The fundamental cause for concern with regards to UCG is that the conditions under which the reaction takes place are naturally variable and difficult to know (sometimes unknowable), placing an inherent limitation on process control. This, combined with a number of significant environmental and human health hazards, creates risk. The table below outlines the main hazards associated with UCG.

Hazard	Environmental/health concern	Cause(s)	Example(s)
Inadequate: **- site selection** **- process modelling** **- monitoring** **- process control**	- Given that the UCG reaction is largely dependent on external factors, site selection, process modelling, monitoring and process control are crucial to risk mitigation for all of the hazards below.	- Inaccessibility of monitoring points (e.g. in marine environments) - Inadequate regulatory framework - Lack of modelling and data - Lack of expertise (operator, consultant, regulator) - Low maturity of UCG technology, especially for decommissioning and at commercial scale - Costs (commercial viability)	All examples to our knowledge have had problems associated with one or more of these aspects. It should be noted that successful decommissioning has yet to be sufficiently proven. This is especially pertinent for commercial scale sites, where control of temperature and pressure gradients in large cavities is more challenging[1].

Uncontrollable fire (in shallow coal seams)	- Groundwater/air pollution
	- Subsidence
		- Uncontrolled air/oxygen source to gasification cavity
		    - Faults/fractured/subsidence
		    - Damaged borehole casings
		    - Shallow target coal depth
		- Inadequate monitoring/site selection/process modelling
			No instances found in the literature but this may be from lack of reporting and the short duration of most projects. Analogous experience can be drawn from traditional mining activities.

Subsidence	- New pollutant/air pathways in rock fractures - Re-routing surface waters - Impacts to shallow aquifers - Damaged surface infrastructure	- Cavity collapse - Poor structural integrity of overlying rocks - Disturbance of historical coal mines - Inadequate monitoring/site selection/process modelling	- Hoe Creek III, USA[2] – late 1970s, shallow depth (~50m) trial, subsidence seen at surface.

Induced seismicity	- Groundwater/air pollution
	    - New pathways in rock fractures
	    - Damaged wells/monitoring boreholes
	- Damaged surface infrastructure
	- Explosion
		- Stresses imposed by the cavity remaining after combustion
		- Cavity collapse
		- Proximity to existing faults
		- Inadequate monitoring/site selection/process modelling
			No instances found in the literature but this may be from lack of reporting or monitoring. Analogous experience can be drawn from traditional mining activities.

Hazard	Environmental/health concern	Cause(s)	Example(s)

Production and mobilisation of pollutants	- Surface and groundwater contamination
	    - Toxic organic compounds (e.g. Phenols, PAHs, BTEX)
	    - Hazardous inorganic compounds (e.g. ammonia, nitrogen, cyanides)
	    - Soluble gases (e.g. hydrogen sulphide, carbon monoxide)
	    - NORM
		- Inadequate site selection
		- Inadequate decommissioning
		- Post-decommissioning groundwater flow
		- Inadequate treatment and disposal of produced water
		- Excess cavity/well pressure
		    - Inadequate monitoring/ process control
		    - Well blockage
		    - Uncontrollable fires/explosion
		- Subsidence
		- Damaged to monitoring or production boreholes/wells
		- Thermal/mechanical alteration of surrounding rocks
		- Faults/natural pollutant pathways
		- Intersection of historical mines
			- Hoe Creek I, II & III, USA[2,3] – late 1970s, 3 shallow depth (~50m) trials, significant long-term groundwater pollution due to over-pressured cavity.
			- Carbon Energy, Bloodwood Creek, Queensland, Australia – 2008 to present, an injection well blockage caused pressure to spike well above hydrostatic pressure, resulting in the emission of process water through the flare[1].

Gas emissions to atmosphere	- Air pollution
	    - Unburned hydrocarbons
	    - NOx
	    - H_2S and SO_2
	    - CO
	    - Particulate matter
	- Climate impacts
	    - CO_2
	    - CH_4
		- Inadequate monitoring/site selection/process modelling
		- Construction emissions
		- Emissions imbedded in materials
		- Flaring
		- Refining/combustion of syngas
		- Venting during start-up
		- Fugitive (escaped) gases due to:
		    - Leaking/damaged infrastructure
		    - Excess well pressure
		    - Underground explosion/faults
		    - Well blockage
			- Linc Energy, Chinchilla plant, Queensland, Australia – 2007-2013, workers suffered ill health due to “uncontrolled leaks” of syngas[4]. In 2007, a coal tar blockage caused a chamber fire, Linc Energy increased injection pressure causing well casings and overburden to crack and allow syngas to escape to the surface[5].
			
			- Lifecycle climate impacts are estimated (from few studies and limited evidence) to be less carbon intensive than coal but more than natural gas[6,7].

Hazard	Environmental/health concern	Cause(s)	Example(s)
Underground explosion	Groundwater/air pollution - Highly over-pressured cavity - New pathways in rock fractures - Damaged wells/monitoring boreholes - Damaged surface infrastructure - Subsidence - Induced seismicity	- Poor process control - Temperatures too high - Too much gasification agent - Too slow gas collection - Damaged wells - Material defect/installation error - Induced seismicity - Inadequate monitoring/site selection/process modelling	- Experimental Mine “Barbara”, Poland – 2013, a 30m deep engineered reactor, cracks developed causing gases to leak and create explosive accumulations, igniting due to high temperatures[8]. - El Tremedal, Spain – 1997, 550m deep, explosion of accumulated methane terminated the trial[7].

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