

Cleanup of Kafue River Basin – starting at Konkola Copper Mines

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The Problem

- The Kafue River Basin in the Chingola District, Zambia has experienced heavy polluting over the past several decades.
- Konkola Copper Mines (KCM) is the primary source of this pollution, disposing of industrial waste products and various bio-chemical substances directly into the reservoirs.
- They are not the only polluters, however, as the region is home to roughly 40% of the nation's socio-economic activity; a range of other industries are also at fault for the current state of the river basin: pulp-and-paper mills, fertilizer factories, granulation plants, abattoirs, textile manufacturers, and more.
- More than 93,000 tons of industrial waste are produced annually, most of which finds its way into the Kafue River. From there it flows into the Zambezi River – Africa's fourth largest – that claims Zambia as its source and winds through Angola, Namibia, Botswana, Zimbabwe, and Mozambique before eventually emptying out into the Indian Ocean.

The Location – Konkola



Acid Mine Drainage (ADM)

- If pyrites and sulphides are exposed to the air and water, they may form sulfuric acid, which will mobilize many metals including Copper and Cobalt, which is highly soluble in acid.
- This chemical reaction produces what is called acid mine drainage (AMD).

Pollution Levels 2010

	Kitwe	Mufulira	Chingola	Kalulushi	Chililabombwe	Chambishi	Water effluent discharge (mg/l)	
Population *	522 000	161 000	210 000	96 000	90 000	11 000	Suspended solids	100
Mining operations	Nkana & Mindolo	Mufulira	Nchanga & Chingola	Chibuluma	Konkola	Chambishi	Arsenic, total	0,5
As (mg/kg)	>5	>5	3	1	0.5	0.5	Cadmium, total	0,5
Co (mg/kg)	>60	>60	>60	35	9	19	Copper, total	1,5
Cr (mg/kg)	36	36	36	16	25	16	Lead, total	0,5
Cu (mg/kg)	>2200	>2200	>2200	1800	600	300	Mercury, total	0,002
Hg(mg/kg)	>0.06	>0.06	0.035	0.02	0.02	0.02	Iron, total	2
Ni (mg/kg)	12	22	7	5	7	5	pH	6–9 units
Pb (mg/kg)	>60	>60	>60	5	5	5		
Zn (mg/kg)	>60	>60	>60	20	40	10		

Average element concentrations presented per city together with information of population and active mines.

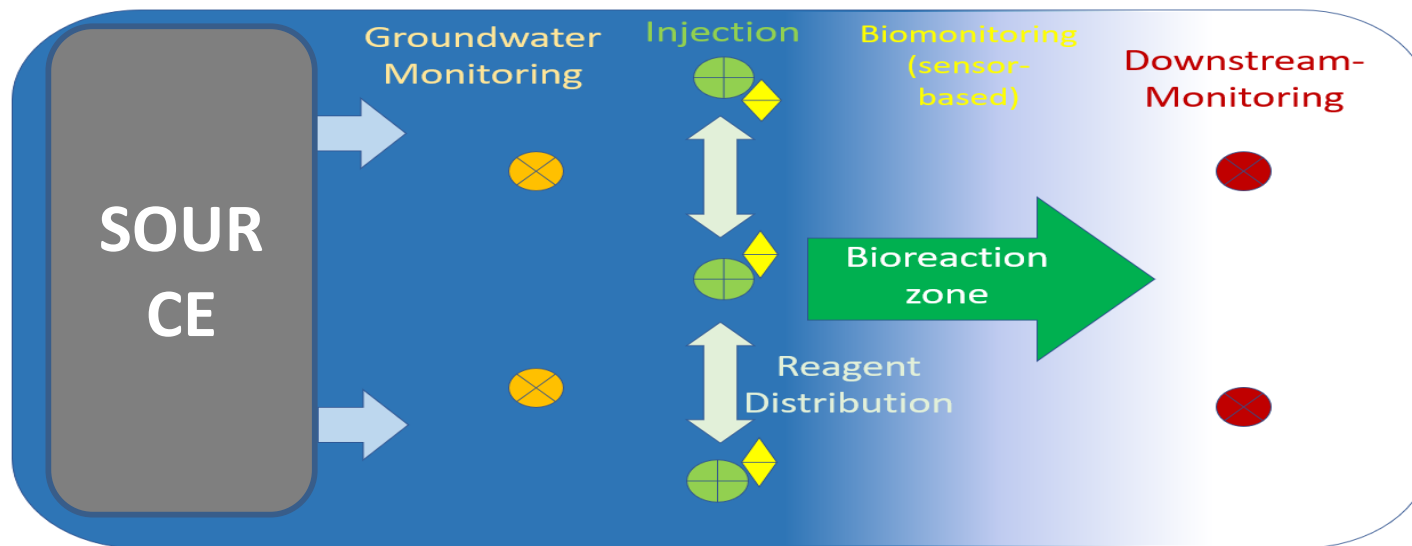
Concentrations marked in green are higher than international guideline values for soil suitable for residential and agricultural purposes, and concentrations marked in blue are likely to also be higher.

Health Effects

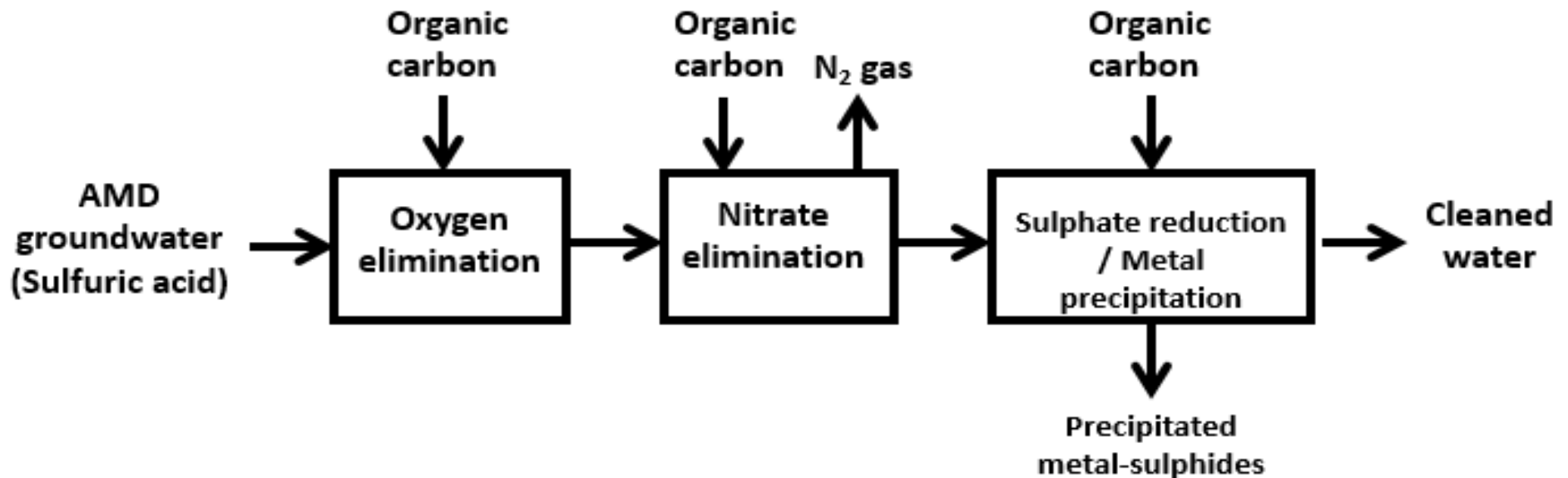
- Both aquatic life and human health are in danger. High incidences of environmentally mediated disease, such as gastro-enteritis, intestinal worms, and diarrhea diseases mostly in children have been reported from communities around the river and have been linked to drinking water from certain parts of the river.
- The raw sewer pollution of Kafue River could inadvertently lead to outbreaks of epidemics like cholera.

The Solution

- We believe an affordable solution is:
 - 1) In-Situ Remediation of the groundwater in the aquifer using Sulphate reducing bacteria
 - 2) And possibly some additional chemical and physical activities, depending on the environmental conditions



Remediation of AMD Contaminated Groundwater



- Sulphate reducing bacteria is grown with some sort of organic material, like cow manure or peat. These bacteria, in anaerobic conditions, use the organic carbon (CH_2O) from these environments to reduce sulfate (SO_4^{2-}) to sulphide (H_2S), which reacts with the dissolved metal ions created by the reactions with pyrite and water to precipitate them

Way Forward – a Pilot

Site specific condition investigation

- Geology and hydrogeology conditions have to be determined.
- Geochemistry conditions have to be determined.
- Bench scale tests with different additives and doses prior to implementation is needed.
- Pilot tests in small scale is advisable to get a final proof of concept
- Emulsified vegetable oil is preliminary the preferred amendment substrate due to:
 - Longevity in the subsurface
 - Cost efficient
 - Can be produced locally

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