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Review

Water footprinting and mining: Where are the limitations and opportunities?

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ABSTRACT

The interactions of the mining industry with water resources are highly complex and site specific, with potential impacts to both hydrology and water quality occurring at all stages of a mine's life. A range of water management approaches are employed by the industry to mitigate the risks of adverse water impacts occurring. Consequently, the significant variability within the industry poses a range of challenges when attempting to quantify the water footprint of mining operations and mineral commodities.

Methods for water footprinting have developed significantly over the past decade and have recently become aligned with life cycle assessment approaches. Despite these advances, relatively few studies have focused upon applying these methods within the mining and mineral processing industry. A range of limitations were identified that hinder the ability to conduct these types of studies. These limitations include: the availability of mine site water use data, inventory data for mining supply chains, the uncertainty of post-closure impacts, and the difficulty of accounting for cumulative impacts and extreme events (e.g. flooding, dam failures, etc.). The spatial resolution and data underpinnings of current water footprint impact characterisation factors also limits the ability to interpret results that may be generated. Overcoming these limitations, through methodological development and data collection efforts, represents a significant opportunity to improve our understanding of the mining industry's water use and impacts.

Beyond this, several key opportunities for more widespread use of mine site water footprint assessments were identified, including: to aid the benchmarking of water performance in the mining industry, to improve the quality of cross-sectoral assessments of water use, to assess the indirect impacts of competing technologies, and to provide improved water use disclosures within corporate sustainability reports.

Contents

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1. Introduction

Approximately 1.7×10^9 people live in regions where groundwater is being overexploited (Gleeson et al., 2012) and an estimated 4×10^9 people live in regions that are exposed to water scarcity for at least 1 month per year (Mekonnen and Hoekstra, 2016). Over the past two decades, these types of pressures have led to the development of approaches to quantify the *water footprint* of regions, products and processes. Earlier approaches had a particular focus on measuring volumes of water consumption (e.g. Chapagain and Hoekstra, 2004); however, more recent methods place greater emphasis on how to relate this water consumption to the potential for impact to end-users and environments. A significant step along this path has been the development of the ISO 14046 standard for water footprinting (ISO, 2014), which has more explicitly aligned water footprinting within the framework of life cycle assessment methodology.

The role of water footprinting differs from individual site based environmental impact assessments, as the methods are not necessarily tailored to understand the *absolute* impact associated with any individual processing facility; rather the methods are tailored to understand the *relative* potential for impact between process facilities and across supply chains. Due to this, results developed using water footprint methods and life cycle assessment may not necessarily be representative of what is actually happening on the ground, particularly when uncertainty related with impact calculation procedures are combined with the current limitations and availability of water use data.

Mining could be considered one of the most diverse industries with respect to how it interacts with water resources (Younger et al., 2002). Mining occurs across the full spectrum of hydrological contexts; from the arid regions of central Australia through the tropics and to the sub-arctic conditions of Canada and Finland. The local climate and hydrology dictates infrastructure requirements at mining operations and has a profound influence on the nature of water related risks faced by mines and nearby communities, ecosystems and industry. Examples of these risks include uncertainty over access to a stable water supply, the potential for flooding of open pits, uncontrolled discharges and catastrophic collapses of waste impoundments. Water quality risks associated with mining can also be viewed quite differently to other industries such as agriculture, as the risks associated with a particular mine are heavily dependent upon a combination of factors, such as: the geochemistry of the ore body, the strategies for managing mine discharge, the types of mining utilised, the processes used to separate valuable minerals from ore, and the approach taken for storage of large mine wastes.

Despite mining being a relatively small consumer of water on a global scale, in the regions where mining does occur it can often represent a major local consumer of water. The impacts of the industry's water consumption, in conjunction with the potential for significant water quality impacts, can lead to social tension with other water user groups such as fisheries (Holley and Mitcham, 2016), agriculture, communities (Ghorbani and Kuan, 2016; Kemp et al., 2010) or tourism (Wessman et al., 2014). As a response, it is increasingly being recognised that mining operations must develop and maintain a social license to operate and, as part of this, that local water quality should be protected at all stages of a mines life (e.g. Caron et al., 2016).

The ability of water footprinting to contribute to our understanding of water usage, impacts and risks across the mining industry will be addressed in this article. The major aims of this article are to:

1. Provide a broad overview of mining's interactions with water resources;
2. Briefly summarise the current state of water footprinting methodology and determine to what extent this has been applied in studies of mined products;
3. Identify the current limitations that need to be overcome to improve water footprints estimates of mining operations and mined products; and,
4. Identify the opportunities for applying water footprint methods in the mining industry.