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Assessment and Remediation of the Environment

CRC CARE is Australia's leading science-based partnership in assessing, preventing and remediating contamination of soil, water and air. With a unique mix of industry, university and government agency partners, CRC CARE's research program focuses on the challenges of best practice policy, better measurement, minimising uncertainty in risk assessment, and cleaning up.



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Hello, and welcome to all our new *Remediation Australasia* readers. I hope you'll enjoy browsing the contents of Issue 8. I would like to wish all ARIC members and magazine readers a (somewhat belated) happy New Year, and hope you all had time to relax and rest during the festive season.

This issue includes articles on dust toxicity measurements and health, advice to enhance the results of your site history investigations, potential remediation techniques for petroleum in soils, and a summary of some of the new CRC CARE II research projects. Other contents also include updates to contaminated sites law and policy from Australian states, and recommendations for risk communication in site remediation.

In light of our contributors' articles in recent issues of *Remediation Australasia*, we believe that the ongoing quality of our magazine content (supplied by a fantastic group of contributors) and increasing interest in the magazine have indicated the importance

of our publication to industry, as well as the importance of the remediation industry itself and its constant need for relevant and timely information. I look forward to bringing you this information in coming issues of the magazine.

Our ARIC member base has grown steadily over the last few months – with a noticeable and well-received boost to numbers since we've moved to our new print format – but I'd also like to welcome the readers of our recently-retired publication, *Remediator*. *Remediator* was the newsletter created in CRC CARE I that included updates on research programs and projects. We hope to now incorporate this information into future editions of *Remediation Australasia*, albeit in this larger magazine-style format. Any former *Remediator* subscribers will be included in our *Remediation Australasia* distribution list, but are welcome to indicate otherwise if preferred by returning the cover slip in this package to the magazine editorial team.

This year brings with it some new exciting activities for ARIC and CRC CARE, including the release of our first training DVD. The DVD is an outcome of our 2011 Australia-wide HSL training workshops, and come as a response to requests from industry for further access to the workshop training materials and content. As such, the DVD package includes a recording of the Adelaide workshop presentation, as well as

a CD with training materials and associated technical reports.

ARIC member numbers, as mentioned earlier, are growing rapidly in number – many of these new people are being alerted to our presence via our LinkedIn forum, and joining via that medium. I encourage all ARIC members not currently connected to our LinkedIn forum to join – if you're on LinkedIn already, visit our forum (<http://linkd.in/nsO2TN>) and send a request to join the forum directly. You are also welcome to direct any related queries to the ARIC team by email (aric@crccare.com).

Submissions of content are now being received for Issue 9 of *Remediation Australasia*. If you have any information you would like to contribute, including: case studies, regulator updates, reports from industry groups, full technical articles, news relating to new technologies and developments in the industry, or training, international conferences or events in Australasia, please forward your content to aric@crccare.com.

As always, any feedback can be sent to aric@crccare.com – we would love to hear your thoughts and ideas about *Remediation Australasia*, or contributions for the next issue.

Prof Ravi Naidu
Managing Director, CRC CARE
Editor, *Remediation Australasia*

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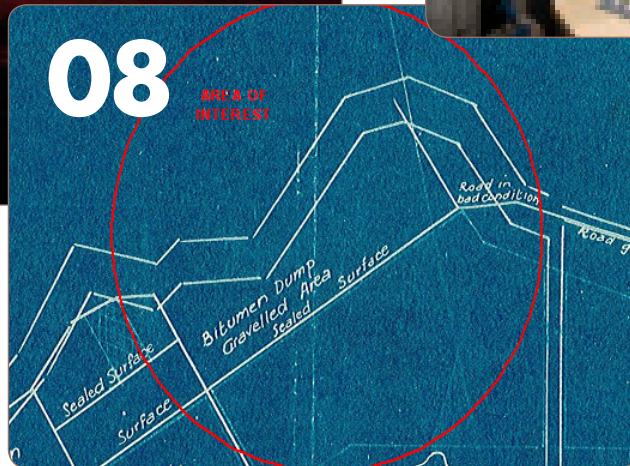
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Iron ore dust: using 3D cell cultures to establish

New toxicity measurement methods

Shiva Prakash, University of Queensland



Australia is the world's third largest producer of iron ore. Since 2009, growth expectations for the iron ore industry have continually been revised upwards, and by 2014 it is expected that production will have increased by approximately 30% to 505 million tonne per annum. It is widely recognised that large-scale mining can have a significant impact on the environment, and concerns about air quality have arisen due to the vast quantities of dust generated by mining. According to the National Pollutant Inventory, 22% of all airborne dusts in Australian airspace originate from metal ore mines. It has been estimated that in many of the towns associated with iron ore export, iron rich dusts account for up to 80% of airborne dusts.

The presence of organic compounds and particulate matter in the atmosphere is ubiquitous and their health effects in and around industrialised areas of the world are well documented. Within Australia, environmental protection agencies set limits on industrial emissions, focussing primarily on the quantities of particulate matter and organic compounds released into

the atmosphere. The prescribed limits are derived from the health effects of individual components.

In more recent times, atmospheric dust pollution has been raised by sectors of the Australian community as being responsible for a number of health problems including respiratory ailments.

Regulatory limits on concentrations of atmospheric dust pollution in Australia are based primarily on international epidemiological studies of metropolitan air pollution. However, from a toxicological perspective, these studies do not necessarily accurately reflect the specific composition of iron-rich dusts generated in some mining towns. Current research is designed to measure the toxicological risk posed to humans by the inhalation of iron-rich dust particles, and to develop a rapid means of assessing gross toxicity in the form of in-vitro tests for the benefit of monitoring systems in the field. Once the toxicology of iron-rich dust inhalation is fully understood, it will be known whether modifying allowable atmospheric dust concentrations in

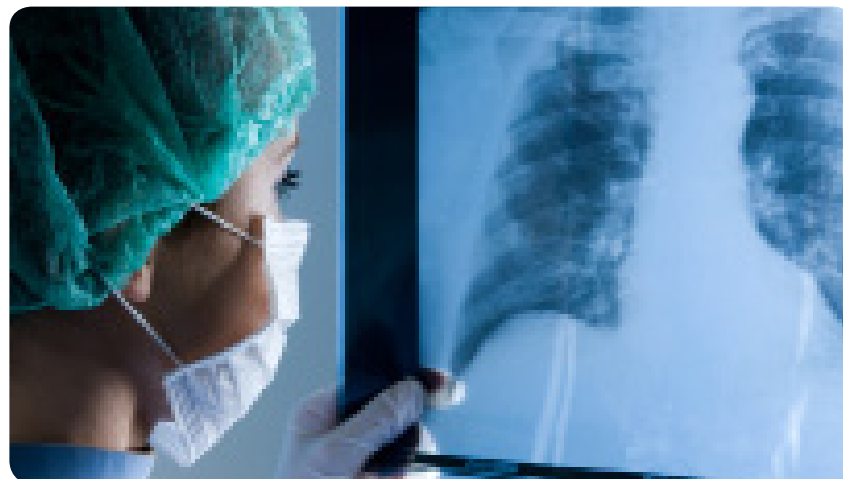
relevant areas is appropriate.

The average diameter of dust particles which become suspended in the atmosphere, and are thus carried for many hundreds of kilometres in strong winds, is about 50 μm (a sheet of paper is about 90 μm thick). When dust is inhaled, most large particles are filtered out in the nose and trachea and are carried into the gastrointestinal system, but the fraction of particles less than 10 μm in diameter make it into the bronchioles. This fraction, known as the thoracic fraction, is classified as PM10. In the Ambient Air Quality NEPM the standard for PM10 is set at 50 $\mu\text{g}/\text{m}^3$ based on a one day averaging period. The fraction of particles less than 2.5 μm in diameter is classified as PM2.5, and penetrates the lungs largely unimpeded down to the alveoli. For this reason, PM2.5 is also known as the respirable fraction. As PM2.5 presents a greater surface area for a given mass than larger fractions, it is assumed that toxic interactions will be enhanced and so standards are tighter; the advising reporting standard for PM2.5 the Ambient Air Quality NEPM is 25 $\mu\text{g}/\text{m}^3$.

How particles interact with the lungs when inhaled is dependent on both the physical characteristics of the particles, and the chemistry of the particles. Because physical characteristics of dust particles mediate many health effects, simply knowing the size distributions of the particles can help predict morbidity and mortality. It has been established that increasing urban PM_{2.5} by 10µg/m³ over the course of a year increases mortality by up to 14%. The aggravation of bronchitis or asthmatic conditions, physical obstruction of lung function, stimulation of fibrosis, and even a link with heart disease due to particles entering the bloodstream, are major contributors to this figure. The aspect ratio, crystalline structure and chemistry of particles further modulate these effects, and are in themselves important to outcomes such as cancer, inflammatory responses, and which cellular components receive the most damage. It is therefore the chemistry-dependent aspects of the particles which require the most investigation when examining new air pollution sources.

“Because physical characteristics of dust particles mediate many health effects, simply knowing the size distributions of the particles can help predict morbidity and mortality.”

Modelling dust exposure in animals such as rats has been the traditional method for understanding toxicity. However, the substantial amount of time, costs and ethics approvals that these studies require make them an undesirable method for monitoring purposes. There can also be uncertainty as to whether human lungs will respond similarly to animal lungs. The rationale in pursuing in-vitro methods is that once an in-vitro system is standardised by applying the most effective exposure methodologies and endpoints, toxicity observations can be obtained at a greatly reduced cost and shorter timescale. Additionally, because human cell lines can be used as part of the methodology, any uncertainty about the relevance of measurements to humans should be minimised. However, using



New methods of measuring dust particles may assist in developing new methods to prevent health problems, including diseases caused or aggravated by dust inhalation.

traditional in-vitro systems is not without drawbacks. Specifically, muted or inconsistent responses to dust samples in comparison to in-vivo methods have been reported, and the limited solubility of dust particles hinders bioavailability. Traditional cell culture assay methods also must be refined to work with the unique properties and interferences of dusts.

CRC CARE funded research at the University of Queensland is using innovative in-vitro experiments in an attempt to overcome existing limitations in a variety of ways.

Firstly, not one but multiple human cell lines (including lung epithelial cells, lung fibroblasts and monocyte derived macrophages) are employed to represent human lungs. Each cell line's strengths and weaknesses enable different aetiologies of major disease outcomes to be explored in finer detail. For example, if epithelial cells exposed to a dust sample prove to die readily or experience damage from increased reactive oxygen species, then that sample will readily agitate the lungs if inhaled. Similarly, if fibroblasts show increased collagen deposition in response to a sample, then scarring and decreased lung function will result. If macrophages show increased and prolonged cytokine production in response to a sample, inflammation will be enhanced and long-term cancer outcomes more likely.

The concept of bioavailability is also addressed; dust exposures are conducted in synthetic lung fluids, made up of conventional media with specific proteins and phospholipids added that are present in living lungs. The use of these factors ease interactions between cells and particles as would occur in natural lung fluid, increasing particle uptake. Last but not least, data is collected from not just traditional 2D cell cultures but also 3D cell cultures, where cells are either allowed to differentiate in structures that more closely resemble living tissues, or interact with other cell types.

It is anticipated that the 3D cell cultures will allow subtle dynamics, dependent on cell differentiation and communication, to be observed which might ordinarily be missed. So far, results are encouraging; iron-rich PM₁₀ and PM_{2.5} collected from regional mining towns show acute toxicity ranges similar to that of pure iron oxides, and cells have shown that they can survive exposures for relatively long periods of time. However, the scope of chronic toxicity effects is being assessed with novel methods, and a new range of freshly-characterised samples may reveal site-dependent toxicities. Currently, health issues arising from residential communities over mining emissions continue to remain unresolved as no causative agent has been identified. Ultimately, it is hoped that this project, along with others in Australia, will impact on the way exposure health standards are currently derived in Australia, and help open the doors to routine toxicity measurement of local air pollution. ■



Developing a comprehensive conceptual site model:

What should you be looking for, and where?

Ruth Keogh and James Corbett, Parsons Brinckerhoff

Contaminated land assessment requires the implementation of a staged process, each part contributing towards the development of a comprehensive conceptual site model (CSM). The neglect of any one stage of this process can result in an incomplete or flawed CSM being used as the basis for decisions regarding:

- the contamination status of a site
- associated risks to human health and/or the environment
- the suitability of a site for a particular end land use, and
- the requirement for, and design of, a site remediation program.

The first step of the assessment process, as nominated by the National Environment Protection (Assessment of Site Contamination) Measure (NEPM), Australian Standard AS4482.1-2005 and various state-based guidance documents, involves the completion of a site history review (also identified as a Preliminary Site Investigation or Phase 1 Environmental Site Assessment). Standard site history research generally includes a desktop study followed by a detailed site inspection. The desktop study comprises collating data from a number of sources and should include the following (as a minimum):

Site definition

Comprising a summary of current information (e.g. the physical extent of the site, land title

information, zoning and local planning restrictions, site use(s) and ownership), this information provides a snapshot of existing site characteristics.

Regional geological and soil characteristics

Consulting relevant geological/soil (including acid sulphate soil) maps, published literature and/or regional bore drill logs may aid in predicting the subsurface profile at the site, thereby facilitating an understanding of how chemical contaminants are likely to behave over time and what conditions may be encountered during a possible future intrusive site investigation program.

“The neglect of any one stage of this process can result in an incomplete or flawed CSM being used as the basis for decisions.”

Regional hydrogeology

Hydrogeological maps, published literature and state/territory records of registered groundwater bores may assist in understanding the likely localised groundwater conditions beneath the site, including depth(s) to groundwater, flow direction(s) and physico-chemical characteristics.

Surrounding land uses and surface water bodies

Perusing local maps and current aerial photographs may aid in identifying possible sources of regional contamination and local sensitive receptors.

Historical and recent aerial photographs of the site and surrounds

Taken at intervals of 10 years or less, these are consulted to obtain information regarding temporal changes to land use and/or infrastructure on, and adjacent to, the site.

Historical land titles records

Consulted as far back as either the first land grant or, where impractical, to evidence of land ownership that is unlikely to have included significant potentially contaminating activities (PCAs), this research is undertaken to obtain a history of land ownership and/or use over time.

Dangerous goods licensing records

Generally held by state/territory government departments, these records are accessed to determine whether licensed fuel or chemical storage facilities, including underground and aboveground storage tanks, may have been located on, or near, the site.

Heritage registers

Commonwealth and state/territory Aboriginal and European heritage

agencies should be consulted to determine whether possible heritage issues require further consideration during future site use/management.

Contaminated sites databases

The local contaminated sites regulatory body (i.e. Environment Protection Authority or equivalent) should be consulted regarding the recorded presence of contamination, PCAs, existing/historical licences and/or contaminated land audits (current or completed) for the site and surrounding area.

Local government authority records

Contacting the local council regarding possible recent and historical records regarding the site (including development plan approvals) may aid in establishing the chronology of land use and development.

Underground services

A preliminary investigation into the presence and configuration of underground service conduits, usually undertaken using historical/current site plans and/or dial-before-you-dig information, may aid in determining whether subsurface preferential contaminant pathways might be present on the site.

Site inspection

The site inspection, which should be undertaken (where possible) in the company of a person with knowledge of the site layout as well as past and present site use(s), involves collating as much visual, olfactory, anecdotal and documentary (i.e. site-based records) information as possible regarding the site and immediately surrounding properties. This should include (but not necessarily be limited to) an assessment of factors such as:

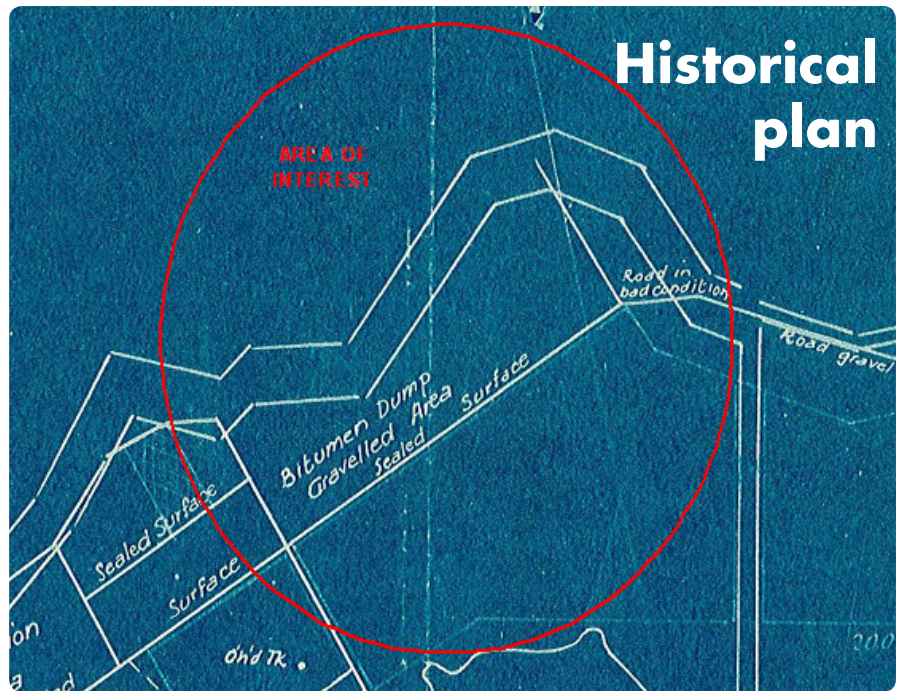
- local topography
- surface water flow direction(s), surface water bodies and/or areas of ponding
- types, condition and distribution of surface paving

- current and remnant site infrastructure
- site use activities
- evidence of surface soil contamination, imported fill material(s), stockpiles, waste and/or stressed vegetation
- fuel/chemical storage areas and inventories
- waste management procedures
- presence of asbestos building

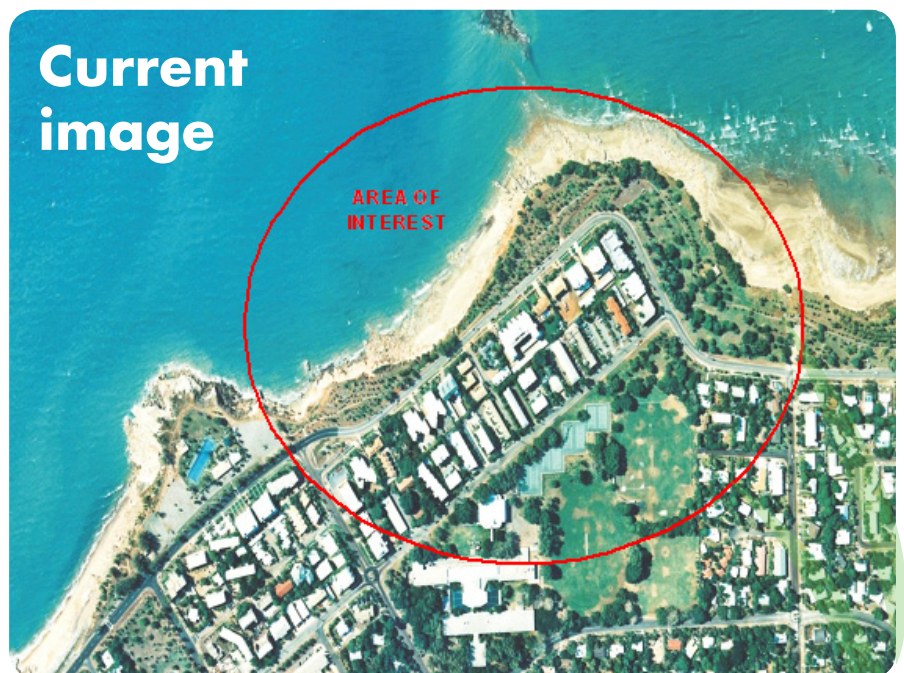
materials and site asbestos register, and

- records of spills, leaks or complaints.

Once the research phases have been completed, the next stage of the site history review involves collating the various pieces of information to establish a preliminary CSM for the site and immediately surrounding area. This CSM should include a summary of the PCAs



Useful information can be obtained from State and/or National Archives - in this case, if this historical plan (above) obtained from State archives had not been found, the presence of a former World War II depot (including a landfill/bitumen dump) at the location of a current coastal residential subdivision (below) would not have been identified.



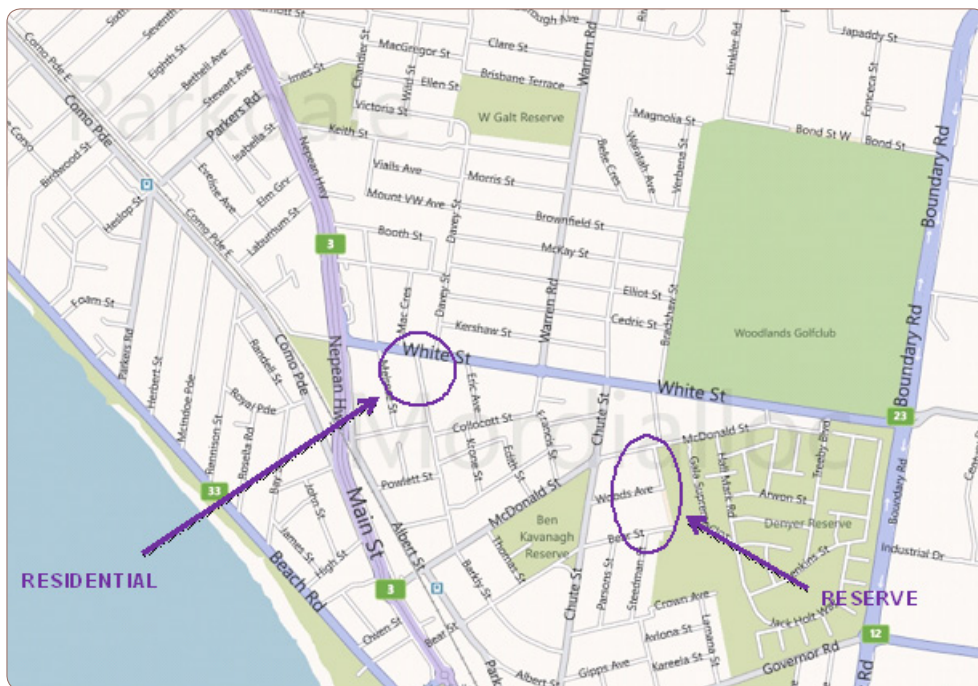
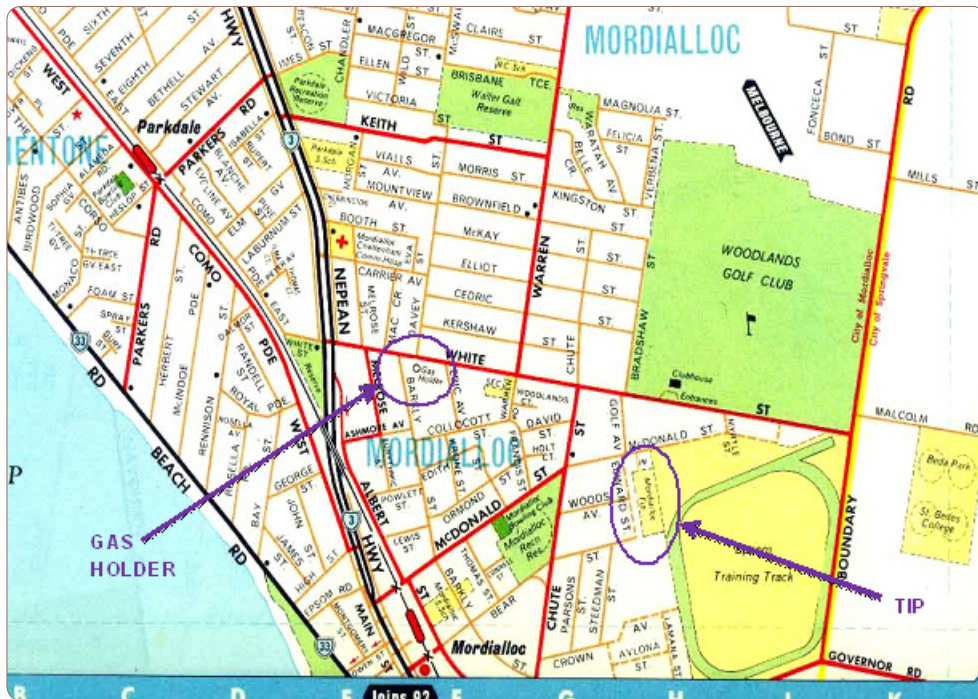
1966 street directory map

Publicly available historical maps (e.g. old street directories) may assist in the identification of historical surrounding land use activities.

In this case, the surrounding area had previously hosted a gas holder and a tip on properties that were currently in use for residential purposes.

The accurate identification of current and historical surrounding land uses may have implications for the nomination of contaminants of potential concern for the investigation site.

current map



that may have occurred on, and in the immediate vicinity of, the site as well as the associated potential contaminants, their likely behaviour within soil and/or groundwater (both on- and off-site), possible contaminant transport routes, sensitive receptors and exposure pathways. The CSM should then be used as the basis for scoping the subsequent intrusive investigation program (if required) and should be progressively updated as more information become available for the site.

Although the standard format for a site history review is now generally well understood by those who undertake the work, it is important to realise that such a format may not necessarily be sufficient to appropriately characterise your site, particularly if it has a long history of land use (e.g. inner city properties) and/or has been used for various industrial activities (e.g. manufacturing, railway, council/fuel/transport depot, commercial service station or Defence facilities). These sites require the assessor to

think ‘outside the box’ in terms of possible sources of information that may contribute to obtaining a complete picture of the history of the site and the development of the CSM. Additional sources of information that may be of assistance in this regard include:

Local and state libraries

These may host relevant historical plans, books, photographic databases or other information to assist in determining the history of land use activities.



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12 & 13 March – Perth
15 & 16 March – Adelaide

19 & 20 March – Melbourne
22 & 23 March – Sydney

For more information or to register online, visit www.aclca.org.au

Local historical societies

A possible source of additional anecdotal information, historical photographs and published/unpublished records for the local area.

Local museums

These may be of assistance with regard to specific areas of interest (e.g. railway, military and mining museums).

State and national archives

A possible source of historical plans or records, particularly with respect to current or former government sites or sites of interest to government bodies, including admiralty charts (i.e. changes to coastlines over time) and military records.

State government department plan rooms

A possible source of detailed plans for infrastructure located on government sites (e.g. school sites, railway facilities).

Historical topographic maps

These may show the locations of former features such as landfills, quarries or (backfilled) surface water bodies.

Historical post office directories (i.e. predecessors of recent phone books/street directories)

A possible source of chronological information regarding the owners/occupiers of the site and surrounding properties.

Historical street directories

These could indicate additional historical surrounding land use activities that may have resulted in regional contamination.

In summary, if you are responsible for commissioning work on a potentially contaminated site, it is important not to underestimate the importance of this stage of the assessment process, whereby a relatively limited outlay of time and expense may enable the development of a more comprehensive CSM as well as a more streamlined and successful overall approach to the intrusive site investigation and/or remediation programs. ■



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Feb 1 *Call for Special Session topics*
June 1 *Online abstract submission opens*
Nov 1 *Deadline for online abstract submission*
Nov 30 *Early online registration*

for further information visit the conference website: <http://icobte2013.org/>



ALS takes home new industry innovation award



Above: Celebrating their win at the CleanUp Gala Dinner presentation were Marc Centner (left) and Geoff Anderson of ALS Environmental.

Contaminant testing in water can now be performed in a much safer, more efficient and environmental-friendly way, thanks to an award-winning innovation in the laboratory.

Pollutants such as TPH, TRH, PAH and phenols and other semi-volatile compounds in water can now be tested using significantly lower sample volumes as a result of evolutionary method development by ALS Environmental. The new methodology also decreases waste, greenhouse emissions and improves manual handling considerations across the industry.

In recognition of this development, ALS Environmental was awarded the inaugural CARE Award for sustainable environmental technologies during the recent 4th International Contamination Site Remediation Conference.

Over the last six years, ALS has progressively refined the technology and its methodology, to accommodate lower sample volumes without compromising

quality and detection levels. The concept of reducing sampling volumes came about by observing field and laboratory receipt staff moving large eskies, and listening to field sampler feedback on the difficulty of obtaining samples from low recharge wells.

Instead of pumping and moving 10 litres of liquid from ten locations, field staff can now sample 10 wells and carry only 1 litre. The ability to sample in smaller volumes enables fieldwork to be performed more efficiently, reducing consultant time and costs.

An independent panel of industry, regulatory and scientific experts selected the winner of the award. This panel noted that with a lower sample volume, the total amount of solvent required could be cut by up to 90%, and that the glassware usage and waste could also be reduced by 70%.

CRC CARE Managing Director Professor Ravi Naidu and Deputy Secretary of the Department of Innovation, Ms. Patricia Kelly,

presented the award during the CleanUp Conference Gala Dinner.

“This is an exceptional piece of technology that is going to make the task of contaminant identification and cleanup a whole lot easier,” Professor Ravi Naidu noted during the award presentation.

“We felt it was a fitting winner of the inaugural CARE Award.”

Mr Geoff Anderson graciously accepted the award on behalf of ALS Environmental. In his acceptance speech, Mr Anderson credited the win to his team’s drive to change the industry to benefit safety, quality, the environment and efficiency through the project.

Mr Anderson said that the criteria for the CARE award also aligned with ALS’ core values (including honesty, integrity and safety), and their selection as winner was a testament to the focus of ALS staff as a team. He attributes the win to ALS’ belief that they could make a difference, and their success in planning, implementing, changing and delivering benefit to clients and the industry. ■



Above: The inaugural CARE Award.

Site remediation and risk communication:

A problem of common interests

Linda Heath, University of South Australia

The purpose of risk communication is to assist people to obtain the information they require to make informed choices about the possible risk they face. It has been found that there are notable differences in the approach towards risk communication across state and local government organisations, land owners, developers, and communities. These different levels of risk may be explained by the different nature of projects; which vary widely in their relative degree of innovation and risk, and the public's perception of risk from suspected intentional and/or accidental concealment of information.

The National Environmental Protection Measure (National Environment Protection Council (NEPC) 1999, Assessment of Site Contamination National Environment Protection Measure, Canberra) was developed to provide nationally accepted guidance for the assessment and management of contaminated sites. An integral component of the risk assessment and risk management process for site remediation is the risk communication process. Risk communication means a two-way process involving the exchange among individuals, groups and institutions of information and expert opinion about the nature, severity and acceptability of risks and the decisions taken to combat them (adapted from enHealth 2004, *Environmental health risk assessment – guidelines for assessing human health risks from environmental hazards*, enHealth Council: Department of Health and Ageing, Canberra, Australia.).

The presence of site contamination has the potential to affect people's health, livelihoods and financial situation. Communicating about land contamination and proposed remediation solutions is exceedingly complex and often emotionally charged.

"Characterising different public beliefs about risk as being just 'perception' or labelled as a 'nuisance' is guaranteed to undermine trust and mutual respect, and has the potential to create open conflict and outrage."

This is because of the potentially serious implications of the problem, the diverse range of people

involved and competing priorities. The investigation of social and environmental factors that sustain or diminish health has become a growing area of environmental health research. In many cases it is the lack of knowledge on hazards, related risks, vulnerabilities and the preparedness by the local communities that serves as a hindrance for community action. Nevertheless subject to events of the past, people may respond to a hazard in accordance to the risks they pose or to their perception of the risk they pose.

Many approaches to risk communication in the past have been mistakenly directed towards getting the public to accept the risk estimates of experts. Technically orientated risk professionals have attempted to 'fix' the public's misperception of risk rather than recognising that there are valid reasons for the differing views. Characterising different public beliefs about risk as being just



'perception' or labelled as a 'nuisance' is guaranteed to undermine trust and mutual respect, and has the potential to create open conflict and outrage.

A critical step for communicating contaminated land and remediation issues usually begins with an intensive dialogue between the landowner/developer, the contaminated land consultants, government authorities and associated construction businesses. These groups consist of individuals who share common goals and often demonstrate group polarisation, that is, they all shift towards a better comprehensive decision and increased acceptance of a solution. Nationally recognised standards and guiding principles of good practice for managing contaminated sites also incorporates good risk communication practices. The consensus between all relevant stakeholder groups on sensitive issues requires a communication process that is tailored to include public involvement, learning and information sharing.

The community's response to exposure to contaminating activities outside of their control often heightens their perceptions of risks to health (Russell 1999, 'Living can be hazardous to your health: How the news media cover cancer risks', *Journal of the National Cancer Institute Monographs*, vol. 25, pp. 167-170). In part, this may be fuelled by uncertainties about the extent and nature of contaminants, how exposures might occur and the performance of treatment technologies. As an example, novel in-situ remediation technologies face higher barriers to adoption compared to existing technologies for several reasons. These may include a perceived sense of increased risk by the public, a lack of experience with the new technologies among managers and/or regulators, or simply the fact that decision makers are not aware of the risk associated with the new technology. Uncertainties arise from not knowing enough to meaningfully predict what will happen.

Environmental, biological, social and economic uncertainty is a fact of life. Science tries to bring the uncertainties back into focus by collating the relevant scientific evidence to explain the estimates of risk. Risk communicators therefore, need to interpret scientific findings to enhance the technical understanding of a broad range of stakeholder to inform the community about choices they need to make. Those involved with the process of investigating, assessing and managing land contamination should consider carefully how they will respond to public and stakeholder concerns, anxieties and expectations that may arise, prior to, the submission of site remediation plans.

There will often be some who disagree with any decision. At times there will be conflict over information, data, ideas and knowledge. It is an integral part of many environmental conflict resolution processes. If the remediation strategy involves non-negotiable goals, the information explaining the reason behind the non-negotiable goals should be disseminated to the affected community. Conflict resolution means working through the issues until there is an agreed outcome. For those individuals involved in the shaping of a decision-making process, a good communication strategy will see the emergence of commonly constructed and shared realities for the present and future projects. Every development proposal is unique and every remediation process has to be considered on its merits. The main task of risk-based management is to develop adequate tools for dealing with problems of complexity, uncertainty and ambiguity, whilst communicating and managing these problems. Therefore, effective risk communication is a balance between procedure and outcome. Achieving this balance requires the use of practitioners who can adjust and adapt their communication techniques in different situations. ■

Engaging the Community: a handbook for professionals managing contaminated land



Addressing issues of public confidence during contaminated site assessment and remediation is a necessary step requiring community consultation and participatory decision making. This is now widely recognised among the contaminated land practitioner community.

'*Engaging the community: a handbook for professionals managing contaminated land*' (Heath, et al., CRC CARE, Adelaide, Australia) presents a framework for community consultation in the context of contaminated site projects, and describes the communication principles that can be used in community consultation.

The handbook is broken up into five parts, providing readers with the principles of community engagement, national and international perspectives on best practice in risk communication, Australasian case studies, and a structural framework for involving the public in environmental decision making.

The handbook is available to purchase at a cost of AUD\$35 per copy.

To purchase your copy, please visit www.crccare.com

Emerging socio-economic drivers for remediation:

Moving toward value-based decision making

Roelof Plant, University of Technology, Sydney

Community concern and outrage about contaminated livelihoods first demanded prompt and comprehensive government action during the late 1970s and early 1980s. Since then, the drivers for site cleanup have come a long way.

The initial lessons about the scope, scale and costs of remediation from such highly-publicised cases as the Love Canal disaster (1978) in the USA and the Lekkerkerk scandal in the Netherlands (1980) quickly led to a demand for more cost-effective solutions. Yet, as policies for site remediation were put in place and increasing effort was put into the discovery of historical contamination, the number of potentially and actually contaminated sites kept increasing over the years.

Where technological innovations (to an extent, due to enhanced R&D investment in contamination and remediation science) led to a variety of cost-effective remediation solutions (for example, MNA), developments in analytical techniques also enabled more sites to be assessed as contaminated. In approximately 1983 the US estimated 600,000 sites to be contaminated with toxic substances, while 1992 estimates for the Netherlands ranged from 200,000 to 600,000 sites. Thus, although progress was made towards cost-effectiveness on a per-site basis, the estimated total costs of the cleanup

operation at the national scale continued to increase. This forced governments to pursue a broader suite of policy tools. From the mid-1990s onwards, more emphasis has been placed on financial and legal incentives for landowners to promote private-sector initiatives, while risk-based approaches to dealing with contaminated sites have also become more common.

As the pursuit for cost-effective solutions continues, emerging socio-economic drivers for remediation have been shifting the focus away from costs and towards a broader suite of potential benefits – public and private – that could be derived from the remediation process. At the CRC CARE fourth International Contaminated Site Remediation Conference (CleanUp 2011), held in Adelaide from 11–15 September 2011, a special session was held on the emerging socio-economic drivers for remediation.

The first part of the session showcased examples and lessons from the UK, Fiji, Ethiopia and the Netherlands, while the second part of the session featured three case examples from Australia. As session



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chair, I had the honour of opening the session with a brief presentation outlining CRC CARE's past and current policy research agenda, and setting the scene by asking the question: 'can more value be created from the remediation process by explicitly considering additional socio-economic drivers?'

Gary Foster (URS Scott Wilson Ltd, UK) highlighted how the National Industrial Symbiosis Programme (NISP) has been highly successful in engaging traditionally separate industries in a network to foster innovative strategies for more sustainable resource use. The presentation highlighted the wealth of capacity and knowledge that is readily available in the British remediation industry, and the importance of harnessing this capacity in an effective and engaging manner.

The presentation paper from Biruck Yirshaw (Hawassa University, Ethiopia) analysed how skills, capacity and responsibility for remediation are currently misaligned between governmental

and non-governmental organisations in Ethiopia due to a siloed approach to the governance of public health and environmental health. The paper made a strong case for maintaining a focus on the link between human health and ecosystem health – ultimately all human activity and wellbeing depends on healthy ecosystems.

Joanne Chong (University of Technology, Sydney), in her paper about value-based land remediation, presented a case study of EU-funded rehabilitation of the contaminated Lami Dump site in Fiji. Adopting an analytical framework that focuses on the institutions governing the remediation decision-making process – that is, the formal and informal rules and norms that people adhere to when making cleanup decisions – the paper concluded that there are important lessons to learn from studying values. These include issues around communication about public health impacts; building knowledge, capacity and governance structures to enable linking risk, rehabilitation

and site redevelopment decisions; promoting collaborations between government departments and universities; collaborations between government agencies; option identification and selection; and contracting and donor administration requirements.

Wil Van Deur (CRC CARE) offered a thought-provoking perspective on the policy process, drawn from a comparison between the remediation policy responses in Australia and the Netherlands. Where the Netherlands was faced with a significant 'trigger' three decades ago (the Lekkerkerk scandal), to date Australia has never had such an incident, or a general sense of urgency for the site contamination problem. Moreover, Australia's federal system would have been unlikely to have been amenable to the national approach taken by the Dutch Government had a major incident occurred. However, there are important lessons to be learnt for Australia from the responsiveness of the Dutch to incorporating

new knowledge into policy and legislation.

The special session also featured three presentations showcasing Australian experiences with socio-economic drivers for remediation. Jean-Paul Pearce (GHD) presented a best-practice example of effective risk communication, demonstrating what good science can do when it is combined with effective risk communication. The case presented was a school expansion on a site with elevated methane. The paper concluded by emphasising early risk communication, project planning and communication with key stakeholders as critical success factors to risk communication.

Sean Shiels (EPA Victoria) presented a regulatory perspective on decision frameworks. Drawing from life cycle assessment techniques and EPA Victoria's determination of 'Clean Up to the Extent Practicable' (CUTEP), the paper presented a Sustainable Decision Framework (SDF) that can potentially increase the robustness and improve the

overall environmental outcomes of current CUTEP decision-making.

The paper from Aleta Lederwasch (University of Technology, Sydney), applying the Institutional Analysis and Development (IAD) analytical framework, reported on research that aimed at exploring the institutional arrangements governing remediation decision-making. Values are a critical determining factor of how institutions – the rules and norms that people use when making decisions – operate and affect the broader public and private benefits from the remediation process. The findings indicated that the rules-in-use (payoff rules and information rules) and the measurement of value created (evaluation criteria) may be of particular interest to policy makers. The paper concluded by emphasising the significance of this type of research, given the limited existing international and Australian research, on how to maximise value (including actual and perceived risk reduction) through the remediation of contaminated sites.

After a brief synthesis by the session chair, a lively decision ensued about how socio-economic drivers could be given more weight in the remediation process, and how policy could be more enabling to promote value-based decision making. The importance of stakeholder and community engagement – at the right time and with the appropriate levels of information – was once again stipulated.

A key conclusion from the special session was that a multi-pronged approach is needed: theories, methods and practice with respect to risk communication, value creation in the remediation decision-making process, and decision-making tools promoting sustainable decisions are all complementary and should be brought together to shape and inform a National Remediation Framework for Australia.

Selected presentations and abstracts from this session at the 2011 CleanUp Conference are currently available at the conference website, www.cleanupconference.com. ■

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Remediating petroleum-contaminated soil with cyclodextrins

By investigating the effect of HPCD on three PAH-contaminated soils, South Australian researchers have demonstrated how biological technologies can reduce adverse health effects on people and the environment

Ilia Rostami, FMG Engineering



Petroleum contamination in soil. Petroleum contaminants include PAHs, which are known carcinogens.

In 1997, David Natusch estimated the number of contaminated sites in Australia to be up to 100,000, with remediation costs possibly in excess of \$2 billion per year (Application and development of contaminated site remediation technologies in Australia, *ANZAC Fellowship Report to Department of Internal Affairs*, Wellington, New Zealand and Department of Foreign Affairs and Trade). A particular group of pollutants, known as polycyclic aromatic hydrocarbons (PAHs), contribute to a number of these Australian contaminated sites and constitute a complex public health hazard.

“Substantial research has demonstrated the microbial degradation of PAHs, especially in liquid culture, with numerous genera of bacteria, fungi and algae able to degrade a variety of PAHs.”

PAHs are petroleum contaminants, and include known carcinogens – some of which are amenable to remediation by specialised microorganisms. Research has shown that microbial population in soil can be stimulated to clean up PAHs. The outcomes of this

research are applicable to industry, government, researchers and other stakeholders, and demonstrate how biological technologies can reduce the adverse health effects on people and the environment. The research themes were investigated using three PAH-contaminated soils in South Australia collected from a former wood preservation site, a former manufacturing gas plant and a former tram yard site. *Note: only data from the tram yard site will be discussed in this article.*

The main purpose of this research was to determine whether simple, rapid, inexpensive chemical extraction methods can estimate PAH bioaccessibility in order to predict the efficacy of PAH bioremediation strategies. Substantial research has demonstrated the microbial degradation of PAHs, especially in liquid culture, with numerous genera of bacteria, fungi and algae able to degrade a variety of PAHs. While liquid culture experiments allow a controlled medium to determine the ability of microorganisms to degrade PAHs (i.e. metabolic range, rate and extent of degradation), soil based experiments (microcosms) provide a more realistic representation of solid phase bioremediation performance. Moreover, microcosm results may also be useful in developing more effective bioremediation strategies.

Figure 2: The large cyclodextrin hydrophobic cavity traps organic contaminants. Adapted from Dean and Scott (2004).

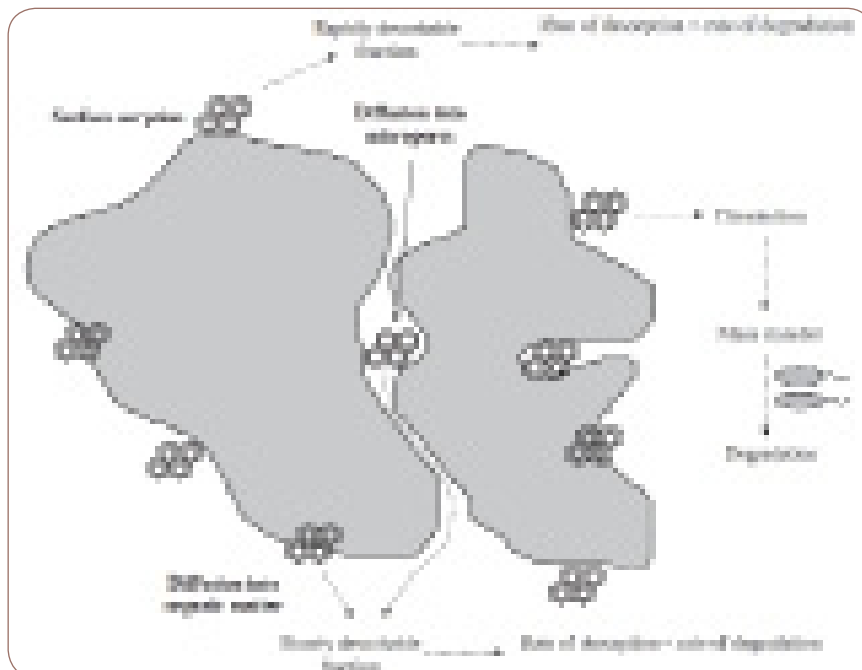
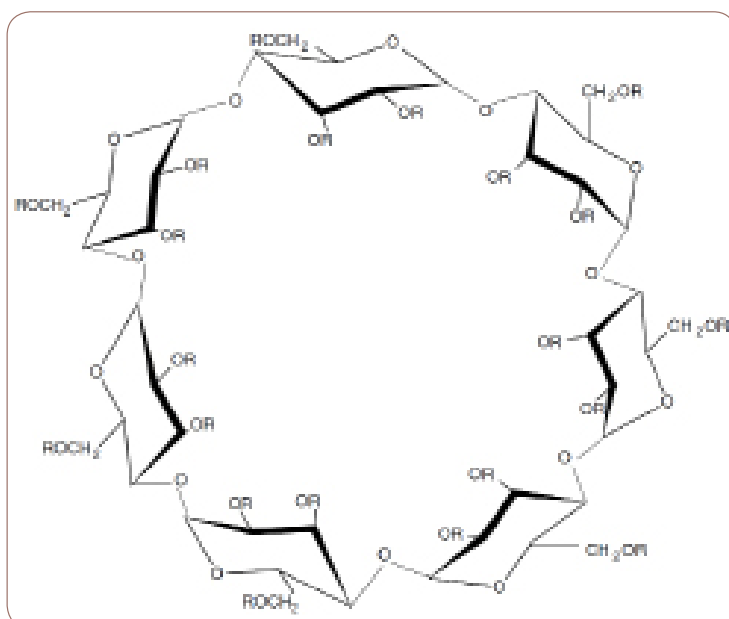


Figure 1: Schematic diagram representing the formation PAH-soil particle bounding in contaminated soil matrices (Juhász et al. 2008).

PAH behavior in soil

Following entry into the soil environment, a number of physical and chemical processes can influence the fate and dynamics of PAHs. PAH sequestration in soil is an important mechanism which affects bioaccessibility. In addition to environmental parameters, a major factor influencing the efficacy of PAH bioremediation is contaminant bioavailability. The bioavailability of PAHs decreases as the amount of time they are in contact with the soil increases. This process, called 'ageing', is the result of the formation of strong

hydrophobic bonds between soil particles and PAHs (Figure 1). Bioremediation often fails to achieve target clean up levels due to low PAH bioavailability. Researchers have demonstrated a close link between bioavailability and the rate of PAH biodegradation in petroleum contaminated sites.

Hydroxypropyl-beta-cyclodextrin (HPCD)

Cyclodextrins are cyclic oligosaccharides formed from the bacterial enzymatic degradation of starch. The torus α-1-4-linked glucose units have a high aqueous solubility and, importantly, contain a hydrophobic cavity that can bond with organic contaminants. Organic compounds interact with the walls of the cavity to form inclusion complexes. The hydroxyl and hydroxypropyl groups are located on the exterior of the molecule, and interact with water to increase the aqueous solubility of the HPCD and the complexes made with the HPCD. Moreover, the prevalence of hydroxyl functional groups on the exterior of the torus, as well as a large hydrophobic organic cavity (Figure 2), are examples of the advantages of using HPCD in terms of formation of stronger bonds with organic matter and increasing the detergency effect of



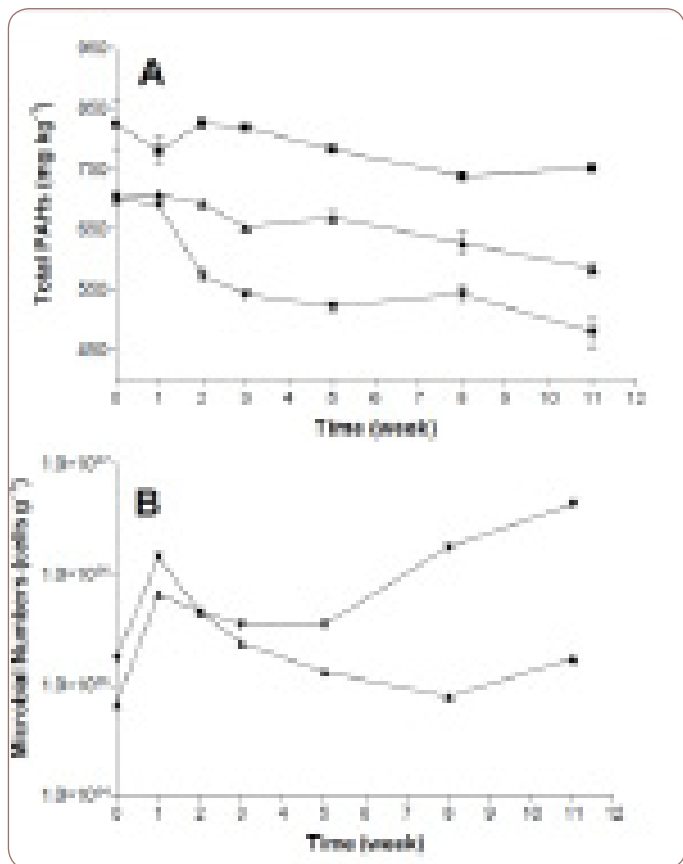


Figure 3 (above): Changes in total PAH concentration (A) and microbial numbers (B) in soil treated using (NA) natural attenuation (▲) and (ENA) enhanced natural attenuation (▼) strategies. The change in PAH concentration in mercuric chloride killed control microcosms is also shown (■).

HPCD. Utilising HPCD as a non-exhaustive extraction method for estimating PAH bioaccessibility has been suggested as a suitable method, due to its ability to effectively predict PAH biodegradability.

Results

1. Degradation in soil (natural attenuation (NA) and enhanced natural attenuation (ENA))

Some variability in total PAH concentration was observed over the incubation period at the former tram yard in mercuric chloride-killed controls of soil. These observations were similar to those in the results obtained for other soils. While total PAH concentration at the end of the 11-week period was measured, this was not statistically different to the starting concentration (Figure 3).

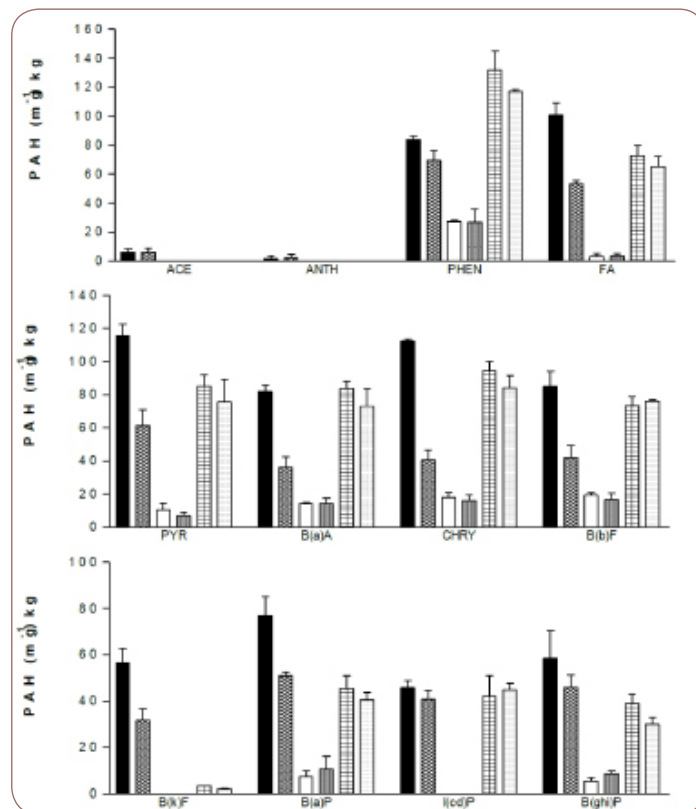
A considerable decrease in total PAH concentration was observed following the application of an ENA strategy. PAH degradation proceeded after a 1-week lag period, resulting in a decrease of 19% in PAH concentration. Following the initial rapid decrease in PAH concentration, degradation slowed, resulting in the residual PAH concentration (36% decrease) at the end of the 11-week incubation period. The application of nutrients to ENA microcosms resulted in the stimulation of bacterial growth. A significant increase in microbial numbers was observed compared

to NA microcosms, with microbial numbers increasing following the 11-week incubation period (Figure 3). After this period, ENA accounted for decreases of 53%, 50%, 43%, 34% and 29% in pyrene, fluoranthene and benz(a)anthracene, benzo(b)fluoranthene, B(a)P and chrysene (Figure 4).

2. Assessment of PAH bioaccessibility using HPCD

For most individual PAHs, there were no significant differences between residual fractions following biodegradation and butanol or propanol extraction (Figure 4). The residual fractions following persulfate oxidation and HPCD extraction were not statistically different ($P < 0.05$) for some PAHs (e.g. fluoranthene, benzo(b)fluoranthene, benzo(k)fluoranthene, B(a)P and indeno(123 c,d)pyrene). Residual PAH fractions follow persulfate oxidation, and HPCD extractions were greater than those observed for butanol and propanol extraction. The phenanthrene concentrations obtained from HPCD assays following extraction were elevated compared to the concentration in microcosm controls, which may be due to the heterogeneity issues associated with the contaminated soil.

Figure 4 (below): Comparison of the residual PAH fraction in above soil following 11 weeks of ENA (▨) and residual PAH concentration following bioaccessibility assessment using butanol (□), propanol (▤) and HPCD (▧) non exhaustive extraction and persulfate oxidation (▩). The concentration of PAHs in above soil at the start of biodegradation and bioaccessibility assessment is also shown (■).



PAH nomenclature

ACE: acenaphthylene	B(a)A: benz(a)anthracene	fluoranthene
ANTH: anthracene	B(a)P: benzo(a)pyrene	
PHEN: phenanthrene	CHRY: chrysene	I(cd)P: indeno(123-c,d)pyrene
FA: fluoranthene	B(b)F: benzo(b)fluoranthene	B(gh)P: benzo(g,h,i)perylene.
PYR: pyrene	B(k)F: benzo(k)fluoranthene	

3. Correlation between remaining PAH fractions following biodegradation in soil and HPCD extraction

While studying the bioaccessibility-biodegradability relationship among the different soils in this study, and applying HPCD, a linear relationship was observed between residual PAH concentrations using non-exhaustive extraction and residual PAH concentrations following ENA. The PAH concentrations removed using HPCD were similar to those removed after biodegradation (1.2 times). While the value of the r^2 correlation coefficient was similar for two soils (0.74 and 0.75 respectively), the third soil showed an r^2 correlation coefficient of 0.93. This suggests that biodegradation endpoints may be accurately predicted using HPCD extraction. Like the results obtained for the three individual soils using HPCD, a strong biodegradability-bioaccessibility relationship was also observed for HPCD ($r^2 = 0.75$) in the combined data results from all soils in this study (Figure 5).

Conclusion/future connectivity via human health risk reduction

The research highlights the potential for a new method of estimating the likely proportion of contamination that can be cleaned up using such bioremediation methods, which is an especially valuable outcome for practitioners responsible for planning and costing site remediation projects. Given that many severely contaminated sites are located in high-value inner city areas, this outcome is of substantial economic significance. The work performed in this research demonstrated the degradation of PAHs within contaminated soils. While a number of methods may be used to determine the bioaccessible PAH fraction, HPCD extraction provided the best estimation of biodegradable PAH compounds among four extraction techniques (correlation: $r^2 \sim 0.78$, slope ~ 0.82 – data not yet published)

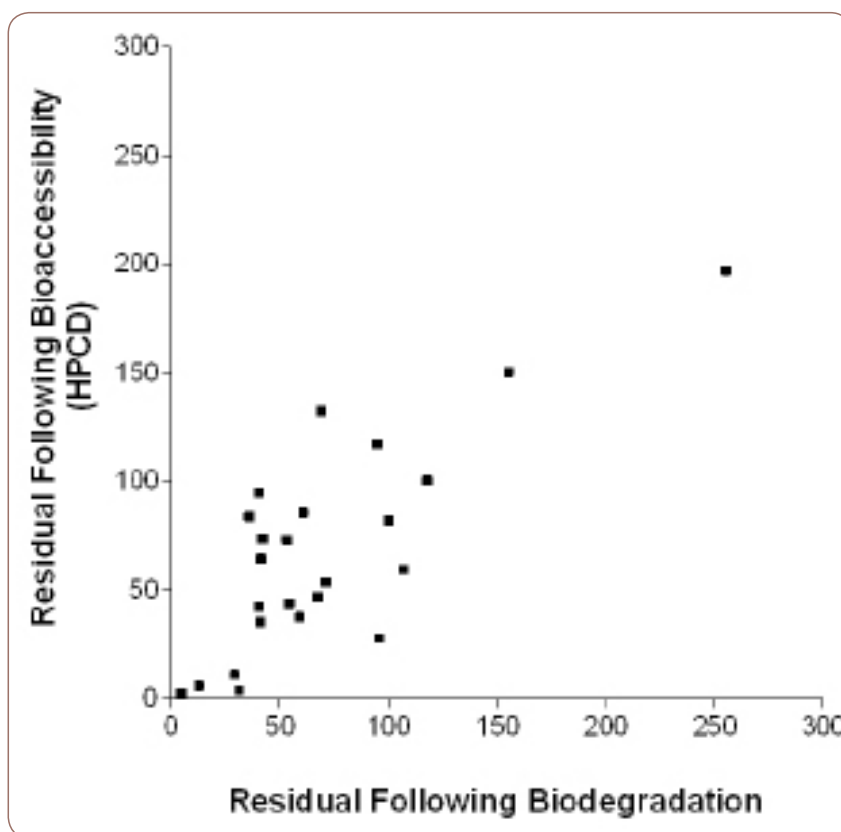


Figure 5: Relationship between residual PAH concentration (mg kg⁻¹) following HPCD extraction assessment and ENA biodegradation.

better than persulfate oxidation and LMW primary alcohol extraction. It was shown that natural attenuation of PAH contaminated soil was limited, presumably due to a lack of nutrient availability. However, it was determined that nutrients may enhance bioremediation of PAH in contaminated soil by increasing microbial activity (residual PAH following ENA 552 mg kg⁻¹ \sim 36% degraded). When comparing PAH rates from liquid to soil matrices, it was evident that solid matrices have significant effects on degradation due to mass transfer limitations that govern contaminant bioaccessibility. Nevertheless, not all biodegradable PAHs were removed due to bioaccessibility limitations. Partially-developed human health risk assessment techniques worldwide pose the question of potential achievements in terms of significant risk reduction. Considering the number of polluted sites in Australia, it is important to ask whether the residual PAH fraction after biodegradation poses any risk to human and ecological health, if concentrations exceed national guideline values.

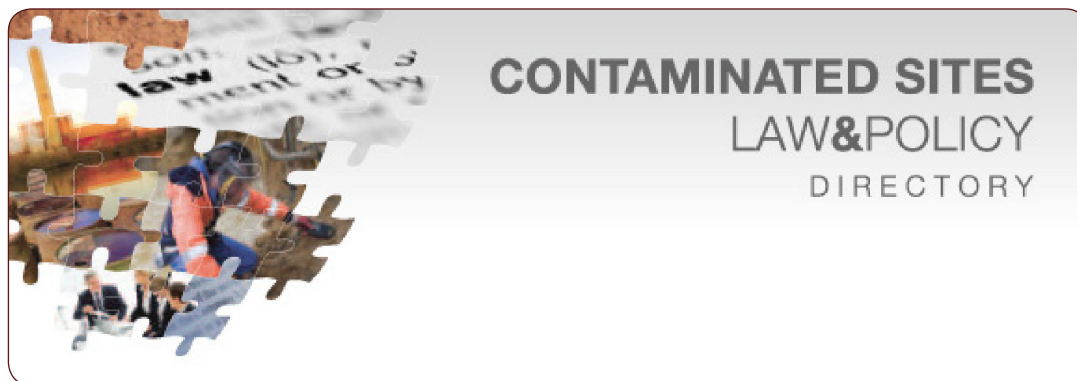
Assessing the bioavailability of residual PAH for human health (more specifically, children, because of frequent hand-to-mouth behavior and increased incidences of ingestion) is an area of expertise for laboratories. Until now, there has been a lack of reliable and standard agreed in-vitro bioavailability methods for assessment of PAHs from contaminated soils. Therefore, we seek – as a potential future area of work – to develop a standard protocol for in-vitro bioavailability of organic pollutants, such as PAHs associated with residual PAHs in pre- and post-remediated soil (Rostami & Juhasz 2011, ‘Assessment of persistent organic pollutant (POP) bioavailability and bioaccessibility for human health exposure assessment: A critical review’, *Critical Reviews in Environmental Science and Technology* vol. 41, no. 7, pp. 623–656). However, these experiments on their own should be based on quality bioaccessibility (extraction) data. ■



Recent changes to

Contaminated sites law and policy in Australia

David Cole and Sara Bray, Fox Tucker Lawyers



Since the last update of Contaminated Sites Law and Policy was published in Issue 4 of *Remediation Australasia* in October 2010, several changes have been made to policies and guidelines that inform contaminated sites assessment and remediation in different Australian jurisdictions. However, there have been no significant statutory changes. The following briefly summarises the more notable changes that have occurred within Australia during the above period.

National

Following public consultation during 2010 on recommended variations to the National Environment Protection (Assessment of Site Contamination) Measure 1999, significant changes are imminent. The proposed NEPM variations are intended to improve clarity of, and consistency within, the NEPM and to place a greater emphasis on the decommissioning of industrial activities than exists under the current NEPM. All Schedules to the NEPM will be varied to meet these objectives. The adoption of these

variations will affect contaminated sites assessment in all jurisdictions and may lead to legislative changes in some cases. During 2011 the Commonwealth Competition and Consumer Act 2010 came into effect, replacing the Trade Practices Act 1974. The provisions of the latter Act that had the potential to support a claim of a misleading or deceptive conduct in relation to dealings with contaminated land have been replaced with equivalent provisions.

South Australia

The site contamination provisions of the Environment Protection Act 1993 have only been in effect for approximately 2 years. No significant changes or additions to these provisions have occurred since their introduction. However, in the last 12 months, the South Australian EPA has updated its Transfer of Liability Information Sheet (October 2010) which addresses section 103E of the Act. The EPA has also updated its Guidelines for the Site Contamination Audit System (now dated May 2010).

Australian Capital Territory

No relevant changes to the ACT contaminated sites legislation (Environment Protection Act 1997 and Planning and Development Act 2007) have occurred in the last twelve months. However, the ACT Environment Protection Authority has recently completed replacing its contaminated sites Practice Notes with Information Sheets 1–7.

Queensland

The Department of Environment and Resource Management has updated the document *Operational Policy – Contaminated Land – Third Party Reviewer Terms of Reference* 15 February 2008 to a document of the same name, dated 15 June 2010. As its title suggests, this policy sets out the framework for the administration of the third party reviewer process (the Queensland equivalent of contaminated site auditor schemes elsewhere in Australia) and terms of reference for third party reviewers.

Tasmania

No changes to the site contamination provisions of the Tasmanian Environmental Management and Pollution Control Act 1994 have been introduced in the last year. However, the Tasmanian EPA has recently introduced an information bulletin on the site contamination sign-off process in that State. Additionally, a working group of local government representatives is developing a planning schedule/code to assist planning authorities to determine when the requirement for a site contamination assessment should be triggered.

Western Australia

No significant changes have been made to contaminated sites legislation or administrative guidelines in the last 12 months.

New South Wales

In the last 12 months there have been no significant changes to the NSW Contaminated Land Management Act 2007 or the provisions of the Environmental Planning and Assessment Act 1979 utilised for the assessment and development of contaminated sites in that State.

Victoria

In the last year, no notable changes have been made to the provisions of the Victorian Environment Protection Act associated with contaminated sites assessment and remediation, the State Environment Protection Policy (Prevention and Management of Contamination of Land) ("SEPP"), or the State's planning legislation controlling redevelopment of contaminated sites (Planning and Environment Act, 1987). ■

The Contaminated Sites Law and Policy website: How to access the directory online

The Contaminated Sites Law & Policy Directory is a resource developed to provide vital information about the legal framework surrounding contaminated sites in selected jurisdictions in Australia and around the world. The directory brings together the many complex pieces of contaminated site law and policy in a fully

searchable online database, and has been analysed and comprehensively annotated by leading authorities.

How does it work?

A free subscription-based website (the Contaminated Sites Law & Policy Directory) delivers search results through the use of a standard template

to enable comparison between jurisdictions. The summaries are designed to provide the reader with a clear understanding of the legislation, guidelines and other documentation and government policies that underlie the approaches taken by authorities in addressing contaminated sites management.

Who will benefit from this resource?

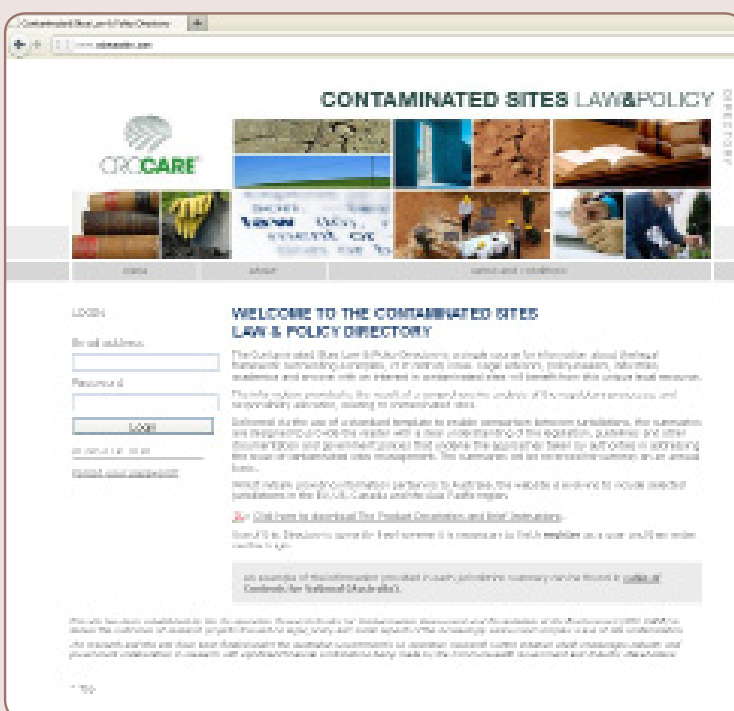
Legal advisors, policy makers, industries, academics and anyone with an interest in contaminated sites will benefit from this unique legal resource.

Current status?

The directory is available online now, and currently features Australian jurisdictions as well as Hong Kong and Singapore. The website will continue to evolve to include selected jurisdictions in the EU, US, Canada and the Asia Pacific region.

How can I access it?

The directory can be accessed at www.cslawpolicy.com ■



Soil particle size and its relationship to contaminant concentration:

Is it a case of swings and roundabouts?

Andrew Beveridge, CRC CARE



Human exposure to contaminants may result from a variety of pathways including inhalation, oral ingestion or dermal absorption. The major non-dietary pathway for contaminant exposure is via incidental ingestion of contaminated soil, and the assessment of risk associated with soil ingestion requires an estimate of likely ingestion rates and contaminant concentrations.

There are two distinct soil ingestion phenomenon: inadvertent and purposeful (geophagia). Estimates of average soil ingestion rates range significantly and will vary on a number of factors including: the age of the individual, frequency of hand-to-mouth contact, seasonal climate, amount and type of outdoor activity, and personal hygiene practices. Maximum soil ingestion rates, that are unlikely to underestimate exposure, range from 100 to 500 mg/day; a value of 5,000 mg/day is considered a reasonable estimate for a child with habitual pica.

When assessing the potential risk associated with contaminants, often the total concentration of the soil-borne contaminant is included into risk models. However, in

most cases, the concentration of the contaminant that is accessible to humans and other organisms is significantly less. As a consequence of this, and other factors, soil sampling for environmental monitoring of pollutants is, at times, a matter of debate in the community of soil, environmental and analytical sciences.

Despite considerable efforts to improve the design of soil ingestion studies, and estimation of daily soil ingestion rates, there is little information relating to the justification of soil particle size selected for analytical assessment and a 'one-size-fits-all' approach appears to have been adopted. This is despite a number of studies demonstrating the variability of contaminant concentration of the same soil sieved to different particle sizes.

It is widely agreed that larger particles and rocks will contain, on a weight basis, considerably less contaminant than the smaller particles. Furthermore, it is considered that smaller particle size material has a greater bioavailability compared to larger size particles of the same material.

In general, humans are believed to ingest particles that are predominantly smaller than 250 μm in diameter. The US EPA reports that this particle size fraction is also the most likely to accumulate in the indoor environment, as a result of deposition of wind-blown soil and transport of soil on clothes, shoes, pets, toys, and other objects.

Further promoting the adoption of the finer particle size in risk assessments, the US EPA has

also indicated that it is important that bioavailability based risk assessments be determined using this particle size fraction; indeed, within Australia, when developing a site-specific risk assessment, the < 250 μm soil particle size fraction is used for relative bioavailability and bioaccessibility assessment.

However, a disparity occurs when general guidance is provided on soil preparation for analytical assessment in *Schedule B(3) of the Assessment of Site Contamination NEPM: Laboratory Analysis of Potentially Contaminated Soils*, where the following instructions are given: "unless impracticable or required by a method, the analysis portion must be at least pass a 2.0 mm aperture sieve."

Why the disparity between the two approaches? Could it not be assumed that additional uncertainty could be associated with estimates based on the assessment of samples having particle sizes larger than 250 μm ?

While it is generally expected that fine soil fractions will have a higher contaminant concentration compared to total soil fractions, in certain cases, the opposite situation may occur, as in the cases where coarse materials from industrial, or mining, operations contained high concentrations of contaminants.

Is the relationship between soil particle size and contaminant concentration the next part of the puzzle that researchers could investigate as a means to reduce the uncertainty associated with risk assessment? Or is it a case of swings and roundabouts? ■

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Training and events calendar

February

8 – 10 **Module A – Contaminated site assessment remediation & management (CSARM): Ground rules for contaminated site**

University of Technology, Sydney / Sydney
<https://shortcourses-bookings.uts.edu.au/ClientView/Schedules/ScheduleDetail.aspx?ScheduleID=582>

24 **7th Annual Water Symposium**

Legalwise Seminars / Sydney
<http://www.legalwiseseminars.com.au/>

29 **AKOLADE - Environment and planning law fundamentals**

Adelaide and Perth
http://akolade.com.au/single-product?product_id=293

29 **Vapour intrusion - How, where and how it can be fixed**

ALGA / Adelaide
<http://www.landandgroundwater.com/Industry%20Calendar.html>

Public gINT training course schedule

Datgel / Sydney
Dates at <http://www.datgel.com/EventsTraining.aspx>

March

2 **Advanced site remediation and NAPL characterisation**

ACLCA SA / Adelaide
<http://www.aclca-sa.org.au/uploadedFiles/1326757766203-9369.pdf>

7 – 9 **Introduction to Australian groundwater**

Sustainable Resource Industry Training (SRIT) / Adelaide
http://www.srit.com.au/course_details.php?id=17

12 – 23 **ACLCA Short Course: Advanced LNAPL Site Management and Quantitative Analysis**

ACLCA / nationwide
<http://www.aclca.org.au/cms-events/index.phps>
12 & 13 March - Perth (Pattersons Stadium)
15 & 16 March – Adelaide (Stamford Plaza)
19 & 20 March – Melbourne (Karstens)
22 & 23 March 2 – Sydney (Karstens)

14 **1-day Occupational health and safety training**

ACLCA Victoria / Melbourne
<http://www.aclca.org.au/cms-events/index.phps>

21 – 23 **3-day Occupational health and safety training**

ACLCA Victoria / Melbourne
<http://www.aclca.org.au/cms-events/index.phps>

28 – 30 **Module B - Contaminated site assessment remediation & management: Effective site assessment**

University of Technology, Sydney / Sydney
<https://shortcourses-bookings.uts.edu.au/ClientView/Schedules/ScheduleDetail.aspx?ScheduleID=583>

28 **Contaminated sites**

Legalwise Seminars / Melbourne
<https://store.legalwiseseminars.com.au/jsp/session.jsp?sessionId=123V36>

29 **Contaminated sites**

Legalwise Seminars / Sydney
<https://store.legalwiseseminars.com.au/jsp/session.jsp?sessionId=123N42>

April

10 – 12 **Environmental microbiology & biotechnology in the frame of the knowledge-based bio & green economy**

University of Bologna / Bologna, Italy
http://www.claire.co.uk/index.php?option=com_civCRM&task=civCRM/event/info&Itemid=88&reset=1&id=198

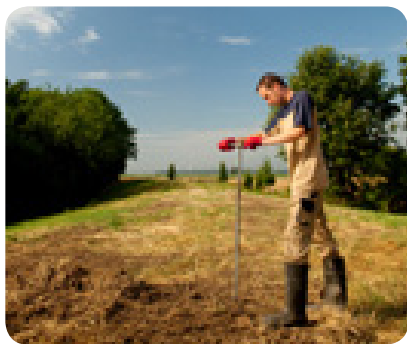
11 **Meet the new Chief of the EPA - Professor Campbell Gemmill, former CE of the Scottish EPA**

ALGA / Adelaide
<http://www.landandgroundwater.com/Industry%20Calendar.html>

16 – 20 **SRIT Advanced master class in Australian groundwater**

Sustainable Resource Industry Training (SRIT) / Perth
http://www.srit.com.au/course_details.php?id=9

Research RoundUp



Research Roundup aims to keep you up-to-date with current research on environmental contamination assessment and remediation in Australia. By keeping content succinct and focusing on particular projects, *Remediation Australasia* makes it easier for you to find the time to read about areas which are relevant to you. In this issue, the focus is on CRC CARE funded projects.

CRC CARE's second term of operation commenced in July 2011, and the research programs have an increased focus on helping to develop uniform national standards for assessing and remediating contamination. The outputs from the research programs will fill knowledge gaps and

allow adoption of remediation that balances health and environmental protection with economic and social considerations. With this focus in mind, the CRC has funded the following projects:

Endpoints for petroleum LNAPL remediation: technology performance and risk reduction

The most common and pervasive contaminants requiring management in urban and industrial environments are petroleum fuels – generically referred to as light non-aqueous phase liquids (LNAPLs). Globally, management costs are billions of dollars. LNAPL removal or destruction in the subsurface is highly problematic and what remains unclear is the level of risk reduction achieved by LNAPL remediation technologies. This research is aimed at determining the practicability and end points of LNAPL remediation technologies in geological settings typical in Australia. This is proposed in the context of the risk reduction achieved via remediation implementation.

A comprehensive side-by-side field comparison of remediation technologies is proposed, with outcomes used to inform multiphase and multispecies models of LNAPL removal and destruction. The models will first be formulated and tested against remediation technology effectiveness data available for a sand aquifer. Heterogeneities and complexities associated with fractured and dual-porosity aquifer field sites will be incorporated. Tests will be undertaken specifically to determine the conductivity/connectivity, and nature/distribution of geological structures within the aquifers that impinge on LNAPL distribution and remediation. Vapour and groundwater exposure pathways will be quantified pre- and post-remediation, and reductions in risk determined via partitioning studies and direct measurement. Performance indicators will be validated and improved based on the practicability end points reached by the remediation technologies. ■



State and international remediation and management frameworks: an overview

In May 2011 CRC CARE held a workshop to specifically consider a national remediation framework. The workshop acknowledged that there is a strong link between the proposed remediation framework and the COAG initiative for national harmonisation. CRC CARE is keen to focus on developing harmonised guidance on the practicalities of cleaning up contaminated sites, as well as regulatory practice that will build upon what is already available. The purpose of this project is:

1. to identify international remediation and management frameworks which may be suitable for adoption or adaption in an Australian context.
2. to survey Australian jurisdictions to identify:
 - a. current regulation of remediation and management of site contamination
 - b. barriers to the adoption of an Australian national framework for remediation and management of contaminated sites.

The outcomes of this project contribute to the work of the National Remediation Framework Steering Group for the development of the national remediation framework. The project will identify current state and territory regulation and international frameworks for the remediation and management of site contamination. It will include reference to the legislative basis of the frameworks under review. ■





Quantifying TPH in soils and sediments: measurement quality and novel analytical methodologies

Petroleum hydrocarbons are regarded as a major environmental contamination problem worldwide. High levels of variability in total petroleum hydrocarbon (TPH) analysis results and in the methods used present a major constraint on industry ability to comply with regulation and improve site remediation.

The National Environment Protection (Assessment of Site Contamination) Measure (NEPM) as varied 2011 proposes the use of new speciation bands based on health screening levels consistent with those issued by the Canadian Council of Ministers of the Environment, and recommends the use of performance-based analytical methodology for TPH in soil that specifies how to define and report the new TPH bands. Laboratories will thus be able to select from a range of extraction and analysis techniques, provided these can be demonstrated to be equivalent to an agreed reference method and their ongoing performance meets an acceptance criterion based on a suitable reference material. ■

Developing mechanism-based bioassays for environmental contaminant toxicity prediction

Intensive chemical use in agriculture, growing mining activities, urban sprawl, and industrial waste and spills have resulted in a range of contaminants being found in the land and waterways. This has made constant monitoring and risk assessment of the environment critical in ensuring public health safety.

Conventional monitoring methods have, until recently, almost entirely consisted of chemical analysis. The limitation of monitoring contaminants solely through chemical analysis is that a range of unidentified contaminants may be missed. Secondly, chemical analysis does not identify the accumulative effect that mixtures of chemicals in the same source may have on living organisms. In light of these shortcomings a number of cell-based bioassays have been developed to measure general toxicity and specific toxicity (mechanism-based assays). The latter assays developed thus far often generate misleading data because of limited understanding on gene regulation mechanisms in eukaryotic cells at the time of their development.

This project will use advanced knowledge in mechanistic toxicology to develop a battery of more sensitive bioassays tailored for analysing and predicting toxicity of environmental contaminants. The outcomes of the project will benefit regulators and researchers in the field of environmental contamination, as well as mining and remediation industries. ■



Mixed contamination: assessing the risks to human health and the environment

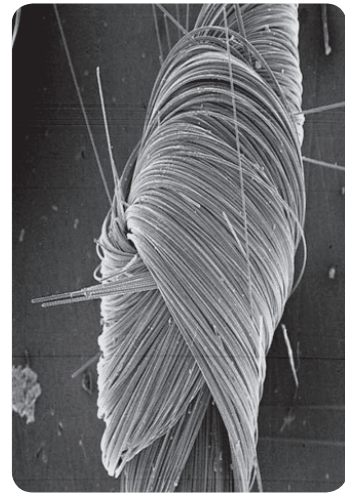
Identifying, measuring and delineating contamination with sufficient certainty to make good decisions within the available budget is a major challenge for risk assessors and remediators. Added to this uncertainty factor is the lack of reliable data on chemical mixture bioavailability and toxicity. Current measurement methodologies and technologies have many limitations which lead to uncertainty, time and cost in the site assessment process. Prior to the risk posed by contaminated sites being

estimated or any remedial activity undertaken, it is vital that the bioavailability and toxicity of contaminants are adequately understood. The results of quantitative toxicological tests play a key role in identification and evaluation of risk, and thereby increase remediation options for contaminated sites.

PAHs and toxic metals such as arsenic, lead, cadmium, zinc and chromium are the common co-contaminants present in former manufacturing gas-plants sites, which account for almost a third of all contaminated sites in this country. However, current toxicity assessments are generally restricted to individual contaminants and rarely are mixtures tested. This project fills data gaps needed for the risk-assessment of mixed contamination by generating scientifically based toxicological knowledge and also improve the current risk assessment methods by integrating the toxicity assays for ecological and human health. ■

Environmental risk assessment of nano-materials for soil and groundwater remediation

Current progress in the nanotechnology sector indicates that large amounts of manufactured nanomaterials could be intentionally released to the environment for the purposes of contaminated soil/groundwater remediation. Risk assessment of these technologies is urgently required due to uncertainties regarding their potential side effects upon release to the environment. Evidence is mounting that the transport of low-solubility contaminants may be facilitated by the presence of naturally occurring environmental nanoparticles. This suggests that manufactured nanomaterials used for remediation purposes may also, as a side effect, promote the movement and dispersion of contaminants away from the primary zone of contamination.



Possible risks relating to the bioavailability/toxicity of contaminants associated with nanomaterials also need to be addressed. Risk assessment of these materials has thus far been hindered by significant analytical challenges, but the experimental methods proposed in this project offer the means to circumvent those challenges and reduce the uncertainties associated with risk assessment of manufactured nanomaterials. The knowledge gained from this project will support the future design of effective yet sustainable nanomaterials. It will also mitigate the risk that premature application of unsuitable nanomaterials could hinder future commercialisation of sustainable nanoproducts by generating negative public perceptions and undermining future innovation. ■



Societal perceptions and acceptability of remediation technologies

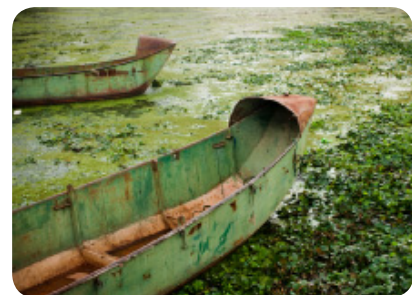
The continual growth of Australia's remediation efforts is dependent not only on the mechanical or technical sophistication and efficiency, but also on the acceptance and understanding of the wider community (Christensen 1997). The objective of this project is to address how communities can best be involved in the selection of remediation technology, and to help provide a robust evidence base to support effective community consultation

practices. The proposed project aims to:

- Contribute to the development of a needed evidence base that facilitates understanding of the ways in which community engage with, and can contribute to, enhancing value development through remediation;
- Allow Australian communities, governments and other key stakeholders involved in remediation to better understand the strengths of both unique and shared aspects of their processes, thus providing opportunities for learning and development;
- Develop and facilitate knowledge exchange to provide a comprehensive and shared information base of 'processes that work';
- Contribute to the strength of institutional arrangements that guide remediation processes. ■

Converting algae to renewable energy

Blue-green algae bloom is a severe environmental hazard to aquatic ecosystems and human health. According to a 2010 environment report published by the Department of Environmental Protection of PRC on water quality in China, over 60% fresh water has been contaminated. Blue-green bloom is one of the major causes.



This project focuses on an innovative technique for the remediation of algal blooms in lakes in Wuhan, China. These lakes are heavily contaminated with both nutrients and certain toxic substances. The presence of nutrients in all seasons except winter leads to severe algal bloom. Although significant resources have been spent on remediating these contaminated lakes, no positive outcome has been achieved thus far. In this proposed project, a long-term remedial option is considered which will focus on remediating the contaminated lakes using algae. To this end, algae will be farmed using the lake water and harvested for biofuel. This process will be continued until lake water and sediments are fully remediated. While a quick-fix solution is not guaranteed, researchers are confident that this approach will provide a long-term solution with significant associated benefits. ■



ARIC Update

The ARIC forum on LinkedIn has grown steadily over the last few months, and over 25% of all ARIC members are now listed in the group. The ARIC team is pleased to see so many members using this chance to network, and showing an interest in another facet of member communication.

Already an ARIC member?

Head to <http://linkd.in/nsO2TN> and send us a request to join the online ARIC forum.

As social media is still an area of negotiation and uncertainty for some organisations and individuals, we aren't expecting 100% of ARIC members to be represented, or participate in the group. Instead, ARIC will aim to engage and inform all members with relevant information as best as possible, using the available tools and ensuring that members, both online or offline, are still kept up-to-date.

Not yet a member?

Complete the membership form on page 25, or head to the ARIC website for a form:

www.remediationaustralasia.com.au

Recent communications through LinkedIn to members have included an update on the recording of the ARIC-hosted Health Screening Levels workshops, which toured Australia in November. To those interested in further access to the training material, DVD recordings

The screenshot shows the ARIC LinkedIn group page. At the top, there are navigation tabs: Home, Profile, Contacts, Groups, Jobs, Inbox, Companies, News, More. Below this is the ARIC logo and the group name: ARIC (Australian Remediation Industry Cluster). There are sub-tabs for Discussions, Members, Promotions, Jobs, Search, Manage, and More. The 'Latest Discussions' section contains four posts:

- ARIC MEMBER UPDATE - HSL Workshops, training DVDs, and Remediation Australasia Issue 8**: A post by a user with a profile picture, stating 'Hi all! The ARIC HSLs workshops are coming along really well - thanks to all who have attended... if you didn't make it to a ...' posted 1 month ago.
- Hi all - just a quick reminder that the ARIC Health Screening Levels workshops start next week!**: A post with the ARIC logo and 'Australasia Issue 8' text, stating 'Visit <http://aric.eventbrite.com> for more...' posted 1 month ago.
- Emerging Contaminants - TNT and RDX**: A post by Andrew, stating 'A colleague has sent me this interesting note from latest USEPA newsletter. I thought I would pass it onto the group for your ...' posted 2 months ago.
- ARIC training workshops - Health screening levels for petroleum hydrocarbons**: A post by Andrew, stating 'ARIC is coordinating a series of full-day training workshops regarding the CRC CARE health-based screening levels (HSLs) for petroleum ...' posted 2 months ago.

of the workshop (specifically, the Adelaide event) will be made available early in 2012. Only 50 copies will be made available; please visit www.crccare.com to purchase your copy. ■



Developing environmental experts.

CRC CARE supports the growth of highly qualified and suitably trained researchers and decision makers in environmental risk assessment and remediation through:

- ▶ PhD and Honours research opportunities
- ▶ workshop training for environment industry professionals
- ▶ linkages with other industry peak bodies
- ▶ focusing on end user needs
- ▶ a suite of publications and guidance documents
- ▶ hosting the biennial 'Cleanup' industry conference

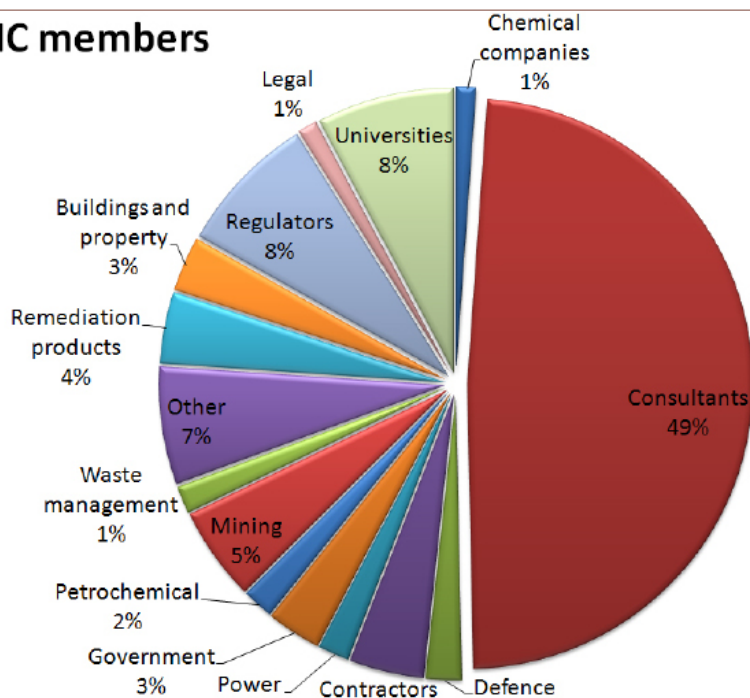
Contact CRC CARE for further information.



Cooperative Research Centre for Contamination Assessment and Remediation of the Environment

Contribute to *Remediation Australasia*

ARIC members



The quarterly *Remediation Australasia* magazine is distributed to all ARIC members by post and email notification. The magazine features a range of material of relevance and interest to members, including:

- Case studies
- Regulator updates
- Reports from industry groups
- Advertisements
- Full technical articles (typically 1–3 pages, including illustrative material)
- News relating to new technologies and developments in the industry, and
- Training, international conferences or events in Australasia.

The editorial team welcome your suggestions for content, as well as article submissions.

Submitted articles should clearly explain the topic of discussion (technology or research,

for example), implications for industry, and how this information can be used to facilitate change or greater understanding of important issues. Advertorial content will not be accepted when submitted as an article (instead, please contact the editorial team with your advertorial enquiries).

Please contact the editorial team if you are interested in contributing any content - whether it be an article or simply a photo. You won't have to sweat over the editorial details; we can edit and format your article ready for publication.

Want more information on advertising opportunities, or to submit your content to be published in upcoming issues of *Remediation Australasia*?

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