Water Resources in Australian Mine Pit Lakes

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Pit Lakes

- Form in open cut mines that extend below the natural water table once dewatering ceases.
- Large lakes with no natural counterparts in Australia.
- Water quality depends on catchment geology and quality of filling water - often poor.
- Pit lakes often poorly considered in mine closure plans, yet are often one of the largest and hardest to deal with legacies.

Australian Pit Lakes

Pit lake in Goldfields Region, WA

One of the pit lake in Collie Region, WA

Pit lake in Collinsville, North Queensland

Silica Sand pit lake in Southern WA

Importance of Pit Lakes

- Unknown number of pit lakes across Australia
- Significant quantity of water in pit lakes
- Australia one of the driest continents in the world
  - Demand for water resources increasing
- Mine pit lakes unique water bodies
  - Few natural counterparts e.g., large depths
  - Chemistry (metals, nutrients)
  - Biota
- Water from pit lakes can be of potential use
- Long term effects of such lakes largely unknown
  - Relatively new, most of them are less than 50-100 years old

Data Collection

- Questionnaire seeking information and data on pit lakes was sent to all major State and Federal agencies, mining companies, universities, consultancies, etc.
- Detailed literature review was undertaken by searching scientific literature, published reports, conference proceedings, State and Federal agencies webpages etc.

Current Status of Mine Lakes

- There is no comprehensive State or Commonwealth inventory of pit lakes
  - Some efforts in Queensland, New South Wales and Western Australia to create state-based databases or reports
- Most mining legacy databases are of derelict or abandoned mine workings
  - Pit lakes are not specifically surveyed for, particularly those on active or still unrelinquished leases
- Lack of a pit lake database hinders both state and national management of a potentially highly useful or detrimental resource

Mine Rehabilitation & Pit Lakes

- Major focus of Australian mine rehabilitation is on terrestrial communities
  - Esp. establishing functional landscape vegetation
- Water quality data on pit lakes typically not collected as not required by regulators
- When pit lake water quality data is collected, often only for ad hoc compliance reporting
  - Often records e.g., EIS database maintained by the company
  - Most pit lake data remains largely inaccessible

Pit Lake Characteristics

- Majority of pit lake studies have focussed on physical and chemical characteristics of pit lake waters
- Water quality influenced by many factors:
  - climate
  - groundwater quality
  - depth
  - pit filling method and
  - local mineralogy
- Very little known about the environmental values of Australian pit lakes
  - Resource for waterbirds?
  - Natural/managed fishery?

Main Pit Lake Types in Australia

Based on water quality:

- **Acidic** – typical of AMD influenced lakes i.e. low pH, high metal concentrations
- **Saline** – where net evaporation exceeds precipitation leads to brackish to hyper-saline lakes (can also be acidic)
- **Neutral** – often good water quality with one or more metals; eg. Mary Kathleen & Thalanga (Queensland), Wedge pit lake (WA)
- **Good water** – silica sand mining; ex. Kemerton, WA

Australian Mine Pit Lakes - Characteristics

Parameter	Collie Basin, Western Australia (N = 4)	Collinsville, North Bowen Basin, Queensland (N = 4)	Mount Morgan, Queensland (N = 1)	Mary Kathleen, Queensland (N = 1)	Ranger Mine, Northern Territory (N = 1)	Kemerton, Western Australia (N = 1)	St. Barbara Mines, Western Australia (N = 2)	Thalanga Mine, Queensland (N = 1)
GPS	33°21'47"S, 116°09'22"E	20°33'31"S, 147°49'52"E	26°38'22"S, 150°22'02"E	20°45'1"S 140°0'6"E	12°41'S, 132°55'E	33°12'58"S, 115°45'25"E	29°50'25"S, 121°17'17"E	20°20'S, 145°48'E
Ore type	Coal	Coal	Au, Cu	U	U	Silica sand	Au	Cu-Pb-Zn
Depth (m)	9–70	4–14	-	-	-	6	-	70
Area (km²)	0.06–1.03	0.01–0.06	-	-	-	-	0.006–0.95	-
pH	3.8–5.0	1.5–4.9	2.8	6.1	7.6	8.5	8.0–8.6	7.7
Total P	<0.005–0.009	<0.005	-	-	0.01	0.02	-	-
Total N	<0.05–1.5	0.51	-	-	1.96	0.573	7.3–22.8	-
DOC	3.1-7.3	1–59	-	-	-	22	-	-
E.C. (mS cm⁻¹)	0.42–1.4	7.8–23.5	11	5.05	0.89	1.2	–	1.07
Sulfate	31–107	300–25000	12,100	1,840	782	296	2,570–7,190	7,950
Aluminium	0.001–0.006	23–1,300	740	0.032	0.026	0.1	0.02–0.06	<1
Calcium	2.3–6.0	124–519	520	464	0.02	67	334–1,120	718
Cadmium	<0.002	<0.01–0.023	0.15	-	<0.0002	-	0.0002	0.16
Copper	<0.002–<0.05	<0.05–2.5	36	1.17	0.0024	-	0.03	< 1
Iron	0.0003–0.005	139–2,463	248	3.23	<20	0.14	< 0.05-0.06	0.575
Magnesium	0.077–16.3	197–2,239	1240	140	115	58	865-3150	1025
Uranium	-	0.020–0.029	-	0.460	1.76	-	-	-
Zinc	0.0005–6.9	1–46	25.3	0.088	0.0037	0.15	0.01	53.5
Chlorophyll a (µg L⁻¹)	0.1–64	0–64	-	-	-	6.5–8.5	-	-
Zooplankton studies?	Yes	Yes	-	-	-	No	-	-
Macroinvertebrate studies?	Yes	Yes	-	-	-	Yes	-	-
Periphyton studies?	Yes	No	No	No	No	No	No	No
Catchment rehabilitation?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
Pit lake remediation?	1 lake	1 lake	1 lake	1 lake	Backfilling	No	-	Backfilling
Proposed end use(s)	Aquaculture, recreation	Industry use	-	-	-	-	None	-
Catchment lease	Bonded	Bonded	-	-	Bonded	Owned	Bonded	n/a
Potential closure criteria	Recreational use	Bunded lake	-	-	Backfilled	Pond	Bunded lake	-

All values are in mg L⁻¹ unless otherwise stated. N = Number of pit lakes in region considered.
- = no data available. (Adapted from Kumar et al., in press).

Health & Safety Aspects

- Pit lakes may present risks such as drowning for recreational swimmers due to the limited shallow margin
- In agricultural areas, pit lakes may lead to poisoning and drowning of stock and wildlife
- Mixing of local water resources with contaminated pit waters may lead to loss of biodiversity or ecosystem function
- Water in pit lakes may give rise to problems such as potential for harbouring water-borne diseases, risks to native fauna or human health upon consumption of non-potable pit lake water
- Pit lake water may serve as a permanent breeding ground for mosquitoes, enhancing the risk of transmitting human disease

Pit Lake Closure

- There are no specific state or national guidelines for pit lake water quality. Instead, often general environmental water quality guidelines are used to determine acceptability of pit lake water quality
- Present strategies for pit lakes closure in Australia can be grouped into three main categories:
  - Enclose and forget,
  - Strategic closures addressing issues often mainly concerned with development of environmental values such as biodiversity conservation,
  - Initiatives that will result in the creation of employment and business opportunities.

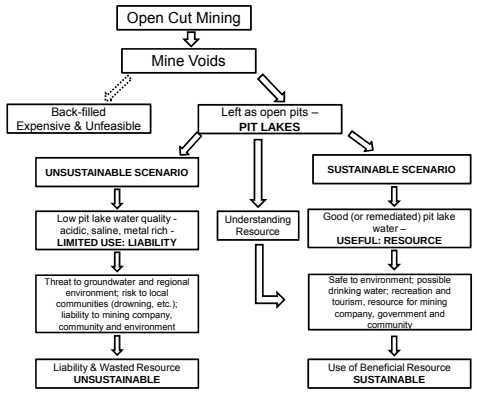
End Uses of Pit Lakes

- Water quality limits likely end use for pit lake water
- Remediation may be required to improve water quality in pit lakes:
  - Active: engineered solutions e.g., liming.
  - Passive: incorporates natural limnological, biological and bio-geochemical processes.
- Current predictive models cannot adequately account for remediative processes
- Instead, models most likely to provide information for advancing conceptual models
  - Provide advice of pit lake response to different management scenarios

Pit Lakes as Water Resources?

- No Commonwealth or State guidelines for developing pit lakes as useful water resources
- Understanding the resource will help in the long run
- Despite the potential usefulness there are many pit lakes across Australia with no planned current or future use

Realization of Water Resources



Range of Uses for Mine Pit Lake Waters

Pit lake end uses currently being explored:

- Aquaculture – assorted in-fish & marron
- Mining Industry – dust suppression
- Irrigation – mango horticulture
- Wildlife conservation – constructed wetlands for waterfowl
- Potable water resource
- Recreation and tourism – boating, water skiing, bathing
- Research and education
- Sacrificial

(Source: McCullough &Lund, 2006. Mine Water and the Environment, 25: 220-226)

Future of Australian Pit Lakes

- Mining likely to remain an important economic activity for next 150 years
- Mining has come at a cost, with pit lakes being an often ignored or poorly understood legacy
- Lack of understanding limits our ability to treat issues associated with pit lakes
- Water quality may need to be remediated or may limit end-uses
- Realisation of pit lakes as significant water resources infrequently explored
- Pit lakes remain a challenge for regulators

A Way Forward

- Avoid water quality problems by considering/ incorporating pit lakes in planning stages of mining development
  - Overburden characterisation and management in/around pit (lake)
- National pit lake inventory for Australia for number and distribution of pit lakes
  - Regional/geographical trends in water quality
- Research and trial new rehabilitation and water quality remediation technologies
  - Bioremediation showing promise
- Develop and trial beneficial end uses
  - Aquaculture

Thanks

Questions & Comments Please!

Fore more information:

Kumar, R.N., McCullough, C.D. & Lund, M.A. (in review). Pit lakes in Australia. In: *Acidic Pit Lakes - Legacies of surface mining on coal and metal ores.* (Ed W. Geller & M. Schultze). Springer, Berlin, Germany.

http://www.chs.ecu.edu.au/miwer/publications.htm