

# Remediation Australasia

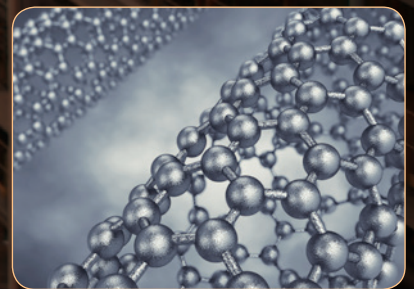
Alumina mining  
and red mud:  
**CONVERTING  
WASTE TO  
RESOURCES**



**GREENING  
HOUSEHOLD  
BEHAVIOUR**  
The role of public policy



**INNOVATIVE  
REMEDiation  
TECHNOLOGIES**  
Permeable reactive barriers to  
remediate groundwater



**NANOMATERIAL  
REGULATIONS**  
Regulatory reform for  
industrial use



Cooperative Research Centre for Contamination  
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.



Collaborations between major industry participants, researchers and end users, nationally and internationally



Producing a generation of young Australian professionals highly skilled at solving and preventing contamination



Extensive industry training and workshop program

Fast-tracking science to the field through a national demonstration sites program

Promoting industry access to new technology and knowledge through the Australian Remediation Industry Cluster (ARIC)

[www.crccare.com](http://www.crccare.com)



Welcome to the new edition of **Remediation Australasia**, which includes many exciting discoveries and announcements that I am glad to share with you. I must also include a special welcome to our many new members, both Australian and international.

The recent focus for both ARIC and CRC CARE has been on the rebid application. To share insight into this achievement with our international readers, CRC CARE was shortlisted for funding support from the Commonwealth's Department of Innovation, Industry, Science and Research. In the next stage of the application, a team of CRC CARE staff, researchers and partner representatives engaged in extensive second round interview process in September 2010. As a result, CRC CARE was successful in our bid for a further 9 years of funding support.

This month, our attention has been drawn away from the rebid – which continues to grow into a planning process about how to develop and transform into CARE 2 – toward several exciting new topics.

Firstly, the ARIC team has noted a trend in the increase of membership numbers. Our membership base has expanded gradually since the inception of ARIC in mid-2007. We continue to offer expert industry advice and insights into emerging technologies, and look forward to sharing new and innovative research and practices with you. As this occurs, we also anticipate our member base to continue to increase.

Secondly, we can proudly announce that the ARIC website is currently being utilised in more than 300 cities globally. With around 20-30 of those located in Australia, this means that our information is being disseminated to a widespread global audience, and contributing to remediation practices around the world. The impact of ARIC information is reaching further and moving faster than we anticipated.

Thirdly, we have redesigned our ARIC Member Forums to offer a more user-friendly experience to members. The *Ideas Generator* and *Solutions Generator* have been replaced by a united forum framework, in which there are several topics available for discussion. These topics are synonymous with the majority of industries that our members are aligned with. Please make yourself welcome in the Member Forums, add some information about yourself for other industry professionals to connect back with you, and contact us if you would like any new topics introduced.

I look forward to connecting with you all through your contribution to the Member Forums, and also via the upcoming communications in relation to CleanUp 2011, which is fast approaching.

Research completed for CRC CARE thus far this year has included a report on community attitudes to contaminated land, now published as Technical Report 17. You can access electronic copies of three recently-published technical reports, including no. 17, by following the links on the Publications page of this issue. An excerpt from these findings has been included in this issue of **Remediation Australasia**, as well as:

- an excerpt from a recent OECD study on trends in energy use
- calls for development of a new landfill site specifically to handle contaminated soil
- new administrative processes for assessment and notification of industrial nanomaterials
- red mud utilisation and remediation, and
- permeable reactive barriers as remediative techniques.

I hope you enjoy the content within this issue, and its focus on public attitudes and policy revision related to contamination and remediation industries. Attitudes and policies change with the times, and we too embrace the future and all the possibilities that come with it as we transform into CARE 2.

#### Prof Ravi Naidu

Managing Director, CRC CARE  
Editor, *Remediation Australasia*

**Remediation Australasia** is a quarterly industry magazine produced by the Australian Remediation Industry Cluster (ARIC) for the Australian remediation industry.

#### Circulation

The publication is currently distributed to more than 2,000 recipients throughout Australasia, free of charge.

#### Editorial and production

Editor: Ravi Naidu

Sub-editor: Andrew Beveridge

Sub-editor, production:  
Sharmin Patard

#### Editorial enquiries

Andrew Beveridge, CRC CARE  
T. 08 8302 3937 / M. 0429 779 226  
E. Andrew.Beveridge@crccare.com

Front cover image: The Pinjarra refinery (pictured) has a production capacity of about 4.2 million tonnes per year, making it one of the world's biggest alumina refineries. Image supplied by Alcoa; available at the Alcoa image library at [www.alcoa.com/australia/en/news/pictures.asp](http://www.alcoa.com/australia/en/news/pictures.asp). Alcoa ensures that its environmental scientists monitor rehabilitated mined areas, and was the first company to return 100% species diversity in mined areas.

Articles which appear in *Remediation Australasia* may be reproduced with written permission from ARIC and CRC CARE. Acknowledgement of the source of both the research and the story will be a requirement. This publication is provided for the purpose of disseminating information relating to scientific and technical matters. Participating organisations of ARIC and CRC CARE do not accept liability for any loss and/or damage, including financial loss, resulting from the reliance upon any information, advice or recommendations contained in this publication. The contents of this publication should not necessarily be taken to represent the views of the participating organisations.

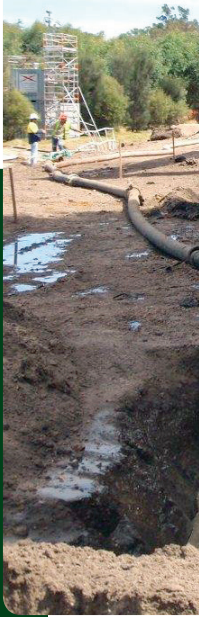


10

cover  
story



14



06

features

contents

**06 Greening household behaviour: the role of public policy**

A major survey of households offers insight into what really works when it comes to energy usage, and what factors affect people's behaviour

**14 Innovative remediation technologies**

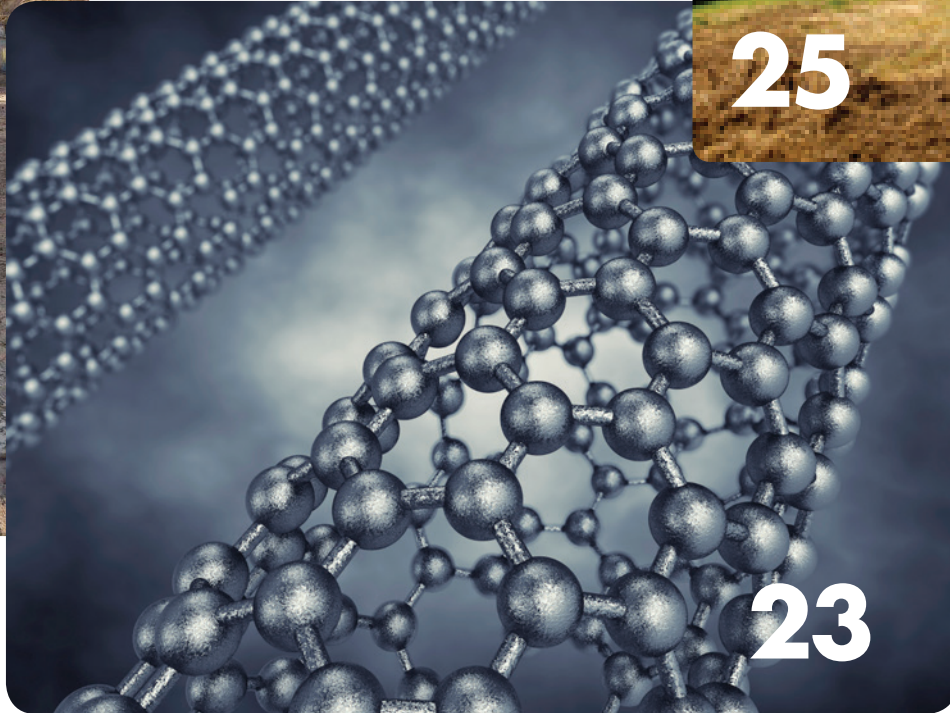
Taking a closer look at Western Australia's installation of what is believed to be the nation's first double-trenched permeable reactive barrier at Bellevue, a suburb in the Perth foothills

**10 Converting wastes to resources**

The caustic nature (high alkalinity) of red mud makes it a worldwide environmental problem, particularly when discharged in an inadequate way

**17 Risk communication**

The results of a CRC CARE-funded project are in. The goal? To better understand how Australian communities perceive and experience contaminated land and its remediation



25

23

every issue

## 23 Nanomaterials: emerging emphasis

The national industrial public consultation process proposes new administration for the notification and assessment of industrial nanomaterials

## 24 Landfills for contaminated soil

Industry's call for new landfill sites to solve obstacles faced by brownfield remediation

## 13 Publications Update

## 25 Research RoundUp

An update on current research focused on environmental contamination assessment and remediation in Australia



Greening household behaviour, and

# The role of public policy

An OECD survey of households offers insight into what really works when it comes to energy usage, and what factors affect people's behaviour.

As governments promote strategies to encourage more environmentally sustainable consumption patterns, this Organisation for Economic Co-operation and Development (OECD) survey of households offers insight into what really works and what factors affect people's behaviour. The study focuses on five areas: households' water use, energy use, personal transport choices, organic food consumption, and waste generation and recycling.

This article presents a condensed summary of the main results and the policy implications arising from the analysis of the survey responses. It is based on responses from over 10,000 households in 10 OECD countries: Australia, Canada, the Czech Republic, France, Italy, Korea, Mexico, the Netherlands, Norway and Sweden. Household consumption patterns and

behaviour have a profound effect on stocks of natural resources and the quality of the environment. As a consequence, governments have introduced a wide variety of measures to encourage people to take environmental impacts into account in their purchases and practices. Recent initiatives include the phasing out of incandescent light bulbs, the introduction of energy performance labels for homes, and the provision of tax incentives to purchase alternative-fuelled vehicles.

Provision of the right incentive is important in spurring behavioural change, and price-based incentives encourage energy and water savings. Households charged for their consumption on a volumetric basis consume approximately 20% less water than those who are not charged. They are also more likely to install water-efficient equipment at home. Similarly, charging households for the mixed waste they generate increases recycling volume, while higher fuel costs reduce car ownership and use. Pricing consumption on a volumetric basis provides a signal to households about consumption levels. Survey respondents indicated a lack of knowledge about their actual water and electricity consumption levels if their consumption is not metered at the household level. Metering and introducing a price on environment-related resource usage affected people's decision making, even if the price was very low. This suggests that campaigns to inform consumers about energy use in the home (e.g. by installing smart meters that display accurate real-time information) will affect household decisions to some extent, even at low prices. Introducing price-based measures and changing relative prices (for electricity, water, fuel or waste disposal services) is necessary to reduce emissions and conserve natural resources.

Environmental awareness and households' concern for the environment affect decision making. Respondents who expressed concern for the environment were more likely to adopt practices and make investments which reduce environmental impacts. Environmental awareness encourages water-saving behaviours and reduces the likelihood of owning a car. Concern for the environment also influences demand for energy-efficient appliances and renewable energy, as well as the intensity of waste recycling and decisions to consume organic food. In some cases, the effects may



be indirect – for example, concern for solid waste generation has a negative impact on the likelihood of drinking bottled water. This indicates that governments may need to bolster information campaigns to raise people’s environmental awareness and induce behavioural change. Increased awareness of the environmental impacts of consumption choices may also increase the political acceptability of policies, facilitating their implementation.

Social and environmental norms can be affected by policies, for instance on how we see the environmental good which is to be protected by the government measures. Households’ willingness to pay for a recycling program can be affected by intrinsic motivations like a sense of civic duty. As such, policy makers need to take into account the effect of different policy measures on individuals’ underlying norms. Despite consumer concern about the environmental impacts of their purchase decisions and possession of strong pro-environmental norms, a lack of access to information may prevent people from behaving accordingly. Product information is important and useful for consumers to make informed decisions. Eco-labels need to be clear and comprehensible to work and, as such, measures that encourage ease of identification and understanding of eco-labels are likely to be more effective.

Trust in the information provided (and the source of such information) is also central to their effectiveness. Moreover, labels prove to be particularly effective if they identify both ‘public’ and ‘private’ benefits. People are more likely to respond to eco-labels if the environmental benefits co-exist with more direct personal benefits, such as reduced energy bills resulting from energy-saving behaviour. The personal health benefits which many respondents associate with the consumption of organic food is another example. Eco-labels could exploit the potential for such private benefits to a larger extent, particularly since

people’s willingness to pay for improved environmental quality is often limited.

Demand-side measures such as collection services for recyclable materials, the provision of public transportation, or the characteristics of electricity supply tend to have a more significant effect on individual behaviour when implemented in combination with investments in environment-related services. For instance, access to public transport has an impact on people’s car ownership and how many kilometres they drive. Furthermore, the presence and quality of collection services for recyclables increases recycling participation and intensity, and recycling levels are highest when households have access to door-to-door collection services. However, there are costs associated with infrastructure provision.

“Relatively few households are prepared to spend more than 5% above their current electricity bill to use green energy, and almost half of them are not willing to pay anything.”

For instance, public transportation use increases significantly if the nearest stop is within five minutes of their residence, yet implementation of this can be exceedingly costly.

A drop-off scheme may be less effective with respect to recycling rates than a door-to-door collection scheme, but the service provision of the latter is likely to cost significantly more.

Governments may have to rely particularly heavily upon supply side measures in areas where

environment-friendly decisions tend to be only weakly driven by household demand. For instance, people do not seem willing to pay very much for ‘green’ energy, such as wind or solar, rather than conventional energy. Relatively few households are prepared to spend more than 5% above their current electricity bill to use green energy,

and almost half of them are not willing to pay anything.

Similarly, generally less than 15% of people want to pay a significant price premium for organic food products rather than conventional substitutes.

Overall, 30% of respondents are not willing to spend anything extra for organic food. This implies that underlying household demand for environmental quality is unlikely to be sufficient to reach ambitious policy objectives.



If there are significant political constraints on the introduction of measures which sufficiently increase the price of environmentally-damaging behaviour and consumption, supply-side measures will have a significant complementary role to play.

Under certain conditions, it may be necessary to combine instruments in order to increase the efficiency and effectiveness of policies. The combined use of market-based instruments, information-based policies, and supply-side measures has been discussed above. When implementing policy packages targeting household behavioural change, households may adjust only after a significant time-lag. Taking into account this delayed responsiveness to price incentives is particularly important when addressing certain environmental concerns where consumption is affected by choices related to investment in capital goods (such as appliances or vehicles), and even by the location and characteristics of their residence. The short-term response may be limited until households adjust their stock of durables and lifestyles, and different measures may provide incentives at different decision points. Some measures (prices) may have a greater impact on use, while others (labels) may primarily affect investment decisions. This underlines how instruments can usefully complement each other.

Environmental behaviour and responsiveness to policy measures vary across different segments of the population. Responsiveness to waste policies varies

depending upon whether households live in rural or urban settings, as well as according to housing type. In many cases, such variation reflects differences in costs and preferences across segments of the population, and is not necessarily directly policy relevant.

Demographic and socio-economic characteristics (age, education and others) can be used to define distinct segments of the population for which policies are likely to be most effective. For instance, information campaigns to modify personal transport choices will be most effective if they target those groups which have higher car use: men, the middle-aged, and those with higher incomes and education. Policies other than environmental can play a significant complementary role, such as revenue redistribution measures addressing distributional issues or housing policy. Many environmental policies are likely to have adverse distributional effects, particularly with respect to residential water use. Low-income households are likely to be most adversely affected by increases in water charges as they spend proportionately more than twice as much on residential water use than high-income households. When introducing measures to address possible disparities between income groups, policymakers need to ensure that the economic efficiency and environmental effectiveness of the policy remains intact. Analysis of environmental policy from the demand side is receiving increasing attention from governments, with issues such as the adoption of eco-innovations by households. ■

## *Engaging the Community* handbook **AVAILABLE NOW**

*'Engaging the community: a handbook for professionals managing contaminated land'* presents a framework for community consultation on contaminated site projects.

The handbook provides 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 a useful tool for state and local authority officers, site planners and environment agencies, and land owners, environmental consultants, contractors, and others involved in the management of contaminated sites.



**purchase your copy at [www.crccare.com](http://www.crccare.com)**



Call for Papers  
NOW OPEN

# CleanUp 2011

**6th International Workshop on Chemical Bioavailability  
in the Terrestrial Environment  
(7–9 September 2011)**  
and the  
**4th International Contaminated Site Remediation Conference  
(11–15 September 2011)**  
**Hilton Adelaide hotel**

On behalf of CRC CARE and the Australian Remediation Industry Cluster (ARIC), I invite you to join us for the biennial CleanUp conference, to be held at the Hilton Adelaide hotel, in South Australia.

CleanUp 11 will combine the 6th International Workshop on Chemical Bioavailability in the Terrestrial Environment (7–9 September 2011) and the 4th International Contaminated Site Remediation Conference (11–15 September 2011).

The CleanUp Conference is the premier Australian-based conference related to the contaminated site and remediation industry.

It is expected that CleanUp 2011 will have an attendance comparable to the 2009 conference, which attracted over 500 scientists, engineers, regulators, and other environmental professionals from 25 countries. Delegates were able to promote technology transfer and exchange information, innovations and developments in fundamental and applied environmental research towards the assessment, management and remediation of environmental contamination.

The organising committee is pleased to again have secured the Hilton Adelaide hotel as the host venue for the events. This medium sized venue enables attendees to focus on the tightly paced program and exhibits, and to easily meet and share ideas and information.

Ample networking will be possible with a full complement of lunches, receptions, and other meals being served during the breaks in the program. After the sessions conclude each evening there will be poster sessions and networking drinks, with the conference dinners again expected to be a highlight of the social program. At the conclusion of each day's activities, conference participants will find ample sightseeing, shopping and dining options nearby. Located on central Victoria Square, the Hilton Adelaide hotel is in the heart of Adelaide city.

Your contribution to these events is welcome as a presenter, sponsor, exhibitor or delegate.



I look forward to seeing you at the conference in 2011.  
I know you will value the experience.

**Professor Ravi Naidu**  
Managing Director  
CRC CARE



# Transforming wastes into resources

Yanju Liu, University of South Australia

Red mud is a waste product created through the bauxite refinery process. Its caustic (highly alkaline) nature makes it a major worldwide environmental problem, particularly if it is discharged inadequately, and it has become a problem that demands increasing attention from researchers.

Currently, large quantities of red mud are stored in impoundments or dumped into the sea near production sites, depending on the surroundings and the facilities available.

The disposal of large quantities of alkaline sludge is expensive, costing the industry about US\$3 per tonne of alumina produced. The residue treated with this method not only occupies a large area, but also poses a threat to the environment due to its high alkalinity and ability to leach.

As a toxic industry waste, red mud must be treated before discharge. Its impact on environmental and human health is contributed to by a range of events, including:

- conventional disposal on large areas of potentially productive land
- leachates generated during storage and potential risk to groundwater
- dry-season generation of fine dust and its transport to clean environments, and
- inhalation of fine particulate matter by animals and humans.

It is critical for environmental sustainability that red mud is treated prior to disposal onto land and into water bodies. The pH and sodium content of red mud worldwide and its adverse impacts are summarised in Table 1.

Most mined bauxite is produced in Australia. After they are mined, bauxites are refined locally or exported to other countries for processing.

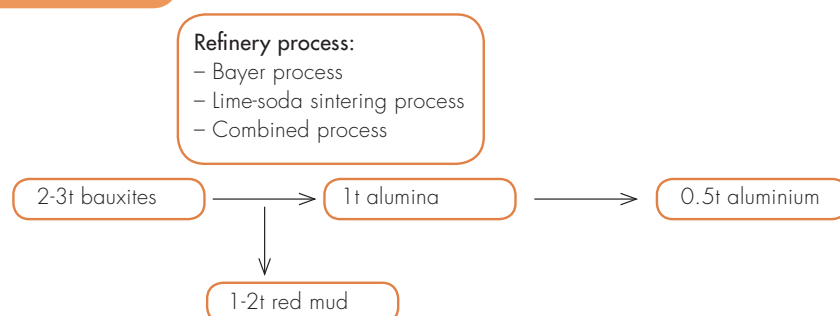
Australia has seven alumina refineries, producing mostly smelter-grade alumina for both domestic and export markets. There are numerous alumina refineries around the world, with the total production in 2011 exceeding 92 million metric tonnes.

“Treatment of red mud prior to disposal on or into land and water bodies is considered critical for environmental sustainability.”

## Refinery processes and residual waste

Aluminium (Al) is the most abundant metallic element in the earth's crust (more than 7% by weight) and the third most abundant of all elements (after oxygen and silicon). Its chemical reactivity means it is mostly found in an oxidised form, and almost never occurs in the elemental state. Aluminium hydroxide [Al(OH)<sub>3</sub>], mainly in the form of gibbsite, and the bauxite minerals boehmite [ $\gamma$ -AlO(OH)] and diasporite

FIGURE 1 Production chain of alumina and aluminium



	Red mud source	pH	Na/Na <sub>2</sub> O (%)	Toxic metals	Adverse impact
Australia	Kwinana	11.45	/3.4	-	Surface and groundwater contamination resulting from high pH leachate, adverse impact on soil physical properties, plant ecotoxicological impacts
	Pinjarra	11.63	/4.2	Cd, Cu, Pb, Hg, Ni	
	Wagerup	11.99	/3.2	-	
	Worsley	12.56	/2.2	-	
	Nabalco	12.44	/7.1	-	
China	Zhengzhou Changcheng	11.58	3.76/	Rb, Sr, Zr, Nb, Ba, Ce, Pb, Th	
	Shandong	-	/2.37	-	
	Shandong	-	/5.94	-	
Spain	Alcoa-San Ciprian	12.58	/8.40	Dy, Er, Eu, F, Gd, Pr, Tb	
Germany	-	12.08	/8.15	V	
Italy	Eurallumina	11.5	/12.06	Pb, Cd, Zn, Cu, V, Cr, As, Zr, Ba, Hg	
US	Reynold	11.04	/6.1	-	
Canda	Quebec	12	/7.16	Cu, Pb, As, Zn	
Hungary	-	10.5	-	Cd, Cr, Mn, Cu, Ni, Pb, Zn	
Suriname	-	10.6	-	Cd, Cu, Pb, Hg, Ni	
Adsorbents	For wastewater and gas treatment; anion adsorption, trace elements - heavy metals and metalloids, dye, organics, bacteria and virus				

TABLE 1 Worldwide production of red mud and its potential adverse environmental impact

[ $\alpha$ -AlO(OH)] are the basic raw materials for primary aluminium production. In addition, bauxite ore also consists of the iron oxides goethite and hematite, the clay mineral kaolinite and small amounts of anatase TiO<sub>2</sub>. Different alumina refining processes are applied depending on the composition of bauxite ore in different countries. Regardless of the method used, bauxite processing generates large volumes of waste residue in the form of red mud (Figure 1). The application of different refinery processes is summarised in Table 2.

The most popular method of alumina refinery is the Bayer process, with 95% of alumina produced via

this method. The traditional Bayer process is briefly described in Figure 2.

The Bayer process is used for fine quality bauxite and almyte ore, especially for bauxite with low levels of silica. Ground bauxite and caustic liquor are mixed with a small amount of lime to achieve pre-desilication by holding the mixture at approximately 100°C. Bauxite is then digested by washing with a hot solution of sodium hydroxide (NaOH), which converts the alumina to aluminium hydroxide. The other components of bauxite do not dissolve in red mud after filtering the solution.

The Bayer process is not sufficiently effective for processing low-grade bauxite ores containing

The world alumina industry has been operating for more than a century.

1856 - 1860

The birthplace of alumina industry was probably Salindere in France, where the calcination process was invented during this period

1858

Chadli proposes the production of alumina with the bauxite-soda sintering process

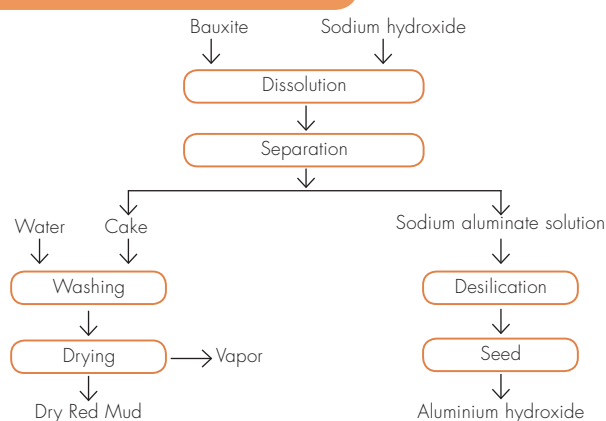
1880

The sintering process is improved by adding lime to bauxite in order to reduce the yield of sodium aluminosilicate

1889

Austrian KJ Bayer invents a process for dissolving alumina using caustic alkali solution, now known as the Bayer process.

FIGURE 2 Flow sheet of traditional Bayer process



The combined method (Bayer and calcination) incorporates three approaches:

1. The series process: the Bayer process occurs first;  $\text{Na}_2\text{O}$  and  $\text{Al}_2\text{O}_3$  from red mud are recycled in the procedure of calcination, especially applied for diasporite-bauxite
2. The multiple process: the Bayer and calcination processes are conducted separately;  $\text{NaOH}$  is produced in the calcination process and recycled in the Bayer process
3. The 'mixed combined process' deals with bauxite as well as red mud from the Bayer process.

Different types of red mud result from each of these processes.

substantial amounts of silica. The sintering method is an effective alternative, especially for processing almyte and nephelite. In sintering, bauxite ores are mixed with limestone and sodium carbonate (instead of sodium hydroxide) at a specific ratio; the mixture is then heated to a high temperature to form a clinker containing sodium aluminate ( $\text{Na}_2\text{O}\cdot\text{Al}_2\text{O}_3$ ), sodium ferrite ( $\text{Na}_2\text{O}\cdot\text{Fe}_2\text{O}_3$ ), calcium orthosilicate ( $2\text{CaO}\cdot\text{SiO}_2$ ) and sodium titanate ( $\text{Na}_2\text{O}\cdot\text{TiO}_2$ ). Soluble sodium aluminate is obtained by adding diluted alkaline solutions or water to the clinker. After desilication and injection of carbon dioxide ( $\text{CO}_2$ ) into the refined sodium aluminate solution, a precipitate of aluminium hydroxide is obtained. The remaining residue is red mud from the calcination method.

Increasingly, a combined approach incorporating both the Bayer and calcination method is used for alumina refining, particularly in areas where bauxite ores contain a high proportion of silica. This is especially common in China, where 15 m t of red mud are disposed of annually, and only about 10% of this is derived from a pure Bayer process.

### Characteristics of red mud

The adverse environmental effects of red mud are attributed to its highly alkaline pH and presence of sodium. There are numerous reports on the composition of red mud, which includes hematite (which gives it the characteristic red colour), goethite,

boehmite, titanium, quartz, sodalite, crinite-type sodium aluminium silicate and gypsum, with a minor presence of calcite, whewellite and gibbsite. The composition of red mud depends on the composition of native bauxite, which varies from one mineral deposit to another (Poulin, Blais and Mercier 2008, 'Transformation of red mud from aluminium industry into a coagulant for wastewater treatment', *Hydrometallurgy*, vol. 92). Chemical analysis reveals that red mud contains silica, aluminium, iron, calcium and titanium, as well as an array of minor constituents, including sodium, potassium, chromium, vanadium, nickel, barium, copper, manganese, lead and zinc. The major components of red mud across the world are shown in Table 2.

Aside from its composition, red mud also poses a difficult disposal problem due to other physicochemical properties. A substantial amount of caustic liquor (sodium hydroxide) and lime is added during the alumina refining process. Thus, despite being washed and considered as an inert solid waste, red mud residue remains strongly alkaline (Sushil & Batra 2008, 'Catalytic applications of red mud, an aluminium industry waste: A review', *Applied Catalysis B: Environmental*, vol. 81). It is also highly corrosive, with an average reported pH of 10–13.4.

Red mud is an extremely fine material in terms of particle size distribution, having an average particle size smaller than 10  $\mu\text{m}$  across. This makes it hard to precipitate, and many organic or inorganic matters must be added for its separation. Typically, 90% of its particles by volume are less than 75  $\mu\text{m}$  (Snars & Gilkes, Evaluation of bauxite residues (red muds) of different origins for environmental applications, *Applied Clay Science*, in press). The Brunauer-Emmett-Teller ('BET') surface area of red mud is around 7.3–34.5  $\text{m}^2$  per gram, which can be substantially increased using certain treatment methods as well as increasing the internal catalytic activity of red mud. Red mud particles carry a significant negative charge under the basic conditions due to ionised hydroxyl groups on their surfaces. Hydroxyl groups and the corresponding surface charge are primarily due to the silica-containing compounds formed in the alumina refining process.

Table 2. Composition of red mud generated in plants in different parts of the world

Country	Plant	Major composition (wt %)					Method
		$\text{Fe}_2\text{O}_3$	$\text{Al}_2\text{O}_3$	$\text{TiO}_2$	$\text{SiO}_2$	$\text{Na}_2\text{O}$	
Australia		40.50	27.70	3.50	19.90	1-2	Bayer
USA	ALCOA mobile	30.40	16.20	10.11	11.14	2	
	Arkansas	55.6	12.15	4.5	4.50	1.5-5.0	Bayer
	Sherwon	50.54	11.13	Trace	2.56	9.00	Bayer
India	Al.Corp	20.26	19.60	28.00	6.74	8.09	
	MALCO	45.17	27.00	5.12	5.70	3.64	Bayer
	HINDALCO	34.46	23.00	17.20	5.00	4.85	
	BALCO	33.80	15.58	22.50	6.84	5.20	Bayer
	NALCO	52.39	14.73	3.30	8.44	4.00	Calcination
China		6.85	7.29	2.45	13.89	2.73	
Hungary		38.45	15.20	4.60	10.15	812	
Jamaica		50.9	14.20	6.87	3.40	3.18	Bayer
Suriname		24.81	19.00	12.15	11.90	9.29	Bayer
Germany	Baudert	38.75	20.00	5.5	13.00	8.16	Calcination

# Publications Update

The following CRC CARE titles have been published since the last edition of *Remediation Australasia*. The publications may originate from research institutions, regulators or industry groups. Please let us know if you have any appropriate publications (no promotional material) to be included by sending details to [aric@crccare.com](mailto:aric@crccare.com).

## CRC CARE Technical Reports

**Technical Report no. 17:**  
*The Australian experience: A comparative analysis of the effects of contamination and its remediation on individuals and communities at two Australian sites*



**Technical Report no. 18:**  
*Selecting and assessing strategies for remediating LNAPL in soils and aquifers*



**Technical Report no. 19:**  
*Winery wastewater irrigation: Effects of sodium and potassium on soil structure*



Visit [www.crccare.com](http://www.crccare.com) to see our full suite of Technical Reports

## CRC CARE Fact Sheets

**Fact Sheet 12:**  
*PFCs (perfluorocarbons)*

Visit [www.crccare.com](http://www.crccare.com) to read our full suite of fact sheets.



## CRC CARE newsletters

**Remediator: Autumn 2011**

Visit [www.crccare.com](http://www.crccare.com) to read our full range of newsletters.



## CRC CARE media releases

**May 2011: Mining our manure mountains**

Visit [www.crccare.com](http://www.crccare.com) to see our full range of media releases.

Strategies for treatment	Examples
Neutralisation	Neutralisation for sewage, seawater and acid mine tailings
Making radiopaque material	New material can be used for the construction of X-ray diagnostic and CT scanner room
Producing composites	Epoxy/red mud, red mud/polyaniline
Ceramic production	Ceramic glazes
Building materials Bricks, cement, concrete, road base material	Bricks, cement, concrete, road base material
Metal recovery	Fe, Al, Ti, Ca, V, Sc,
Catalysis	Hydrogenation and liquefaction catalyst, hydrodechlorination catalyst, exhaust gas clean-up catalyst, miscellaneous reactions, oxidation of hydrocarbons
Revegetation	After amended by different amendments, it can be used for revegetation
Soil amendment	Soils contaminated by heavy metals
Adsorbents	For wastewater and gas treatment; anion adsorption, trace elements - heavy metals and metalloids, dye, organics, bacteria and virus

Table 3. Strategies for treating and reusing red mud

## Red mud remediation and reuse

To solve the red mud disposal problem, a large volume of research and development work has been carried out globally among industry actors, legislators and environment managers, but so far very few technically feasible and economical solutions have been found. Table 3 summarises the main strategies for remediating and reusing red mud.

The Bayer process is the most widely used method for the extraction of alumina from bauxite, although other methods including lime-soda sintering and a combination of Bayer and bauxite calcination processes are also being used. For every t of alumina produced, 1 to 2 t of red mud are released into the environment. Despite significant efforts by scientists and engineers, red mud still remains the major problem for alumina industry. Many strategies for the decontamination and reuse of red mud have been investigated in almost all countries with alumina refineries. These include:

- using red mud to manufacture building materials
- recovering heavy metals
- disposal into the ocean

- neutralisation with seawater or acid drainage
- making radiopaque (impenetrable to radiation) materials
- amending contaminated soil for revegetation
- remediating with bacteria for revegetation
- producing novel coagulants, adsorbents and catalysts for water treatment
- gas treatment or soil amendment, and
- reinforcement for functional materials.

Some of these strategies are quite effective, but they are not economical enough for implementation on the very large scale required, so red mud continues to pose a serious environmental problem. More recently, attention has focused on the use of red mud to produce novel material for waste treatment and management, in light of its negligible cost in raw form, the 'win-win' scenario achieved by reducing two or more wastes with a single process, and the potential for a novel product to generate income for waste management industries. ■

Permeable reactive barriers:

# Cost-effective, long-term solutions for groundwater contamination

Clare Nixon, Department of Environment and Conservation

A permeable reactive barrier (PRB) is an in-situ method for remediating contaminated groundwater. It combines a passive chemical or biological treatment zone with subsurface fluid flow management to address a wide range of groundwater contaminants such as chlorinated solvents, other organics, metals, inorganics, and radionuclides.

PRBs are a proven, effective means of treating chlorinated solvents, including trichloroethylene, in groundwater. PRBs can provide cost-effective, long-term solutions for many groundwater contamination problems. There are almost 200 PRBs worldwide. The very first was installed in California some 15 years ago and is still operating today. The most commonly used PRB configuration is a continuous trench perpendicular to groundwater flow, which is backfilled with treatment material.

Western Australia has installed what is believed to be the nation's first double-trenched PRB at Bellevue, a suburb in the Perth foothills. In February 2001,

Bellevue Waste Control (a liquid waste treatment and recycling facility) was destroyed by fire. The subsequent contamination at the site and beyond is complex. There are two groundwater plumes and a range of contaminants, including petroleum hydrocarbons and chlorinated solvents, which can be attributed to both historical site operations and the fire of 2001.

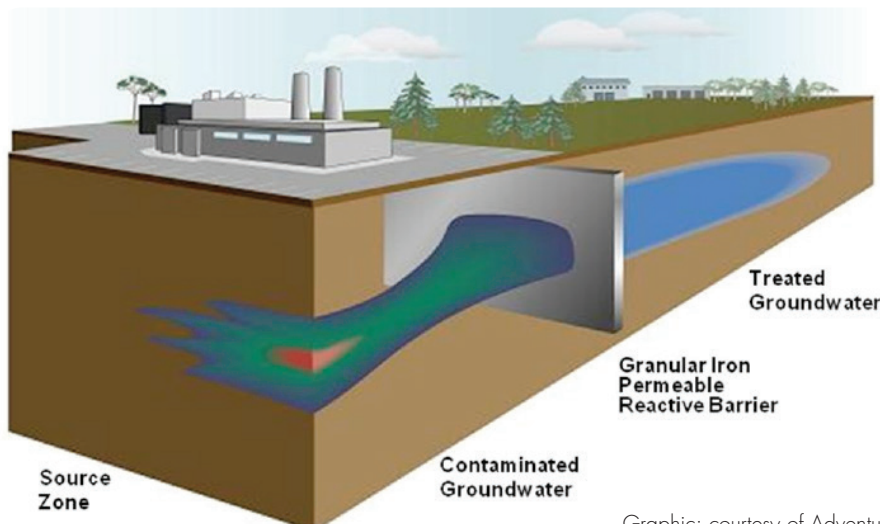
The WA Department of Environment and Conservation, on behalf of the state government, took over management of the site after the business went into receivership following the fire. Since then, there have been extensive and detailed investigations to determine the best clean up methods for the site, including consideration of techniques that have not yet been used in Australia.

## The Bellevue barriers

The project managers, Landcorp, contracted Menard Bachy, in partnership with Geo-Solutions, to install the permeable reactive barrier

at Bellevue in April 2010. The PRB comprises two parallel trenches, 76 m long by 9 m deep and 1 m wide, keyed in to a low permeability unit at the top of the underlying Leederville aquifer. The first wall is a denitrification barrier, filled with a mixture of sand and sawdust and installed upgradient of the zerovalent iron (ZVI) barrier to reduce the potential passivation of the ZVI by nitrates. The second trench, closest to the Helena River, is filled with a ZVI/sand mix to remediate the trichloroethylene. The percentage of ZVI in the ZVI/sand mix was increased in the central panel of the barrier to treat the most contaminated part of the plume. The trenches were constructed using a modified slurry trench technique that temporarily supported the trench excavation below the groundwater table using a biodegradable polymer slurry.

The PRB trenches were excavated with a 40 tonne long-arm excavator capable of excavating up to 12 metres deep. As each trench was excavated, bio-polymer slurry was added to maintain a constant slurry head above the natural groundwater table and to keep the trench open. The ZVI/sand mix was backfilled using a tremmie system. For the sawdust/sand mix, the backfill was placed with either the tremmie or by more conventional progressive displacement similar to the backfill method used for installing bentonite slurry walls. The ZVI differing density panels were separated using a removable end stop to ensure an effective partitioning of the mixes. Multi-level monitoring wells and temporary wells were installed as part of the backfilling process. Slurry



Graphic: courtesy of Adventus

inset and below left: images captured during the PRB installation process at Bellevue



aerial depiction of the Bellevue PRB installation site



The PRB trenches had to be widened to allow removal of the boulders, and this increased the materials required to fill the trenches. Although a geotechnical investigation had been undertaken, this was not comprehensive enough to provide an accurate soil

are located upgradient, within and downgradient of the PRBs in plume centreline and edge plume locations. The standard sampling parameters are:

- volatile organic compounds (chlorinated ethenes, ethanes, methanes, BTEX)
- nitrate, nitrite, ammonia and Kjeldahl nitrogen
- pH, electrical conductivity, total organic carbon, total dissolved solids, and
- field measurement of water level, redox potential, dissolved oxygen, pH and EC.

breaking agents were added via the temporary wells to degrade the bio-polymer once the PRB installation was complete. The PRBs have been designed for a minimum 15-year lifetime.

### Site characteristics and challenges

The Helena River is the main drainage feature of the area, and is located approximately 120 m from the base of the river valley escarpment where the PRB system has been installed. The flow of groundwater heads towards the Helena River.

The PRBs were constructed in difficult subsurface conditions. The subsurface along the alignment contained large deeply buried boulders and rocks which made excavation difficult and slurry support of the excavation problematic.

profile along the exact alignment of the PRB trenches.

During construction of the denitrification trench, microbial breakdown of the bio-polymer slurry was much higher than typical. The source of the aggressive microorganisms may have been the sawdust or the native soils. Warm (>20°C) groundwater temperatures may also have contributed to the aggressive breakdown of the bio-polymer.

### Monitoring the barrier

The PRB performance monitoring network consists of 48 monitoring points, comprising 13 multi-level monitoring wells with 1m screens, and six regional water table wells with 3m screens. The monitoring points

The PRB performance monitoring network will be gauged and sampled on a quarterly basis for the first year following installation. Following review and interpretation of the first year's monitoring results, this frequency may be increased or decreased depending upon the degree of variability observed and the stability of the groundwater chemistry observed. A separate strategy is being developed to clean up soil and groundwater contamination at the Bellevue site. The clean-up plan is expected to be finalised later this year, following further community consultation. ■



## 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

[www.crccare.com](http://www.crccare.com)



# Community attitudes to contaminated land

Jason Prior and Emma Partridge, University of Technology, Sydney

The results of a CRC CARE-funded project are in. The goal? To better understand how Australian communities perceive and experience contaminated land and its remediation.

There are potential environmental health risks to people living in proximity to contaminated sites. This risk garners legitimate interest by the surrounding communities, in relation to how the contamination and subsequent remediation and reuse of the land is managed by government and public agencies, and industry and commercial stakeholders. Significantly, studies exploring community perceptions and attitudes to land contamination and the related remediation within the Australian context are extremely limited.

In an effort to address this research gap, CRC CARE funded a project to respond to the need expressed by regulators, site managers and other practitioners in the industry to better understand how Australian communities perceive and experience contaminated land and its remediation.

Two case study sites were selected, both in New South Wales, Australia – the Botany Area, consisting of the Botany Industrial Park and adjoining Southlands site, and the North Lake Macquarie Area, consisting of the adjoining industrial sites of Pasminco Metal Sulphide Ltd and Incitec Pivot Cockle Creek. Both study sites have been exposed to a range of toxins from over a century of industrial activity, with the resulting contamination extending beyond the industrial property boundaries into the surrounding residential areas.

A mixed method research approach was adopted to generate primary empirical data on community perceptions of contaminated land and its remediation. Methods included media content analysis, stakeholder analysis, community surveys, interviews and focus groups. The quantitative outcomes of the telephone surveys conducted are the key focus of this report, supplemented by the results of other qualitative research. Similarities were found between the experiences and perceptions of the residents in the two case study sites, and those held by other research communities, both in Australia and internationally. Five themes were identified for exploration in the project, and are listed as the headings in the following tables.

These tables present the main findings of the research and suggest some possible implications. The authors wish to stress that because the research was case-study based, and the findings specific to the two locations studied, these suggested implications are tentative only, and further research would be needed to test the degree to which the findings and the apparent implications of this particular study might be relevant more broadly.

## **Issue: Residents' level of concern about and interest in local contamination and associated remediation**

Main findings	Possible implications
<ul style="list-style-type: none"><li>• Respondents were generally concerned about local contamination and associated remediation processes, and interested in keeping up to date with relevant information.</li><li>• Age was a factor that affected levels of concern and interest. In both case study areas people in older age groups (35–54, 55–74, 75+) reported higher levels of concern and interest than those in the youngest age group (18–35).</li></ul>	<ul style="list-style-type: none"><li>• A high level of concern about a given contaminated site can be expected among local residents, who are also likely to be interested in receiving up to date information about both the contamination itself and its remediation.</li><li>• Risk communication strategies need to be tailored to different age groups, to take account of different levels of concern and interest.</li></ul>



**Issue: Residents' sources of information about local contamination and remediation**

Main findings	Possible implications
<ul style="list-style-type: none"> <li>Residents were most likely to receive information about the contamination and remediation from the following sources (in descending order): local media, the remediating company, and local councils.</li> <li>Residents were least likely to receive information from community or environmental groups, and the State Government.</li> <li>Residents typically received information from only one or two sources.</li> <li>Media was the most common source for those receiving information from only one source.</li> </ul>	<ul style="list-style-type: none"> <li>Residents receive information on local contamination and remediation from a fairly limited range of sources, with a large proportion likely to access only the information provided by the media or the remediator.</li> <li>Reliance on limited information is likely to effect residents' perceptions of the issue – particularly given their varying levels of trust in different sources (discussed below).</li> </ul>

**Issue: Perceived trustworthiness of information sources**

Main findings	Possible implications
<ul style="list-style-type: none"> <li>Information sources that were rated most trustworthy were (in descending order): community and environmental groups, local government and other residents.</li> <li>The information sources that residents rated less trustworthy were those that might be described as more 'distant' from the local community. They included (in descending order): the media, the NSW government, the remediators and associated private companies.</li> <li>Those who had actually received information from a particular source rated that source as more trustworthy than those who had not.</li> <li>The majority of respondents received most of their information from the sources that they trusted <i>least</i> – namely the local media and the private company conducting the remediation.</li> </ul>	<ul style="list-style-type: none"> <li>The source of information provided to residents is important, because people can be expected to have varying levels of trust in different sources. Levels of trust are likely to be associated with how 'close to the community' those sources are perceived to be.</li> <li>Simply providing information has the potential to increase people's level of trust in that particular source. This suggestion is supported by international research that suggests that if people are not provided with sufficient information, their level of trust can decrease as their level of uncertainty and stress about the situation increases.</li> <li>Information and communication strategies need to give careful consideration to the impact of providing information through particular sources, or relying on limited sources to provide residents with information.</li> </ul> <p>Current approaches to information and communication strategies may not be making effective use of those information sources that residents are most likely to trust. There may be opportunities for industry and government to work more closely with community and environmental groups, local councils and local resident groups to assist with the provision of accurate, transparent and timely information to residents.</p>

**Issue: Residents' level of confidence in the remediation processes**

Main findings	Possible implications
<ul style="list-style-type: none"> <li>A variety of factors including age, gender and the presence of children in the household were found to affect the level of confidence that local residents had in the remediation. In general:                             <ul style="list-style-type: none"> <li>men were slightly less confident about remediation than women</li> <li>older age groups were more confident</li> <li>those with children in the household were less confident.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Information and communication strategies need to be sensitive to demographic factors that affect people's level of confidence in remediation processes. Tailoring and targeting information at those likely to have lower levels of confidence in the remediation may be an effective strategy.</li> </ul>

**Issue: Impact of awareness of contamination on residents**

Main findings	Possible implications
<ul style="list-style-type: none"> <li>The majority of survey respondents reported that awareness and knowledge of the contamination and remediation had not changed the daily habits of their household, however a minority reported changing a range of daily or household habits.</li> <li>For some residents, awareness of the contamination had disrupted or inverted normal assumptions about the security, safety and privacy of their home.</li> <li>For some residents, awareness of the contamination appears to have changed their perception of the local environment from something that is a 'benign backdrop' to everyday life to something about which they had a heightened awareness, and for some, a sense of distrust, suspicion or invisible threat or danger.</li> <li>For some, a significant impact was the need for various 'experts' or 'authorities' to be involved in their daily lives, which for some lead to a feeling of loss of control to 'outsiders'.</li> </ul>	<ul style="list-style-type: none"> <li>There is a need to acknowledge the significant impacts that awareness of contamination can have on people – beyond any obvious physical risk. As the literature suggests, these impacts can include a destabilising of people's core assumptions about fundamental aspects of their life. Feelings of trust, health, safety, privacy, security, and a sense of control can be replaced by distrust, perceptions of loss of health, security, and control. These concerns can manifest themselves for residents at both the household level, and in terms of their relationship to the local environment.</li> <li>Strategies to communicate with or engage the local community in relation to a contamination issue need to be respectful of the potential 'lifescape' impacts that residents may experience. This needs to be considered independently from the assessment of any physical risk, and strategies should be developed to address these impacts.</li> <li>Remediation or risk reduction strategies that involve the need for 'experts' and 'authorities' to become involved in people's daily lives (for example, by entering their homes or gardens), need to be sensitive to the potential psychological impact of this experience on residents, and should preferably include measures to increase residents' sense of control over the situation.</li> </ul>

**Issue: Residents' interpretation of and response to risk**

Main findings	Possible implications
<ul style="list-style-type: none"> <li>Respondents drew on a range of different knowledges in interpreting risk and formulating their responses to the contamination and remediation.</li> <li>Expert knowledge can reduce uncertainty about contaminated environments and the increased danger that they pose; however, it can also induce fear and stress in residents.</li> <li>Lay knowledge emerging from the tangible experiences of local residents plays a key role in reducing uncertainty and providing people with a sense of control over the contamination risk that they face in their home and local area.</li> </ul>	<ul style="list-style-type: none"> <li>Authorities need to understand that local residents are likely to draw on a combination of knowledges, including both expert and lay knowledge, in interpreting risk and formulating their responses to the contamination issue.</li> <li>Local residents often trust and place greater significance in personal experiences than in 'expert' risk-based communication. This knowledge plays a key role in reducing uncertainty and providing people with a sense of control over the situation. Authorities should consider ways of incorporating these kind of 'personal experiences' into risk communication materials (such as through the use of case studies or profiles of residents and their experiences).</li> </ul>



**Issue: Community experiences of and responses to stigma associated with contamination and remediation**

Main findings	Possible implications
<ul style="list-style-type: none"> <li>• A sense of stigma associated with the contamination was intertwined in complex ways with broader histories of stigmatisation associated with the particular locations under study.</li> <li>• Residents explained that borders ‘marking’ places affected and not affected by contamination were socially constructed around suburbs, with suburb names becoming the primary means of identifying contaminated areas (rather than the more precise borders defined by scientists or contamination experts).</li> <li>• Between a quarter and a half of respondents thought that other people’s perceptions of their area were negatively affected by the contamination issue.</li> <li>• Just over half the residents thought the remediation had not affected people’s perceptions of their area – that is, that perceptions were no better or worse as a result of remediation.</li> <li>• Most respondents were neutral or unsure whether the media had any impact on perceptions of their area. On balance, in the NLMA study, media portrayals of the contamination and remediation were deemed to have had a slightly positive impact, while in Botany respondents thought media impact had been slightly negative.</li> <li>• The views of property owners about whether their property value had been adversely affected by the contamination were varied, with those in the NLMA study more negative than those in Botany. Differences in perception were most noticeable in the suburbs closest to the contaminated sites in each area.</li> <li>• NLMA residents reported a wide range of tactics used by real estate agents, property developers and owners to reduce the stigma associated with the contamination and increase property values. These included changing suburb borders, renaming suburbs and ‘talking up’ the potential gains to be made by buying into the area before remediation.</li> </ul>	<ul style="list-style-type: none"> <li>• Consideration needs to be given to the way in which stigma associated with contamination might compound other forms of stigma that may already be affecting a local area.</li> <li>• When providing technical or scientific definitions of a ‘contaminated area’, experts need to be aware that these will be interpreted and understood in different ways by the community. ‘Official’ borders may quickly be replaced with more intuitive divisions based on already known boundaries (such as between suburbs). Authorities need to anticipate and plan for this.</li> <li>• Authorities need to be aware that residents are sensitive to the ways in which their local area (and their property values) are perceived by others – including those living outside the area, and the media.</li> </ul> <p>With many people suggesting that perceptions are not changed as a result of remediation there may be a need to more effectively explain and promote the results and benefits of remediation.</p>

**Issue: Perceptions of whether community views influence the remediation process**

Main findings	Possible implications
<ul style="list-style-type: none"> <li>• A large proportion of residents in the study areas believed that the community’s views had some influence on the remediation process.</li> </ul>	<ul style="list-style-type: none"> <li>• When residents make their views known, or see others doing so, it is important that they also see an appropriate response from the remediators or responsible authorities. When this happens, residents feel positively about their capacity to influence the decision-making process.</li> </ul>

<b>Issue: Impact on community relationships</b>	
<b>Main findings</b>	<b>Possible implications</b>
<ul style="list-style-type: none"> <li>• While views were mixed, a significant proportion of residents perceived the experiences of contamination and/or remediation to have had a community-level impact.</li> <li>• Of those who perceived such an impact, a larger proportion felt that the experience had helped bring the community together, with a minority feeling it had caused community divisions.</li> </ul>	<ul style="list-style-type: none"> <li>• Those designing communication and engagement strategies need to be aware of the potential for community-level (as opposed to just individual) impacts. This is supported by a number of international studies that show awareness of contamination can not only have significant impacts on individuals but can transform the social structures through which people engage with their community.</li> <li>• There is potential for community level impacts to be positive, rather than negative. There are exciting opportunities to explore how effective engagement strategies and appropriate industry and government responses to community concerns might help strengthen community cohesion.</li> </ul>

<b>Issue: Residents' actions in response to contamination and remediation</b>	
<b>Main findings</b>	<b>Possible implications</b>
<ul style="list-style-type: none"> <li>• Residents engaged in a diverse range of activities in response to their awareness of the contamination and/or remediation. These included various forms of what one survey respondent called 'meeting and dialogue' within the community, ranging from discussions between neighbours, to public meetings and information sessions, protests or rallies, and participation in community groups that were engaged in the issue. The most common form of action taken was to discuss the contamination with neighbours.</li> <li>• While some people were relatively active, over half of NLMA residents and just under half of BA residents had not engaged in any type of activities as a result of the contamination and remediation.</li> </ul>	<ul style="list-style-type: none"> <li>• Many local residents can be expected to engage in a range of activities in response to their awareness of the contamination and/or remediation. Talking with neighbours is the most common form of social activity that residents are likely to engage in.</li> <li>• A large proportion of local communities may not engage in any social activity in response to the issue.</li> <li>• Engagement strategies need to acknowledge the range of ways people choose (or choose not) to engage with the issue, and encourage and support a range of responses. Specific strategies will be needed in order to provide appropriate opportunities for those who are 'hard to reach' to engage with the issue.</li> <li>• Authorities should respect people's preference for discussing the issue with their neighbours, and where possible provide opportunities to facilitate this (such as community meetings, workshops, information days or stalls at community events).</li> </ul>

While approximately half of the survey respondents in both areas had discussed the contamination with their neighbours, far fewer had engaged in more active forms of community or individual action. By providing alternative and possibly more accessible opportunities for engagement may be another way for site managers and government agencies to improve affected residents' level of satisfaction with the contamination management and remediation processes.

The themes explored in this research project, and the findings presented, provide a useful starting point for future research. The results warrant consideration by

those charged with the regulation and management of contaminated sites in Australia, contributing to a deeper understanding of community perceptions, which in turn has the potential to inform the development of more effective community engagement practices across this industry.

The information in this article is an excerpt from CRC CARE Technical Report 17 (which resulted from a research project conducted by Jason Prior and Emma Partridge) entitled *The Australian experience: A comparative analysis of the effects of contamination and its remediation on individuals and communities at two Australian sites.* ■



# Subscribe today to *Remediation Australasia*

*Remediation Australasia* is a quarterly magazine produced by the Australian Remediation Industry Cluster (ARIC) for the Australasian remediation industry.

The publication is currently distributed to ARIC members and contributors throughout Australasia, free of charge.

Each edition of *Remediation Australasia* includes a range of full technical articles, regulator updates, case studies, training events, publications, and news relating to new technologies and research developments, keeping the reader ahead of the public debates and scientific advances within the industry.

It informs people working in the Australasian remediation industry about new research and outcomes that may impact on their business, and helps them to better respond to the challenges of dealing with contamination.



## Subscribe to *Remediation Australasia* today

Name .....

Occupation .....

Organisation .....

Address .....

Town/City .....

State .....

Postcode .....

Country .....

Phone .....

Email .....

EMAIL [aric@crccare.com](mailto:aric@crccare.com)  
POST P.O. Box 486, Salisbury South, SA, 5106  
FAX +61 (0) 8 8302 3124

# Nanomaterial regulations: proposed changes and public consultation

In the December 2009 edition of the ARIC magazine, it was reported that the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) had initiated a series of public consultation meetings on a proposal for regulatory reform related to industrial nanomaterials.

It was expected that the consultations would be an opportunity to gather information on the impact and feasibility of proposed changes to industrial nanomaterial regulations from business, the community and government.

NICNAS has recently announced the outcome of this public consultation by proposing new administrative processes for the notification and assessment of industrial nanomaterials, which will be of interest to companies introducing nanomaterials as new chemicals in Australia. Visit [www.nicnas.gov.au/Current\\_Issues?Nanotechnology.asp](http://www.nicnas.gov.au/Current_Issues?Nanotechnology.asp) to view the consultation documents.

The new administrative processes are for notifying about, and assessing, industrial nanomaterials that are considered new chemicals under Part 3 of the *Industrial Chemicals Notification and Assessment Act 1989* (the Act). These new arrangements came into effect from 1 January 2011, and were published in the Australian Government's Chemical Gazette (5 October 2010). They now apply to any new chemical that falls under the following working definition of 'industrial nanomaterial':

"industrial materials intentionally produced, manufactured or engineered to have unique properties or specific composition at the nanoscale, that is a size range

typically between 1 nm and 100 nm, and is either a nano-object (i.e. that is confined in one, two, or three dimensions at the nanoscale) or is nanostructured (i.e., having an internal or surface structure at the nanoscale)."

Some important points regarding the above definition are as follows:

- intentionally produced, manufactured, or engineered materials are distinct from accidentally produced materials
- 'unique properties' refers to chemical and/or physical properties that are different because of their nanoscale features, as compared to the same material without nanoscale features, and result in unique phenomena (e.g. increased strength, chemical reactivity, or conductivity) that enable novel applications
- aggregates and agglomerates are considered nano-structured substances, and
- where size distribution shows 10% or more of a substance (based on the number of particles) is at the nanoscale, NICNAS will consider this substance a nanomaterial for risk assessment purposes.

The administrative changes will cover exemption, certificate, and permit categories. Introducers will also be required to provide additional information under certain circumstances.

The use of nanomaterials in both commercial products and industrial applications, particularly in the environmental remediation field, has increased greatly in recent years.

While many of the novel properties of nanomaterials may be beneficial, there are still concerns about the uncertainty that nanomaterials present to health, safety and the environment due to the lack of adequate international research. To date, there is limited research into the potential hazards of these materials, but research is being undertaken in these areas.

In some instances, this research is starting to identify possible health concerns relating to specific kinds of nanomaterials. Use of these materials is uncertain, and therefore the changes in notification will initiate data collection and formation of a national inventory.

As reported in the earlier Remediation Australasia article, new technologies are not introduced without some risk, and this risk needs to be understood and managed. An important part of this process is research to develop the understanding and education to inform those who need to know. Nanotechnology has far reaching implications for our society, and it is important that we embrace what the technology has to offer without shying away from the challenges it presents us with. ■

# Developers call for new landfill to store contaminated soil

Ilia Rostami, FMG Engineering

The Master Builders Association of Victoria is calling on the state government to create a new landfill site equipped to store contaminated soil. The issue will be raised in a submission to an Environmental Protection Agency (EPA) licensing fee review, which is also urging the regulatory body not to increase landfill levies.

Calls for development of a new landfill site specifically to handle contaminated soil are being made, in light of concern that current arrangements and levies are posing as significant obstacles for brownfield redevelopment.

“...current arrangements and levies are posing as significant obstacles for brownfield redevelopment.”

On 1 July 2007, the EPA increased its levies (imposed on landfill operators) for Category B and Category C material by 862 and 169% respectively. The current levy is \$250 per tonne for Category B, and \$70 per tonne for Category C.

“A significant obstacle to project viability in the inner suburbs is the high cost of managing contaminated soil waste,” Master Builders Association of Victoria executive director Brian Welch said.

“A big increase in the levy imposed by the EPA in 2007 forced up the cost of storing contaminated waste, leading to a surge in building costs. During the financial crisis this increase contributed to the postponement and cancellation of some projects.

“Similarly, any rise in the current cost of disposing of contaminated material will mean that many important housing developments, particularly within the inner metropolitan area, may not be viable.”

Lyndhurst Landfill is the only site in Victoria equipped to receive contaminated soil. On January 1 2011 the ‘gate rate’ for storing Category B contaminated soil at Lyndhurst increased from \$715 to \$737 per tonne, and from \$517 to \$539 per tonne for Category C material.

“There is a desperate need for a second facility to store contaminated soil,” Mr Welch said.

“The creation of a second waste storage facility would provide the building industry with the facility it needs to continue to produce the essential housing and infrastructure Victorians need.

“Due to the historical nature of Victoria’s industrialisation, and high levels of arsenic in our soil, brownfield site development here is already considerably more expensive than in any other state. We need to address this issue now.”

Visit [www.bit.ly/EPAReview2011](http://www.bit.ly/EPAReview2011) for more information about the EPA review. ■

## FAST FACTS

Victorian developers sent 13,310 tonnes of contaminated soil (Category B) off-site in the 2009/10 FY. In the same year they sent 233,523 tonnes of low-level contaminated soil (Category C) off-site.

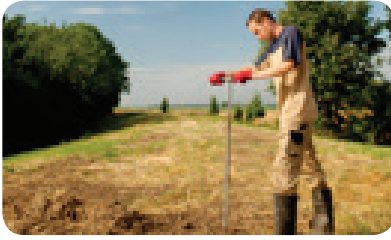
The ‘gate rate’ for storing Category B contaminated soil at Lyndhurst Landfill increased from \$715 to \$737 per tonne on 1 January (2011).

The ‘gate rate’ for storey Category C material rose from \$517 to \$539 per tonne.

On 1 July, 2007, the EPA increased its levies for Category B material by 862%, and its levies for Category C material by 169%.



# Research RoundUp



Research RoundUp, an ARIC initiative and recent addition to *Remediation Australasia*, features current research on environmental contamination assessment and remediation in Australia. 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. ■

## Plant uptake of soil contaminants, bioavailability and human health risk

Vegetable crops grown in soils that are unknowingly contaminated can pose a risk to the health of consumers. This project has focused on the assessment of exposure by inorganic and organic contaminants in contaminated soils collected from various areas across Australia, especially land previously used for agriculture or industry. Specifically, the research investigated land contaminated with metals (Cu, Cd and Pb) as well as organics (DDT, dieldrin and chloridane). The overall objectives of this research were to:

1. Assess the potential for contaminant uptake by vegetable crops commonly grown by Australian gardeners

2. Develop a soil-to-plant transfer model for contaminants to be incorporated into an exposure pathway assessment model, and
3. Develop a bioavailability transfer model from plants to humans using animal models.

Six vegetables commonly grown in Australian backyards, including lettuce, radish, silverbeet, zucchini, carrot and cabbage, were selected for contaminant uptake studies using field and laboratory-spiked samples. The highest plant tissue concentrations of arsenic, lead or DDT were observed in plant roots, with progressively less in the tuber, stem, leaf and fruit. However, the highest cadmium concentrations

were observed in the above-ground tissues.

Uptake studies with these vegetables under hydroponic conditions found no yield effect with increasing concentrations of arsenic, lead or DDT in plant tissue. In contrast, yield decreased significantly with increasing levels of cadmium. Because the majority of daily contaminant exposure for people is primarily through soil or dust exposure, the model developed is also able to take into account the ingestion of contaminated soil. ■



## Use of ultrasound technology for treatment of organic pollutants

Some organic contaminants, such as dichlorodiphenyltrichloroethane (DDT), are more persistent and toxic than others. While DDT as a pesticide has assisted food production and saved many lives by suppressing malaria-carrying mosquitoes, it is known to accumulate in the food chain. This can damage the human nervous system and cause cancer. Despite a global ban in 2004, a history of indiscriminate use has resulted in a very large number of DDT-contaminated sites around the world.

In Australia, significant quantities of DDT still exist in old stock dip sites and may be causing groundwater contamination. Although limited information is available on

remediation of DDT in sands, no research has been focused on difficult soil fractions of clay, silt and organics where the DDT is more tightly held.

It is known that various wavelengths of acoustic energy are able to break down a range of complex organic molecules, including DDT. This PhD project combined heat and surfactants with lower energy ultrasonics, resulting in a cheaper and more practical technique to break the strong adhesion of DDT to soil particles. This allows the DDT to then be collected and disposed of by incineration or other means. The work also identified aspects of reactor size and shape that were critical for overall energy transfer. Similar ways to treat chloroform as

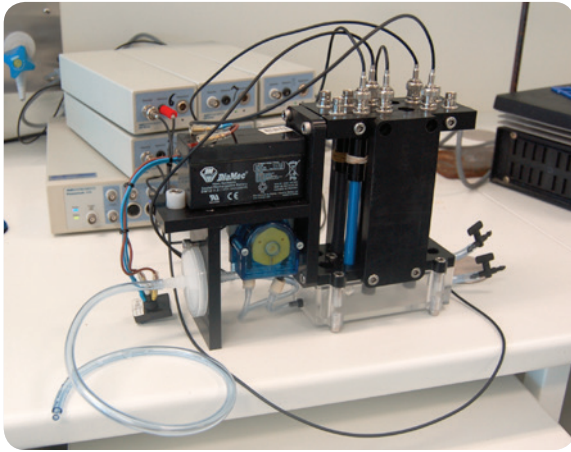


a contaminant in rural groundwater supplies were also identified.

The way DDT tends to be isolated in hot spots on farms makes it especially amenable to the batch treatment which this approach has made possible. It also offers the prospect of a new green, affordable technology for the management of DDT contamination wherever it is found. This PhD research was selected for special presentation by the CRC Association at its 2010 national conference. ■



## Bridging maths and chemistry in sensor development



Strong interaction among metal ions and sensor electrodes can generate signal interference that is difficult to compensate for. CRC CARE PhD student Liang Wang, based at the Mawson Lakes campus of UniSA, has developed a new pattern recognition algorithm that overcomes the interference from copper, calcium and chloride ions to sensors designed to monitor levels of lead, cadmium and other metal contaminants.

The new software gives environmental managers a clearer picture of what compounds are present and in what concentrations. It also represents a three- to nine-fold improvement in accuracy over standard sensor arrays now in common use. ■

## Re-use of industrial waste and domestic waste as nutrient resources

This research aims to immobilise and/or eliminate contaminants so that wastes can be converted to useful products. Waste streams investigated include those generated by steel makers, mining and smelting activities, seafood processors and breweries. In particular, materials being tried as adsorbing agents for heavy metals in wastewater include organic waste (crushed tree bark, compost, filter press mud, shellfish waste and yeast waste), and inorganic waste (steel and blast furnace slag, coal fly and bottom ash, water treatment sludge and red mud).

Recent results have shown that water treatment sludge, an inorganic waste produced in large amounts during the treatment of drinking water, is a highly effective adsorbent for heavy metals. Other results have shown that long-term irrigation of pastures with dairy factory effluent causes an accumulation of phosphorus and sodium in the soil. However, it also induces large increases in the size and activity of the soil microbial community. The fact that such activity is not affected adversely by this type of irrigation leaves the way open for further developments in the biological remediation of dairy wastes.

The project is also investigating the use of organic wastes and clays in the revegetation of red sand from bauxite processing. Preliminary results in 2009-10 demonstrated that addition of organic wastes such as biosolids, poultry manure and compost improve fertility, physical properties and microbial activity in bauxite processing sand. Finally, the project team is looking at the use of waste products (e.g. slags, red mud, fly ashes) as silicon fertiliser sources for sugarcane and rice production. Blast furnace slags have been shown to be particularly effective sources of silicon fertiliser. Altogether, the project has generated twelve research publications to date. ■



## Modelling and field assessment of vapour intrusion threats – review and national guidance

This project was initiated to review available models to assess petroleum hydrocarbon vapour intrusion, and to prepare a guidance document on the assessment of vapour intrusion threats. The guidance document was endorsed by the Policy Advisory Committee and the Policy Committee, as well as been published as Technical Report no. 13, now available on the CRC CARE website. The document has also been submitted to the National Environment Protection Council for its possible incorporation into the revised *National Environment Protection Measure*. Visit [www.crccare.com](http://www.crccare.com) for a copy of *Technical Report 13: Field assessment of vapours*. ■

# Advertise with *Remediation Australasia*...

*Remediation Australasia* gives advertisers access to an emerging market of clients and product users each time we publish a new issue.

*Remediation Australasia* is now distributed to more than 2,000 recipients, not only exclusive to the Australasian region (Australia, New Zealand, Papua New Guinea, western Pacific Islands), but also from the United States, Canada, India, Germany and Russia.

Visits to the publication online come from more than 80 countries, resulting in an even wider readership of the magazine.

See our advertising packages at [www.remediationaustralasia.com.au](http://www.remediationaustralasia.com.au) for more information.



Want more information  
about advertising in  
*Remediation Australasia*?

## CONTACT ARIC

[aric@crccare.com](mailto:aric@crccare.com)

[www.remediationaustralasia.com.au](http://www.remediationaustralasia.com.au)

## ...Australia's only dedicated environmental remediation magazine.

The *Remediation Australasia* magazine is distributed quarterly 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
- Technical articles
- 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.

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.

Get in touch with 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.

**Just flick an email to [aric@crccare.com](mailto:aric@crccare.com), and we'll take care of the rest.**

