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Non-energy, non-agriculture raw materials production:

Data to monitor the sector's water use and emissions to water

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Abstract

Water is an essential resource in the operation and sustainability of facilities producing raw materials and it is used and impacted in multiple ways. Therefore, there is a need for sound data to monitor the EU sector water performance and its pressures on the environment from a quantitative and qualitative point of view. This study assesses available water data for a well-informed EU raw materials policy which covers the extraction of non-fuel, non-agricultural raw materials. In this study, EU available national-level data on water use and water pollution were assessed. We found that official records are limited for a comprehensive assessment of the sector, and accessible water accounting by the industry is poor. Limited country and sector coverage and comparability of different datasets illustrate some of the challenges faced in providing sound data for some policymaking areas. This highlights the need to combine data from official-, scientific- and industry-data sources, yet this remains challenging. Therefore, an improvement in the systematic compilation of comprehensive, detailed and validated raw data related to water use, water pollution and industrial production remains the main priority.

Key words: EU raw materials policy, sustainability, environmental performance, water use, water pollution

1 INTRODUCTION

1.1 Policy background

The communication *For a European industrial renaissance* (European Commission, 2014) stressed the need to promote growth and modernisation in the EU after the crisis period and called on EU countries to recognise the central importance of industry for creating jobs and growth. More recently, the new industrial policy strategy (European Commission, 2017a) further aims at empowering European industries to continue delivering sustainable growth and jobs.

Within this framework and as recognised by the raw materials initiative (European Commission, 2008), non-fuel, non-agricultural raw materials are the building blocks of the economy, essential for the functioning of European industries (e.g. construction, chemicals, automotive, aerospace, machinery and equipment sectors). This includes abiotic materials such as metals, non-metallic minerals, and industrial minerals and biotic materials such as wood and natural rubber. Some of these materials are considered 'critical' (European Commission, 2017b), since they are very relevant to the EU economy while at the same time they show risk of supply disruption due to e.g. poor governance conditions in supplying countries or the setup of trade restrictions.

Reliable and undistorted access to raw materials is increasingly becoming a significant factor for the EU's competitiveness. Secure and sustainable sourcing of raw materials is also considered crucial towards a circular economy, where the circular economy action plan (European Commission, 2015) is working on 'closing the loop' of products' life cycle from production and consumption to waste management, as well as to boost the market for secondary (recycled) raw materials.

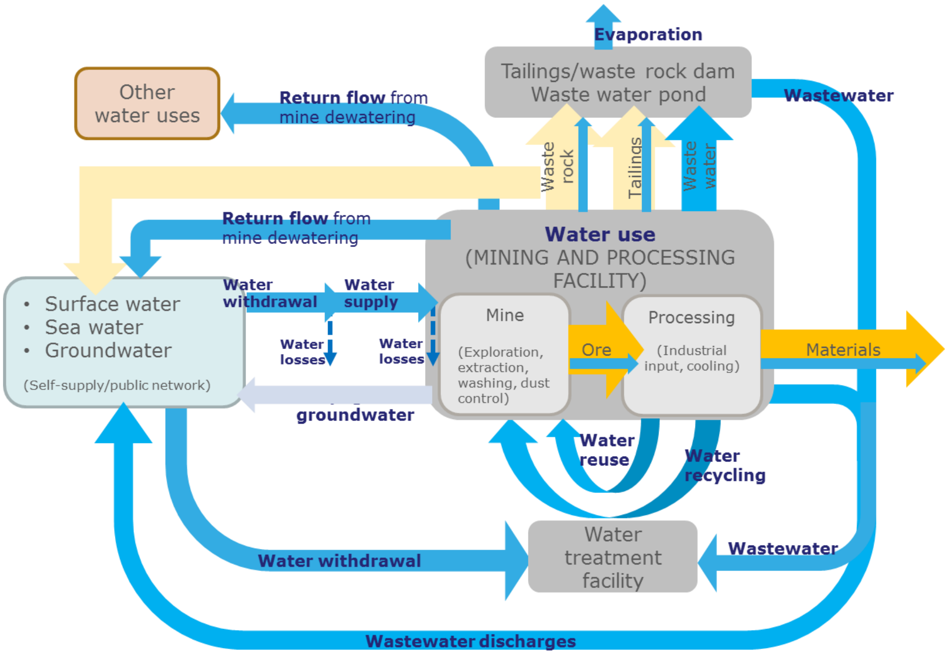
Resource efficiency, which embraces materials (e.g. raw materials) and resources such as land and water, is also part of the Europe 2020 strategy for smart, sustainable and inclusive growth (European Commission, 2010). Resource efficiency means doing more with less and aims to decouple economic growth from resource use and its environmental impact, considering the full life cycle of products.

In order to count on a sound and continuously updated knowledge base for the support of EU policies, in particular the raw materials and circular economy policies, the European Commission is developing the raw materials information system (RMIS 2.0) (European Commission, 2017c) and the raw materials scoreboard (European Commission, 2016; forthcoming), which aim to provide reference information and data to follow up on the challenges of the EU raw materials industry. These challenges cover a comprehensive set of topics such as framework conditions for mining, materials trade flows and end uses, recycling or environmental performance, covering e.g. the release of pollutants to and the use of water by the sector.

1.2 Water use by the raw materials sector

Water is an essential production factor for raw materials production. It is used in multiple ways, from ore processing to dust suppression, cooling processes and as material input for most industrial processes (Figure 1). Industries need the right amount of water in the right moment and with the required quality. To that aim, mining and processing facilities often count on self supplies of water, which might come from local water bodies, groundwater or the sea. Water might also be supplied by the public network. For the specific case of mining operations, additional water resources are usually available from mine dewatering, which often satisfies the facility requirements and also may provide additional resources for other water users. As a drawback, dewatering might lead to drawdown of the water table under certain circumstances (Northey et al., 2016). Depending on the water-quality requirements for the specific mining and industrial processes, water supplies might require pretreatment. After water has been used the incurring wastewater is treated and discharged to nature. Facilities might set up different types of dedicated ponds and dams for wastewater management (Northey et al., 2016). Often, wastewater is reused and/or recycled and looped back into the facility for processes that are less demanding in terms of water quality (cascade use). While manufacturing industries are point pollution sources, diffuse pollution from mining activities can be significant (e.g. acid mine drainage from sulphide minerals). This applies to active but also to non-operating or even abandoned sites, since many of the water impacts may occur post-closure (Northey et al., 2016).

Figure 1: Use of water by a typical non-energy mining and processing facility.



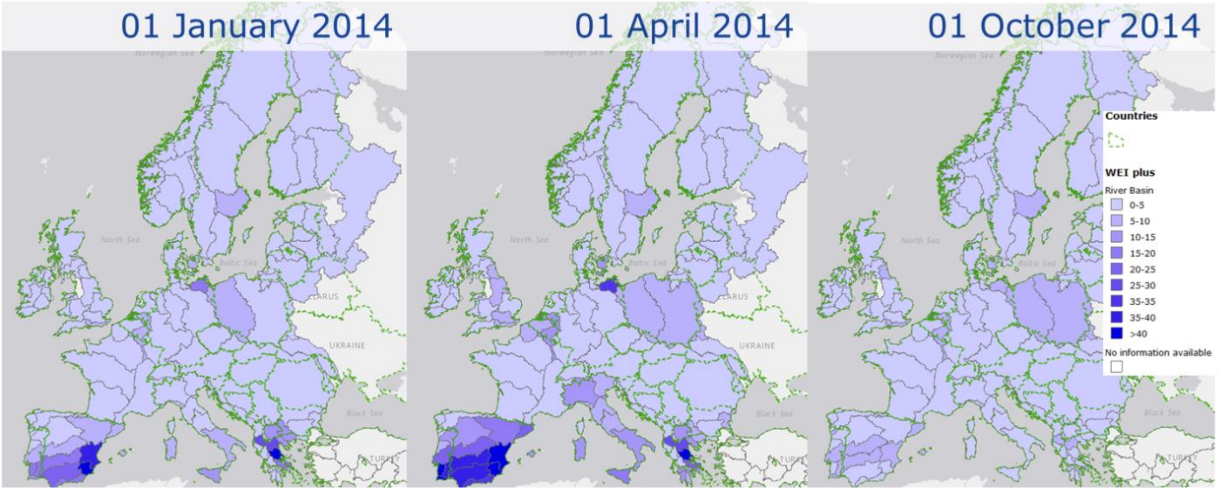
The environmental performance of industrial facilities, and therefore the pressures they pose to water quantity and quality, depends on these in- and out-water flows, which highly differ among types of operations, local water-framework conditions and regulatory frameworks. These pressures may be translated into impacts on ecosystems and human health in general and to water resources in particular.

Although generally the raw materials sector is a relatively small water consumer as compared to other sectors such as agriculture both globally (Northey et al., 2016) and within the EU (European Topic Centre on Inland, Coastal and Marine Water (ETC), 2017a), some raw materials production activities are among the most water-intense economic activities (ETC, 2017a, Organisation for Economic Cooperation and Development (OECD)/Eurostat, 2014). The extraction of some minerals such as precious metals, and the manufacture of basic metals (such as iron and steel or aluminium) and pulp and paper use large amounts of water both in terms of total water use and water use per unit of industrial output (i.e. water intensity). The manufacture of non-metallic mineral products (such as glass, ceramic products, cement, plaster, etc.) and fabricated metal products are also among the most water-use-intensive sectors (OECD/Eurostat, 2014). Wood manufacturing is usually less water demanding.

Therefore, the raw materials industries can have a significant relevance to the local water balance. At the same time, some activities of the sector are among the activities having a stronger impact on water quality (Soerme et al., 2016; ETC, 2017b). For instance, the sector releases relevant amounts of heavy metals and pollutants such as organic halogen compounds.

The impact of the sector on water availability, both in terms of water volume and water quality, might determine the sustainability of the activity. Indeed, water scarcity, water quality and water price can be the main determinants in the location of an operation site in water-scarce environments (INE, 2013). Moreover, there are rising concerns worldwide about the further increase of water stress (WRI, 2018), which might result in production disruptions, also for the case of raw materials industries (ICMM, 2013). In this regard, under water-stress conditions, water supply to industry is usually not given priority over e.g. supply to households. In the EU, although the use of water resources can be considered sustainable in the long-term overall, specific regions in southern Europe already face water-stress problems (Figure 2), which might be accentuated under the effects of climate change.

Figure 2: Water exploitation index plus (WEI+) by European catchment and rivers network system ([1]). WEI+ compares freshwater use with long-term water availability. A WEI+ value above 20 indicates water stress and above 40, severe water stress.



Source: Adapted from EEA (2017) ([2]).

1.3 Policy response and data needs

So far, given the importance of safeguarding water resources, several regulations have been developed at EU and national level in order to control activities creating pressure on water resources and recover the good status of water bodies and water-related ecosystems. The water framework directive (WFD) (European Commission, 2000, currently undergoing a review ([3])) establishes the quality objectives for EU water bodies. Water use and wastewater discharges are also regulated by the industrial emissions directive (IED) (EU, 2010), which covers the largest installations producing metals and minerals, the wood processing sector and the production of pulp and paper and processing of natural rubber. This directive requires facilities to adopt the so-called best available techniques (BAT) for obtaining the operation permit, which is managed generally by environmental authorities at national or sub-national level. However, industries might be exempt from the adoption of BATs under some circumstances. BATs are detailed in the BAT reference documents (BREFs) ([4]), which are also further promoted by the circular economy action plan (European Commission, 2015), and which include standards for the water use and water discharge of industrial processes. The European Commission has adopted BREFs for several industry sectors such as iron and steel, wood and ceramic, while other BREFs are under development. In addition, the BREF on *Management of tailings and waste-rock in mining activities* (European Commission, 2009), is currently under review. However, standards in this latter BREF document will not be binding for the mining sector. Apart from that, the impact of mining sites on water quality falls under the extractive waste directive (European

(1) ECRINS.
(2) https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/water-exploitation-index-for-river-2.
(3) Commission's regulatory fitness and performance (REFIT) programme.
(4) http://eippcb.jrc.ec.europa.eu/reference.

Commission, 2006), currently under review, and which provides for measures, procedures and guidance to prevent or reduce as far as possible any adverse effects on the environment from extractive industries. The directive calls on all EU Member States (EU-28) to require the extractive industries to apply monitoring and management controls in order to prevent water and soil pollution. In addition, new industrial projects require an environmental authorisation according to the environmental impact assessment directive (EU, 2011), which also covers the use of water and the release of pollutants to water. In parallel to these regulations, the *Roadmap to a resource efficient Europe* (European Commission, 2011) highlights the need to promote water efficiency, and declares that efficiency could be significantly improved based on technological improvements. Furthermore, boosting water reuse and recycling, in a context of increasing water-scarcity problems is also further promoted by the circular economy action plan (European Commission, 2015).

In this context, it becomes essential to count on sound data to monitor the EU sector water performance from a quantitative and qualitative point of view. Data are needed for instance for the development of sound indicators that can inform policy about water stress, which is also promoted by the sustainable development goals (SDGs) through indicator 6.4.2 — Level of water stress). Also to monitor changes in water efficiency, as suggested by SDG indicator 6.4.1 — Change in water efficiency over time. Counting on sound data considering both the environmental and socioeconomic performance of the different raw materials activities would inform decision-making about the trade-offs and synergies of the development of such activities.

For a sound assessment of the associated impacts, the specificities of the geographical location need to also be considered (Northey et al., 2016; Fonseca et al., 2014). However, the assessment of water use is a very complex task. First, water use is very industry-specific. Further, water supply and distribution networks are complex, often with both public authorities and private stakeholders involved. In addition, regulatory frameworks for water pricing, water allocation, etc. vary across countries and regions, which drive changes in water use and water efficiency differently. The sound assessment of water performance by mining activities is particularly challenging, since water use and water production (from dewatering) often coexist (Schultze, 2012) and several water sources with different quality levels might be used, and water demand might strongly vary depending on the processing requirements of the ore mined (Northey et al., 2013; 2016).

1.4 Recent trends and challenges ahead

Awareness of the impacts of the raw materials industry on water started back in the 1960s, with e.g. mining companies introducing measures to prevent the generation of contaminated water (UNEP, 2013). In recent years, the raw materials industry claims to have made strong efforts to reduce water use and wastewater discharges through e.g. improvements in water reuse (WssTP, 2013; CEPI, 2014). The deployment of the EU legislation (e.g. IED, the BREFs standards, and also the urban waste water directives ([5]))also had a positive impact on controlling pressures on water resources within the EU such as the reduction of discharges to water bodies due to the increase in wastewater-treatment rates, which have improved in all parts of the EU in the last 15-20 years (ETC, 2017b). In addition to that, increasing water costs and the sometimes limited availability of water resources (in e.g. semi-arid environments with drought periods) have fostered the adoption of water-saving technologies: creating closed water circuits, recycling wastewater, equipment optimisation, etc. (INE, 2013). When water availability is a concern, mining facilities try to reduce evaporation from water stores (Northey et al., 2016).

However, many challenges remain. First, water reuse capacity is limited, partly due to the fact that it generates additional management problems such as water salinisation and the resulting corrosion (Egerer and Zimmer (2006)). Therefore, the industry often prefers 'new'

([5]) http://ec.europa.eu/environment/water/water-urbanwaste/index_en.html water over reused/recycled water whenever this is physically and economically feasible (Egerer and Zimmer (2006)). The adoption of new technologies with better water performance can also be costly. Furthermore, while the prevention of water contamination nowadays is a significant part of mine operation and closure, and although mines have been incorporating control systems as required by the regulation, the potential of old abandoned sites to pollute water can be high (Paya Perez and Rodriguez Eugenio, 2018). In fact, abandoned and historic mining is among the water pollution sources listed in the WFD inventory of emissions, discharges and losses (European Commission, 2012, in ETC, 2017b). Decreasing ore grades, which the subsequent increase of water demand for ore processing, also challenges improvements in water performance by the mining activities (Northey et al., 2016).

Given the relevance of water use and water efficiency in the EU policies, accurate data on water use and water pollution and production volumes in raw materials facilities are required. While this type of data are generally provided by facilities to the authorities responsible for the operation permits, a comprehensive outlook on the pressures of the whole raw materials sector is missing. This study aims to identify and assess available data sources for monitoring the pressures on the environment posed by the EU raw materials industries over time. Our findings should serve to identify valuable data sources for monitoring the water performance of raw materials industries for a well-informed support to the EU raw materials policies.

2 METHODS

This study consisted of the following:

— Identification of the most relevant data sources for the assessment. The starting point was the list of water data sources considered for the 2016 Raw Materials Scoreboard (European Commission, 2016) (Table 1). This previous assessment, similar in scope to this current study, targeted water data for the EU-28 that inform about the main pressures from the industry on water in terms of quantity and quality of water and the performance of the sector. This embraced data on water withdrawal, water supply, water intensity, water discharges, pollutant releases, etc. (see Table 2). Data at sector level (see

— Table 3 for sector coverage) and for the production of specific commodities (e.g. copper, aluminium) were targeted.

— Interview experts for some of the data sources mentioned above. These interviews led to additional data sources such as sustainability-reporting initiatives, the EEA water accounts, and water-use data directly obtained from EU national-level statistical offices (see results (Section 3)).

— Assessment of the data sources identified. This included the understanding of the underlying methodologies, and assessing the sector/material, time and geographic coverage, as well as the completeness of the data. At this stage we performed additional interviews with experts, and the analysis of the data provided by the different data sources, as well as further reviews of scientific and grey (non-scientific) literature on the data sources identified.

Table 1: Water data sources assessed for the 2016 Raw Materials Scoreboard (European Commission, 2016).

Data sources considered	**Disregarding reasoning**
Eurostat on water use by supply category and economical sector.	Limited data available and lack of data on water consumption.
Water exploitation index (WEI) ([6]) and development of the improved WEI+ index, which can better describe how water scarcity affects different parts and basins of each Member State.	Not disaggregated by sector.
Environmentally extended input-output tables e.g. the world input-output database (WIOD).	Data availability for the raw materials sector is very limited (e.g. missing data for mining and quarrying and for many countries).
Eurostat data on generation and discharge of wastewater.	It focuses on urban activities and does not provide data broken down by sectors.
European pollutant release and transfer register (E-PRTR).	This information cannot be used to assess changes in water quality. Such an assessment would require monitoring of the concentration of pollutants in water.
Potential data sources in the future	
The International Standards Organisation (ISO) standard on water footprint ([7]): released in 2014 and based on a life cycle approach, this standard requires computing the water-footprint inventory, i.e. the water flows (considering inputs, recycle/reuse and discharges) associated with production, not only by product but also by organisation. This includes water quantity and quality, whenever relevant.	
Life cycle data: although this approach is restricted to specific products (rather than sectors), it could be used to identify and analyse key processes in terms of water consumption in the raw materials production chain. This could be used to compare water intensity between products.	
Other indicators derived from water accounting following the United Nations (UN) approach (system of environmental-economic accounts for water (SEEAW)) ([8]).	
Additional considerations	
To get a complete picture of water use in the raw materials sector, the information on water use and water discharges should be complemented with background information on water scarcity to reflect the differential impact of water use under different water-availability conditions.	

Source: Own elaboration based on previous analysis for the European Commission (2016).

([6]) https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/water-exploitation-index-for-river-2.

([7]) ISO 14046:2014 *Environmental management — Water footprint — Principles, requirements and guidelines*.

([8]) Several pilot projects on water accounts have been completed in various Member States, and a guidance document on water asset accounts (water balances) has been published by the Commission

Table 2: Water indicators.

Water withdrawal (also called abstraction or extraction): water removed from any source, either permanently or temporarily. Mine water and drainage water are generally included whereas water for hydroelectricity generation should be excluded. However, for some countries only the withdrawal of water that will be used by the activity will be accounted for as withdrawal, excluding e.g. water from drainage in construction activities. While gross water withdrawal includes all water removals, net water withdrawal is the result of gross water withdrawal minus returned water. While some approaches (e.g. Eurostat) estimate water withdrawal based only on self intakes, some national statistics calculate it considering self intakes plus water supplied by the public network.
Returned water: water abstracted and then returned to the water bodies without being used, such as water from mines and from water drainage in construction activities.
Water supply: is the amount of water that arrives or is available to the activity for use. This might comprise the public network supply only or also self supply.
Water use: it is the actual volume of water used by an activity, so abstraction minus returned water. This includes also possible water losses. Water use is sometimes also used as a synonym for water withdrawal (e.g. by input-output tables). Definitions vary nationally, e.g. some also consider cooling water as water use.
Water consumption: water that is no longer available since it might have evaporated, been lost or now forms part of the products.
Water intensity: water withdrawal or other water intake/use indicator related to the output of the sector. It could be related to production in monetary values or physical units.
Water discharges: water discharged after being used in, or produced by, industrial production processes. Cooling water and surface runoff is excluded.

Source: Adapted from Eurostat/OECD (2014) and own elaboration.

Table 3: Raw materials sectors in scope as following the general industrial classification of economic activities within the European Union (NACE) Rev.2 classification ([9]).

B07: Mining of metal ores
B08: Other mining and quarrying
C16: Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C1711: Manufacture of pulp
C1712: Manufacture of paper and paperboard
C221: Manufacture of rubber products
C23: Manufacture of other non-metallic mineral products
C24: Manufacture of basic metals

Source: NACE Rev.2.

([9]) Eurostat (2012). This refers to revision 2 of the statistical classification of economic activities in the EU, which imposes the use of the classification uniformly within all Member States.

3 RESULTS

3.1 Overview

This study identified and assessed the data sources detailed in Table 4: EU Eurostat data by sector and over time for water withdrawal, water use and wastewater discharges; Member State national-office data on water withdrawal; EU official-register data on pollutant releases to water; private companies' water-use data reported by operating facilities; and data on water withdrawal, water use, water consumption and water discharges provided by research models such as the environmentally extended input-output tables or the EEA water accounts. In addition, this study assessed LCA and water footprint inventories, which provide estimates on water inputs and outputs per unit of material produced (i.e. water intensity) and the related environmental impacts of water use. A detail characterisation of these sources is provided in Table 4.

Table 4: Overview of the data sources assessed.

Option	Description	Indicators (and water sources)	Coverage (country, time, sector)	Data completeness
Data reported by Member States				
Eurostat	Harmonises data by EU Member State and sector following Eurostat/OCDE (2014). Those are also used to estimate water intensity (related to the economic output).	— Water withdrawal (gross abstraction; total, from surface water and groundwater; net abstraction only for the total economy). — Water use (from public water supply and from self and other supply). — Wastewater discharges.	— EU-28+ (no EU aggregate estimates, and data only for selected countries). — Time: 1970-2015 (2014 for discharges) — Sectors: B, C17, C24 (C17 and C24 only for water use and discharges).	Poor
Member States' national offices (competent authorities and state agencies identified by Reynaud (2016))	Data obtained directly from the EU Member States, generally more detailed and complete than those reported to Eurostat. No harmonisation among countries, and in some cases indicators and methodologies differ.	— Water withdrawal (water source specified for some countries). — Water use (varying among countries, and water source specified for some countries).	— AU, BG, DE, DK, EE, ES, HR, PL (non-exhaustive list, following Reynaud, 2016). — Time: Ranging from 1991 and 2015 (varying among countries, see Table 2). — Sectors: B, B07, B08, C16, C17, C22, C23, C24 (varying among countries, see Table 2).	Moderate
European Pollutant Release and Transfer Register (E-PRTR)	Europe-wide register that provides data on the releases of a complete set of pollutants to water for the major EU industrial facilities. Data provided at facility, sector and national level.	— Release of pollutants to water (total and accidental quantities).	— EU-28+ — Time: 2007-2016. — Sectors: B07, B08, C16, C17, C23, C24.	Good
Data reported by the industry				
Industry water disclosures	Data from industry disclosures such as the global reporting initiative (GRI) and the Carbon Disclosure Project (CDP) water programme.	— Water withdrawal (by water source). — Percentage of water recycled and reused (only GRI). —Water consumption (CDP) — Water discharge by destination (and by quality, only for GRI). — Water intensity (CDP) — Water sources significantly affected by withdrawal of water (GRI).	— Many countries: some EU-28 Member States (AU, BE, CZ, FR, FI, DE, EL, IE, IT, LU, NL, PT, PL, SL, ES, SE, UK). — Time: 1999-2016 (GRI); 2010-2016 (CDP water programme). — Sectors: construction materials, forest and paper products, metals products, mining.	Poor

Option	Description	Indicators (and water sources)	Coverage (country, time, sector)	Data completeness
Data from research and modelling				
EEA water base	Data on water abstraction, water use and return flows across Europe at national and regional scales as reported under the obligation of water-information system for Europe (WISE) SoE (*) — water quantity (WISE-3).	— Water withdrawal (abstraction) — Water use — Return flows	— EU-28+ (partial coverage and non-EU aggregate estimates). Data on annual sectoral water use and abstraction are available for several countries at national level and for different time periods. C sector available also at river-basin-district level. — Time: 2003-2015. C sector available also on a monthly basis. — Sectors: Mining and quarrying (B), Manufacturing (C). Data on return flows are not grouped by sector.	Poor
Life cycle assessment and water footprint	Data from individual production processes, considering not only direct water use on-site but all water used (i.e. also indirect) and along the production chain from extraction to transport, smelting, refining, etc.). Data refer to production units.	— Water inflows (water intake from different sources) and outflows by production unit (in physical units). —Pollutant release to water bodies by production unit (in physical units).	— Data from production process in specific countries (e.g. US, CH etc.). — Time: specific reference years. — Sectors: broad set of commodities.	Moderate
Environmentally extended input-output tables	Data on inputs to production (e.g. water) as well as emissions associated to production, derived from the calculation of flows of materials through the economy. They might account for both direct water used on-site and by the upstream value chains.	— Water withdrawal and water intensity (related to monetary value). —Water consumption and water intensity (related to monetary value).	—EU-28 and broad non-EU country coverage. — Time: 1995-2011. — Sectors: diverse sector of minerals and metals mining and production, and metals reprocessing.	Moderate for manufacturing, very poor for mining.

EU-28+ refers to the EU-28 plus countries still negotiating to join the EU (candidate countries) and European Free Trade Association (Stockholm Convention) (EFTA) members.

Countries: AU = Austria, BG=Bulgaria, DE=Germany, DK=Denmark, EE=Estonia, ES=Spain, HR = Croatia, PL=Poland. EU-28+ = EU-28 and EFTA countries (e.g. Norway, Serbia or Switzerland).

Sectors (following the NACE Rev.2 classification): B=mining and quarrying, B07=mining of metal ores, B08=other mining and quarrying, C16=manufacture of wood and wood products, C17=manufacture of paper and paper products, C23=manufacture of non-metallic minerals and C24=manufacture of basic metals.

(*) Water-information system for Europe standard operating environment (WISE-SoE).

3.2 Data reported by Member States

3.2.1 Eurostat — water withdrawal, water use and wastewater discharges

Eurostat collects and harmonises water statistics over time at national level that cover water use by the industry. Data are based on reporting by Member States following the Eurostat/OCDE joint questionnaire on inland waters (Eurostat/OCDE, 2014). Reporting is done on a voluntary basis, based on the guidance provided in the questionnaire, which details the methodology to be followed for the reporting, and which also provides supporting data to compute the estimates when there are no direct measurements (e.g. water coefficient factors for industry). This source includes data on water withdrawal (abstraction) ([10]), water use ([11]) and waste-water discharges ([12]) by economic sector (see Table 4), following the NACE activity classification.

Data on water withdrawal, i.e. water removed from any source, either permanently or temporarily, are available for mining and quarrying (Figure 3, top left) and for the whole manufacturing industry, with no breakdown into industry sectors. Current available estimates cover water taken from self-supplies, both from surface and from groundwater (data are reported as total and by water source). Under 'mining and quarrying', water for the mining of metals or industrial minerals, etc. is reported together with that for oil and gas extraction — which are beyond the scope of this study. An increasing trend has been observed in the rate of abstraction from groundwater as compared to surface water, which points to increasing pressure on groundwater resources (ETC, 2017a).

Next, Eurostat provides data on water use, i.e. withdrawal minus returned water, which includes supply from the public network and from self and other supplies. Water use data are available also for mining and quarrying (Figure 3, top right), and for the manufacturing of basic metals and the production of paper and paper products (Figure 3, bottom). Next, data on water discharges is the volume of water after being used in industrial production, excluding cooling water. Data are available for the three sectors mentioned above: mining and quarrying, the manufacture of paper and paper products and the manufacture of basic metals. The completeness of these data sets is limited since data are missing for many countries and years, especially between 1970 and 2000, which is very incomplete and totally missing for water use. Data are missing for several Member States (Austria, Cyprus, France, Italy, Portugal and Spain). Furthermore, the set of Member State reporting is not comprehensive and varies for the different indicators.

Eurostat estimates the intensity of water use (ETC, 2017; Eurostat, 2014([13])), based on water use related to the economic output of each sector (measured as inflation – corrected gross value added). Production data in physical units, which could be used to estimate water intensity independently of economic fluctuations, are not available.

According to the data reported to Eurostat, total volumes of water withdrawn by the mining and quarrying activities (Figure 3, top left) showed rather stable, and in some cases, decreasing trends in the period 2000-2010, followed by a recovery in more recent years. Similar trends were observed for water use by the same sector (Figure 3, top right). Water use values were overall below withdrawal figures, yet there are some Member States for which the opposite applies. This is due to the fact that, as mentioned above, only self-supplies are considered in the water withdrawal estimates, while water use accounts also for public supply. The set of Member States reporting both water withdrawal and water use data are very reduced.

([10]) Annual freshwater abstraction by source and sector (env_wat_abs).

([11]) *Water use in the manufacturing industry by activity and supply category* (env_wat_ind, only manufacturing, including also C17 and C24) and *water use by supply category and economical sector* (env_wat_cat, which includes sector B). Although the data series name refers to 'water use' it contains explicitly data on 'water supply'.

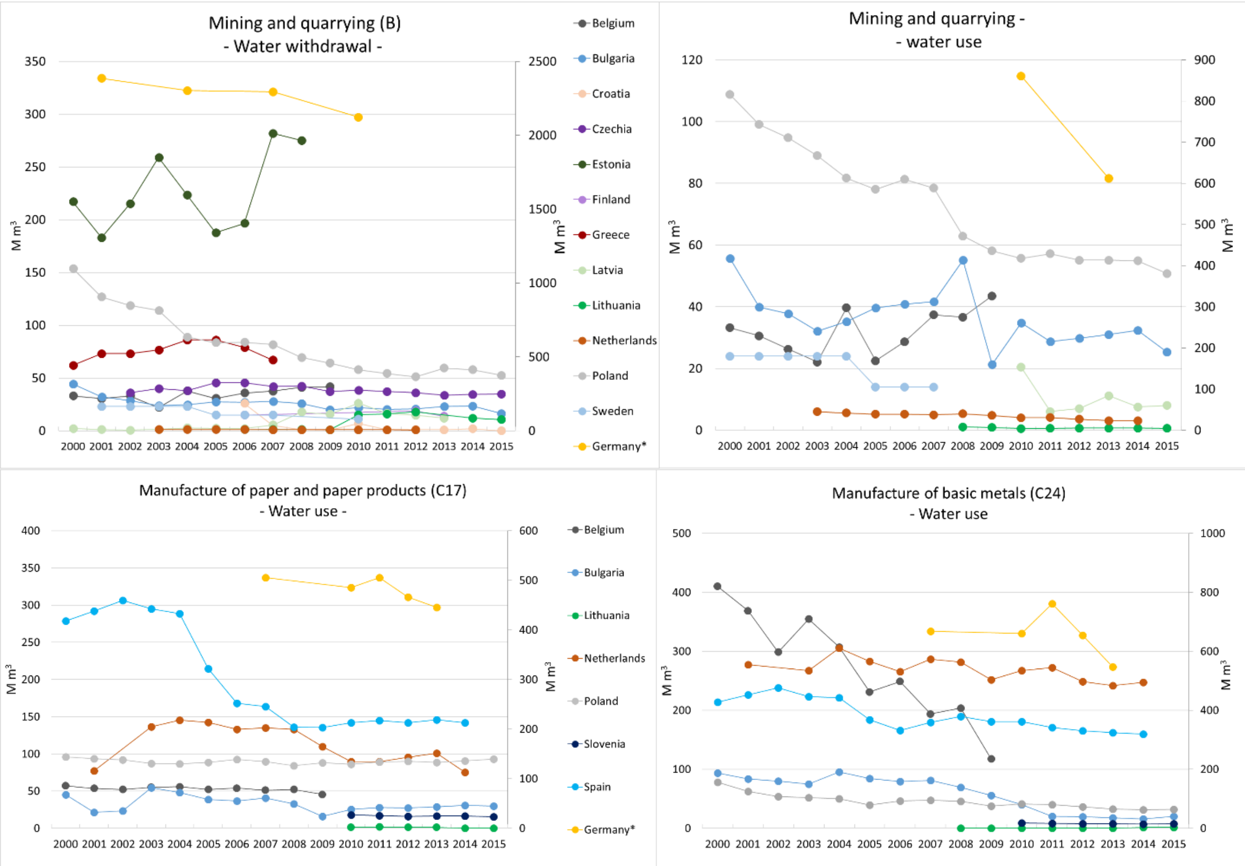
([12]) Generation and discharge of wastewater (env_ww_genv).

([13]) http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Water_use_in_industry&oldid=196127

Data on water use for the manufacture of paper and paper products show overall stable trends over time except for Spain, while the basic metals sectors showed slight decreasing trends (Figure 3). According to these data, the manufacture of basic metals was using the highest volumes of water, followed by paper and then by mining and quarrying.

Wastewater discharges reported volumes of wastewater without data on quality parameters. Volumes of wastewater discharges (not shown here) followed the decreasing trends of water withdrawal for the mining and quarrying sector, and very remarkable decreasing trends overall.

Figure 3: Water withdrawal and water use for mining and quarrying, and water use for paper and basic metals manufacturing sectors per EU Member State ([14]) based on Eurostat data. Water withdrawal is the sum of abstractions from groundwater and surface water. Only self-supplies are considered for the water withdrawal estimates, while water use also accounts for public supply.



(*) Member State data refers to the right axis.

Source: Eurostat data (env_wat_abs, env_wat_cat and env_wat_ind).

The completeness of these data are very limited, partly due to the voluntary nature of reporting. Also, although Eurostat provides extensive guidance on how the survey should be filled in, and how the water accounts could be estimated, the interpretation by Member States (MS) of this guidance seems to have introduced uncertainty in the estimates. Indeed it is considered that these data are useful to follow general trends but not for a sound time-trend analysis (ETC, 2017a).

3.2.2 Member State national offices– water withdrawal

Water withdrawal data by sector and over time can be also obtained directly from the MS national statistical offices. We considered the data sources compiled by Reynaud (2016),

([14]) For visibility reasons the list is not exhaustive. Data before 2000 are not displayed.

which underwent research on water-use data for the industry sector. According to this study and our further investigation, some of the EU-28 provide relevant water-related data for specific raw materials sectors (Table 5). While the study by Reynaud (2016) refers only to data on water withdrawal/use, national statistical offices often provide other data sets such as water discharges. The data listed here often are disaggregated by water source (surface and groundwater). The underlying data ranges from estimates for abstraction permits, actual measurements, estimates derived from production volume, etc.

These national statistical offices generally follow a more disaggregated sector classification than the Eurostat datasets, generally also following the NACE classification. Raw materials sectors covered include mining and quarrying, and the manufacturing of wood and wood products, paper and paper products, basic metals and other non-metallic minerals (see Figure 4). Data following a more disaggregated sector classification (e.g. mining of metal ores, manufacturing of natural rubber or pulp) are available for some MS, especially for Germany and Poland. In addition, data for the manufacturing of rubber is generally available but aggregated with plastic production. For these set of MS, data completeness is higher than that of the Eurostat data sets. As a drawback, these data have not been harmonised among MS, and the methodologies to compute the water indicators often differ, considering different inflows and outflows. Therefore, MS comparability cannot be granted.

Similar to Eurostat, in most cases national statistical offices also provide data on the economic output of the sectors in monetary value, which could allow the calculation of water use intensity (Figure 5, bottom figure). However, production data in monetary value are not always available, and if so they are often reported following a classification not fully compatible with the water data.

Table 5: Water data sources from EU MS providing data disaggregated for raw materials sectors.

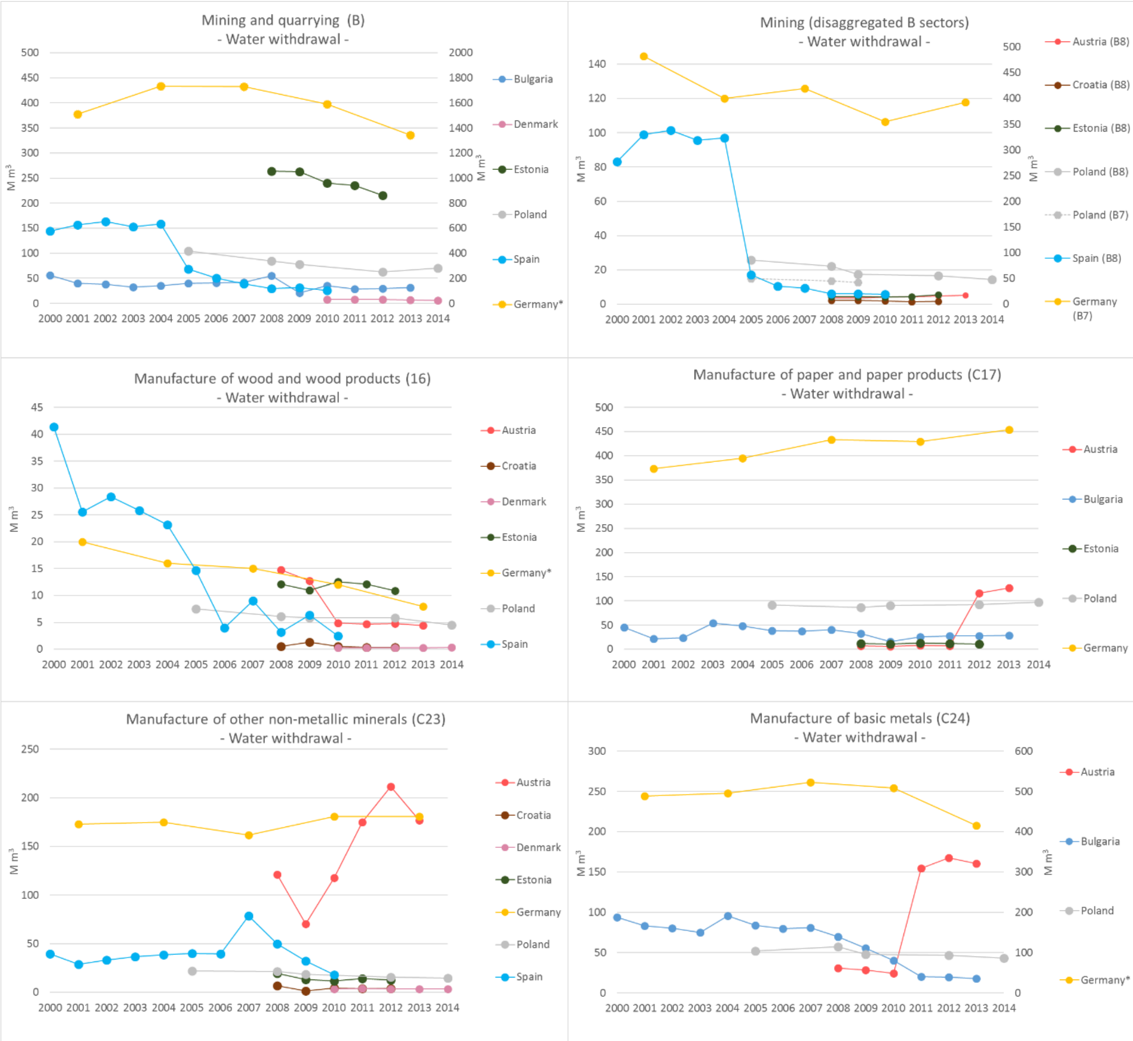
			Coverage	
Member State	**Indicator (*)**	**Source**	**Sector**	**Time**
AT	Water withdrawal (supply)	STATcube — statistical database of Statistic Austria — Services of water supply and water trade through pipelines	B, B08, C16, C17, C22, C23, C24	2008-2013
BG	Water use	National statistical institute of Bulgaria — water used by economic activity	B, C17, C24	2000-2014
DE	Water withdrawal (Water extraction from nature; Receipt of water from water works or other establ.)	Destatis (the federal statistical office of Germany) — environmental-economic accounting	B, B07&08, C16, C17, C22, C23, C24	1991-2013
DK	Water withdrawal (Water extraction)	Statistics Denmark — extraction and consumption (water accounts) by water type, measure, industry and time	B, B08**C16, C17, C22, C23, C24	2010-2014
EE	Water withdrawal (Water extraction)	Statistics Estonia — Water extraction by country, economic activity and type of water	B08, C16, C17, C22, C23	1998-2012
ES	Water withdrawal (Continental water withdrawal)	Instituto Nacional de Estadística (national institute of statistics) — water environmental accounts	B08, C16, C17, C22, C23	2000-2010
HR	Water withdrawal (Water supply)	Croatian bureau of statistics — utilisation of water and protection of waters from pollution in industry	B, B08, C16, C17, C22, C23, C24	2002-2016
PL	Water withdrawal (Income of water — from different intakes)	Central statistical office of Poland — Ochrona środowiska — environment (2006-2015)	B, B07, B08 C16, C17, C22, C23, C24	1998-2015

(*) Original denomination (translated to English) specified in brackets.
(**) Only extraction of gravel and stone.
Source: Our elaboration based on Reynaud (2016) and own further investigation. See details on the data sources in Annex.

National statistical offices' water withdrawal data show overall decreasing trends for the mining and quarrying sector (Figure 4). Figures generally differ from those provided by Eurostat. For instance, water withdrawal values for Germany are much lower than the values reported to Eurostat (noting that those cover only self-supply); for Estonia the year coverage is longer as also compared to Eurostat, and trends over time do not always match. Also, data for some MS that were available from Eurostat records are missing from these dataset.

MS data show steady decreasing trends for the manufacture of wood and wood products, while stable and even increasing trends on water withdrawal are observed for some MS for the remaining sectors (Figure 4). Comparatively, according to MS data on water withdrawal, mining and quarrying abstract the highest volumes of water, followed by the manufacturing of basic metals, the paper industry and wood processing.

Figure 4: Water withdrawal for mining and quarrying (aggregated, and for specific mining sectors, and some raw materials manufacturing sectors) based on MS national statistic office data ([15]).



(*) MS data refers to the right axis.

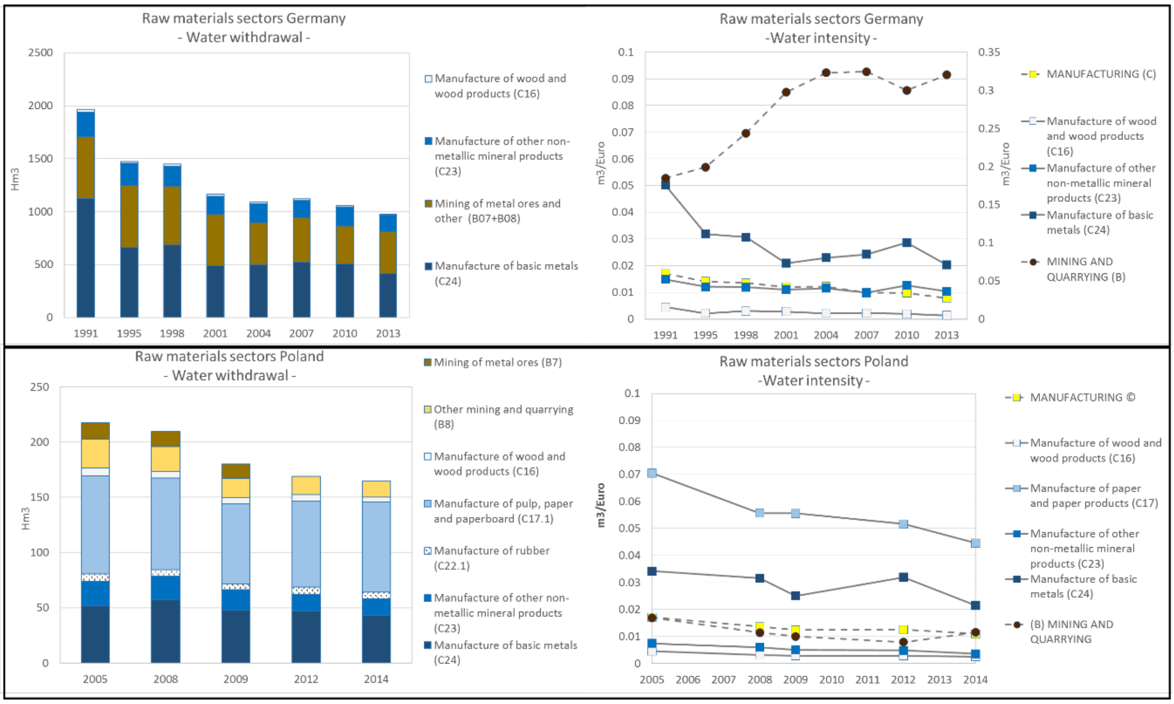
Non-metallic minerals cover water use for the quarrying of stone, sand, clay, ornamental and building stone, the operation of gravel and sand pits, the extraction of salt and the mining of commodities not elsewhere classified.

Source: MS national statistical offices (see Annex).

([15]) For visibility reasons the MS list is not exhaustive.

Estimates of water intensity based on these data suggest that improvements in water efficiency in some raw materials manufacturing sectors have been observed. This is mirror by the trends observed for Germany and Poland depicted in Figure 5, which show a reduction in water intensity for paper and basic metals production, and for the mining of some commodities in Poland. It is worth noticing that Germany showed stronger improvements in water efficiency in paper and basic metals production before the time period displayed here (between 1990 and 2000).

Figure 5: Water withdrawal and water intensity over time for Germany (top) and Poland (bottom) based on national statistical offices data (see Table 5 and Annex).



Source: MS national statistical offices (see Annex).

3.2.3 European pollutant release and transfer register (E-PRTR) — pollutant releases to water

E-PRTR ([16]) is the Europe-wide register that provides data on pollutant releases to water (also to air and soil) for the major EU industrial facilities, from 2007 until 2016 for all EU MS, plus EFTA countries. It covers pollutant releases embodied in treated wastewater (ETC, 2017b). Data from this registry are reported annually, publicly available and validated. The registry covers industrial facilities that produce emissions above certain sector-specific thresholds, which generally depend on the production capacity or on the area under extractive operation for some mining-related activities. The thresholds have been set with the intention of covering for each specific pollutant about 90 % of the total mass emissions from industrial facilities. For some specific activities, pollutants have to be reported regardless the facility production capacity (e.g. underground mining, metal ore roasting/sintering, etc.). E-PRTR provides pollutant-release data by facility, which can be aggregated by economic sectors (an own classification also adapted to the NACE codes).

Pollutant-release data are provided for each single substance, covering a complete substance set (heavy metals, inorganic substances, pesticides, organic pollutants, etc.), which also includes priority substances such as cadmium (Cd), mercury (Hg), nickel (Ni)

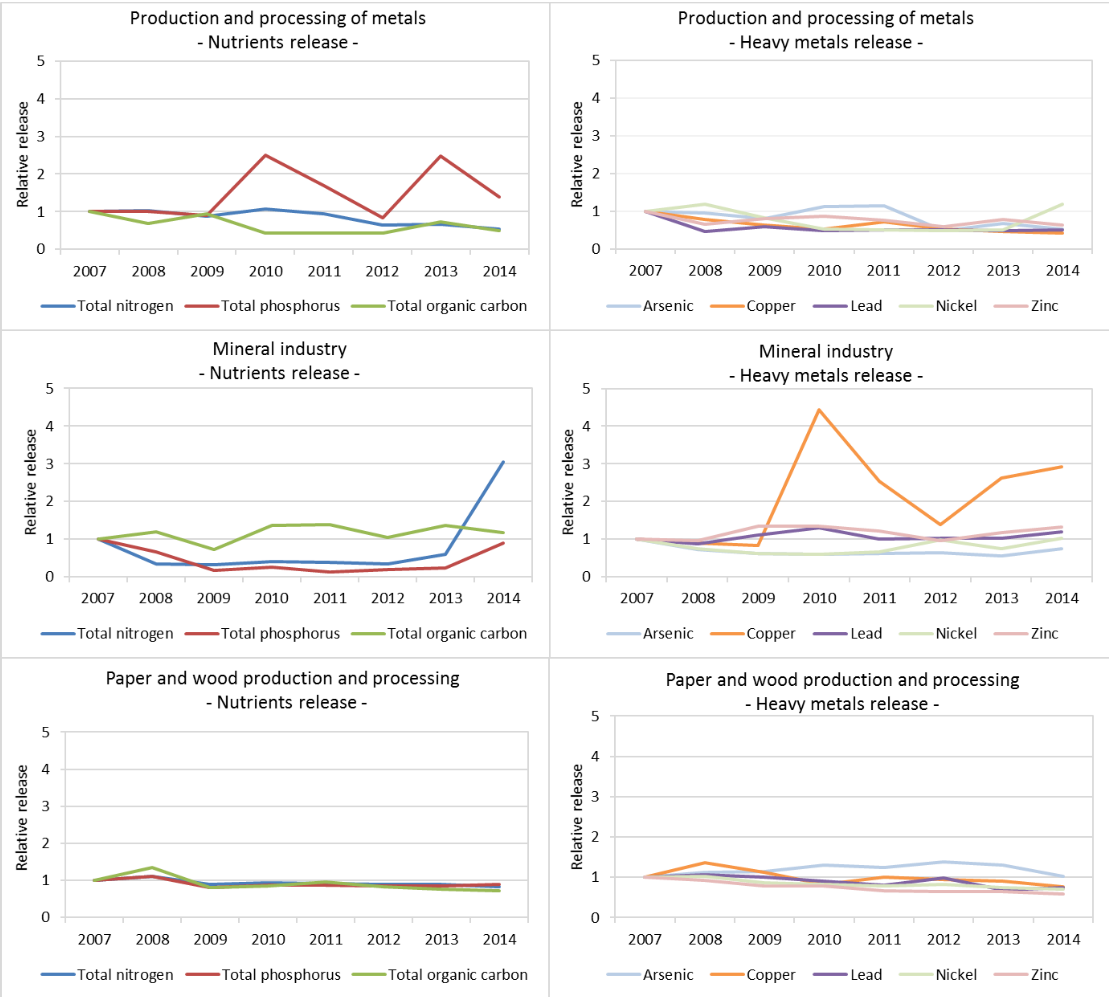
([16]) https://www.eea.europa.eu/data-and-maps/data/member-states-reporting-art-7-under-the-european-pollutant-release-and-transfer-register-e-prtr-regulation-16 and lead (Pb). Diffuse pollution sources reported under E-PRTR cover also all emissions below the fixed thresholds. However, for many countries the emissions below are at least partly quantified as stemming from point sources (ETC, 2017b). Accidental releases can be reported to the E-PRTR, yet there are very few records of accidental releases as compared with the number of total releases reported (ETC, 2017b).

Although industrial facilities are asked to report their production data (‘activity’ data), the completeness of this variable is very limited. Therefore, a sound estimation of pollutant release related to production (i.e. emissions intensity) is not possible. Neither it is possible to obtain emission-intensity estimates using official data for the monetary value of production, since production volumes refer to whole economic sectors while E-PRTR refers to a subset of facilities — those reporting to E-PRTR.

According to E-PRTR as analysed by the ETC (2017b) (focusing on the eight most reported pollutants and excluding pollutant releases by urban waste water treatment plants on average terms over the period 2007-2014) facilities producing metals appear as the major contributor to the release of heavy metals such as lead and nickel. The mineral industry was the main contributor to the release of copper, lead and zinc, noting that most copper and zinc originated from underground mining and related operations. The release of substances was generally concentrated on a small number of facilities, especially for the release of copper, lead and zinc by the mineral industry. In addition, paper- and wood-production industries are the second contributors to the release of total organic carbon (TOC) to water, plus significant amounts of zinc.

According to the reported data, pollutant releases from the metals industry have decreased overall except for the increase in copper (Figure 6). For the mineral industry, emissions have increased overall (especially for copper for eastern Europe, from open-cast mining), but showing very variable trends. Paper and wood production showed very stable trends for nutrient releases and overall decreasing trends for heavy metals, except for arsenic. These trends took place in the context of general decreasing trends for the whole set of E-PRTR facilities for lead, zinc, nickel and TOC, while increasing trends were observed for copper.

Figure 6: Release of pollutants from the metals, minerals, paper and wood industries ([17]) over the period 2007-2014 according to E-PRTR data. Data refer to values relative to 2007 and cover the eight most reported pollutants in E-PRTR.



Source: ETC (2017b).

Despite the potential of this comprehensive database, many limitations prevent its use for accurate assessment on pollutants releases over time. First, and as highlighted by the ETC (2017b), it is sometimes unclear whether trends are actual observation or derived from e.g. changes in reporting. E-PRTR was intended to measure the progress towards the reduction or phasing out of emissions, yet the ETC (2017b) concludes that data limitations do not allow for that. Furthermore, although the aim is to cover 90 % of emissions from industry (by covering the biggest facilities), it is not easy to assess this figure do to the lack of alternative data sources that could serve as a reference for the total amount of emissions. In addition, E-PRTR does not cover emissions of untreated wastewater (ETC, 2017b).

3.3 Data reported by the industry

3.3.1 Industry water disclosures

Sustainability reporting by industries makes data on the environmental performance of the companies available in order to increase their accountability. The global reporting initiative

([17]) E-PRT facilities classified as mineral industry include mining and manufacturing in some cases.

(GRI, 2015 ([18])) and climate disclosure project (CDP) ([19]) are among the most common voluntary company-disclosure schemes. They cover several raw materials sectors including mining, construction materials, metals production and forest and paper products.

The water-related performance indicators within the GRI guidelines address both water quantity and quality. Companies most commonly report data on water withdrawal, percentage of water recycled, sometimes providing (short) time-series data. They also sometimes provide water intensity data referring to their production volume (Table 6). However, the water-related data are not often provided in the reports.

CDP has recently developed a water programme ([20]), which compiles data from relevant companies about the existence of water risks associated with production and their water management practices, based on an annual survey. The survey also compiles data on the company's total water use, discharges and consumption, as well as on water intensity (Table 6) — water use per tonne of material in physical units. The latter indicator was reported only until 2014.

Table 6: Water intensity for a selection of commodities based on GRI and CDP water programme data (2014).

Commodity	Headquarters	Water intensity (based on water use) (litre/tonne)
GRI (2014)		
Primary aluminium, liquid aluminium, aluminium products	Austria	7 100
Aluminium products	Greece	1 750
Steel	Luxembourg	24 300
Copper products	Greece	1 430
Semi-finished copper products	Spain	1 080
CDP (2014)		
Iron ore	South Africa	380
Steel	Taiwan	4 960
Finished steel	India	5 580 000
Platinum	South Africa	374 558 304
Copper	Chile	66 000
Gold, copper, etc.	Argentina	51
	Australia	858
	Canada	335

Having sound water intensity figures from these reporting schemes is challenged by the fact that the volumes of water reported are assigned to the whole production of the company. Moreover companies are classified by the location of their headquarters, while production often takes place elsewhere. Furthermore, especially for the case of mining, water is often used for the production of several commodities simultaneously (co-production), and the disclosures do not specify how much water is used for each commodity/product.

In addition, the coverage of EU companies is very limited as compared to the total number of industries operating (Table 7). Furthermore, these data, reported on a voluntary basis, neither follow an official validation nor official endorsement.

([18]) https://www.globalreporting.org/Pages/default.aspx.
([19]) https://www.cdp.net
([20]) https://www.cdp.net/en/water

Table 7: EU raw materials industry coverage of GRI and CDP water programmes ([21]).

GRI		CDP	
Sector	**Number of reports** (2016)	**Sector**	**Number of reports** (2015)
Construction materials	44	Construction materials	2
Mining	24	Mining — iron, aluminium, other metals	5
		Mining — other (precious metals and gems)	1
Forest and paper products	27	Forest and paper products (also rubber)	4
Metals products	41		

3.4 Data from research and modelling

3.4.1 EEA water base — water quantity

Water base — water quantity (EEA, 2017) is a dataset provided by the EEA. Among other data, it contains time series of water withdrawal and water use across Europe at national and regional scales, such as level 2 of the Nomenclature of territorial units for statistics (NUTS-2) or river basin districts (RBD). The data are part of the water-assets accounts (ETC, 2017a), which have been an ongoing process during the last decade with multiple datasets and publications (EEA, 2013, 2012, 2010, 2009; Estrela, et al., 2001).

The water-assets accounts are constructed according to the system of environmental-economic accounts for water (SEEAW), a conceptual framework for environmental accounting by the UN (2012). This requires databases with figures on quantities of water flows and stocks. The data on water use and abstraction are reported by individual MS and EEA members under the reporting-obligation scheme of the water information system for Europe (WISE) — water quantity, WISE-3.

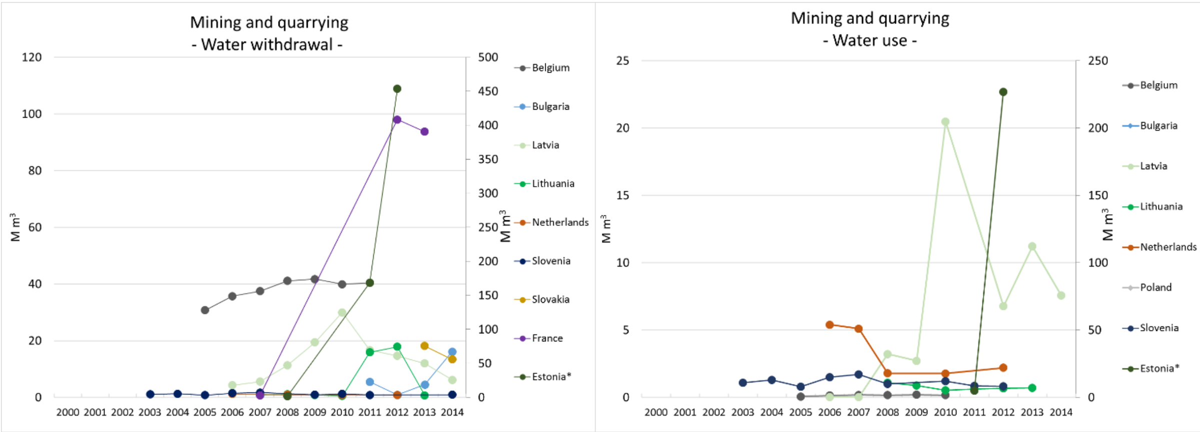
The EEA has also made an effort to construct SEEAW-suited estimates of water use and abstractions to fill data gaps and improve regional and sectoral detail (EEA, 2013). These estimates were based on industrial production output from official datasets (e.g. Eurostat, E-PRTR, FAO) and water intensity information provided by the best available techniques reference documents (BREFs) and sector associations (e.g. Confederation of European Paper Industries, European Steel Association). Although the methods seemed promising, the results showed substantial inconsistencies and high levels of uncertainty due to limited data availability (EEA, 2013). Despite the high level of sectoral detail described in the report (EEA, 2013), the EEA have not yet published a dataset with matching sector classifications as part of their water-assets accounts.

The most recent published water-use dataset (EEA, 2017) is at section level of the NACE Rev. 2 classification (e.g. B: mining and quarrying, C: manufacturing). This dataset provides time series of water use and water abstraction with partial EU coverage at national and regional scales from 2002 to 2014 (Figure 7). It distinguishes whether water is abstracted from groundwater or from surface waters. In the case of the mining and quarrying sector, only national totals with annual intervals are available.

Despite the consistent reporting scheme (WISE-3), the figures reported by individual countries are different from the data reported in Eurostat (Figure 3). Water withdrawal time series show mixed patterns, with some countries remaining fairly constant, while some (especially eastern European countries) have experienced substantial increases and decreases since 2006. Water use data available for a different set of countries and time series generally show less extreme changes.

([21]) The number of GRI reports presented in the table refers to all the 2016 reports included in the GRI database (consulted in 2017); the CDP water programme report refers to the water reports from 2015, taken from the list of water reports 2010-2015, provided by the CDP water programme.

Figure 7: Water abstraction and water-use time series from the EEA water base — water quantity dataset (EEA, 2017). Water abstraction is the sum of abstractions from groundwater and surface water.



*Country data refers to the right axis.

Source: EEA water base — water quantity dataset (EEA, 2017).

3.4.2 Life cycle assessment and water footprint

Water use by the raw materials industries can be also approached from a life cycle perspective. This includes the life cycle assessment (LCA) and water footprint (WF) methodologies. LCA is a method used to quantify the potential environmental impacts of products and services. This also includes the impacts associated with the use of water and the discharge of pollutants to water bodies. A complete LCA is conducted throughout the product life cycle from *cradle-to-grave* (i.e. from extraction of raw materials, to transport, smelting, refining, use, and to final waste management) considering all material flows (including water, the energy associated to production, etc.), and the resulting emissions and waste streams. These flows constitute the life cycle inventory, which is part of the LCA model. This inventory considers that different stages of the supply chain might take place in different locations. Based on these materials and energy flows considered in the inventory, LCA further estimates the potential impact ([22]) on the environment and humans.

In terms of WF, two different concepts exist nowadays. Originally, the concept appeared as the volumetric measurement of water used to produce any good or service, dividing the use of water into three categories (blue, green and grey water). The WF concept has then been further developed in order to measure the environmental impacts associated with water use, based on LCA methodologies (LCA-based WF). This led to the development of the international standard on WF (ISO, 2014). This standard specifies that the life cycle inventory phase of the WF assessment is focused on water inputs and outputs and emissions to water; as well as air and soil emissions that can affect water quality.

LCA and WF inventories include data on water inputs and outputs from/to surface water, groundwater, seawater and atmospheric water, as well as emission of substances to water bodies. These flows include direct (i.e. at the production facility) and indirect water uses (i.e. used in auxiliary processes needed for the main supply chain such as energy, chemicals, etc.). These inventory data allow for estimating water-cycle indicators such as water withdrawals, water use, water consumption and wastewater discharges, both for the whole production chain and by production stage. Also, since data inventories are linked to production data in physical units. (e.g. the production of 1 kg of material), it allows for assessing the water-use intensity of the production chain.

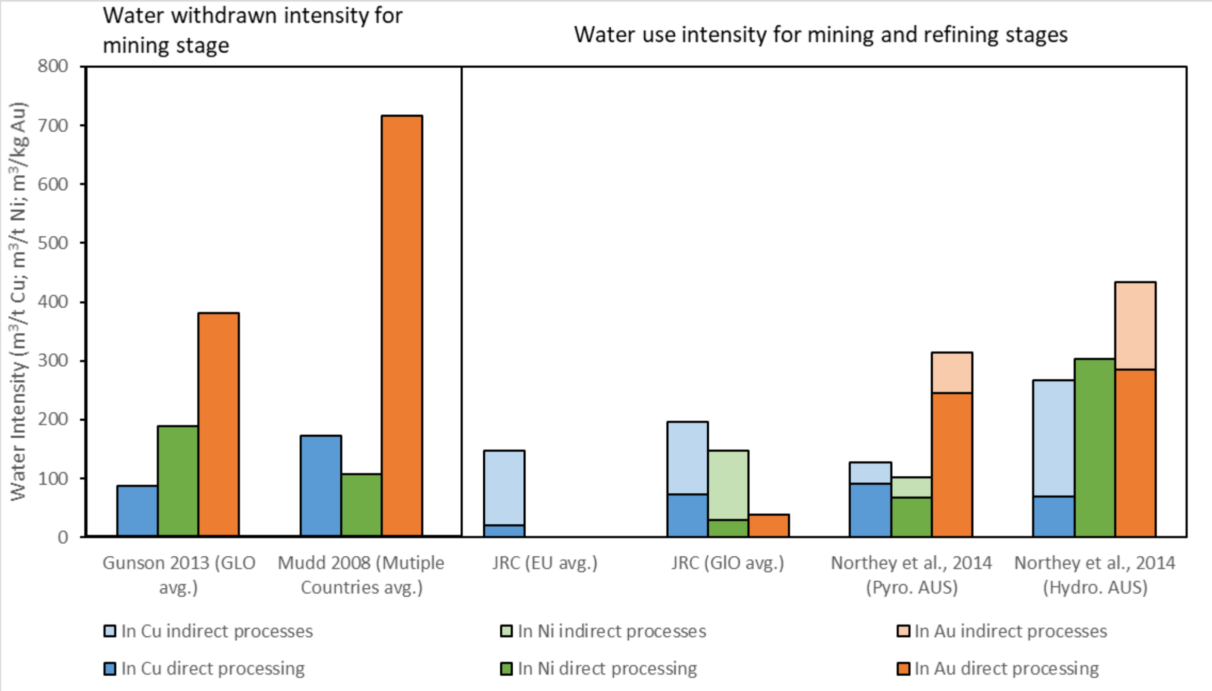
([22]) Pressures (material/energy flows) might have an impact on the environment. For instance, greenhouse gas emissions contribute to global warming, water use might lead to water depletion, and emissions might damage ecosystem health.

Complete LCA studies typically refer to the impacts of a product supply chain in several impact categories (e.g. those described in the International Reference Life Cycle Data (ILCD) method (European Commission-JRC, 2011)) including those related with water such as resource depletion-water, water eutrophication potential and ecotoxicity. On the other hand, WF assessments focus only on how water consumption and pressure on quality (provided by the inventory data) will impact the environment. This will depend on the regional water status, type of water used (e.g. groundwater or surface water) and amount of water polluted.

The main limitation of the LCA and WF approaches remains the availability of site-specific data to develop complete and accurate water inventories. While agriculture sectors are well covered, there are still several gaps in water accounts for industrial sectors. It is more difficult to find databases completely dedicated to water inventories. The information typically used in WF studies comes from: (1) Life cycle inventories with water-related estimates, available from material associations that have carried out LCA studies on their targeted commodities (e.g. European Aluminium association and European copper institute); (2) LCA databases; and (3) from scientific literature with a dedicated focus on WF (Northey et. al., 2016; Northey et. al., 2014; Gunson, 2013 and Mudd, 2008). While inventories based on studies developed ad hoc for a specific facility can use very detailed data, common LCA databases available for the LCA practitioners typically provide average estimates for representative production technologies, e.g. average water withdrawal per unit of steel produced and regional averages. Moreover, although LCA aims to reflect that different stages of the production chain might take place in different countries, the set of facilities for which data are available is still limited. Thus, LCA databases often use regional averages e.g. global, European, the United States, etc. values for different production stages. In addition, while there are more data on the consumptive use of water, the analysis of water pollution is usually more limited, due to the complexity of water outflows quality characterisation.

Figure 8 and Figure 9 intend to demonstrate the type of information that can be obtained from the LCA and WF methodologies to assess water use for raw materials production. First, Figure 8 shows examples of data on water use and withdrawal intensities for different commodities and processing technologies from the literature (Gunson, 2013; Mudd, 2008), from our own calculations based on LCA inventories (Ecoinvent v3 — Wernet et al., 2016) and from specific raw materials mining and refining facilities (as in Northey et. al., 2014). The examples displayed show water intensity data for copper, nickel and gold, covering similar life cycle stages such as mining and refining. For the water estimates from our own calculations and from Northey et al. (2014), water-use intensity figures are provided for the direct use at the facility and also covering indirect processes. The latter reflects water used for energy production and other ancillary materials production. Figure 8 clearly shows the different water performance of the use of different technologies and the production of different commodities. For instance, in the example it is possible to depict that hydrometallurgy processing is more water intensive than pyrometallurgy (considering both direct and indirect processes). Results also show that gold processing generally demands more water than copper and nickel processing (more than one order of magnitude difference in most cases). This is mostly due to differences in ore concentration (while for the gold facilities considered it is very low –around 3.6 g/ton (values are much higher for copper and nickel respectively, above 7.5 and 10 kg/ton).

Figure 8: Water use and withdrawal intensity for the production of Cu, Ni and Au metals reported in the literature and based on life cycle data from Ecoinvent v3 (EU and GLO avg.). Data are also divided between water used in direct and indirect processes. Water intensities are given in m^3/t for Cu and Ni, and in m^3/kg for Au. EU average data on water use for Au and Ni mine production is not available in Ecoinvent v3, probably due to the fact that the EU mining production of these materials is limited (e.g. only 1 % of gold produced globally takes place in the EU).

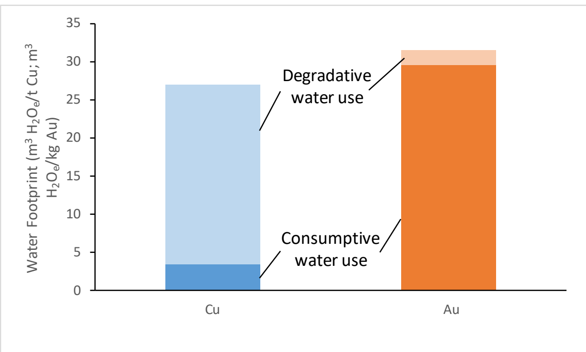


NB: Cu = copper, Ni = nickel, Au = gold; EU avg. = European average data, GLO avg. = world average data. Au refers to data from Australian metal production using pyrometallurgy (Pyro.) or Hydrometallurgy (Hydro.) technologies; multiple countries refer to Brazil and Namibia for Cu mines, to Ireland and Zimbabwe for Ni mines and to Ghana and South Africa for Au mines.

Source: Based on Gunson (2013), Mudd (2008), Ecoinvent v3 (Wernet et al., 2016) and Northey et al. (2014).

Figure 9 shows an example of the kind of data that can be obtained with an LCA-based WF approach. The results reported by Northey et al. (2014) show two components of the WF. First, a WF consumptive component, which relates the water use in the production of a raw material to the regional water availability: this data transformation can be done by e.g. weighting water use based on local water stress (Northey et. al., 2014). Second, a WF degradative component, which represents the impacts resulting from changes in the quality of water that are attributed to the raw material processing.

Figure 9: Water footprint, single score for copper production in Mount Lyell and gold production in Henty gold mine.



Source: Based on Northey et al. (2014), both for Australia.

3.4.3 Environmentally extended input-output tables

Traditional input-output (IO) tables map the economic structure of a country in the form of matrices that depict monetary inter-industry flows. They show how output from one industrial sector becomes input to other industrial sectors.

By linking environmental data on resource use (e.g. natural resources inputs and emissions to air, water and soil) to an IO table, an inventory of the environmental pressures related to the inter-industry flows is introduced.

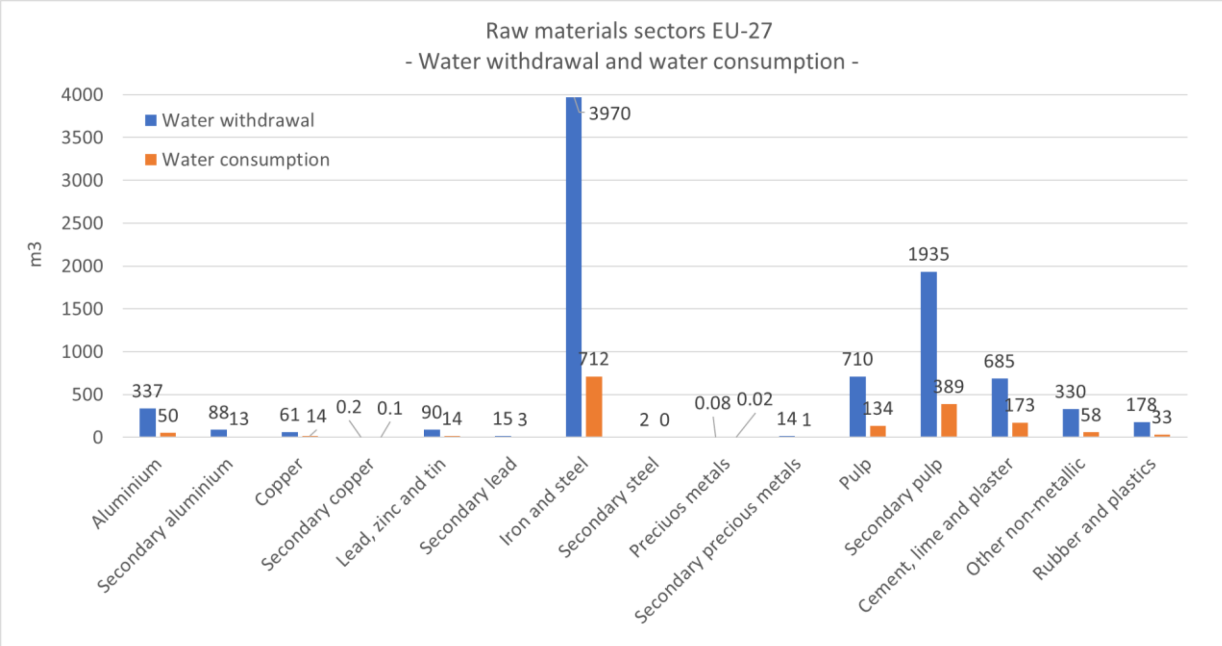
Different global IO models are available which also include water extensions, e.g. Eora (Lenzen et al., 2012 and 2013) or Exiobase (Stadler et al., 2018). As an example, the water extensions of Exiobase version 3 (version 3.3.4, provided by the authors in February 2017) were assessed. It provides data on industrial water withdrawal and water consumption (called blue water withdrawal and blue water consumption, respectively), for a broad selection of sectors between 1995 and 2011. It allows for estimating water intensity figures for different categories of final demand or for economic activities, by comparing direct and indirect water flows occurring along the specific supply chains with the value added created. This is because applying the IO logic all direct uses of water along the supply chain of a product can be allocated to the production or the final consumption of the product (WF). This means that both the direct use (e.g. at the industrial facility) and the indirect use of water (e.g. associated to the electricity or other ancillary inputs produced off-site) are accounted for. However, due to limited water data availability, the figures on the indirect water-use component of the WF are not complete. While the main water uses, e.g. water use for cooling purposes in the energy sector, are covered, for instance, water used for mining is not considered.

The water withdrawal/consumption estimates for the industry are based on the water GAP model (Floerke et al., 2013), which provides detailed figures for the agricultural and animal husbandry sector, and more aggregated figures for the energy sector and the manufacturing sector. Water estimates following a further sector disaggregation were obtained by water allocation rules based on the physical output of the sectors. The match of these data with official records of water withdrawal is very limited.

Although not all sectors withdraw data themselves, results on embodied water consumption associated with production activities are available for most sectors, but not yet covering mining (Figure 10). However, the authors are also working on datasets for the latter. Sector coverage is more limited for data on water intensity (Figure 11).

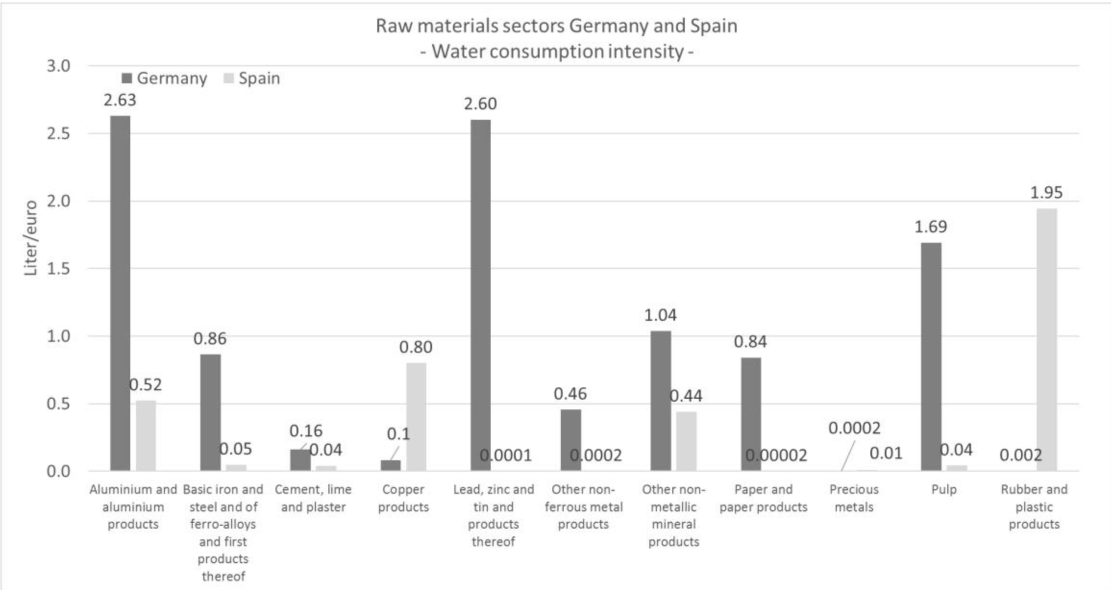
According to these estimates, iron and steel manufacturing appears to be the biggest water consumer for the EU among the considered raw materials industries. Moreover, water intensity varies strongly among sectors, countries (see Figure 11) and years (see Figure 12). The latter might be due to the volatility of the monetary value of production.

Figure 10: Embodied water withdrawal and water consumption for a selection of raw materials sectors for the EU-27 (2011) based on Exiobase ([23]) v3.3.4 data. Water consumption refers to water withdrawal minus return flows. Data accounts for direct and indirect water withdrawal/consumption.



Source: Exiobase v3.3.4 data.

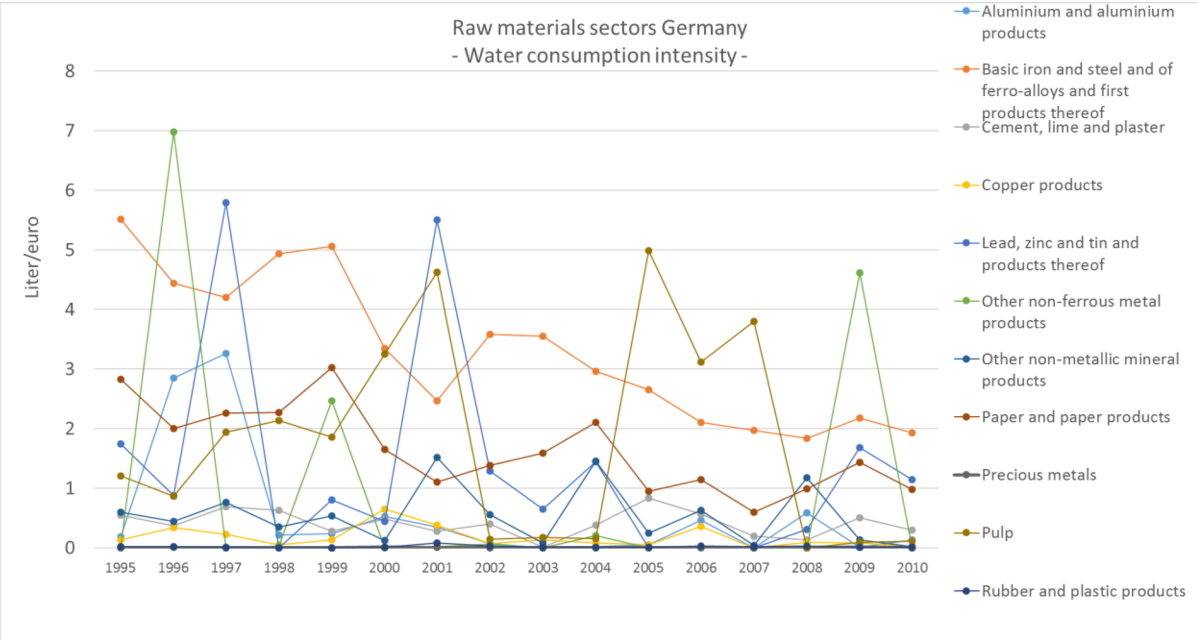
Figure 11: Water consumption intensity for a selection of raw materials for Germany and Spain (2011) based on Exiobase v3.3.4 data. Data accounts for direct and indirect water consumption.



Source: Exiobase v3.3.4 data.

([23]) 'A global, detailed multi-regional environmentally extended supply and use/input output (MR EE SUT/IOT) database' https://www.exiobase.eu.

Figure 12: Water consumption intensity for a selection of raw materials sectors for Germany based on Exiobase v3.3.4 data. Data accounts for direct and indirect water consumption



Source: Exiobase v3.3.4 data.

4 DISCUSSION

4.1 Usability of the data sources identified for policy support

Different data sources were identified that could serve for assessing the water use and water performance of the EU raw materials industries. While Eurostat data aims to provide water use data with comprehensive coverage, MS do the same at national levels. Underlying methodologies vary, since in some cases data are based on industry surveys or even on measurements. E-PRTR provides a relatively comprehensive coverage of pollutant releases by sector, yet it considers only the major EU industrial facilities.

This type of sector-level data are essential to monitor and inform policymaking about the main environmental pressures by the industries, as well as their trends over time. However, these data sources showed significant data gaps, limited sector coverage, etc. EEA water accounts try to fill these gaps in water use by using complementary modelling techniques. However, although the methods seem very promising, the EEA has so far only published a dataset with the sectoral detail of NACE sections (EEA, 2017) that is insufficient to monitor the performance of raw materials sectors.

All these sector-level data sources proved limited in the assessment of water intensity, which is needed to monitor trends in water efficiency. For a sound comparison of water efficiency over time and across sectors, water use along the whole supply chain needs to be accounted for. However, none of the sector-level approaches above allow robust, comprehensive calculations of water intensity. This can be partly tackled by EE-IO tables and by LCA and WF methodologies. While EE-IO tables do not provide very accurate data on water-use estimates for the industry, they do permit a general overview of the pressures of the economic sectors including their complex supply chains, embedded in trade flows. Further, in order to identify water hotspots, data are needed on the water performance by production stage, which can be provided by LCA and WF. These approaches also allow for exploring scenarios of e.g. changes in technologies, increasing use of secondary materials as input to production, etc. This would in turn allow for *ex ante* assessments of possible solutions to mitigate the impact of the sector on water. Decreasing the impact on water would also benefit the raw materials sector itself, avoiding possible production disruption due to reduced water availability. A more challenging task is to assess water use by mining activities, where mine ore grades strongly determine the water requirements for processing (Northey et al., 2013).

In parallel, data from industry disclosures can inform about patterns in the water performance of specific companies. However, the sector coverage is still very limited to allow for a sound assessment. This applies particularly to mining facilities since, given the complexity of the sector, a large coverage is needed to guarantee the representativeness of water estimates (Northey et al., 2016). Moreover, since disclosures data are generally not disaggregated by facility and commodity produced, data cannot be used for benchmarking, as is done by the water-use standards specified in the BREF documents. Moreover, the data lack official endorsement and some studies have criticised the presentation of unreliable data in GRI reports (Fonseca et al., 2014).

Different complementary data sources could potentially be combined to develop more detailed and comprehensive datasets of water use by raw material sector. An example is the attempt by the EEA to complement the water accounts with water-use estimations based on industrial productivity data (EEA, 2013).The results were however limited (see section 3.4.1). Also the study by Soerme et al. (2016), who estimated the potential impact (toxicity) of pollutant releases, based on E-PRTR data, applying life cycle impact assessment methodologies. However, such combinations of data sources and approaches are complex and often challenged by the lack of harmonisation of water indicators, varied sector classifications, etc.

Finally, it is important to bear in mind that all these data sources do not allow for performing sustainability assessments at local level by their own. Data on local water conditions and local water use (see section 4.3.5), as well as analysis of water use prospective, competing uses, accumulative effects, etc., is needed for that (Fonseca et al., 2014).

4.2 Patterns and trends observed

The raw materials sectors use a small share of water overall as compared to other sectors of the economy. The sector generally uses less than 3 % of water of the total use by agriculture, manufacturing industries, etc.) ([24]). This is in line with the patterns observed in non-EU countries such as Canada, Chile, the United States or South Africa (ICMM, 2013). However, there is a high variability in total volumes of water used by the raw materials sector among EU countries.

Among the non-fuel, non-agricultural raw materials sector for which data were available, the sector with higher values of withdrawal (according to MS data) was mining and quarrying, followed by the manufacture of basic metals, the manufacture of non-metallic minerals, and paper and wood production. This order changed when referring to water use (withdrawal minus return flow, according to Eurostat data), where the manufacture of basic metals was first, followed by paper production and then mining and quarrying. This might be due to a more circular use of water within the manufacture of basic metals and the paper sector, which rank top in the use of water but rank below for water withdrawal.

Overall, according to both Eurostat and MS data, the mining sector has shown slightly decreasing trends for water withdrawal in some countries, more remarkable regarding water use, but also increasing trends for some other countries. The more marked decreasing trend for water use than for withdrawal might reflect the need for deeper excavation, which requires higher amounts of mine dewatering (quantified as withdrawal but not considered as water use). As for the manufacturing sectors water withdrawal (following MS data) showed increasing trends for paper production, variable trends among countries for the manufacture of non-metallic minerals, overall decreasing trends for basic metals manufacturing, and marked decreasing trends for wood processing. Water use (following Eurostat figures) for paper production and basic metals manufacturing was shown overall to be decreasing.

The reductions observed of the total water withdrawal and water use seem to be very much related to the reduction of production volumes of most raw materials within the EU. However, noticeable improvements in water efficiency have been observed for basic metals manufacturing and the manufacture of paper products, as well as for wood products overall (as claimed by CEPI, 2014). In contrast, trends for mining are very variable among countries. This is mirrored by the trends observed for Germany and Poland depicted in Figure 5Figure 5: Water withdrawal and water intensity over time for Germany (top) and Poland (bottom) based on national statistical offices data (see Table 5 and Annex). In this regard, it is important to bear in mind that the figures on water intensity do not refer to the production in physical units (since data are not available), but to the monetary value of production. This provides only a limited proxy to water intensity, since the monetary value is affected by other variables such as prices.

In addition, in line with the overall decreasing trends of water use, water discharges decreased overall. As analysed by ETC (2017b) (covering a limited set of pollutants), the raw materials industries are relevant contributions to water pollution. Over the period 2007-2014, pollutant releases from the metals industry decreased overall except for the increase for copper (Figure 6), while for the mineral industry emissions increased overall. As for paper and wood production, they show stable trends for the release of nutrients and overall decreasing trends for heavy metals. However, it needs to be borne in mind that E-PRTR data are considered limited for a sound time-trend analysis (see section 3.2.3).

([24]) Water use relative to A to D NACE sections. A: Agriculture, forestry and fishing; B: Mining and quarrying; C: Manufacturing and D: electricity, gas, steam and air conditioning supply.

4.3 Data sources available: overall limitations

Despite of the fact that both the sectoral and the microscale data sources assessed by this study provide valuable information, there are some features/limitations that should be taken into account when deriving conclusions from their data, which are discussed in this subsection.

4.3.1 Lack of harmonised definitions for water indicators

One of the main outcomes of this study is the realisation that definitions for water indicators (e.g. water withdrawal, water use, discharges, etc.) often do not match across approaches and among countries. This applies to official datasets, to company disclosures/reporting and to modelling/scientific approaches. This is a frequent problem, which limits the capacity to carry out sound comparisons between different data sources and across countries. As illustrative examples, we observed that generally, by definition, water withdrawal includes all intakes, but the Eurostat dataset includes only water from self-supplies. Therefore, water-use figures might be above water abstraction values. Differently, national data on withdrawal might account for all supply sources (e.g. Spain's data on withdrawal includes water taken from any source). In addition, many single countries use the denomination 'water supply' for indicators that match the Eurostat definition of water withdrawal. Definitions might often be even contradictory and introduce uncertainty in accounting. Thus, Spain's water accounts state that withdrawal includes extraction of water for its use, while at the same time it accounts for mine water and drainage, which is not considered as a use of water by Eurostat. In addition, while Eurostat considers 'return flow' as the water returned without being used, other studies describe 'return flow' as the sum of water without being used and waste water discharges (Vanham et al., 2018). In addition, the definition of water indicators used in LCA studies is usually not available or does not detail in a straightforward manner which flows were considered in the calculation of water use or water consumption. Finally, water indicators definitions for industry disclosures are rather vague and might be differently interpreted by different reporting companies.

Due to this lack of clarity, many studies can be found in the literature where data from possibly different water indicators are assessed as though water indicators refer to the same boundaries. There is therefore an urgent need for harmonisation and awareness of the relevance of using clear definitions when assessing and comparing water data figures.

4.3.2 Lack of sufficient sector disaggregation and limited sector coverage

Water estimates provided at sector level provide relevant insights into the overall use of water. However, Eurostat data and data produced directly by the MS at sector level are generally provided with a high level of aggregation. This prevents the distinguishing of the share of water use associated to the specific raw materials industries, covering mining and manufacturing. Mining activities are aggregated usually as the mining and quarrying sector, together with water use associated to oil and gas extraction. While for the manufacturing sectors (e.g. basic metals), data does not allow for assessing the amount of water used by each sub-sector (e.g. aluminium or steel production). This is a frequent limitation, which impedes the identification of the activities contributing the most to water intakes and discharges. It also impedes deriving more sector-specific water intensity figures, which is essential to monitor advances in water efficiency (see section 4.3.3).

The use of water within one sector and in the different production stages might vary strongly. Therefore, data assessment might lead to uncertain interpretations of the trends observed. For instance, within the basic metals sector, trends might be driven by the production of specific commodities and/or specific production stages. This could mean that water-use trends might not reflect changes in water efficiency or production level, but they might also reflect other changes e.g. the offshoring of specific production processes (with higher or lower water requirements) to other countries. Data provided by IO tables might help in assessing whether the underlying causes of trends are rather due to changes in the production model. However, harmonisation between IO methodologies and official water data sources requires complex analysis, or might even be fully incompatible.

In addition, Eurostat, MS and EEA accounting frameworks do not consider water use associated to processes that do not take place on-site, e.g. water use from energy production or for upstream manufacturing. Instead, these water uses will be accounted for and assigned to other economic sectors. A similar example can be found for the tourism sector, whose associated water use is spread among other categories (energy, transport, households, etc.) from which it cannot be discriminated (ETC, 2017a). In this regard, LCA and EE-IO tables have the capacity to consider direct water use, i.e. associated to on-site production, and also indirect water use, i.e. associated to the ancillary processes. Therefore, there is a need for using approaches such as LCA and WF or EE-IO tables for a comprehensive assessment of water use associated to the production of products and sectors. Again, this requires the development of complex analysis and significant harmonisation efforts. Moreover, LCA and WF studies are often not comparable due to differences in system boundaries, allocation rules, etc.

4.3.3 Challenges for water efficiency estimates

The importance of assessing improvements towards increasing water use efficiency is widely recognised. It is, for instance, within the set of national indicators for the monitoring of the SDGs (indicator 6.4.1 — Change in water-use efficiency over time). It is also considered for the water performance of specific production processes within the BREF documents, such as blast furnaces for steelmaking, pulp and paper mills, etc. Counting on water intensity data by economic sector would allow for the identification of priority sectors to be targeted by water efficiency policies. This requires sound and comprehensive data on water use and industry production volumes. The limitation of water data are many, as described in previous sections. In particular, water-use data with high level of disaggregating are needed for a meaningful analysis, given the heterogeneity in the use of water by the different industries. This would allow the identification the industries in which there is more room for improvement. As for production data, they are available in the best cases only in monetary value units. Monetary value data might not properly reflect production volumes since they are derived from other variables such as prices, which can be very volatile. Production data are usually available at an even higher level of sectoral aggregation than the water-use data.

The study by AMEC (2015) analysed the impact of the adoption of BATs, as specified in the BREF documents) on the reduction of emissions, also including those emissions to water. They concluded that the lack of comprehensive raw data limits the possibility to perform such an assessment. Examples of data lacking are the level of adoption of BATs by the industry (since for instance industries might be exempt from the adoption of BATs under some circumstances), and data on the emission-level authorised in the operation permits. There are ongoing studies developing methodologies for further estimating this aspect as well as the compliance costs of BATs ([25]), for which results are not yet available. Still, while efforts are being done for the assessment of emission reduction, little has been done with regards to assessing the impact of BAT adoption on water use.

4.3.4 Time-series harmonisation

For the development of sound data series analysis, historical series data need to be systematically corrected upon the release of new data that might follow different underlying estimation methodologies. Such corrections are carried out for some sources such as E-PRTR and WISE-SoE, but not for e.g. the Eurostat water-use data (ETC, 2017a).

4.3.5 Spatial and temporal resolution for sound impact estimates

Local water conditions will determine which type of pressures would be more relevant to consider for the sustainability of the sector, and the subsequent impacts associated with

([25]) http://ec.europa.eu/environment/industry/stationary/studies.htm these pressures. This can vary strongly depending on the spatial and temporal resolution considered. For instance, the impacts of water pollution can be very localised in space and time. Similarly, the assessment of water stress, which is among the indicators within the SDG framework (indicator 6.4.2 — Level of water stress: freshwater withdrawal as a proportion of available freshwater resources), might take place at very specific locations and might be very time specific. Sound water scarcity assessments should also consider how the water is used, including water storage in reservoirs, supply network, possible water transfers, the differential use of surface water and groundwater, as well as the minimum flow required by the ecosystem (Vanham et al., 2018). Therefore, while annual, national-level and even watershed-level data can be useful to monitor overall average trends, this information informs in a very limited way about the ultimate environmental impacts. Although the reporting of pressures on water and water status in the context of the WFD is carried out at watershed level, detailed data on the single industrial sources responsible for these pressures are not provided with enough sector resolution. This limits the capacity to identify the sectors posing the most relevant pressures on water. Such higher resolution data are often available at regional or municipal level (from e.g. industrial permits or audits), yet it has not been systematically compiled and processed to provide figures at national level and for the whole EU.

4.3.6 Limited coverage of contaminated water

The analysis of contaminated water is usually more limited than that of water intake. This aspect is often absent in data records and studies due to the complexity of water-flow-quality characterisation, which significantly limits the assessment of the pressures posed by the sector. On one hand, the Eurostat dataset on water discharges, apart from having limited national coverage, does not provide data on the quality (quality parameters, pollutant concentration) of wastewater discharges. This means that it cannot be concluded that pressures on water bodies have reduced over time even though wastewater discharges have been decreasing: wastewater discharge volume might have decreased while pollutant concentration might have increased at the same time. On the other hand, the official register on industrial emissions (E-PRTR) still presents many limitations for allowing for a sound assessment of pollution derived from the industry (see section 3.2.3). Further efforts are being made (e.g. by the EEA) to develop automatic data-quality checks of E-PRTR data, a register which recently underwent a policy review (the Commission's regulatory fitness and performance (REFIT) programme).

Even if complete data records on pollutant releases were available, the assessment of the potential ultimate impact of pollutants on ecosystems and human health is challenging due to the manifold impacts existing. Impact characterisation methods, such as those proposed by LCA (e.g. USEtox) would allow for the estimation of the aggregated potential impact (ecotoxicity, human toxicity) derived from the mix of pollutant releases by the sector. In this regard, Soerme et al. (2016), combined E-PRTR pollutant-release data with LCA impact assessment methodologies for a case study for Sweden. They found that many sectors within the scope of the present study are very significant contributors to chemical impacts, considering toxicity to both humans and ecosystems. However, the uncertainties associated to these impact-estimation methods are still high (European Commission, JRC, 2011) and not easy to communicate. In addition, LCA and WF water quality inventory data need to be updated and improved, to e.g. to incorporate pollutants that are currently not covered (Northey et al., 2016).

Beyond these considerations, it is important to mention that both the Eurostat and E-PRTR data series focus on active facilities, not accounting for post-closure pressures, which can be particularly relevant for mining activities. In this context, the assessment of the pressures on water quality by the mining sector is usually challenging. For instance, it is difficult to account for wastewater flows such as leakages from dams or runoff at mining sites, which can have a very significant negative impact on water and soil quality. Contaminated sites are being monitored by the European Commission on a continuous basis (van Liedekerke et al., 2014, Paya and Rodriguez Eugenio, 2018), identifying the pollution sources and the remediation measures put in place by the MS, based on MS reporting. Yet, the pollution sources classification followed by this assessment does not allow for differentiating the raw materials industrial sectors, which would be required in order to identify the main contributors to pollution.

4.3.7 Limited coverage of accidents

Beyond environmental pressures associated with 'normal' operation, accidents may also occur, while all the datasets considered in this study provide data on 'normal' operation conditions. However, the environmental impacts from accidents might be severe. For instance, mining tailing dam failure can be considered the risk with the largest environmental impact for mining activities (Dolega et al., 2016). These events are more prone to occur under specific framework conditions such as higher tectonic activity and heavy rainfall (Dolega et al., 2016). Tailing dams have a failure rate above that for conventional storage dams (Azam and Li, 2010). Spills due to maintenance problems, or unexpected discharges even due to human errors also occur, as it is clearly shown by the EU major accident reporting system (MARS) (also eMARS as per its release online ([26])) on accidents, established by the EU's seveso directive ([27]). The MARS database aims to improvements information on lesson learned from accidents involving dangerous substances. Therefore, it provides data on major accidents, near misses, etc. aggregated by type of economic activity and single events reports. However, the information contained in reports and investigations varies considerably among reporting industries. Also, some features limit the use of these data for monitoring the performance of the different raw materials sectors across countries and industries. First, the location of the companies remains confidential, since it is understood that anonymity helps to encourage information sharing. Further, accidents are systematically classified following a high level of sector aggregation. Having more disaggregated and spatialised data would allow for assessing potential higher incident rates in some specific industry typologies and locations. Lastly, since it takes about three years for the reporting process to be completed, MARS annual statistics are not reliable for the final three years of data.

4.4 Conclusion and looking forward

Assessing water use and water efficiency are key sustainability indicators, as highlighted also by the SDGs. Zooming into the economic activities that pose the most relevant pressures is a requirement for well-informed policymaking. Our results show that assessing the environmental pressures and water performance by the raw materials sector is a complex task, which at the moment needs to be targeted using different water sources and indicators, and for which data are restricted to some sectors and some countries. The incompleteness of data limits the sound calculation of the water stress SDGs indicator considered in the Eurostat SDGs monitoring framework ([28]) (the water exploitation index) at EU and national level. Moreover, although water efficiency is one of the indicators considered under the SDGs, such an indicator is not even included among the indicators within the Eurostat SDG monitoring framework.

Despite of the relevance of the SDGs, and although safeguarding water is a priority in the policy agenda, trends in the EU reporting entities do not seem to move towards the collection of data of sufficient spatial, sectoral and temporal resolution. Therefore, there is a need for compulsory reporting to comprehend the data on the use of the water by the whole sector in a more disaggregated manner. Robust, validated data on withdrawal, water use and water discharges are needed to assess the multiple impacts of industrial activities on water. Data on the quality parameters of the discharges are also required to estimate the impact of the sector on the quality of water bodies and soils. To this aim, E-PRTR, although covering only major facilities, counts already on very valuable data. However, for the time being the use of these data to derive trends of pollutants releases by sector over time requires complex and manual processing. Further, counting on methods such as those

([26]) https://minerva.jrc.ec.europa.eu/en/emars/content
([27]) http://ec.europa.eu/environment/seveso
([28]) https://ec.europa.eu/eurostat/web/sdi

used in LCA impact characterisation (which weight pollutants based on e.g. the different toxicity) could facilitate estimating the overall impact on water quality by the different sectors. This would help to identifying policy priorities, as Soerme et al. (2016) proposed to implement at national level.

Having more information about the effect of BAT adoption on water performance would also be essential to set out the most effective paths towards sustainability. In this regard, there are many ongoing projects where the process industries are carrying out studies and exchanging data on better practices and technologies for improved water management and water circularity (under e.g. the European Commission Horizon 2020 programme). In addition, the International mine water association (IMWA) gathers together experts from all around the world to discuss more effective mine water-management practices and technologies. Many sectors of the industry consider practices and technologies with a view not only of water use but also of energy consumption. This is due to the fact that these sectors are energy intensive and often trade-offs between reductions in water and energy use (with the subsequent greenhouse gas emissions) might arise. For instance, the use of reverse osmosis membranes and extreme desalination techniques can lead to higher energy demand (ICMM, 2012).

Some industry sectors are doing efforts to address the most common challenges that are faced when carrying out sound LCAs for the metals and mining sector such as how to handle co-production, how to account for different levels of recyclability, etc. (Santero and Hendry, 2014). They suggest the collection of comprehensive inventories covering also water, but focusing on net water consumption (and not water withdrawal). Moreover, they propose not to consider water-related impact categories due to the still high levels of associated uncertainty. In parallel, LCA water data are evolving: from a past situation where the focus was given to inventory data, more advanced impact characterisation methods are becoming available (Northey et al., 2016). This includes the recent publication of regionalised characterisation factors related to water stress and water availability (Northey et al., 2018). However, the need for reliable, up-to-date underlying data remains; and the uncertainty associated to the estimates is still high.

Although data coming from the industry is very limited, many industries are increasingly working on the assessment of the water-related production risks ([29]). For that, there is an increasing number of tools for a more standardised water data collection (such as the global water tool ([30]), etc.). Different reporting initiatives are also doing efforts towards a clearer linkage between their questionnaires (e.g. GRI and CDP-water ([31])). Currently, water data are contained within the single industry disclosing reports, which need to be scanned through manually to extract the data. The systematic compilation of these data in a usable format by the reporting initiatives (e.g. spreadsheets) would facilitate the assessment of data by researchers. In addition, external validation of these industry data should be encouraged to count on fully reliable data. In view of a more informative assessment of the impacts from water use and discharge in the sustainability reports, it would be essential to find data about the local water conditions.

In addition, in order to also assess the possible risks of supply disruption associated with water scarcity, it would be beneficial to move towards a supply chain perspective, assessing water use not only on-site but also from the supplying companies. Some reporting initiatives are already on this path, analysing possible water risks associated with the upstream sectors in their supply chain ([32]).

It is important to highlight that the assessment of the pressures on water by the mining sector is usually more challenging than for the manufacturing sectors. The comparison of water performance among commodities and regions is very challenging since the ore grade and other variables need to be taken into account (Northey et al., 2013). Finally, regardless

([29]) CDP's water program 2015, *Accelerating action — CDP Global Water Report 2015.*
([30]) https://www.wbcsd.org/Clusters/Water/Resources/Global-Water-Tool
([31]) https://www.globalreporting.org/standards/resource-download-center/linking-gri-and-cdp-how-are-gri-standards-and-cdp-water-questions-aligned
([32]) ICMM, 2013, *Adapting to a changing climate*.

of its life stage (construction, operation, closed) a mine can potentially contaminate water and soil. International institutions provide lessons learned from mining case studies for sustainable water management (ICMM, 2012, Wolkersdorfer and Bowel, 2004; 2005a; 2005b).

Derived from all the previous considerations, there is a clear need for basic, validated, systematic compilation of raw data related to water, with a sufficient disaggregation and spatial coverage, which allows for identifying the most relevant pressures and impacts and to monitor the effectiveness of policies implemented in each of the sectors. Further harmonisation of reporting also becomes essential, making sure water indicators definitions are comparable across reporting schemes, countries, etc. The need for such data should be addressed when reviewing the related policies and regulations that determine the content and the format of reporting obligations for water-related data.

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