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Working globally for a toxic free future

National Toxics Network Submission to the
People's Permanent Tribunal on Human Rights and Unconventional Gas

February 2018

Unconventional Gas Impacts on Environmental Health and Human Rights

'Living in a pollution-free world is a basic human right'

National Toxics Network (NTN) is a NGO (non-government organisation) network working for pollution reduction, protection of environmental health and environmental justice. Established in 1993, NTN is committed to a toxics free future.

Introduction

The protection of the environment is a vital part of contemporary human rights doctrine as it affects the right to life and the right to health. The damaging impact of toxic chemicals on basic human rights is indisputable.[1] In 2001, the United Nations Human Rights Commission (UNHRC) acknowledged that *'living in a pollution-free world is a basic human right'* and those who pollute violate these rights. They established that, *"the fundamental right to life is threatened by exposures to toxic chemicals, hazardous wastes, and contaminated drinking water."*

Australia has ratified the Convention on the Rights of the Child[2] (CRC) which specifically describe a child's right to health, adequate food and clean water, *"taking into consideration the dangers and risks of environmental pollution."*[3] Australia agreed to respect, protect and fulfill the rights of children as described by the CRC.[4]

Despite this, citizens, including vulnerable children, in gas fields and around gas infrastructure across Australia, are exposed to toxic chemicals through the unconventional gas (UG) industry's intentional releases, contaminated dust particles, storage ponds and associated waste water spills, accidents and fugitive emissions.

In 2012, the United Nations Environment Program (UNEP) Global Environmental Alert System confirmed*, "UG exploitation and production may have unavoidable environmental impacts. Some risks result if the technology is not used adequately, but others will occur despite proper use of technology. UG production has the potential to generate considerable GHG emissions, can strain water resources, result in water contamination, may have negative impacts on public health (through air and soil contaminants, noise pollution), on biodiversity (through land clearance), food supply (through competition for land and water resources), as well as on soil (pollution, crusting)."*

[1] WHO estimated that in 2004 at least 4.9 million deaths (8.3% of all deaths) were due to environmental exposure to selected chemicals. http://www.who.int/gho/phe/chemical_safety/en/ Also in 2015, reducing environmental risks could have prevented more than a quarter of the 5.9 million deaths of children under 5 years. http://who.int/features/factfiles/children_environmental_health/en/

[2] *Convention on the Rights of the Child*, 1989. Australia ratified the CRC on 17 December 1990.

[3] Article 24 2(c) To combat disease and malnutrition, including within the framework of primary health care, through, iner alia, the application of readily available technology and through the provision of adequate nutritious foods and clean drinking-water, taking into consideration the dangers and risks of environmental pollution;

[4] UN Office of the High Commissioner for Human Rights, What are Human Rights? (2008). http://www.ohchr.org/EN/Issues/Pages/WhatareHumanRights.aspx

Recognised need to protect children from toxic chemicals

As signatory to the CRC, Australian governments are bound to a greater duty of care to our children. Children are not simply 'little adults' and their unique vulnerability to hazardous chemical exposures is recognised by the World Health Organisation (WHO), the United Nations Children's Fund (UNICEF) and UNEP.[5] These agencies have identified a wide range of health impacts on children from chemical exposures including, asthma, birth defects (e.g., hypospadias), behavioural disorders, learning disabilities, autism, cancer, dysfunctional immune systems, neurological impairments and reproductive disorders.

It is also widely understood the timing of chemical exposures in children is critically important, as there are 'windows of susceptibility' during child development that put them at greater risk of harm.[6] Exposures early in life can contribute to health problems later in life, for example, dioxin exposure in utero can affect neurological function and learning ability well into childhood.[7] Exposure to carcinogens in early development has been shown to increase the risk of developing cancer later in life.[8] In utero and in early infancy, pollutants can cause permanent brain damage at levels of exposure that would have little or no adverse effects in an adult.[9]

Maternal exposure to air pollutants carries significant risks as the placenta is not an effective barrier to chemical transfer from mother to the foetus. Toxic chemicals can also be transferred from mother to baby through breast milk.

A Colorado study found children born in areas with the highest number of gas wells had a 30% increased rate of congenital heart defects compared to children born in areas with no gas wells within a 10km radius.[10] A 2015 retrospective cohort study, using electronic health records data on 9,384 mothers linked to 10,946 neonates between January 2009 to January 2013, showed that prenatal residential exposure to unconventional natural gas development activity was associated with preterm births and high risk pregnancies, adding to evidence that unconventional natural gas development may impact on children's health.[11]

Preliminary testing of children's homes adjacent to south east Queensland gas fields has shown they are exposed to a range of carcinogenic and neurotoxic chemicals associated with the UG industry. Samples of ambient air from around their homes detected many toxic volatile organic compounds (VOCs) including acetone, acrolein, alpha-pinene, benzene,

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[5] UNEP, UNICEF & WHO. 2002. Children in the New Millennium: Environmental Impact on Health. Available at www.unep.org, www.unicef.org and www.who.int.

[6] Olin, S. R. & B. R. Sonawane. 2003. Workshop to Develop a Framework for Assessing Risks to Children from Exposure to Environmental Agents, September 2003. *Environmental Health Perspectives* 111/12: 1524-1526

[7] Pluim, H.J., J.G. Koppe, K. Olie, J.W. van der Slikke, P.C. Slot, & C. van Boxtel. 1994. 'Clinical laboratory manifestations of exposure to background levels of dioxins in the perinatal period. *Acta Paediatrica* 83: 583-587.; OIlsen A., J.M. Briët, J.G. Koppe, H.J Pluim, & J. Oosting. 1996. Signs of enhanced neuromotor maturation in children due to perinatal load with background levels of dioxins. *Chemosphere*: 33(7), 1317-1326.; Weisglas-Kuperus, N., T.C.J Sas, C. Koopman-Esseboom, C.W. Vanderzwan, M.A.J Deridder, A Beishuizen, H. Hooijkaas, H.& P.J.J. Sauer. 1995. Immunologic effects of background prenatal and postnatal exposure to dioxins and polychlorinated biphenyls in Dutch infants. *Pediatric Research* 38(3):404-410

[8] Barton, H. A., V. J. Cogliano, L. Flowers, L. Valcovic, R. W. Setzer & T. J. Woodruff. 2005. Assessing Susceptibility from Early-Life Exposure to Carcinogens. *Environ. Health Perspect. 13(9): 1125–1133*

[9] Dr Philippe Grandjean MD & Philip J Landrigan MD, Neurobehavioural effects of developmental toxicity, *Lancet Neurology*, Volume 13 (3), 330 - 338, March 2014 http://www.thelancet.com/journals/laneur/article/PIIS1474-4422(13)70278-3/abstract

[9] Hill, E. (2013). The impact of oil and gas development on infant health in Colorado. Cornell Dyson School Working Paper

[10] McKenzie et al., Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, *Environ Health Perspect;* http://ehp.niehs.nih.gov/1306722/

[11] Casey et al., Unconventional Natural Gas Development and Birth Outcomes in Pennsylvania, USA *Epidemiology* 2016 27(2):163-72 https://www.ncbi.nlm.nih.gov/pubmed/26426945

benzothiazole, chloromemethane, cyclohexane, dichlorofluromethane, ethanol, ethyl acetate, ethylbenzene, 2-ethyl-1-hexanol, heptane, hexane, heptadecane, hexadecane, 2-methylbutane, methylcyclohexane, methylene chloride, methyl ethyl ketone, 3-methylhexane, 3 methylpentane, naphthalene, pentane, phenol, propene, tetradecane, tetrachlorethylene, 1,2,4,-trimethylbenzene, toluene, vinyl acetate, xylene, ethanol, phenylmaleic anhydride, methyl ethyl ketone.[12]

While Australian governments acknowledge the use of hazardous substances in the UG industry, they appear to dismiss the risks based on dilution factors and argue lack of exposure routes. However, there has never been a comprehensive study undertaken in Australia on exposure to the UG industry's chemical releases.

Significant data gaps exist for the environmental fate of UG chemicals and pollutants, including their chemical metabolites or breakdown products and their endocrine disruption potential. Very little is known about the toxicity of the intentional hydraulic fracturing ('fracking') mixtures or their interaction with natural contaminants of the gas seam.

Children's right to clean water

A child's right to clean water is at risk from the UG industry. Contaminated 'produced water' and flowback represent serious threats to water quality. For those companies undertaking fracking, the mixtures forced into the wells at high pressure can contain many tonnes of chemical additives. Up to 18,500 kilograms of fracking chemicals have been reported to be used in a single hydraulic fracturing (HF) process in Australia. Figures reported to the US industry Fracfocus database have been as high as 100 tons per HF. A significant proportion of this chemical load is not recovered and is released directly into the environment. What is recovered is often a complex mixture of natural and manmade contaminants.

An assessment of the impacts from hydraulic fracturing in shale and tight gas on West Australia's drinking water supply areas by the WA Department of Health found there were 96 substances in the flowback fluids of which 28 were listed by regulatory agencies as known or suspected carcinogens.[13] Published studies from the USA show that even after treatment, flowback water had dangerous levels of bromine and radium-226.[14]

Community based opportunistic sampling of flowback in Queensland detected dichlorodifluoromethane, a potent chlorofluorocarbon (CFCs), which damages the ozone layer.[15] Samples taken from the top of the wellhead, a day after the well had been 'fracked', found bromodichloromethane, bromoform, chloroform and dibromochloromethane, as well as benzene and chromium, copper, nickel, zinc.[16]

[12] See Symptomatology of a gas field, An independent health survey in the Tara rural residential estates and environs - http://www.ntn.org.au/wp/wp-content/uploads/2013/05/Symptomatology-of-a-gas-field-An-independent-health-survey-in-the-Tara-rural-residential-estates-and-environs-April-2013.pdf

[13] Hydraulic Fracturing for Shale and Tight Gas in Western Australian Drinking Water Supply Areas: Human Health Risk Assessment. Public Health Division, Department of Health WA June 2015

[14] Valerie J. Brown, Radionuclides in Fracking Wastewater: Managing a Toxic Blend, *Environ Health Perspect;* DOI:10.1289/ehp.122-A50

[15] Australian Government National Measurement Institute, Report of Analysis of Air Canisters Low Level, Report No. RN900555 (2 Feb 2012), Report No. RN893233 (16 Dec 2011), Report No. RN893232 (16 Dec 2011) as reported in Lloyd-Smith & M, Senjen, R Halogenated Contaminants From Coal Seam Gas Activities, Proceedings of Dioxin 2012 Conference, Cairns, Australia.

[16] Labmark Environmental Laboratories, Certificate of Analysis, Report 331850-W Composite: Roma Water Analysis, Mar 26, 2012 as reported in Lloyd-Smith & M, Senjen, R Halogenated Contaminants From Coal Seam Gas Activities, Proceedings of Dioxin 2012 Conference, Cairns, Australia.

International principles of chemical management

There are well-recognised international principles of chemical assessment and management that can help protect the right to a pollution free and healthy environment. These include:

- Intergenerational equity - taking long-term impacts into account and sustain the Earth for future generations.
- Precaution - a decision-making tool in response to threats of serious or irreversible harm when full information is not available.
- Substitution - if a chemical can cause harm it should be avoided if less dangerous products or processes exist.
- Polluter pays - producing industries should internalise the true costs of their products and activities.
- No data for your chemical product, no market.
- Good governance - transparent, accountable, honest government operation is key to sustainable development.
- Liability - responsibility and compensation for injury or harm.
- Right to know - public access to information regarding harms to human health and the environment from chemicals.

Unfortunately, it appears these principles have largely been ignored by Australian governments in their rush to support the UG industry.

Right to Know versus Industry Secrecy

Civil society has an internationally recognised right to life and health and it has rights to adequate information to protect the environment and human health. Yet, in Australia, civil society attempts to ensure access to information about UG pollution has met with a culture that fosters industry confidentiality and secrecy, rather than an open information exchange as enshrined by Agenda 21[17] and other international instruments.

The community's right to know was reinforced in the *Bahia Declaration on Chemical Safety* at the Intergovernmental Forum on Chemical Safety (IFCS), Brazil 2000. The declaration affirmed that an informed public is vital for effective chemical management and called on all governments to not only increase access to information on chemicals, but to recognise *'the community's right-to-know about chemicals in the environment'* and to recognise *'the community's right to participate meaningfully in decisions about chemical safety that affect them.'* [18]

The *Strategic Approach to International Chemical Management* (SAICM) in which Australia also participates aims to ensure all stakeholders have *"information on chemicals throughout their life cycle,"* [19] while the UN Sustainable Development Goals includes targets to *"Ensure public access to information…"* (16.10).[20]

[17] Agenda 21: Programme for Action for Sustainable Development Rio Declaration on Environmental Development, United Nations Conference on Environment and Development (UNCED), 3–14 June 1992, Rio de Janeiro, Brazil. Chapter 19 of Agenda 21, "Environmentally Sound Management of Toxic Chemicals" focused on the generation, harmonisation and dissemination of chemical data, and strengthening capacity for chemical management. It also contained specific reference to the right of communities to chemical information and the obligations on industry and governments to generate and provide that information.
[18] http://www.who.int/ifcs/documents/forums/forum3/en/Bahia.pdf
[19] UNEP - WHO (2006) Overarching Policy Strategy para 8, Strategic Approach to International Chemicals Management http://www.saicm.org
[20] https://sustainabledevelopment.un.org/sdg16

Commercial Secrets, UG Chemicals and Persistent Organic Pollutants

The *Stockholm Convention on the Persistent Organic Pollutants* 2001, a U.N. convention to eliminate the worst of manmade chemicals obligates Parties to provide the public with *"all available information on persistent organic pollutants."* This requirement is essential as POPs chemicals like the short chain chlorinated paraffins and perfluorinated chemical, PFOS are known to be used by the oil and gas industry.

Article 9 of the Stockholm Convention while recognising industry's rights to secrecy, also ensures that *"information on health and safety of humans and the environment shall not be regarded as confidential."* Other international instruments such as the *Minamata Convention on Mercury* and SAICM have also included this chemical safety principle.[21]

Despite this, Australia's chemical regulatory system still provides extensive protection for commercial business information (CBI), limiting public knowledge of the chemical constituents of UG products. One example is the material safety data sheet (MSDS) for the UG friction-reducing chemical, INFLO 150. It was listed as being used by a WA fracking company. The Australian MSDS provides the active ingredients as:

- Methanol (CAS 67-56-1) at 5-10%
- Ethylene Glycol (CAS 107-21-1) at 10-30%
- Oxyalkylated Alcohols (trade secret) 10-30%

The following are also listed on the Australian MSDS but with no details on Chemical Abstracts Service Registry Number (CASRN) they cannot be identified.

- Fatty Alcohol, Oxylalkylated Alkanolamine(s), Silicone(s), Surfactant(s)

The US MSDS for INFLO 150 on the other hand provides a little more information describing the surfactant as a 'fluorocarbon surfactant' but still does not provide a distinct CAS number. Fluorocarbon surfactants are a group of very persistent and toxic chemicals; one of which PFOA / C8 has been found to be a persistent organic pollutant (POP).

The 2015 Californian assessment of hydraulic fracturing (HF) chemicals recommended that all operators should report the unique Chemical Abstracts Service Registry Number (CASRN) identification for all chemicals used in HF and acid stimulation, and the use of chemicals with unknown environmental profiles should be disallowed.[22]

Examples of Health Impacts Associated with Chemicals Used in Hydraulic Fracturing

A review of the health impacts associated with HF chemicals used in Australia demonstrates that many are toxic to human health or the environment. The following information was compiled from publically available sources.[23]

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[21] www.mercuryconvention.org Also see UNEP - WHO (2006) Dubai Declaration para 22, Strategic Approach to International Chemicals Management http://www.saicm.org/index.php?option=com_content&view=article&id=73&Itemid=475

[22] Birkholzer, J.T., et al An Independent Scientific Assessment of Well Stimulation in California Executive Summary An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry, July 2015

[23] See International Program on Chemical Safety, INCHEM, www.inchem.org ; US Agency for Toxic Substances & Disease Register, www.atsdr.cdc.gov ; Material Safety Data Sheets and NICNAS literature. Health data for 560 HF chemicals is available for download at http://www.endocrinedisruption.com/chemicals.multistate.php

Glutaraldehyde - a biocide; is highly irritating to the eyes, skin and the respiratory tract of humans and laboratory animals. It has caused skin sensitization in humans and laboratory animals, and asthma in occupationally exposed people. In animal tests, glutaraldehyde by inhalation caused lung damage in rats and mice and in tests using in mammalian cells in culture glutaraldehyde caused DNA damage, mutations and some evidence of chromosome damage. Data indicates that both algae and fish embryos may be particularly sensitive to long-term glutaraldehyde exposure.

Ethylene Glycol - a scale inhibitor and solvent; is known human respiratory toxicant and can also irritate the eyes, nose and throat. Exposure is associated with increased risks of spontaneous abortion and sub-fertility in female workers and birth defects in animals. Ethylene Glycol is an endocrine disrupting substance (EDC).

2-Butoxyethanol (2BE, ethylene glycol monobutyl ether, EGBE) - a surfactant and solvent; high doses of 2BE can cause reproductive problems and birth defects in animals. Animal studies have also shown it can destroy red blood cells. There are no carcinogenicity studies available for 2BE and it was declared a 'Priority Existing Chemical' by Australian regulators due to its high mobility, low degradation and potential to contaminate aquifers.

Nonylphenol Ethoxylate - a surfactant; NPE is a persistent, bioaccumulative, endocrine disruptor, which has been detected widely in wastewater and surface waters. NPE can mimic the natural hormone, estradiol and binds to the estrogen receptor in living organisms. Nonylphenols (NP) are formed from the environmental degradation of NPEs. NP can cause the feminisation of aquatic species, decrease male fertility, and decreases survival in young fish. Sexual deformities were found in oyster larvae exposed to NP and it is linked to increases in breast cancer in mice. Canada classified NPE metabolites as toxic. The European Union classifies NP as very toxic to aquatic organisms, which may cause long-term adverse effects in the aquatic environment.

Methanol - a corrosion inhibitor; methanol is volatile organic compound (VOC), which is highly toxic to humans. It causes central nervous system depression in humans and animals as well as degenerative changes in the brain and visual system. Chronic exposure to methanol, either orally or by inhalation, causes headache, insomnia, gastrointestinal problems and blindness in humans and hepatic and brain alterations in animals. Methanol is highly mobile in soil and can volatilizes from water. Once in air, its half-life is over 2 weeks. The chemical reacts with photochemically produced smog to produce formaldehyde. Methanol was listed as the most commonly used HF chemical by the United States House of Representatives Committee on Energy and Commerce.[24]

Sodium Persulfate - used as a gell breaker; exposure via inhalation or skin contact can cause sensitization, i.e., after initial exposures individuals may subsequently react to exposure at very low levels of that substance. Exposure can also cause skin rashes and eczema. Sodium persulfate is irritating to eyes and respiratory system and long-term exposure can cause changes in lung function resulting in disease of the airways and/or asthma.

Tetrakis hydroxymethyl)phosphonium sulfate (THPS) - a biocide; is toxic to microorganisms with acute toxicity values for algae less than 1 milligram per litre. Repeated

[24] Methanol was used in 342 of the 750 hydraulic fracturing products, and is a hazardous air pollutant and on the candidate list for potential regulation under the US *Safe Drinking Water Act* due to its risks to human health. See United States House of Representatives Committee on Energy and Commerce, Minority Staff, April 2011 Chemicals Used in Hydraulic Fracturing.
http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf

skin exposure to THPS can result in severe skin reaction and cause skin sensitization.[25] It has shown mutagenic potential (in vitro) and cancer potential in rats. No exposure information is available for either humans or organisms in the environment and little is known about the effects of the break down products of THPS

Naphthalene – *a* friction reducer; is classified by the International Agency for Research on Cancer (IARC) as a *'possible human carcinogen'* and by the US EPA as *'reasonably anticipated to be human carcinogen*' based on nasal and lung tumours in lab animals. Chronic exposure of workers and rodents to naphthalene causes cataracts and/or damage to the retina. Naphthalene metabolites have been found in the urine of workers.

Failings of Australian Government's Assessment of CSG chemicals

In 2011, the National Toxics Network determined that of the 23 commonly used 'fracking' chemicals in Australia, only 2 had been assessed by the national industrial chemical regulator (National Industrial Chemical Notification and Assessment Scheme (NICNAS). Of the two that had been assessed, neither had been assessed for their use in CSG exploration and production.[26]

In mid 2012, the Australian government announced the National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia. The report was finally released in December 2017.[27]

The Government assessment focused solely on the above-ground (surface) handling of 113 chemicals used for drilling and hydraulic fracturing for coal seam gas in NSW and Queensland only. Chemicals were identified through an industry survey, direct requests for information made to companies involved in the Australian coal seam gas industry and by reviewing the limited publicly available information.

The final report identified 113 chemicals used for coal seam gas extraction in Australia during the period 2010 to 2012. Industry reports that only 59 of the 113 chemicals were still being used in 2015-17, which suggests they have been replaced with other products not covered by the assessment. Some of the data provided by industry, including the identity of some chemicals, is claimed as CBI and therefore, secret.

While the UG industry was deeply involved in the assessment of UG chemicals, affected residents, NGOs and the wider civil society had no opportunity for input.

The assessment was limited to impacts from 'above-ground (surface) handling' and did not assess:

- chemicals in the coal seam or rock that are mobilised by the fracturing process
- fugitive emissions and ambient air contaminants
- shale or tight gas extraction
- toxicity of the mixtures of chemicals
- potential effects on agriculture or the food chain
- site specific risks of chemicals

[25] NTP Study Reports, Abstract for TR-296 - Tetrakis(hydroxymethyl)phosphonium sulfate (THPS) (CASRN 55566-30-8) and Tetrakis(hydroxymethyl)phosphonium chloride (THPC) (CASRN 124-64-1

[26] Lloyd-Smith, M.M & Senjen, Rye, *Hydraulic Fracturing in Coal Seam Gas Mining: The Risks to Our Health, Communities, Environment & Climate*, National Toxics Network Sept. 2011 www.ntn.org.au

[27] https://www.environment.gov.au/water/coal-and-coal-seam-gas/national-assessment-chemicals

The assessment concluded that if there were no protective measures in place, 40 of the 113 chemicals tested could potentially cause harm to the health of people. This could be from contaminated water either from a leak from a storage pond or in the event of a large transport spill. The study went on to dismiss these risks arguing the transport and use of industrial chemicals and the storage of waste water is strictly regulated by State and Commonwealth governments and this protects the community from any harm. This conclusion is totally at odds with practices allowed by regulators including the use of wastewater as dust suppression and the ongoing utilization of holding ponds allowing uncontrolled volatilisation of UG contaminants to the atmosphere.

Groundwater Screening

The Australian Government's desktop study 'Deeper groundwater hazard screening for chemicals used in coal seam gas extraction' [28] was also released in December 2016. This study modeled 13 chemicals, supposedly representative, but limited to those chemicals with reliable data. Only a fraction of Australia's industrial chemicals have been assessed and have 'reliable data.'

There were critical omissions including the sub-lethal effects of contaminants such as endocrine activity, which were not considered and nor were the effects of mixtures of contaminants as the ecotoxicological data was not available.

The desktop study also included discretionary assumptions regarding breakdown products e.g., the very persistent brominated biocide, Bronopol has been found to degrade to a range of very toxic byproducts.[29] Yet for the purpose of the study, it was assumed that bronopol will degrade to formaldehyde only, thereby ignoring the potential risks of these other highly hazardous metabolites.

The study estimated the concentration of a chemical when it reaches a water-dependent asset such as a water bore or a groundwater-dependent ecosystem. The predicted environmental concentrations (PECs) for individual chemicals were used to assess potential risks to human health and environment. The study concluded that dilution would reduce the concentration of chemicals to an acceptable level before it reached places where it would come into contact with people and/or the environment. The study dismissed concerns about possible exposure pathways of concern as either unlikely or extremely unlikely to exist.

Unconventional Gas and Chemical Mixtures

A 2015 review[30] of more than 100 scientific, peer-reviewed publications on unconventional oil and gas (UOG) chemicals and their impacts found that research points to potential adverse health outcomes from mixtures of the chemicals used in this industry.

The review suggests there is strong evidence of endocrine disrupting chemical mixtures having additive effects. In light of the potential for environmental release of UG chemicals that can disrupt hormone receptor systems, it is desirable to assess the complex hormonally

[28] https://www.environment.gov.au/water/publications/deeper-groundwater-hazard-screening-chemicals-used-in-csg

[29] E.g., formaldehyde, 2-hydroxymethyl-2-nitropropane-1,3-diol (tris), 2-bromo-2-nitroethanol, bromonitromethane, nitromethane (bromo-nitroethane, bromo-ethanol, and bromo-nitroethanol

[30] Christopher D. Kassotis, Donald E. Tillitt, Chung-Ho Lin, Jane A. Mcelroy, and Susan C. Nagel. Endocrine-Disrupting Chemicals and Oil and Natural Gas Operations: Potential Environmental Contamination and Recommendations to Assess Complex Environmental Mixtures. Environmental Health Perspectives, 2015 https://ehp.niehs.nih.gov/1409535/

active environmental mixtures when assessing the health impacts of UG chemicals and releases.

The WHO framework for assessing mixtures[31] provides example situations where the combined exposure of people to multiple chemicals needs to be assessed. Where there are emissions of multiple substances from a common source; the presence of multiple substances in surface waters; exposure to multiple pollutants in the atmosphere; and exposure to a formulated multicomponent chemical product. These criteria are clearly evident in the UG industry and the Australian Government assessments should have considered them.

Endocrine Disrupting Compounds

The failure of both Australian assessments to investigate the impact of endocrine disrupting compounds (EDCs) used by the gas industry is a major omission. US studies[32] have found surface and groundwater near UG activity contained EDCs and had moderate to high levels of EDC activity, whereas samples taken from sites with little drilling, showed little EDC activity.

Assessment of endocrine activity associated with Australia's UG industry is both essential and well overdue, particularly as EDCs are specifically listed as being used by the Australian UG industry, e.g., ethylene glycol, bronopol, ethylene glycol monobutyl ether.[33]

Chemicals associated with unconventional oil and gas (UOG) have been shown to block or antagonise hormone receptors, particularly androgen and estrogen receptors (antiestrogens, antiandrogens).[34] Prenatal exposure to anti-androgenic EDCs like ethylene glycol, can lead to delayed sexual development and birth defects such as hypospadias. Prenatal exposure to ethylene glycol monobutyl ether is associated with reproductive damage and congenital birth defects, while perinatal exposure to toluene can reduce serum testosterone in rats. Perinatal exposure to EDCs has also been shown to cause permanent changes in the brain and effect behaviour, obesity, fertility, cancer and result in other adverse health outcomes in laboratory animals depending on the timing of exposure. Some impacts may not become apparent for many years.[35]

Naturally Occurring Radioactive Materials

Neither Government assessment considered the impacts of the UG product Cesium 137 or the naturally occurring radioactive materials or NORMs, such as uranium, thorium and their progeny, radium-228 and radium-226. NORMs are likely to be present in both coal and shale seams. UG activities such as drilling, fracking, removal of produced water, earthworks and transport result in radioactive substances being remobilized and relocated either via waste water, 'bonding' with dust particulates or via re-suspension in air. Direct particle fallout, as well as washout from rain provides an effective pathway for these contaminants to find their way into the wider environment including surface water and onto rooftops and into domestic water tanks.

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[31] M.E. Meek et al. Risk assessment of combined exposure to multiple chemicals: A WHO/IPCS framework *Regulatory Toxicology and Pharmacology* 60 (2011) S1–S14 https://www.ncbi.nlm.nih.gov/pubmed/21466831

[32] Kassotis et al (2013) Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region, *Endocrinology* http://www.endo.endojournals.org

[33] https://www.environment.gov.au/water/coal-and-coal-seam-gas/national-assessment-chemicals. Also see Kassotis et al (2013)

[34] Webb et al (2014) Unconventional oil and gas operations: developmental and reproductive effects. *Rev Environ Health* 2014; 29(4): 307–318 https://www.ncbi.nlm.nih.gov/pubmed/25478730

[35] Webb et al 2014

In 2014, a Santos coal seam gas project in the NSW Pilliga Forest was found to have contaminated aquifers with uranium at 335 micrograms per litre, which is 20 times the Australian Drinking Water guideline of 17 ug/l. [36]

A US analysis of waste obtained from reserve pits used in unconventional natural gas mining confirmed elevated beta radiation readings. Specific radionuclides present included [232] Thorium decay series (^{228}Ra, ^{228}Th, ^{208}Tl), and ^{226}Radium decay series (^{214}Pb, ^{214}Bi, ^{210}Pb). The research indicated the potential for exposure to technologically enhanced naturally occurring radioactive materials and potential health effects from individual radionuclides.[37]

Radium is a known carcinogen[38] and exposure can result in increased incidence of bone, liver and breast cancer. Consuming radium in drinking water can cause lymphoma, bone cancer, and leukemia.[39] Radium is known to bioaccumulate in invertebrates, mollusks, and freshwater fish, where it can substitute for calcium in bones.

Radon is an inert gas, so it doesn't react with other elements and usually separates from produced water along with methane at the wellhead. When inhaled, radon can cause lung cancer, and there is some evidence it may cause other cancers such as leukemia.[40]

UG Toxic Air Pollutants

There are many sources of toxic air pollutants in gas fields and related infrastructure, including high point vents, equipment/engines, drilling rigs, boilers/heaters, generators, flares, storage tanks, injection pumps, dehydrators, vehicles and gas skimmers. Major sources of air pollutants are the compressor stations that move natural gas through pipelines and gas processing plants.[41] The air toxics associated with UG activities can cause serious, irreversible health effects, including cancer, neurological problems and birth defects.[42] In 2013, the World Health Organisation [43] declared that outdoor air pollution is carcinogenic.

Australia's National Pollutant Inventory

On an annual basis, the UG companies must report estimates of their chemical releases and emissions to the Australian Government's National Pollutant Inventory (NPI). For approximately 100 substances, industry must provide estimates of their releases to air, water and land, including fugitive emissions and transfers. Data from the NPI shows the UG industry is a significant source of air pollutants with releases of hazardous particulates (PM_{10}, $PM_{2.5}$), nitrogen oxides and volatile organic compounds (VOCs). According to the NPI data, the quantities emitted are increasing.

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[36] Santos coal seam gas project contaminates aquifer, SMH 2014 http://www.smh.com.au/environment/santos-coal-seam-gas-project-contaminates-aquifer-20140307-34csb.html

[37] Rich AL, Crosby EC. Analysis of reserve pit sludge from unconventional natural gas hydraulic fracturing and drilling operations for the presence of technologically enhanced naturally occurring radioactive material (TENORM). *New Solut.* 2013;23(1):117-35.

[38] http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=790&tid=154

[39] EPA. Radionuclides: Radium [website]. Washington, DC:Office of Radiation and Indoor Air, U.S. Environmental Protection Agency (updated 6 March 2012). http://www.epa.gov/radiation/radionuclides/radium.html#affecthealth

[40] NRC. Health effects of radon progeny on non-lung-cancer outcomes. In: Health Effects of Exposure to Radon, BEIR VI. Washington, DC:Committee on Health Risks of Exposure to Radon (BEIR VI), National Research Council, National Academies Press (1999). http://www.nap.edu/openbook.php?record_id=5499&page=118

[41] http://toxtown.nlm.nih.gov/text_version/locations.php?id=150

[42] Reducing Air Pollution from the Oil and Natural Gas Industry EPA's Final New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants, April 17, 2012 http://www.epa.gov/airquality/oilandgas/pdfs/20120417presentation.pdf

[43] International Agency for Research on Cancer, press release no 221 17 Oct 2013 - http://www.iarc.fr/en/media-centre/iarcnews/pdf/pr221_E.pdf

The following are known UG industry pollutants.

Nitrogen Oxides - NO_x are emitted from machinery, compressors and flaring. NO_x can react with VOCs to form ground-level ozone, which is linked to asthma attacks and other serious health effects. Nitrogen dioxide can cause respiratory problems, heart conditions and lung damage. Many thousands of tonnes of NO_x are released by the UG industry every year

Carbon monoxide - CO is emitted during flaring and from machinery and is poisonous if inhaled. It inhibits the blood's ability to carry oxygen and can cause dizziness, unconsciousness and even death.

Sulfur dioxide - SO_2 reacts with other chemicals to form acid rain and particulate pollution, which can damage lungs and cause respiratory illness, heart conditions and premature death.

Hydrogen sulfide - H_2S occurs naturally in some gas formations and can be released when gas is vented or flared, or via fugitive emissions. It is a toxic gas, which is lethal if inhaled at high concentrations

Volatile Organic Compounds - VOCs are present during all stages of UG activities including drilling, flaring, from equipment/machinery, hydraulic fracturing, flowback and holding ponds. Semi volatile chemicals are injected underground during fracking, a percentage of which eventually surfaces. Some VOCs cause cancer in animals (e.g. methylene chloride), in humans (e.g. formaldehyde) or are suspected human carcinogens (e.g. chloroform, bromodichloromethane). VOC exposure may result in eye, nose, and throat irritation, headaches, visual disorders, memory impairment, loss of coordination, nausea, damage to liver, kidney, and central nervous system.[44] Some VOCs like formaldehyde and styrene are endocrine disrupting chemicals (EDCs).[45] Sampling of air around homes near gasfields detected a wide range of VOCs.[46]

BTEX (benzene, toluene, ethylbenzene, xylene) - BTEX chemicals are naturally occurring VOCs released from coal deposits and are also found in associated groundwater.[47] Drilling, fracking and removal of produced water release BTEX from the coal seam. Their short-term health effects include skin, eye and nose irritation, dizziness, headache, loss of coordination and impacts to respiratory system while chronic exposure can result in damage to kidneys, liver and blood system. In 2014, BTEX was detected in the water from two of four coal seam gas (CSG) wells and an aboveground water storage tank at the AGL CSG project in Gloucester in New South Wales. Five samples included BTEX, one at concentration of 555 ppb.[48] The New South Wales EPA suspended AGL's CSG Waukivory Project.

Benzene causes leukemia, non-Hodgkin's lymphoma and also affects the immune system. It may also cause chromosomal aberrations and mutations in human and animal cells. [49] It has been linked to birth defects [50] and sperm abnormalities. [51] The WHO identified exposure to

[44] http://www.epa.gov/iaq/voc.html
[45] US National Library of Medicine http://toxtown.nlm.nih.gov/text_version/chemicals.php?id=65
[46] Geralyn McCarron, Air Pollution and human health hazards: a compilation of air toxins acknowledged by the gas industry in Queensland's Darling Downs, *International Journal of Environmental Studies* http://www.tandfonline.com/doi/full/10.1080/00207233.2017.1413221
[47] http://www.ehp.qld.gov.au/management/coal-seam-gas/btex-chemicals.html
[48] http://www.agl.com.au/~/media/AGL/About%20AGL/Documents/How%20We%20Source%20Energy/Gloucester%20Document%20Repository/Fact%20Sheets/20150302__Fact%20Sheet%20GGP%20%20%20BTEX_V3.pdf
[49] http://www.atsdr.cdc.gov/toxprofiles/tp3-c6.pdf
[50] http://www.ncbi.nlm.nih.gov/pubmed/20923742
[51] http://www.environmentalhealthnews.org/ehs/newscience/benzene-linked-to-sperm-abnormalities

benzene as a major public health concern. They note that benzene is a well-established cause of cancer in humans with IARC classifying benzene as carcinogenic to humans (Group 1). In community sampling around homes close to Queensland gasfields, Passive samplers detected Benzene at 0.6 ppb; above the US EPA recommendations of 0.4ppb.[52] The benzene result was dismissed as an *'outlier'.*

Polycyclic Aromatic Hydrocarbons - PAHs are a group of toxic volatile compounds. They are a significant air pollutant associated with unconventional gas production. Research [53] indicates that people living or working near active natural gas wells may be exposed to pollutants at higher levels than the US EPA considers safe for lifetime exposure. Highest levels of PAHs were found closest to the wells. The higher a baby's prenatal exposure to PAHs, the more serious the impact on the brain and the greater the behavioural and developmental problems.[54]

Particulate Matter - PM is released during construction of the gas infrastructure, engines and diesel exhaust, venting, flaring and via silica based proppants. Chronic inhalation of PM_{10} and $PM_{2.5}$ can cause respiratory problems, cancer, heart attacks, strokes, diabetes, asthma, hypertension, renal disease or premature death. Particulate matter can travel deep into the lung and cross directly into the bloodstream carrying with it other toxic chemicals. The surface area of the particle drives a synergistic response, producing greater than an additive response.[55]

In 2015, the USEPA banned gas flaring (the burning off of natural gas from a new well) in most practices due to growing concerns over air pollution.[56] There are no such restrictions on UG flaring in Australia. Flaring is recognised as a significant source of soot or black carbon pollution.[57]

The Australian government acknowledges that there is no threshold for particulate matter pollution at which health effects do not occur[58]. Yet, they do not require UG companies to report emissions of either $PM_{2.5}$ or PM_{10} to the National Pollutant Inventory unless they exceed a threshold of 400 tonnes per year, or 1 tonne per hour.

Airborne Silica

Silica based proppants are used extensively by the UG industry. The US National Institute for Occupational Safety and Health (NIOSH) released a Hazard Alert, identifying exposure to airborne silica as a health hazard to workers conducting hydraulic fracturing operations.[59] While workers experience the most direct exposure, silica dust may also be an air

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[52] http://www.anapolschwartz.com/practices/benzene

[53] Paulik et al., Impact of natural gas extraction on PAH levels in ambient air. *Environ Sci Technol*. 2015 Apr 21 ;49(8):5203-10. doi: 10.1021/es506095e. Epub 2015 Apr 9.

[54] Peterson et al, Effects of Prenatal Exposure to Air Pollutants (Polycyclic Aromatic Hydrocarbons) on the Development of Brain White Matter, Cognition, and Behavior in Later Childhood *JAMA Psychiatry*. Published online March 25, 2015. doi:10.1001/jamapsychiatry.2015.57
http://archpsyc.jamanetwork.com/article.aspx?articleid=2205842

[55] David Brown, Beth Weinberger, Celia Lewis and Heather Bonaparte, Understanding exposure from natural gas drilling puts current air standards to the test. *Rev Environ Health* 2014; DOI 10.1515/reveh-2014-0002 http://www.fraw.org.uk/files/extreme/brown_lewis_2014.pdf

[56] http://www.epa.gov/airquality/oilandgas/pdfs/20120417presentation.pdf

[57] Stohl, A., Klimont, Z., Eckhardt, S. et al. (2013). Black carbon in the Arctic: the underestimated role of gas flaring and residential combustion emissions. *Atmospheric Chemistry and Physics*. 13: 8833–8855. Also see http://ec.europa.eu/environment/integration/research/newsalert/pdf/349na5.pdf

[58] http://www.npi.gov.au/resource/particulate-matter-pm10-and-pm25

[59] www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.htm

contaminant of concern to nearby residents.[60] Exposure to respirable crystalline silica can cause silicosis, lung cancer, autoimmune diseases, pulmonary disease and chronic kidney disease.[61]

Appropriate Engineering and Scientific Solutions?

The 2014, the NSW Chief Scientist report ('Independent Review of Coal Seam Gas (CSG) Activities in New South Wales') [62] recommended CSG go ahead only if there was *'appropriate engineering and scientific solutions in place to manage the storage, transport, reuse or disposal of produced water and salts.'* In 2018, these solutions are still not evident.

The UG industry has offered no solution for its largest waste stream – salts - other than disposal to landfill. The extensive storage of waste water in holding ponds which evaporate and volatilize pollutants does not fulfil the criteria of *'appropriate engineering and scientific solutions.'* The practice of burying drilling cuttings at the well site is also not an appropriate solution. Drilling cuttings and muds consist of drilling fluid, weighting agents and stabilizing materials.

Trials undertaken in Queensland of land spraying of drilling byproducts identified the release of potentially toxic additives, salt compounds, heavy metals, hydrocarbons, pH-control additives, and total suspended solids (TSS).[63] The report noted that concentrations of aluminium, boron, iron, manganese, molybdenum, vanadium and mercury exceeded the Australian guidelines.[64] Detectable concentrations of petroleum hydrocarbons were also found in drilling muds. The trial concluded that the C6–C9 fraction, which include benzene, toluene, ethyl benzene and xylenes (BTEX) may pose a risk to the environment and to human health.

In June 2013, New Zealand milk giant, Fonterra, announced it would no longer accept milk from farms that accept CSG muds and drilling cuttings on their properties, citing both contamination concerns and the extra cost of testing the milk at about $80,000 per year.[65]

The NSW Chief Scientist's report also found there were human health risks at all stages of CSG extraction with exposures via water, soil and air pollution. They listed possible adverse health outcomes as respiratory, cardiovascular, genitourinary and digestive diseases, skin problems, some types of cancer, injuries, hormonal disruption, and fertility and reproductive effects. The CSS report acknowledges there was a need to better understand the nature of the risks of pollution or other environmental damage from CSG, as well as the capacity and cost of mitigation and/or remediation for abandoned wells. It stressed the need for a better understanding of the industry impacts and to better manage cumulative impacts of the industry. This has not occurred.

[60] Seth B.C. Shonkoff, Jake Hays,and Madelon L. Finkel, (2014) Environmental Public Health Dimensions of Shale and Tight Gas Development, *Environ Health Perspect*; Vol 22: 8 DOI:10.1289/ehp.1307866
[61] NIOSH Hazard Review, Health Effects of Occupational Exposure to Respirable Crystalline Silica. National Toxicology Program [2012]. Report on carcinogens 12th ed. U.S. Department of Health and Human Services, Public Health Service.
[62] http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0005/56912/140930-CSG-Final-Report.pdf
[63] Origin's EMP Landspraying While Drilling (LWD) Trial Program OEUP-Q8200-PLN-ENV http://www.aplng.com.au/pdf/Environmental_Management_Plan_Landspraying_While_Drilling_Trial_Program.pdf
[64] http://www.environment.gov.au/resource/australian-and-new-zealand-guidelines-fresh-and-marine-water-quality-volume-1-guidelines
[65] http://www.stuff.co.nz/taranaki-daily-news/news/8813978/Fonterra-rejects-new-landfarm-milk

Failure of UG Waste Water Management

The Australian UG company, AGL, had 600,000 litres of flowback water from its Gloucester projects transported to be discharged into Hunter Water's network. This was despite Hunter Water previously advising that it would not accept the flowback, which contained 450 litres of the biocide, Tolcide (active ingredient THPS).[66] AGL then made arrangements to send its flow backwater to WORTH Water Treatment Plant in Windsor, however, the company also rejected CSG wastewater.

AGL was also forced to end its trial of CSG wastewater for irrigation after regulators found it left behind unacceptably high levels of salt and heavy metals.[67] The UG industry continues to trial the reinjection of produced water into the aquifer risking underground water contamination.[68] A CSIRO reinjection trial in Queensland found that it led to high levels of arsenic forming in aquifers.[69]

Methane and Climate Impacts

In January 2018, the US National Aeronautics and Space Administration (NASA) published a study showing methane emissions overall have continued to rise sharply and noted the oil and gas industry is responsible for the biggest piece of that growing problem.[70] Methane (CH_4) is a powerful greenhouse gas with a global warming potential much greater than that of CO_2 - 34 times stronger as a heat-trapping gas than CO_2 over a 100-year time scale.

Fugitive methane emissions are associated with the complete gas exploration and production cycle, including abandoned wells. Research conducted at Australia's Southern Cross University[71] confirmed the widespread enrichment of both CH_4 and CO_2 within the production gas field, compared to outside. The CH_4 and CO_2 values showed distinct differences within and outside the production field, indicating a CH_4 source within the production field had a signature comparable to the region's CSG. In their submission to the Australian government, they reported hotspots with concentrations of methane (CH_4) as high as 6.89 ppm compared to background atmospheric CH_4 outside the gas fields of lower than 2ppm.[72]

A Queensland government study found 26 of 58 gas wells tested leaked methane, one above the LEL, four at or above 10% of the LEL and 21 with levels between 10-3,000ppm. Similar figures were found in surrounding gas fields.[73]

Further evidence of fugitive CH_4 emissions associated with the UG industry is the bubbling methane reported along a five-kilometre stretch of the Condamine River in Queensland,

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[66] http://www.theherald.com.au/story/3710148/curtain-descends-on-agls-comedy-of-errors-how-the-csg-farce-came-to-an-end/?cs=12

[67] http://www.smh.com.au/environment/water-issues/agls-irrigation-trial-using-csg-waste-water-found-to-be-unsustainable-20150416-1mmf82.html

[68] http://research.ccsg.uq.edu.au/projects/aquifer-injection-csg-production-water-phase-1-pre-feasibility-assessment

[69] http://www.news.com.au/national/queensland/csiro-coal-seam-gas-water-experiment-causes-arsenic-spike-in-queensland-aquifers/news-story/9606815ea505dc93840b5ce8d84ac053

[70] https://www.nature.com/articles/s41467-017-02246-0

[71] Damien T. Maher & Isaac R. Santos & Douglas R. Tait, (2014) Mapping Methane and Carbon Dioxide Concentrations and δ13C Values in the Atmosphere of Two Australian Coal Seam Gas Fields *Water Air Soil Pollution* 225:2216

[72] Submission on National Greenhouse and Energy Reporting (Measurement) Determination 2012 - Fugitive Emissions from Coal Seam Gas. Submitted 19 October 2012 to Department of Climate Change and Energy Efficiency by Dr. Isaac Santos Southern Cross University, NSW Australia

[73] Investigation report, Leakage testing of coal seam gas wells in the Tara 'rural residential estates' vicinity, The State of Queensland, Department of Employment, Economic Development and Innovation, 2010. http://www.dnrm.qld.gov.au/__data/assets/pdf_file/0011/119675/tara-leakage-csg-wells.pdf

Australia. The Queensland government's initial investigation[74] notes that four CSG wells were within a five kilometre radius of the gas seep. Methane was measured at 80% of the lower explosive limit (LEL) (at river surface) equating to 4% gas in air.

Conclusion

The basic human right to life and to enjoy a safe and healthy environment is something we all cherish and something that generations of Australians have been willing to fight for.

Our children's right to pollution free environment in order to develop to their full potential are put at risk by the unconventional gas industry both through their pollution and their impacts on climate change.

The continuing evidence of the UG industry's myriad of unresolved waste issues, the vastly inadequate assessments of the chemicals used, their toxic releases and resultant health impacts clearly demonstrate that governments are willing to sell out our basic human rights in exchange for profits from this polluting finite industry.

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[74] Summary Technical Report - Part 1 Condamine River Gas Seep Investigation, December 2012 Version 1 State of Queensland, Department of Natural Resources and Mines, 2012. http://www.dnrm.qld.gov.au/mining/coal-seam-gas