still at the rate of 4,200 metric tonnes/annum and hence 80% of the vegetable samples showed contamination and 14% recorded residue limits above permissible limit (Agnihotri, 1999). Hence, the need to minimize the residues in the soil as bioremeidation using degrader bacterium proves to be a success in eliminating the pesticide residues (Karanth and Vasantharajn 1974, Sahu et al., 1990, Johri et al. 1998). Also, production of biosurfactant is necessary for ensuring bioavailability of hydrophobic chemicals (Anu Appaiah and Karanth, 1991).

Roger C.H. Kwan, Chiyui Chan, Reinhard Renneberg. (The Hong Kong University of Science and Technology, Department of Chemistry and Sino-German Nano-Analytical Lab (SiGNAL), Clearwater Bay, Kowloon, Hong Kong. The Hong Kong University of Science and Technology, Department of Chemistry and Sino-German Nano-Analytical Lab (SiGNAL), Clearwater Bay, Kowloon, Hong Kong. The Hong Kong University of Science and Technology, Department of Chemistry and Sino-German Nano-Analytical Lab (SiGNAL), Clearwater Bay, Kowloon, Hong Kong). **An amperometric biosensor for determining amino acids using a bienzymatic system containing amino acid oxidase and protease**. Biotechnology Letters, 24(14) (2002), 1203-1207.

An amperometric biosensor for rapid determination of the concentration of l-amino acids has been developed using l-amino acid oxidase (l-AAO) immobilized by gel entrapment with poly(carbamoyl) sulfonate hydrogel. The broad substrate range of l-AAO allows this biosensor to be flexible in application. The artificial sweetener, aspartame, was determined by coupling l-AAO with pronase.

S. Vincent, M. Mary Jee Jee Cruz, A. Leo Thomas. (P.G. & Research Department of Zoology Loyola College, Chennai - 600 034. India). **Bioremediation of chromium by the aquatic macrophyte *caldesia paranassipolia* (L) parl**. Poll Res, 20(1) (2001), 75-77.

Young plants of *Caldesia paranassipolia* were selected and analyzed to study their role in bioremoval of chromium. The observations showed the uptake of chromium by the plant samples show increase in chromium as the concentration increase. It has been interpreted that due to increase in the concentration and exposure to number of days, the uptake of chromium also increases. Thus by the introduction of biological agent such as *Caldesta paranassipolia* we can reduce the

contamination of natural habitat at a lower cost.

S.S. Radwan *, R.H. AI-Hasan, S. Salamah and S. Al-Dabbous. (Department of Biological Sciences, Faculty of Science, Kuwait University, **P.O. Box** 5969, Safat 13060, Kuwait). **Bioremediation of oily sea water by bacteria immobilized in biofilms coating macroalgae**. International Biodeterioration & Biodegradation, 50(1) (2002), 55-59.

Using the standard plate method and a solid mineral medium containing crude oil as a sole source of carbon and energy, 10 different macroalgae from the Arabian Gulf were found associated with large numbers of oil-utilizing bacteria. Each gram fresh alga was associated with about two to about 30 million cells of bacteria predominantly belonging to the nocardioforms and the genus *Acinetobacter*. Shaking macroalgal samples in sea water batches containing known amounts of individual hydrocarbons led to considerable attenuation of these compounds as measured by GLC. Thus, bacteria associated with macroalgae consumed about 64-98% of n-octadecane and about 38-56% phenanthrene from medium aliquots containing 0.03% of the test hydrocarbon after 2 weeks. Meanwhile, the oil-utilizing bacteria, especially the nocardioforms, associated with the macroalgae increased in number by about 32-490 fold, depending on the macroalgae and hydrocarbons studied. On the other hand, relatively negligible numbers of bacteria were released into the seawater compared with the numbers immobilized on the macroalgal surfaces. Individual bacterial isolates could grow on a wide range of pure alkanes and aromatic hydrocarbons as sole sources of carbon and energy. It was concluded that macroalgae submerged in the seawaters are coated with biofilms rich in oil-utilizing bacteria that contribute to hydrocarbon attenuation in water. These natural biological consortia represent valuable tools that could be of high potential for phytoremediation of oily seawater.

Sanjeet Mishra, Jeevan Jyot, Ramesh Chander Kuhad, Banwari Lal. **In Situ Bioremediation Potential of an Oily Sludge-Degrading Bacterial Consortium**. Curr Microbiol. 43 (2001), 328-335.

A field-scale study was conducted in a 4000 m2 plot of land contaminated with an oily sludge by use of a carrier-based hydrocarbon-degrading bacterial consortium for bioremediation. The land belonged to an oil refinery. Prior to this study, a feasibility study was conducted to assess the capacity of the bacterial consortium to degrade oily sludge. The site selected for bioremediation contained approximately 300 tons of oily sludge. The plot was divided into four blocks, based on the extent of contamination. Blocks A, B, and C were treated with the bacterial consortium, whereas Block D was maintained as an untreated control. In Block A, at time zero, i.e., at the beginning of the experiment, the soil contained as much as 99.2 g/kg of total petroleum hydrocarbon (TPH). The application of a bacterial consortium (1 kg carrier-based bacterial consortium/10 m2 area) and nutrients degraded 90.2% of the TPH in 120 days, whereas in block D only 16.8% of the TPH was degraded. This study validates the large-scale use of a carrier-based bacterial consortium and nutrients for the treatment of land contaminated with oily sludge, a hazardous hydrocarbon waste generated by petroleum industry.

Simoncyril U. Nwachukwu. **Bioremediation of Sterile Agricultural Soils Polluted with Crude Petroleum by Application of the Soil Bacterium, Pseudomonas putida, with Inorganic Nutrient Supplementations**. Curr Microbiol, 42 (2001), 231-236.

The effects of bioremediation program of sterile agricultural soils contaminated with crude petroleum were determined with a view to developing a suitable technique for rehabilitation of similar environments upon pollution by oil spillage. Sterile soils inoculated with the soil bacterium, Pseudomonas putida (PP), with inorganic nutrients monitoring and supplementation constituted the experimental set-ups (ESU). The control set-ups (CSU) contained all the materials present in ESU except that they were not inoculated with PP. In ESU at week 9, the oil pollutant was completely biodegraded, and the inorganic nutrient ions, particularly PO4-3 and NO3-1, were significantly utilized. In contrast, there were no significant changes in the concentrations of oil and inorganic nutrients in CSU. Also, the percentage germination and growth profiles of cress seeds (Lepidium sp.) planted as evidence of the recovery of the oil-impacted soils were poor in CSU (27.5%) with pronounced abnormal morphology when compared with the results obtained for ESU (98.8%). Inoculation of PP with addition of appropriate inorganic nutrients may be a suitable method for a rapid rehabilitation of agricultural land upon pollution with crude petroleum.

Subhashree Pradhan, L.C. Rai. (Laboratory of Algal Biology, Department of Botany, Banaras Hindu University, Varanasi- 221 005, India). **Biotechnological potential of *Microcystis* sp. in Cu, Zn and Cd biosorption from single and multimetallic systems**. BioMetals, 14(1) (2001), 67-74.

This paper provides information on biosorption of Cu, Zn and Cd by *Microcystis* sp. in single, bi and trimetallic combination. Highest biosorption of Cu followed by Zn and Cd in single as well as in mixtures containing two or three metals was noticed. The order of inhibition of Cu, Zn and Cd biosorption in bi and trimetallic combinations was suggestive of screening or competition for the binding sites on the cell surface. This observation was reconfirmed by Freundlich adsorption isotherm. Kf values were maximum for Cu (Kf=45.18), followed by Zn (Kf=16.71), and Cd (Kf=15.63) in single metallic system. The Kf values for each test metal was reduced in solution containing more than one metal. Further, the reduction in biosorption of each metal ion due to presence of other metal ion was of greater magnitude at relatively higher concentrations of interfering metal ion. The biosorption of Cu at saturation was less affected when secondary metal (Cd or Zn) was added in the medium. Above results suggest that Microcystis holds great potential for metal biosorption from mixture.

Surya Kant Mehta and Jai Prakash Gaur. (Laboratory of Algal Biology, Department of Botany, Banaras Hindu University, Varanasi 221 005, India). **Characterization and optimization of Ni and Cu sorption from aqueous solution by *Chlorella valgaris*.** Ecological Engineering, 18(1) (2000), 1-13.

Sorption of Ni and Cu by *Chlorella vulgaris* showed the second-order rate kinetics. Change in biomass concentration altered the kinetic parameters of sorption. When biomass concentration was increased from 5 to 1000 mg I^{-1} , the initial rates of sorption of Ni and Cu were reduced by about five- and three-times, respectively. The metal sorption capacity of the test alga was studied taking different concentrations of Ni and Cu at different biomass concentrations as well as different pH. The sorption of test metals fitted better in Freundlich than the Langmuir model thereby indicating multi-layer adsorption of Ni and Cu onto C. vulgaris. The K_f and Q_{max} both decreased with increase in biomass concentration thereby suggesting that the metal sorption capacity of the test alga was impaired at higher biomass concentrations. The maximum sorption of Ni and Cu occurred at pH 5.5 and 3.5, respectively. Heat-killed cells showed a greater potential of

metal sorption than the live cells. The test alga was subjected to different pre-treatments to enhance its metal sorption capacity; acid (HCI and HNO,) pre-treatments were most effective. The maximal removal of Ni and Cu, 93 and 96%, respectively, occurred from solutions having their 2.5 mg I^{-1} concentration. Thus *C. vulgaris* has a great potential for removing Ni and Cu especially when concentrations of these metals are low in the external environment.

Valentina Murygina, Mikhail Arinbasarov, Sergey Kalyuzhnyi. (Department of Chemical Enzymology, Chemistry Faculty, Moscow State University, 119899 Moscow, Russia. All-Russian Research Institute of Oil and Gas, 125422, Dmitrovskiy proyezd, 10, Moscow, Russia. Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, 142292, Pushchino, Moscow Region, Russia. Department of Chemical Enzymology, Chemistry Faculty, Moscow State University, 119899 Moscow, Russia*).* **Bioremediation of oil polluted aquatic systems and soils with novel preparation `Rhoder'.** Biodegradation, 11(6) (2000), 385-389.

This paper summarises the experience accumulated during the field application of biopreparation `Rhoder' (solely or in a combination with preliminary mechanical collection of free oil) for remediation of oil polluted aquatic systems and soils in the Moscow region and Western Siberia during 1994–1999. It was demonstrated that `Rhoder' had a very high efficiency (>99%) for bioremediation of the open aquatic surfaces (100 m2 bay of the River Chernaya, two 5,000 m2 lakes in Vyngayakha) at initial level of oil pollution of 0.4–19.1 g/l. During remediation of the wetland (2,000 m2) in Urai (initial level of oil pollution of 10.5 g/l), a preliminary mechanical collection of oil was applied (75% removal) followed by a triple treatment with `Rhoder'. It resulted in an overall treatment efficiency of 94%. Relatively inferior results of bioremediation of the 10,000 m2 wetland in Vyngayakha (65% removal) and the 1,000 m2 marshy peat soil in Nizhnevartovsk (19% removal) can be attributed to the very high initial level of oil pollution (24.3 g/l and >750 g/g dry matter, respectively) aggravated by the fact that it was impossible to apply a preliminary mechanical collection of oil on these sites. A possible strategy for remediation of such heavily polluted sitesis discussed.

Wießner, P. Kuschk, U. Stottmeister. (UFZ - Umweltforschungszentrum Leipzig - Halle GmbH, Sektion Sanierungsforschung, Permoserstraße 15, 04318 Leipzig, Germany). **Oxygen Release by Roots of *Typha latifolia* and *Juncus effusus* in Laboratory Hydroponic Systems**. Acta Biotechnologica, 22(1-2) (2002), 209-216.

Laboratory-scale investigations using individual *T. latifolia* and *J. effusus* plants in hydroponic systems were carried out to evaluate the potentials and differences in the species regarding the release of oxygen into their rhizospheres. Their oxygen release intensities were found to vary between the species and also to depend on the redox state of the rhizosphere. The highest release rates with mean values of 1.1 mg/h plant for *T. latifolia* and 0.5 mg/h plant for *J. effusus* were estimated at Eh - 200 mV for both species. The amounts of oxygen released were sufficient to be of biotechnological relevance for oxidative processes in constructed wetlands. The plants even released oxygen under oxidized rhizospheric conditions and for individual plants, an intensification of the oxygen release was estimated, forming further local release maxima at Eh = 250 - 400 mV with about 0.2 mg/h plant. The total size of the root system does not significantly affect the intensity of oxygen release; instead, the oxygen release state was governed by the size of the above-ground biomass. The intensification of illumination causes an increase in the oxygen release rates, which is pronounced for *T. latifolia* but small for *J. effusus*. Further investigations involving other wetland species and using

laboratory-scale, pilot-scale and fullscale wetland systems to evaluate oxygen release are of biotechnological interest.

Y. Kawamura, K. Fukunaga, A. Umehara, M. Takahashi, H. Morikawa. (Hiroshima University, Department of Mathematical and Life Sciences, Graduate School of Science, Higashi-Hiroshima 739-8526, Japan). **Selection of *Rhododendron mucronatum* Plants that Have a High Capacity for Nitrogen Dioxide Uptake**. Acta Biotechnologica, 22(1-2) (2002), 113-117.

In order to select individuals of *Rhododendron mucronatum* plants that have a high capacity to decontaminate nitrogen dioxide (NO2), which is a major air pollutant, a number of lines prepared by cutting propagation were analyzed for their uptake of NO2. In 1996, 1452 different lines (referred to as the "96-plants") were fumigated with 4 μl/l 15NO2 for 8 hours, and the total nitrogen content of the leaves, derived from NO2, was determined and reflects the plant's NO2 uptake capacity. A 56-fold difference was observed between the individuals with the highest and lowest capacities. About 100 lines each from the high-, middle- and low-capacity groups were propagated and assayed for NO2 uptake in the following year (the "97-plants"). The maximum variation in NO2 uptake was 5.6 times. In 1998, 227 lines propagated from the 96-plants and 95 lines from the 97-plants were assayed for NO2 uptake (the "98-plants"). The variations in NO2 uptake in 97- and 98-plants were a maximum of 4.9 and 5.2 times, respectively. The reason(s) for the disappearance of the initial large variation in NO2 uptake is(are) not yet known. Those lines showing high and low NO2 uptake capacities will be useful when studying the genes involved in this important roadside tree.

Yiiyao Huang *, Zhongxian Zhao, Muqi Xu and Yurong Gao. (Institute of Zoology, Chinese Academy of Sciences, 19 Zhongguancun Road, Beijing 100080, PR China). **Biological approaches for disposing and reusing chemical wastewater**. Ecological Engineering, 16(2) (2000), 281 – 292.

A serial study on the integrated disposal and utilization of chemical industrial wastewater containing high levels of organic compounds, mercury, nutrients and chlorides was carried out with biological approaches in Hangu region, Tianjin city, China. Results indicated that the quality of wastewater could be improved by a biological stabilization pond system under appropriate load of organic matter and well operation. The effluent from this stabilization pond could not be used for irrigation due to high salinity, but it may be used for fish culture. Because of high levels of mercury, the fish living in this effluent could not be used as food for both humans and breeding sables *(Martes zibellina* L.) whereas it could be served as a part of diet for growing sables. Results demonstrated that this chemical wastewater could be controlled and reused through ecological techniques combined with environmental engineering approaches. This system could improve environmental quality and enhance economic.

Biosensor

Carol A. Fierke, Richard B. Thompson**.** (Departments of Chemistry and Biochemistry, University of Michigan, Ann Arbor, Michigan, USA. Department of Biochemistry and Molecular Biology, University of Maryland School of Medicine, Baltimore, Maryland, USA). **Fluorescence-based biosensing of zinc using carbonic anhydrase**. BioMetals, 14(3-4) (2001), 205-222.

Measurement of free zinc levels and imaging of zinc fluxes remains technically difficult due to low levels and the presence of interfering cations such as Mg and Ca. We have developed a series of fluorescent zinc indicators based on the superb sensitivity and selectivity of a protein, human apo-carbonic anhydrase II, for Zn(II). These indicators transduce the level of free zinc as changes in intensity, wavelength ratio, lifetime, and/or anisotropy; the latter three approaches permit quantitative imaging of zinc levels in the microscope. A unique attribute of sensors incorporating biological macromolecules as transducers is their capability for modification by site-directed mutagenesis. Thus we have produced variants of carbonic anhydrase with improved affinity for zinc, altered selectivity, and enhanced binding kinetics, all of which are difficult to modify in small molecule indicators.

Marjorie B. Medina. (U.S. Department of Agriculture, Agricultural Research Service, Eastern Regional Research Center, Wyndmoor, PA 19038, USA (Fax: 215-233-6559E). **Biosensor studies of the binding of extracellular matrix components with immobilized *Escherichia coli* O157:H7 and inhibition by polysulfated polysaccharides**. Biotechnology Letters, 24(1) (2002), 77-84.

Binding interactions of immobilized *E. coli* O157:H7 with collagen I, fibronectin, laminin and glucoaminoglycans were studied utilizing a surface plasmon resonance biosensor. A model system was developed to evaluate the inhibition of collagen-laminin binding on the *E. coli* sensor surface with polysulfated polysaccharides such as heparan sulfate and carrageenans. Results showed that carrageenans inhibited 71–99% while heparan sulfate inhibited 39–41% of collagen/laminin binding to *E. coli* sensor surface. These studies allowed a rapid assessment of compounds for carcass treatment to inhibit or detach pathogens from meat and poultry.

Rekha-K, Gouda-MD, Thakur-MS, Karanth-HG. **Ascorbate oxidase amperometric biosensor for organophosphorous pesticide monitoring**. Biosensors-and-Bioelectronics, 15(9-10) (2000), 499-502.

An amperometric principle based biosensor containing tissues of cucumber, rich in ascorbic acid oxidase, was used for the detection of organophosphorous (OP) pesticide ethyl paraoxon, which inhibits the activity of ascorbic acid oxidase [ascorbate oxidase). The optimum concentration, of ascorbic acid used as substrate was 5.67 IBM. The biosensor response was found to reach steady state within 2 minutes. A measurable inhibition (>10%) was obtained with 10 minute incubation of the enzyme electrode with different concentrations of the pesticide. There was a linear relationship between the percentage of inhibition of the enzyme substrate reaction and the pesticide (ethyl paraoxon) concentration in the range l-10 ppm with a regression value 0.9942.

Roger C.H. Kwan, Chiyui Chan, Reinhard Renneberg. (The Hong Kong University of Science and Technology, Department of Chemistry and Sino-German Nano-Analytical Lab (SiGNAL), Clearwater Bay, Kowloon, Hong Kong. The Hong Kong University of Science and Technology, Department of Chemistry and Sino-German Nano-Analytical Lab (SiGNAL), Clearwater Bay, Kowloon, Hong Kong. The Hong Kong University of Science and Technology, Department of Chemistry and Sino-German Nano-Analytical Lab (SiGNAL), Clearwater Bay, Kowloon, Hong Kong). **An amperometric biosensor for determining amino acids using a bienzymatic system containing amino acid oxidase and protease**. Biotechnology Letters, 24(14) (2002), 1203-1207.

An amperometric biosensor for rapid determination of the concentration of l-amino acids has been developed using l-amino acid oxidase (l-AAO) immobilized by gel entrapment with poly(carbamoyl) sulfonate hydrogel. The broad substrate range of l-AAO allows this biosensor to be flexible in application. The artificial sweetener, aspartame, was determined by coupling l-AAO with pronase.

Biotechnology – Agricultural Issue

Christian J. Peters. (Cornell University, Department of Soil, Crop and Atmospheric Sciences, 616 Bradfield Hall, Ithaca, NY 14850). **Genetic Engineering in Agriculture: Who Stands to Benefit?** Journal of Agricultural and Environmental Ethics, 13(3-4) (2000), 313-327.

The use of genetic engineering in agriculture has been the source of much debate. To date, arguments have focused most strongly on the potential human health risks, the flow of genetic material to related species, and ecological consequences. Little attention appears to have been given to a more fundamental concern, namely, who will be the beneficiaries of this technology? Given the prevalence of chronic hunger and the stark economics of farming, it is arguable that farmers and the hungry should be the main beneficiaries of agricultural research. However, the application of genetic engineering appears unlikely to benefit either of these two groups. This technology is largely controlled by the private sector, and its continued development hinges on its profitability. Thus, the only likely beneficiaries of the application of genetic engineering in agriculture are companies with the capacity to use it.

Egelyng-H. **Managing agricultural biotechnogy for sustainable development: the case of semi-arid India**. International-Journal-of-Biotechnoiogy, 2(4) (2000), 342-354.

This paper suggests that managing agricultural biotechnology for sustainable development demands more than. research and intellectual property rights policies. Economic and regulatory institutions conducive to application of intrinsically sustainable technologies are also required. From an interdisciplinary development research perspective, it is argued that sustainability of Indian agriculture and food crop production may depend more on environmental governance than on biotechnology and globalization in the form of Trade Related Intellectual Property Rights. Without ecological institutions to govern agriculture, privatization of genetic constructs may simply distort the trajectory of agricultural technology-Current agricultural policies discourage adoption of sustainable technologies. From a perspective of poverty alleviation as well as from a perspective of natural resource management, existing policies encourage waste of natural resources and maintain incentives to develop non-sustainable technologies. The Indian research complex is discouraged from realizing its potential for producing bio-innovations suitable for sustainable agricultural development.

Jeffrey Burkhardt. (Institute of Food and Agricultural Sciences, University of Florida, Gainesville FL 32611, USA). **Agricultural Biotechnology and the Future Benefits Argument.** Journal of Agricultural and Environmental Ethics, 14(2) (2001), 135-145.

In the face of criticisms about the current generation of agricultural biotechnology products, some proponents of agricultural biotechnology offer a "future benefits

argument" (FBA), which is a utilitarian ethical argument that attempts to justify continued R&D. This paper analyzes several logical implications of the FBA. Among these are that acceptance of the FBA implies (1) acceptance of a precautionary approach to risk, (2) the need for a more proportional and equitable distribution of the benefits of agricultural biotechnology, and most important, (3) the need to reorient and restructure biotechnology R&D institutions (and the agricultural biotechnology community's values and attitudes) so that future benefits are indeed achieved through agricultural biotechnology.

Maurizio G. Paoletti, David Pimentel. (Department of Biology, University of Padova, Via Trieste 75, 35122, Padova, Italy. College of Agriculture and Life Sciences, Comstock Hall, Cornell University, Ithaca, NY 14853*).* **Environmental Risks of Pesticides Versus Genetic Engineering for Agricultural Pest Control.** Journal of Agricultural and Environmental Ethics, 12(3) (2000), 279-303.

Despite the application of 2.5 million tons of pesticides worldwide, more than 40% of all potential food production is lost to insect, weed, and plant pathogen pests prior to harvest. After harvest, an additional 20% of food is lost to another group of pests. The use of pesticides for pest control results in an estimated 26 million human poisonings, with 220,000 fatalities, annually worldwide. In the United States, the environmental and public health costs for the recommended use of pesticides total approximately $9 billion/yr. Thus, there is a need for alternative non-chemical pest controls, and genetic engineering (biotechnology) might help with this need. Disease and insect pest resistance to various pests has been slowly bred into crops for the past 12,000 years; current techniques in biotechnology now offer opportunities to further and more rapidly improve the non-chemical control of disease and insect pests of crops. However, relying on a single factor, like the *Bacillus thuringiensis* toxin that has been inserted into corn and a few other crops for insect control, leads to various environmental problems, including insect resistance and, in some cases, a threat to beneficial biological control insects and endangered insect species. A major environmental and economic cost associated with genetic engineering applications in agriculture relates to the use of herbicide resistant crops (HRC). In general, HRC technology results in increased herbicide use but no increase in crop yields. The heavy use of herbicides in HRC technology pollutes the environment and can lead to weed control costs for farmers that may be 2-fold greater than standard weed control costs. Therefore, pest control with both pesticides and biotechnology can be improved for effective, safe, economical pest control.

Michael J. Reiss. (Institute of Education, University of London, 20 Bedford Way, London WC1H 0AL, UK). **Ethical Considerations at the Various Stages in the Development, Production, and Consumption of GM Crops.** Journal of Agricultural and Environmental Ethics, 14(2) (2001) 179-190.

The aim of this paper is to clarify the ethical issues surrounding GM crops by examining the various stages or levels in their development, production, and consumption. Previous work about the acceptability or non-acceptability of GM crops has tended to conflate these various levels, partly, as a result of which GM crops are all-too-often simply said to be "good" or "bad". There are, though, various problems with such a binary categorization. I look in particular at the duties of scientists, companies, regulatory systems, farmers, retailers, and consumers.

Nils Holtug. (Centre for Bioethics and Risk Assessment, Department of Philosophy, University of Copenhagen, Njalsgade 80, DK-2300 Copenhagen S, Denmark). **The Harm Principle and Genetically Modified Food.** Journal of Agricultural and Environmental Ethics, 14(2) (2001), 168-178.

It is suggested that the Harm Principle can be viewed as the moral basis on which genetically modified (GM) food is currently regulated. It is then argued (a) that the concept of harm cannot be specified in such a manner as to render the Harm Principle a plausible political principle, so this principle cannot be used to justify existing regulation; and (b) that even if the Harm Principle were a plausible political principle, it could not be used alone in the regulation of GM food, since it does not express a concern for the expected benefits of such food.

Biotransformation

Christopher E. Frencht, Susan J. Rosser, Gareth J. Davies, Stephen Nicklin[1], and Neil C. Bruce*(Institute of Biotechnology, University of Cambrmge, Tennis Court Rd., Cambridge CB2 1QT, UK. 'Defence Evaluation and Research Agency, Fort Halstead, Sevonoaks, Kent, TN147BP, UK. Present address: Institute of Cell and Molecular Biology, University of Edinburgh, Darwin Building, King's Buildings). **Biodegradation of explosives by transgenic plants expressing pentaerythritol tetranitrate reductase.** Nature Biotechnology, 17(may), (1999), 491.

Plants offer many advantages over bacteria as agents for bioremediation; however, they typically lack the degradative capabilities of specially selected bacterial strains. Transgenic plants expressing microbial degradative enzymes could combine the advantages of both systems. To investigate this possibility in the context of bioremediation of explosive residues, we generated transgenic tobacco plants expressing pentaerythritol tetranitrate reductase, an enzyme derived from an explosive-degrading bacterium that enables degradation of nitrate ester and nitroaromatic explosives. Seeds from transgenic plants were able to germinate and grow in the presence of 1 mM glycerol trinitrate (GTN) or 0.05 mM trinitrotoluene, at concentrations that inhibited germination and growth of wild-type seeds. Transgenic seedlings grown in liquid medium with 1 mM GTN showed more rapid and complete denitration of GTN than wild-type seedlings. This example suggests that transgenic plants expressing microbial degradative genes may provide a generally applicable strategy for bioremediation of organic pollutants in soil.

Jagjit S. Yadav, David L. Lawrence, Barbara A. Nuck, Thomas W. Federle, C. Adinarayana Reddy. (Department of Environmental Health, Division of Molecular Toxicology, University of Cincinnati, Cincinnati, OH 45267-0056, USA. Environmental Science Department, The Procter & Gamble Company, P.O. Box 538707 , Cincinnati, OH 45253-8707, USA. Department of Microbiology and the NSF Center for Microbial Ecology, Michigan State University, East Lansing, MI 48824-1101, USA Author for correspondence). **Biotransformation of linear alkylbenzene sulfonate (LAS) by *Phanerochaete chrysosporium* : oxidation of alkyl side-chain.** Biodegradation, 12(6) (2001), 443-453.

The white rot fungus *Phanerochaete chrysosporium*, which generally mineralizes substituted aromatics to CO_2, transformed linear alkylbenzene sulfonate (LAS) surfactants mainly at their alkyl side chain. Degradation of LAS was evidenced by a zone of clearing on LAS-containing agar plates and colorimetric analysis of liquid cultures. Disappearance of LAS was virtually complete within 10 days in low nitrogen (2.4 mM N), high nitrogen (24 mM N) and malt extract (ME) liquid media. After 5 days of incubation in ME medium, transformation of LAS was

complete at concentrations ≤4 mg l^{-1}, but decreased at higher concentrations. The LAS degradation was not dependent on lignin peroxidases (LiPs) and manganese-dependent peroxidases (MnPs). Mineralization of ^{14}C-ring-LAS to $^{14}CO_2$ by *P. chrysosporium* was <1% regardless of the culture conditions used. Thin layer chromatography and mass spectral analyses indicated that *P. chrysosporium* transformed LAS to sulfophenyl carboxylates (SPCs) through oxidative shortening of the alkyl side-chains. While LAS disappearance in the cultures was not dependent on LiPs and MnPs, transformation of the parent LAS moieties to SPCs was more extensive in low N medium that favors expression of these enzymes. The SPCs produced in LN cultures were shorter in chain- length than those produced in ME cultures. Also there was a notable shift in the relative abundance of odd and even chain length metabolites compared to the starting LAS particularly in the low N cultures suggesting the possible involvement of processes other than or in addition to β-oxidation in the chain-shortening process.

Luisa M. Freitas dos Santos, Arnaud Spicq, Anthony P. New, Jean-Claude Wolff, Andrew Edwards. (Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK. Environmental Research Laboratory, Analytical Sciences, SmithKline Beecham Pharmaceuticals, New Frontiers Science Park North, Third Avenue, Harlow, CM19 5AW, UK). **Aerobic biotransformation of 4-fluorocinnamic acid to 4-fluorobenzoic acid.** Biodegradation, 12(1) (2001), 23-29.

The biotransformation of 4-fluorocinnamic acid (FCA) using non-acclimated industrial activated sludge was investigated. FCA is a common intermediate in organic synthesis, and it is often present in aqueous waste streams. Hence, the biotransformation reactions this compound undergoes when exposed to activated sludge micro-organisms should be understood before waste streams are sent to biological wastewater treatment plants (WWTPs). FCA biotransformation was monitored using a wide range of analytical techniques. These techniques were used to monitor not only FCA disappearance, but also the formation of degradation products, in order to propose the metabolic pathway. FCA was biotransformed to 4-fluorobenzoic acid via the formation of 4-fluoroacetophenone. The removal of FCA up to 200 mg L-1 followed first order kinetics. The half-lives for removal of FCA from the test solutions supplied with 200 mg L-1, 100 mg L-1, and 50 mg L-1 were 53, 18, and 5 hours respectively.

Margarate Bucheli-Witschel [1], Thomas Egli. (Swiss Federal Institute for Environmental Science and Technology, Department of Microbiology, Oberlandstrasse 133, CH-8600 Dubendorf, Switzerland). **Environmental fate and microbial degradation of aminopolycarboxylic acids**. FEMS Microbiology Reviews 25 (2001), 69-106.

Aminopolycarboxylic acide (APCAs) have the ability lo form stable, water-soluble complexes with di-and trivalent metal ions. For that reason, synthetic APCAs are used in a broad range of domestic products and industrial applications to control solubility and precipitation of metal ions. Because most of these applications are water based. APCAs are disposed of in waster and reach thus sewage treatment plants and the environment, where they undergo aboitic and/or biotic degradation process. Recently also natural APCAs have been described which are produced by

plants or micro-organisms and are involved in the metal uptake by these organism. For the two most widely used APCAs nitrilotriacetate (NTA) and ethylenediaminetetraacetate (EDTA) transformation and mineralisation process have been studied rather well, while for other xenobiotic APCAs and for the naturally occurring APCAS little is known on their fate in the environment. Where as NTA is mainly degraded by bacteria under both oxic and anoxic conditions, biodegradation is apparently of minor importance for the environmental fate of EDTA. Photodegradation of iron(III) complexed EDTA is supposed to be mostly responsible for its elimination. Isolation of a number of NTA and EDTA utilizing bacterial strains has been reported and the spectrum of APCAs utilized by the different isolates indicates that some of them are able to utilize a range of different APCAs whereas other seems to be restricted to one compound. The two best characterized obligately aerobic NTA utilizing genera (Chelatobacter and Chelatococcus) are members of the subgroup of Proteobacteria. There is good evidence that they are present in fairly high numbers in surface waters soils and sewage treatement plants. The key enzymes involved in NTA degradation in Chelatobacter and Chelatococcus have been isolated and characterized. The two first catabolic steps are catalised by a monooxygenase (NTA MO) and a membrane bound iminodiacetate dehydrogenase. NTA MO has been cloned and sequenced and its regulation as a function of growth conditions has been studied. Under denitrifying conditions, NTA catabolism is catalysed by a NTA dehydrogenase. EDTA breakdown was found to be initiated by a MO also, which shares many characteristics with NTA MO from strictly aerobic NTA degrading bacteria. In contrast degradation of [S.S]-ethylenediaminedisuccinate ([S.S]-EDDS), a structural isomer of EDTA, was shown to be catalysed by an EDDS lyase in both an EDTA degrader and in a NTA utilizing Chelatococcus strains. So far transport of APCAs into cell has only been studied for EDTA and the result obtained give strong evidence for an energy dependent carrier system and Ca^{2+} seems to be co-transported with EDTA. Due to their metal complexing capacities. APCAs occur in the environment mostly in the metal complexed form hence the influence of metal speciation on various degradation process is of utmost importance to understand the environmental behavior of these compound. In case of biodegradation the effect of metal speciation is rather difficult to assess at the whole cell level and therefore only limited good data are available. In contrast, the influence of metal speciation on the intracellular enzymatic breakdown of APCAs is rather well documented but no generalizing pattern applicable to all enzymes was found.

S. Das and S.C.Santra. (Department of Environmental Science, University of Kalyani, Kalvani-741235, West Bengal, India. **Detoxification of hexavalent chromium by fungal isolate from tannery effluent**. Nat.Bot.Soc, 55 (2001), 25-30.

Chromium is one of the major heavy metal pollutants, discharged into environment several industries including leather tanning industries. Biological detoxificatioro by biosorption and conversion of hexavalent chromium to comparatively non-toxic trivalent form is a potential solution for ecomanagement of chromium-loaded effluents. By initial screening, one chromium tolerant *Aspergillus* strain was selected for detailed study. This strain showed high chromium accumulating capacity from nutrient medium as well as effluent. The strain showed considerable conversion of hexavalent chromium to its trivalent form. Acidic pH has positive impact on biodetoxification of chromium by fungal biomass. This fungal biomass can be applied *to* mitigate problem of chromium pollution in tannery effluents.

Si-Jing Wang, Kai-Chee Loh. (Department of Chemical and Environmental Engineering, The National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260). **Biotransformation kinetics of Pseudomonas putida for cometabolism of phenol and 4-chlorophenol in the presence of sodium glutamate.** Biodegradation, 12(3) (2001), 189-199.

A kinetic model to describe the degradation of phenol and cometabolic transformation of 4-chlorophenol (4-cp) in the presence of sodium glutamate (SG) has been developed and validated experimentally. The integrated model accounts for cell growth, toxicity of 4-cp, cross-inhibitions among the three substrates, and the different roles of the specific growth substrate (phenol) and the conventional carbon source (SG) in the cometabolism of 4-cp. In this ternary substrate system, the overall phenol degradation and 4-cp transformation rates are greatly enhanced by the addition of SG since SG is able to attenuate the toxicity of 4-cp and therefore increase the cell growth rate. Model analysis indicates that the maximum specific degradation rate of phenol (0.819 mg $(mg.h)^{-1}$) is lowered by SG by up to 46% whereas the specific transformation rate of 4-cp is not directly affected by the presence of SG. The competitive inhibition coefficient of 4-cp to phenol degradation ($K_{i,cp}$) and that of phenol to 4-cp transformation ($K_{i,ph}$) were determined to be 6.49 mg l^{-1} and 0.193 mg l^{-1}, respectively, indicating that phenol imposes much larger competitive inhibition to 4-cp transformation than the converse. The model developed can simultaneously predict phenol degradation and 4-cp transformation, and is useful for dealing with cometabolism involving multiple substrates.

Tim Kunkel[1], Qi-Wen Niu[1], Yang-Sun Chan[2], and Nam-Hai Chua[1]*. (Labotary of Plant Molecular Biology, The Rockefeller University, 1230 York Avenue. New York, NY 10021-6399. Institute of Molecular Agrobiology, 1 Tresearch Link, The National University of Singpore, Singpore 117604, Republic of Singpore.). **Inducible isopentenyl transferase as a high efficiency marker for plant transformation.** Nature Biotechnology, 17(sept) (1999), 916.

Overexpression of the isopentenyltransferase gene (*ipt)* from the Ti-plasmid of *Agrobacterium tumefac*iens increases cytokinin levels, leading to generation of shoots from transformed plant cells. When combined with a dexamethasone-inducible system for controlling expression, *ipt* expression can be used to select for transgenic regenerants without using an antibiotic-resistance marker. The combined system allows efficient cointroduction of multiple genes (in addition to *ipt)* and produces transgenic plants without morphological or developmental defects.

William B. Gillespic Jr., W.-Bradley Hawkins, John H. Rodgers Jr., Manuel L. Cano and Philip B. Dorn. (ENTRIX, Inc., 5252 Westchester, Suite 250, Houston, TX 77005, USA. The University of Mississippi, Department of Biology, University, MS 38677, USA. Department of Environmental Toxicology, P.O. Box 709, Clemson University, Pendleton, SC 29670, USA. Shell Development Company, Westhollow Technology Center, P.O. Box 1380, Houston, TX 77251, USA). **Transfers and transformations of zinc in constructed wetlands: Mitigation of a refinery effluent.** Ecological Engineering, 14(3) (2000), 279 – 292.

Two pilot-scale wetlands were constructed to facilitate transfers and transformations ofZn in a secondary refinery wastewater effluent. The wetlands (6.1x30.5 m, widthxlength) were planted with Scirpus californicus and were operated wdth 24-h nominal hydraulic retention times (HRT). To evaluate wetland performance in terms ofZn removal at two water depths, one wetland was amended with a nominal concentration of 4.0 mg Zn/l as ZnC1, for 144 days at an operational water depth of 0.3 m, and for an additional 22 days at a water

depth of I m. The second wetland served as an unamended control. From wetland inflow to outflow, approximately 38% of total recoverable and 65% of soluble Zn was removed during the experiment at the 0.3-m water depth. During the flooded period (I .O-m water depth), approximately 18% of total recoverable and 66% of soluble Zn was removed from the effluent. Toxicity of effluent to Ceriodaphnia dubia Richard and Pimephalespromelas Rafinesque decreased from inflow to outflow by ~54 and 73%, respectively, at the 0.3-m water depth, and by at least 100% at the 1.O-m water depth. These data illustrate successful construction of wetlands for transfers and transformations of Zn from the water column and for decreases in associated toxicity.

Biotechnology Policy Issue

Johan A. Brink, Bernard Prior, and EdgarJ. DaSilva.(Johan A Brink is director, UNESCO/BACBETCEN, Agricultural Research Council, Vegetable and Ornamental Plant Institute, Private BagX293, Pretoria 0001, Republic of South Africa. Bernard Prior is co-director, UNESCO MIRCEN, Department of Microbiology, University of Stellenbosch, Private Bag XI, Matieland 7062, South Africa. *Edgar* J *DaSilva is director. Life Science Division, UNESCO, I rue Miollis 75732 Paris cedex 15, France).* **Developing biotechnology around the world.** Nature Biotechnology 17(May), (1999).

It is often assumed that the practice of biotechnology in the vast majority of the nontechnically advanced societies is negligible or virtually nonexistent. This situation is ascribed to the lack of facilities, equipment, and skilled manpower, which minimizes the participation of these countries in the culture of basic science research that is a salient characteristic of industrialized societies. However, this perception belies the quantity and quality of biotechnology research currently being undertaken outside the developed *world.*Last year, directors of the Biotechnology Education and Training Centre (BETCENs), and selected Microbial Resources Centres (MIRCENs) functioning within the framework of the Life Science Programme of the United Nations Education, Scientific and Cultural Organization (UNESCO), attended a symposium in Pretoria, South Africa to asses biotechnology-promoting programs under way at the five regional BETCENs. To create further opportunities to promote the exchange of ideas and communication, the directors of some newly established UNESCO MIRCENs were also invited to present their respective programs.

On the evidence of the presentations, many of the goals of BETCENs and MIRCENs appear to have been achieved, especially efforts to provide training in biotechnology to a growing number of scientists as part of capacity-building efforts in developing countries. It was also apparent, however, that wider adoption of biotechnology will require new funding sources to supplement the initiatives implemented by UNESCO.

Steven Strauss, Wout Boerjan, John Cairney, Malcol-m Campbell, Jeffrey Dean, David Ellis, Lise Jouanin, and Bjorn Sundber. (Steven Strauss is a professor at Oregon State University, Corvalis, Wont Boerjan is a group leader at Flanders Intenmiversity, Gent,Belgium woboe@gengenp.rug.ac.be); lohn Cairney is an associate professor at the Institute for Paper Science and Technology, Atlanta, GA Malcolm Campbell is lecturer at Oxford University, Oxford, UK; Jeffrey Dean is a professor at the University of Georgia, Athens,GA; David Ellis is biotechnology director at BC Research,Vancouver, BC, Canada; Lise Jouanin is a research scientist at INRA, Versailles, France, Bjorn Sundberg is a professor at the Swedish University of Agricultural Science, Umed, Sweden).**Forest biotechnology makes its position known.** Nature Biotechnology, 17(dec) (1999), 1145.

Last July, the world's largest group of scientist studying molecular biology and biotechnology of forest trees met at the University of Oxford, England*. To the surprise of the attendees, the meeting, organized by the International Union of Forestry Research Organizations (IUFRO, Vienna, Austria), was the subject of a protest by antibiotechnology group called GEFF (Genetic Engineering Free Forests, London, UK). During the meeting, GEFF staged a protest outside the meeting hall (the venerable Oxford Natural History Museum) that drew about 30 participants. In addition, the only field trial of genetically modified (GM) trees in the United Kingdom, poplars with modified wood chemistry growing on AstraZeneca's property west of London, was destroyed by vandals at the outset of meeting.These trees had been generated through collaborative research project funded by European Union.

The protest and destruction of the field trial seemed to sending the message that even research understands how trees function at the molecular level was unwelcome. This is curious a key complaint of groups like GEFF, who are against GM organisms (GMOs), is that the knowledge base to assure environmentally safe use is insufficient. In addition to obtaining wood for analysis of pulp characteristics seeing whether the genetic modification had any effects on tree growth and adaptation to the environment rationale for the study. Its ultimate goal was to produce tree that require the use of fewer chemicals in paper and pulp production and thus creating less environmental pollution.

In forestry GM trees are likely to be used primarily in intensive, short-rotaion (e.g., 3-25 years) plantations for which wood production is the primary goal. Plantation of genetically engineered trees could help to increase wood production, and thereby reduce pressure for exploitation of native forest. The social discussion about risk vs. benefits of GMOs must move from a generic consideration of GMOs to the merits of modifying trees with specific traits to be used in specific environments and managements regimes. While transgenic traits pose some risk for plantation and associated ecosystems, many options exits to mitigate their impacts.

Pollen Biotechnology

Ashok K. Jain. (School of Studies in Botany, Jiwaji University, Gwalior 474011, India). **Survey of bioaerosol in different indoor working environments in central India**. Aerobiologia, 16(2) (2000), 221-225.

Aerobiological studies at three different indoor sites viz., food grain godowns, library building and bakery were carried out. The main objective of the study was to find out the fungal flora at these places and its impact on the organic materials which are stored / processed there. The study reveals that over 40 fungal types prevail in such organic matter rich environs. The incidence of fungi was found to be fluctuating according to months and seasons. Studies were carried out by Andersen two stage sampler. Maximum spore concentration was observed in the library followed by bakery and food grain godowns. Common spore types belonged to the species of *Aspergillus. Alternaria, Cladosporium, Helminthosporium, Curvularia, Rhizopus* etc. Such fungi are mainly responsible for the deterioration of paper materials in library and food grains in godowns. Bakery products also get contaminated with a good number of fungi types. The people working at such places also get allergic due to these fungal components.

B.P. Sing. Jyotsna Verma, Susheela Sridhara, Deepak Rai, $S.N.Gaur & Naveen Arora. (Centre for Biochemical Technology, Delhi University Campus, Delhi-110007, India & V.P Chest Institute, Delhi-110007). **Allergens of *Salmalia malabarica* (Eng. silk cotton) Tree Pollen and Seed Fibers**. Indian J Allergy Appl Immunol, 15(1) (2001), 45-48.

Salmalia malabarica (SM) pollen and seed fiber (SF) allergens were investigated for their role in type – I allergic disorders. Intradermal tests with SM pollen extracts showed markedly positive skin reactivity (2+ & above) in 5.6% of nasobronchial allergy patients tested. Skin sensitivity to old and new SF extracts was observed in 12.4% and 6.6% patients, respectively. SDS-PAGE resolved SM pollen extracts into 22 Coomassie brilliant blue stained bands (MW 14-100 kDa). Immunoblotting with pooled patient's sera demonstrated 15 allergenic proteins in pollen extracts. Proteins with molecular weights 50,42,35, 30, 20 and 14 kDa were detected as major IgE binding bands using individual patient sera. Based on the data, we recommend inclusion of SM pollen and its SF extracts in kits routinely used for diagnosis of allergies in India.

D.M Tripathi* and Amitava Chakravorty**. Creative Drug Industries 308, Raikar Bhavan, Sector-17 Vashi, New Bombay. Casablanka Allergy Clinic, Kapali Para, Chadannagore, Hooghly, West Bengal. **Aerobiological survey of Hooghly district with reference to, offending agents of allergic disorders**. Indian J Allergy Asthma Immunol, 15(1) (2001), 27-29.

An aerobiological survey of Hooghly district was conducted from February, 1999 to January 2000. The aim of this study was to identify various airborne allergens responsible for manifestations of allergy ailments. Fifty two types of pollen and fourteen types of airborne fungi were recorded from the atmosphere. Two main seasons were recognized, (1) Mid-January to April and (2) September to November. The first season was loaded with tree pollens while the second season was represented by pollen of weeds and grasses. Fungal spores were present throughout the year with seasonal exacerbations.

F. Lorenzoni-Chiesura, M. Giorato, G. Marcer. (Department of Biology, University of Padova, Via Ugo Bassi 58/B, 35131 Padova, Italy. Department of Occupational Health, University of Padova, Via Giustiniani 2, 35128 Padova, Italy). **Allergy to pollen of urban cultivated plants**. Aerobiologia, 16(2) (2000), 313-316.

Pollens of many plants located in public or private gardens may cause pollinosis in predisposed individuals. There is evidence that the prevalence of sensitization to "new'' tree pollens (Betulaceae, Corylaceae, Cupressaceae, Taxodiaceae, and other families) is increasing in the recent years in Italy. Allergenic plants are often imported from foreign countries, therefore low-allergenic species must be recognized in order to prevent new pollen sensitizations. In this study we suggest a list of recommended and not-recommended plants for public and private green.

Madhu Khanna, P. Kumar, A. K. Prasad. (Department of Respiratory Virology, V. P. Chest Institute University of elhi, Delhi-1100070). **Influenza and its Role in Apoptosis**. Indian J Allergy Asthma Immunol, 15(1) (2001), 7-12.

Programmed cell death or apoptosis is an active process of cell destruction and it has been postulated that virus-induced apoptosis is an important factor in pathogenesis caused by cytopathogenic viruses. Apoptosis is induced by both

influenza A and influenza B viruses, which are cytopathogenic negative-strand RNA viruses. The importance of influenza viruses as worldwide pathogens in humans and domestic animals is well recognized. In this report we review the status of knowledge of the mechanism(s) of influenza virus-induced apoptosis. However, the mechanism(s) of influenza virus-induced apoptosis are not well understood.

Michael Riediker, Theo Koller, Christian Monn. (Institute for Hygiene and Applied Physiology, Environmental Hygiene Section, Swiss Federal Institute of Technology, Zürich, Switzerland). **Determination of birch pollen allergens in different aerosol sizes**. Aerobiologia, 16(2) (2000), 251-254.

Allergens in fine particles may cause symptoms in allergic asthmatics. In order to assess the exposure of susceptible persons, a method to measure the allergen load in fine and coarse particles was developed. Aerosols are collected with a high-volume air sampler by multistage impaction. They are separated into five size classes, ranging from >10 µm to <1 µm and sampled on glass fibre filters. After sampling, filters are crushed into a fine powder using a hydraulic press. Allergens are then eluted on a shaker into Tween-20-containing phosphate buffered saline. After microfiltration, the eluate is ready for analysis with ELISA-techniques (Enzyme Linked Immuno Sorbens Assay). Two different methods are used for the analysis of allergens: One is a sandwich-ELISA using monoclonal IgG-antibodies, the other is a competitive ELISA based on polyclonal IgE-antibodies obtained from patients allergic to birch pollen. Using the monoclonal antibodies information on the amount of one particular allergen (the major allergen Bet v1) is obtained. On the other hand the competitive ELISA using the polyclonal IgE is much more sensitive and indicates the total birch pollen allergens. Data obtained during spring 1998 show good correlation of pollen counts and allergen content in the coarse particle fraction containing intact pollen (>10 µm). In smaller sized fractions, the allergen load is often close to the detection limit. When clearly detectable amounts of allergen are present, in the fine size fraction the allergen load shows only a weak correlation to the pollen counts and the allergen concentrations in the coarse particle fraction.

Nimai Barui, Sunirmal Chanda. (Botany Department, Surendranath College, Calcutta, India. Division of Palynology and Environmental Biology, Department of Botany, Bose Institute, Calcutta, India). **Aeromycoflora in the Central Milk Dairy of Calcutta, India**. Aerobiologia, 16(3-4) (2000), 367-372.

Intramural aeromycological survey was performed at the Central Milk Dairy, Calcutta, covering eight locations within the Dairy using Burkard personal volumetric air sampler. The locations were butter cold storage (-2 °C), cold store (8 °C), packaging section (23 °C), milk processing section (24 °C), reconstituent of skimmed milk (24 °C), quality control lab (25 °C), raw milk reception (28 °C) and loading dock (26 °C). A number of fungal spores, conidia and mycelia were recorded in different rooms: the highest spore quantity was recorded in the packaging section (23 °C) and the minimum at the butter cold store (-2 °C). The dominant spores consisted of *Aspergillus niger*, *A flavus*, *Cladosporium* sp., *Fusarium* sp., *Curvularia* sp., *Alternaria* sp., *Torula* sp., *Myrothecium* sp., *Helminthosporium* sp., *Periconia* sp., *Nigrospora* sp. and *Pithomyces* sp.

Orietta Iannotti, Gianfranco Mincigrucci, Emma Bricchi, Giuseppe Frenguelli. (Department of Plant Biology, University of Perugia, Borgo XX giugno 74, I-06100 Perugia, Italy). **Pollen viability as a bio-indicator of air quality**. Aerobiologia, 16(3-4) (2000), 361-365.

Many air pollutants cause plant deterioration. In this study pollen viability was used as bio-indicator of air quality. The study was carried out in the city of Perugia where road traffic is the most important cause of air pollution. Three areas, with different intensity of road traffic (very high, medium and absent) but all characterized by the presence of the same plant species, were selected. Eight species were studied: *Hedera helix* L., *Convolvulus sepium* L., *Cynodon dactylon* (L.) Pers., *Quercus ilex* L., *Dactylis glomerata* L., *Parietaria diffusa* M. et K., *Daucus carota* L. and *Tilia cordata* Miller. The pollen of these species was treated with TTC (2, 3, 5 Tryphenil-Tetrazolium-Chloride) staining solution and viability was then estimated by light microscopy. The results showed that the pollen viability was inversely proportioned with pollution. The highest difference in pollen viability between the areas was registered in *Tilia cordata. Quercus ilex* instead showed that there was no difference in pollen viability between the three different areas. *Parietaria diffusa* showed a particular behaviour; the highest pollen viability percentage was in polluted areas. The statistical analysis (ANOVA) showed that the main source of variability of the pollen viability depends on the plant but also the site and the interaction between plant and site were very important with a high significant level ($p < 0.0001$).

Paolo Ciancianaini, Roberto Albertini, Silvana Pinelli, Paolo Lunghi, Erminia Ridolo, Pierpaolo Dall'Aglio. (Istituto di Patologia Medica – Scuola di Specializzazione in Allergologia ed Immunologia Clinica, Università di Parma, Italy). **Betulaceae, Corylaceae, Cupressaceae, Fagaceae and Salicaceae around Parma (Northern Italy): Pollen calendars from 1995 to 1997**. Aerobiologia, 16(2) (2000), 309-312.

Many seasonal respiratory allergies are caused by airborne pollens. There is an evident correlation between allergic attacks and the amount of pollens in the atmosphere at any time. The airborne tree pollen concentration and the relevant repercussions on pollinotics has not yet been extensively reported for all Italian regions. We present the results of a 3-year, weekly, tree pollen count by Burkard spore trap from the atmosphere of Parma, Italy. Annual pollen calendars were made from the results. The study has been conducted because, in Europe, an increasing frequency of allergic sensitisation to these pollens has been observed.

S.P.S. Yadav, H.C. Goel, Rakesh Chanda, Rupender Ranga,K.B. Gupta*. (Departments of Otolaryngology, Chest & Tuberculosis*. Pt. B.D. Sharma PGIMS, Rohtak- 124001 Haryana, India). **A Clinical Profile of Allergic Rhinitis in Haryana**. Indian J Allergy Asthma Immunol, 15(1) (2001), 13-15.

The study was conducted to find out the allergic rhinitis profile in the state of Haryana. Detailed history, complete clinical examination and relevant investigations were carried out in one thousand and seventy live patients of either sex suffering from allergic rhinitis who attended the otolaryngology department in one year. The incidence was higher in younger males. Significant seasonal increase related to harvesting was found. The allergic rhinitis was also found to be related to family history of allergy, habitat and socioeconomic status.

Soma Chakraborty, Sukanta Kumar Sen, Kashinath Bhattacharya. (Department of Botany, Visva-Bharati University, P.O. Santiniketan, West Bengal, Pin-731235, India). **Indoor and outdoor aeromycological survey in Burdwan, West Bengal, India**. Aerobiologia, 16(2) (2000), 211-219.

A comparative survey of airborne fungal spores in five indoor and five outdoor environments in Burdwan, West Bengal, India, was carried out for a period of two years using rotorod samplers and sedimentation plates (culture plate). A total of 29 spore types were identified, of which three were Phycomycetous (*Mucor, Rhizopus, Syncephalastrum*), one Ascomycetous (*Chaetomium*), one Basidiomycetous (*Ganoderma*) and the remainder were Fungi Imperfecti. The results revealed lowest count during summer and maximum during the rainy season. *Aspergillus* was quite abundant in all the environments surveyed. The predominance of *Aspergillus, Curvularia, Alternaria, Cladosporium, Drechslera, Fusarium* in all the surveyed environments has been attributed to their ability to grow in various substrata. The occurrence of *Cladosporium* in the winter months suggest that it is sensitive to high temperature. All spore types were common in both environments except *Bispora, Cercospora, Papularia, Spegazzinia, Trichothecium* in the outdoor sites. A correlation has been made between the volumetric composition of airspora and the incidence of seasonal mold allergy.

Name of Journals

1. Acta Biotechnologica
2. Aerobiologia
3. Annual Review-Plant Pathology
4. Annual Review- Ecology And Systematics
5. Annual Review-Biochemistry
6. Annual Review-Biomedical Engineering
7. Annual Review-Biophysics And Biomolecular Structure
8. Annual Review-Microbiology
9. Annual Review-Pharmacology And Toxicology
10. Annual Review-Phyrtopathology
11. Annual Review-Physiology
12. Annual Review-Plant Physiology
13. Annual Review-Public Health
14. Appied Bacteriology
15. Applied And Environmental Microbiology
16. Applied And Environmental Microbiology
17. Applied Micribiology
18. Asian Journal Of Microbiology,Biotechnology&Environmental
19. Australian Journal of plant physiology
20. Biocatalysis And Transformation
21. Biocontrol
22. Biocontrol
23. Biodegradation
24. Biodiversity And Conservation
25. Biomedical and Environmental Sciences
26. Biomedical Engineering
27. Bioremediation Journal
28. Bioscience,Biotechnology,And Biochemistry
29. Biosensors-and –Bioelectronics
30. Bioseperation
31. Biotechnolgy
32. Biotechnolgy Letters Biotechnolgy Progress
33. Biotechnolgy Techniques
34. Biotechnology Advances
35. Biotechnology And Applied Biochemistry
36. Biotechnology And Bioengineering
37. Biotechnology Letters
38. Botanical Review
39. Canadian Journal Of Microbiologyindian Journal of Experimental Biology
40. Cell & Tissue Banking
41. Clinical Micribiology Reviews
42. Critical Reviews In Biotechnology
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44. Current Microbiology
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47. Current Science
48. Cytotechnology
49. Ecological Engineering
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53. Immunological Research
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55. Indian Farming
56. Indian Journal Of Agricultural Science
57. Indian Journal Of Biotechnolgy
58. Indian Journal Of Ecology
59. Indian journal of Plant Physioligy
60. International Biodetoriation & Biodegradation
61. International Biodetoriation & Biodegradation
62. International Journal Of Biotechnolgy
63. International Journal of Biotechnology
64. International Journal Of Phytoremediation Journal Of
65. Journal Of Bacteriology
66. Journal of Environmental Management
67. Journal of Food Science and Technology-Mysore
68. Journal Of Indian Soil Science
69. Journal Of Industrial Microbiolgy & Biotechnolgy
70. Journal Of Scientific And Industrial Research
71. Journal of Scientific And Industrialist Research
72. Microbial Review
73. Molecular Biotechnolgy
74. Nature
75. Nature Biotechnolgy
76. Nature Biotechnology
77. New Biotechnology
78. Perspectives-in-Biotechnology
79. Pesticide research Journal
80. Pestricide Resarch Journal
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83. Pollution Research
84. Re/Views In Environmental Science And Bio/Technology
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91. World Journal Of Microbiology And Biotechnology

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