Pollution registries for mines: Current state and future needs

Ann Maest[1] and Theodor Cojoianu[2]

[1]*Buka Environmental, Vice President, Telluride, Colorado, USA aamaest@gmail.com*

[2]*University of Edinburg Business School, Associate Professor in Sustainable Finance, Edinburgh, Scotland & Member of EU Platform on Sustainable Finance and HM GTAG theodor.cojoianu@ed.ac.uk*

Abstract

A worldwide assessment of pollution releases from mines has never been conducted. This paper compares disclosure requirements and results from mine pollution registries in Europe and the United States. The available data only account for total mass releases to the environment. Although most mines collect large amounts of site-specific water quality data, the generally low availability of the data and lack of interpretation present challenges for regulators and the public. Without increased transparency of water quality data in water bodies affected by mining, the extent and effects of mine-related pollution cannot be fully understood, prevented, or mitigated.

Keywords: Mine releases, pollution registry, mine certification, U.K. screening criteria, data transparency

Introduction

The European Union (EU) is in the process of designing technical screening criteria for pollution prevention and control related to the mining and quarrying sectors. Mining has several unique characteristics when it comes to its pollution profile that distinguish it from other industrial activities and must be considered when developing pollution prevention and control criteria that will minimize pollution from mining sources and prevent or reduce mining-related pollution in water bodies. Such characteristics include unique priority and geogenic pollutants, naturally occurring mine-related contaminants, and the importance of nonpoint/diffuse pollution. Although end-of-pipe data are available across the EU, the availability of water quality data in water bodies potentially affected by mining activities is scant, and the data are not organized at the Member State or EU level.

A worldwide assessment of releases from mine sites has never been conducted, and such an assessment presents many challenges. In general, the transparency and availability of mine pollution data are low. Several sources of end-of-pipe discharge data available worldwide were reviewed. The EU maintains a pollution transparency register that includes 8000 mines in Europe and an industrial emissions directory. The portal merged data from 2017 with data from the past. The data are presented in kilograms rather than concentrations in water bodies, accounting only for total mass releases. The same applies to the US, Australia, and other jurisdictions. For example, the US Environmental Protection Agency requires mines to submit their discharges to air, land, and water to the Toxics Release Inventory (TRI). The largest dischargers to land are mining sites, but the tons of mining waste discharged does not necessarily correlate with pollutant concentrations in water bodies.

Mines around the world are collecting site-specific water quality data, but the quality and quantity of data from modern mines are beyond the capacity of regulators to evaluate. How can access to data be accomplished and be made meaningful? Site-specific water quality data are needed for responsible mining certification programs aimed at improving practices and reducing environmental effects of the sector. Without site-specific data in water bodies affected by mining, the extent and effects of mine-related pollution cannot be fully understood, prevented, or mitigated.

Table 1 Comparison of pollution registry reporting requirements in Europe and the U.S.

Reporting Requirement	European Pollutant Release and Transfer Register (E-PRTR)	U.S. Toxics Release Inventory
Required criteria for reporting	underground mines must report; opencast mining and quarrying must report if area under extractive operation ≥25 hectares.	1) in TRI-listed industry sector (includes metal mines) or federally owned/ operated, 2) ≥10 full-time employee equivalents, 3) processes >25,000 lbs or uses >10,000 lbs of TRI-listed chemical annually
Mines reporting	Mineral industry installations (including coal and metal mining)	Coal, metal, non-metallic mines
# Mines/activities reporting in 2021	141	87 (metal mines)
Releases to land	Yes	Yes
Releases to water	Yes	Yes
Releases to air	Yes	Yes
Reporting units[1]	kg/year	pounds/year
# Chemicals/ chemical categories	91	787/33
Basis for reporting	Yearly aggregations; measured, calculated, or estimated	Continuous monitoring data, periodic or random monitoring data, or mass balance calculations

Disclosure Reporting Requirements for Pollution Registries

The reporting requirements for pollution registries in Europe and the U.S. are listed in Table 1.

European registry

The primary pollution registry for mines in Europe is the European Pollutant Release and Transfer Register (E-PRTR; European Commission 2023). The E-PRTR is deeply connected to the Industrial Emissions Directive, having similar reporting obligations for the emission and transfer of pollutants that adhere to the permit conditions outlined in the directive. The functions of the E-PRTR include: 1) providing dependable and uniform data on emissions of pollutants by the industry in the EU and 2) enhancing transparency and public involvement in environmental policy making. In addition to the requirements set for individual economic activities to disclose, 91 pollutants across air, land, and water have specific disclosure requirements if the quantity released surpasses certain thresholds as per Regulation (EC) No 166/2006. Guidance for data reporting can be found in European Environmental Agency (2021). The E-PRTR, while granular on the reporting of pollutants, does not identify the type of mine that reports, and users of the registry cannot differentiate across commodities.

U.S. registry

The only national-level, mandatory pollution registry for industries in the United States is the Toxics Release Inventory (TRI) of the U.S. Environmental Protection Agency (US EPA). The metal mining sectors reporting to the TRI are covered under North American Industry Classification System (NAICS) code 2122 and include facilities mining gold, silver, lead, zinc, copper, and nickel ores; NAISC code 212299 includes many other less common metal mines that must report (e.g., Sb, Cr, Co, Mn, Pt, Pd, rare earth elements (REEs)) but does not include iron ore or uranium mines. According to the reporting guidance document for metal mines (US EPA 1999), the total amount of waste rock and tailings and an estimated amount of metal in these wastes (using estimated percentages in the wastes) must be reported to TRI on their Form R, but reporting the amount is optional. For heap and dump leaching activities, reporting is not required until the leaching activity is completed, assuming the amount exceeds threshold values (US EPA 1999). The US EPA provides reporting software with built-in data quality alerts and makes calls to facilities to evaluate reporting accuracy if certain conditions are triggered, including those with the largest changes in reporting amounts from the previous year, the largest releases to air or water, and those reporting to

Table 2 Reporting incompleteness across air and water pollutants by metal mines in the EU Member States in 2021.

Release Medium	Pollutant	Reporting Completeness %
Water	Zinc and compounds (as Zn)	22%
Air	Arsenic and compounds (as As)	18%
Air	Nickel and compounds (as Ni)	18%
Air	Copper and compounds (as Cu)	14%
Water	Lead and compounds (as Pb)	13%
Water	Total nitrogen (as N)	11%
Water	Cadmium and compounds (as Cd)	9%
Water	Chromium and compounds (as Cr)	9%
Air	Mercury and compounds (as Hg)	8%
Water	Cyanide (as total CN)	5%

other EPA or non-EPA programs but not to TRI (US EPA 2023a).

Results and Discussion

European registry

In 2021, across the 141 mining-related economic activities in Europe we find sparse reporting by most mines and countries for 27 pollutants. In 2021, data reporting for Czechia, Liechtenstein, Lithuania, Malta, Serbia, Slovakia, and Switzerland was incomplete. In addition, emissions to land have generally been very scarcely reported, and the data that are reported are incomplete (European Environmental Agency 2023). The reporting completeness[2] varies between 22% for zinc and compounds to water and 5% for cyanide to water (Table 2).

The selective reporting for metal mine pollutants by individual Member States makes comparisons across Member States difficult. The lack of access to the permit details and concentration data in water bodies related to these releases results in the poor ability of stakeholder to scrutinise the pollution record of most mining facilities in Europe. Table 3 further illustrates that across Europe, under the current disclosure regime, one could conclude that mines in Germany and Poland are the biggest polluters; however, this would likely be an unreliable conclusion given the lack of reporting completeness.

U.S. Toxics Release Inventory

The TRI does allow identification of different types of mines (e.g., coal vs metal). The results in this section refer to metal mines. The metal mining sector had the largest TRI releases of any industrial sector and accounted for 68% of land disposal and 44% of all TRI releases to land, water, and air. The largest releases by far for metal mines are to land. The metals of potential environmental interest that are required to be reported to TRI include:

- Al (fume or dust)
- Sb, Sb compounds
- As, As compounds
- Ba, Ba compounds
- Be, Be compounds
- Cd, Cd compounds
- Cr, Cr compounds
- Co, Co compounds
- Cu, Cu compounds
- Pb, Pb compounds
- Mn, Mn compounds
- Hg, Hg compounds
- Molybdenum trioxide
- Ni, Ni compounds
- Se, Se compounds
- Ag, Ag compounds
- Tl, Tl compounds
- V, V compounds
- Zn, Zn compounds

For the metals and metalloids that include "compounds," the compound itself is not required to be reported. For example, if the copper compound is CuFeS2, or chalcopyrite, approximately 35% of the compound is copper by weight. Therefore, for metal compounds, the amount of metal (e.g., copper) is less than the reported amount of the metal compound, and the actual amount of metal is not known.

[2] The percent of mines reporting a specific pollutant in their releases to land, air, or water.

Table 3 Total quantities, kg, of air and water pollutants released by mines across EU Member States (2021).

Member State	Air	Water	Air and Water	% Contribution to total pollutant discharge to air and water
Austria	789	0	789	0.01%
Belgium	217	0	217	0.00%
Bulgaria	0	4,607	4,607	0.05%
Estonia	27	0	27	0.00%
Finland	364	99	463	0.00%
France	592	4	596	0.01%
Germany	1,012,319	1,398,893	2,411,212	25.16%
Greece	113	0	113	0.00%
Hungary	125	0	125	0.00%
Ireland	16	1	17	0.00%
Italy	518,975	0	518,975	5.41%
Poland	5,208,153	1,431,485	6,639,638	69.27%
Portugal	105	0	105	0.00%
Romania	2,376	10	2,386	0.02%
Slovenia	3,501	0	3,501	0.04%
Spain	1,692	0	1,692	0.02%
Sweden	297	63	360	0.00
Total (kg released in 2021)	6,749,660	2,835,161	9,584,821	100.00%

Using all the metals listed above, in 2021 the metal mining sector released 643,952 tonnes (metric tons) to land, 27.7 tonnes to water, and 147 tonnes to air (49.5% by fugitive air emissions and 50.5% by stack emissions). Total TRI releases for the metal mining sector in 2021 for the 17 metals listed above were 1,421,728,215 lbs. The top ten metal mines in terms of releasing the 17 TRI metals to land, air, and water in 2021 are shown in Table 4.

Other chemicals used on site that do not derive from constituents in the ore or waste include nitrate and ammonia (from blasting using ammonium nitrate-fuel oil, or ANFO) and cyanide and hydrogen cyanide (used to extract gold and other precious metals from the ore). Releases of these chemicals from the metal mining sector reporting to the TRI are included in Table 5. With the exception of hydrogen cyanide, which is a poisonous liquid or gas, releases to land were higher than to air or water. The majority of the releases in Table 5 were from gold ore mining facilities, and the majority of the reporting metal mine facilities are gold mines in Nevada.

Conclusions and Recommendations for Improvement

Given that much of the emerging EU Sustainable Finance legislation includes pollution prevention as one of its key environmental objectives, having access to a usable and complete pollution registry is paramount. In this respect, we urge policymakers to enable sustainable investment decisions by mandating a better coverage of pollutant disclosures across entities, in particular the concentrations of the different discharges across air, land and water. Reporting of pollutant emissions to land is scarce in the E-PRTR but is especially important for the mining sector, as shown by the dominance of land releases from metal mines in the U.S. TRI.

Knowing the composition of metal compounds would improve TRI reporting. Additional constituents of interest for metal mines that could be added to the TRI list include radioactive elements (uranium, thorium, radon), and chemicals of interest for renewable energy, including lithium, tellurium, gallium, and certain REEs. Although uranium, iron ore, and lithium mines are not currently included in the sectors that must report their releases to the TRI,3 ores and wastes from these and other metal mines can include these constituents, and knowing the amounts in waste releases would help with environmental protection (for the radioactive constituents) and could

Table 4 *Top 10 U.S. metal mines with total TRI releases to land, air, and water in 2021.*

Facility Name	State	Metal Mining Category	Total TRI Releases (lbs)
Red Dog Operations	Alaska	All Other Metal Ore Mining	601,564,301
Nevada Gold Mines LLC – Goldstrike Mines Inc	Nevada	Gold Ore Mining	272,060,230
Kennecott Utah Copper Mine Concentrators & Power Plant	Utah	Copper, Nickel, Lead, and Zinc Mining	149,354,786
Hecla Greens Creek Mining Co	Alaska	Gold Ore Mining	70,879,234
Nevada Gold Mines LLC – Carlin South Area	Nevada	Gold Ore Mining	48,552,839
Montana Resources LLP	Montana	Copper, Nickel, Lead, and Zinc Mining	41,575,557
Nevada Gold Mines LLC-Cortez District	Nevada	Gold Ore Mining	35,958,324
Robinson Nevada Mining Co	Nevada	Copper, Nickel, Lead, and Zinc Mining	19,032,085
Nevada Gold Mines LLC – Phoenix Mine	Nevada	Gold Ore Mining	15,906,928
Nevada Gold Mines LLC – Turquoise Ridge	Nevada	Gold Ore Mining	15,311,057

Metals include (metals + metals and compounds): Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Hg, Ni, Se, Ag, Tl, V, and Zn. Source: US EPA, 2023b

Table 5 *Releases of nitrogen and cyanide compounds from the metal mining sector, TRI data for 2021 (US EPA 2023b).*

Chemical	Total releases lbs	Land releases lbs	Air releases lbs	Water releases lbs	Releasing metal ore mining sector
Nitrate	13,281,024	12,430,185	–	848,932	Gold (98%)
Ammonia	1,775,632	1,470,588	274,424	30,599	Gold (41.5%); Cu, Ni, Pb, Zn (1.7%); All other (56.7%)
Cyanide	1,911,473	1,887,641	23,376	–	Gold (~100%)
Hydrogen cyanide	61,996	–	61,996	–	Gold (100%)

be a first step for examining the remining potential of the wastes for renewable energy (World Bank 2020; IEA 2022).

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