SCRREEN2

This project has received funding from the European

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under grant agreement No 958211.

Start date: 2020-11-01 Duration: 36 Months

FACTSHEETS UPDATES **BASED ON THE EU FACTSHEETS 2020**

SILICA SAND

AUTHOR(S):

TABLE DES MATIÈRES

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SILICA SAND

OVERVIEW

Silica is mainly recovered from silica sand, which is mostly made up of broken-down quartz crystals, and its lithified (quartzarenite) and metamorphic (quartzite) equivalents, along with microcrystalline silica (chert, flint). Silica used for industrial applications is characterised by a high content of quartz (or cristobalite) and a low amount of impurities, thus SiO_2 can be up to 99.9%. Other silica sources – diatomite, tripoli, and perlite – are not considered here. Silicon dioxide, SiO_2, also referred to as silica, has a number of crystalline and amorphous polymorphs. Quartz is one of the crystalline silica polymorphs. It is among the most common minerals in the Earth's continental crust, and silica sand is essentially made up of broken-down quartz crystals. Quartz crystals consist of almost pure silicon dioxide, containing low quantities of impurities (Kogel, 2019).

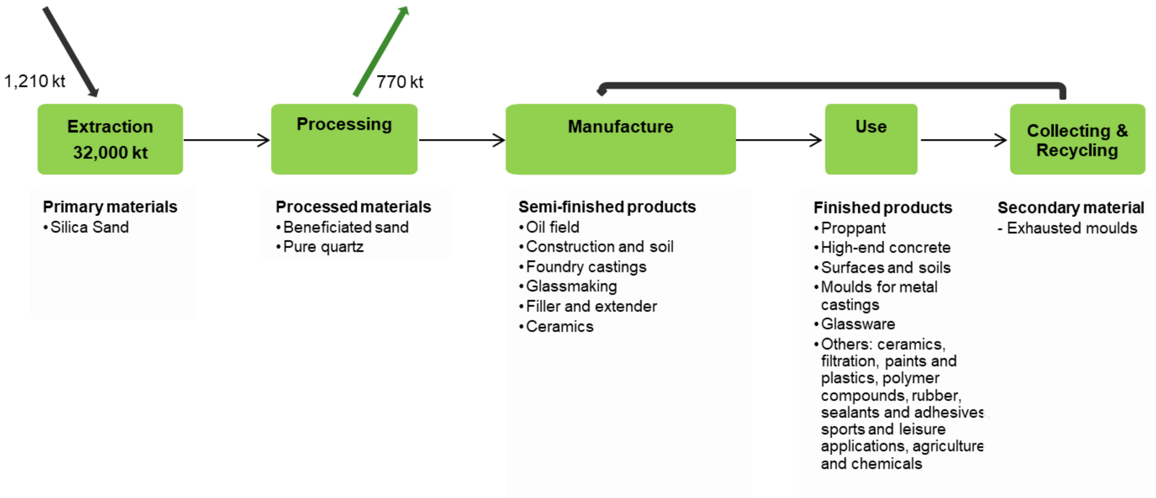

Figure 1. Simplified value chain for silica sand in the EU[1]

Table 1. Silica sand supply and demand in metric tonnes, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
237.94 Mtonnes	USA 41% China 8% India 5% Turkey 5% Germany 4% France 4%	51.1 Mtonnes	21.5%	Tunisia 25% Egypt 13% UK 5%	0%

Prices: Between 2014 and 2020, quartz crystal (as-grown cultured quartz) prices ranged from USD 200 per kilogram to USD 300 per kilogram. The vast majority is sold on the open market and only small amounts are traded on annual contracts (EC, 2020). Silica sand prices depend widely on location of the mine and delivery location.

[1] JRC elaboration on multiple sources (see next sections)

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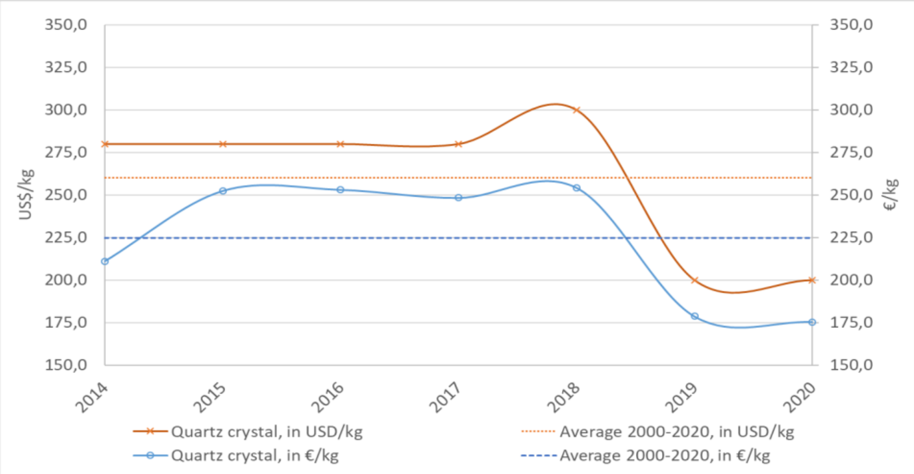

Figure 2. Annual average price of silica sand between 2000 and 2020 (USGS, 2021)[2].

Primary supply: The exact amount of mined silica sand and quartz sand worldwide can hardly be identified due to the lack of provided data by various geological surveys. USGS factsheets provides silica sand data into the "sand and gravel" general group of materials. The annual worldwide produced silica amount over 2016-2020 was 238 million tonnes. Silica sand extraction is taking place in EU at a significant extent. The average annual production during the period 2016-2020 was 51 Mt representing 21.6% of the world production.

Secondary supply: Silica sands cannot be recovered after use in the oil field. Silica utilized in construction and as filler is retained within the matrix of concrete, mortar, rubber, plastics, etc., thus cannot be recycled as silica source. Silica in glass and ceramics is melted and recycled as a whole product.

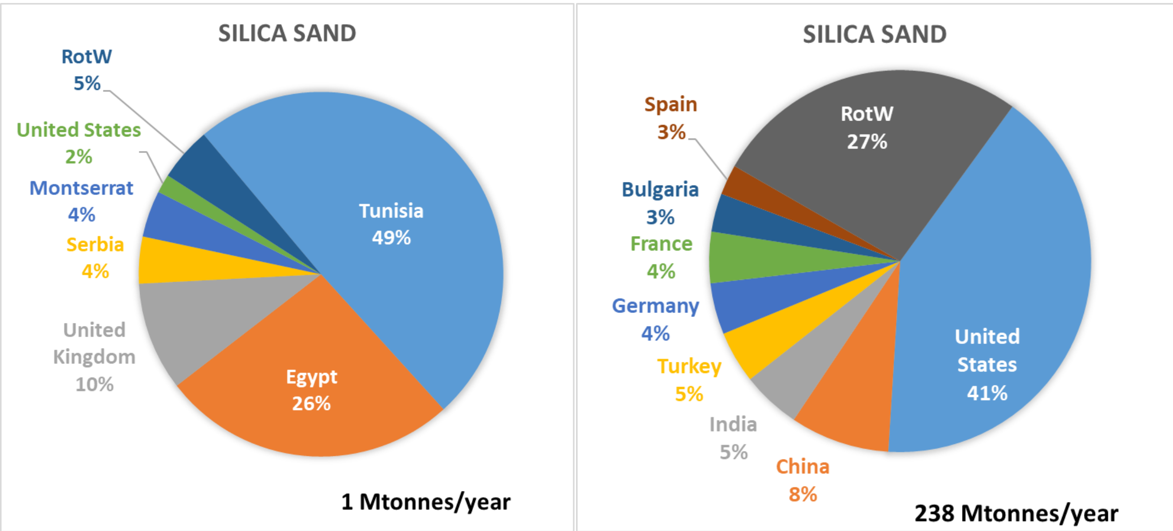

Figure 3. EU sourcing of silica sand and global mine production

Uses: In the EU, there are three major end users (construction and soil 37%, glass manufacture 21%, and foundries 13%) plus a range of different applications accounting for the remaining applications.

[2] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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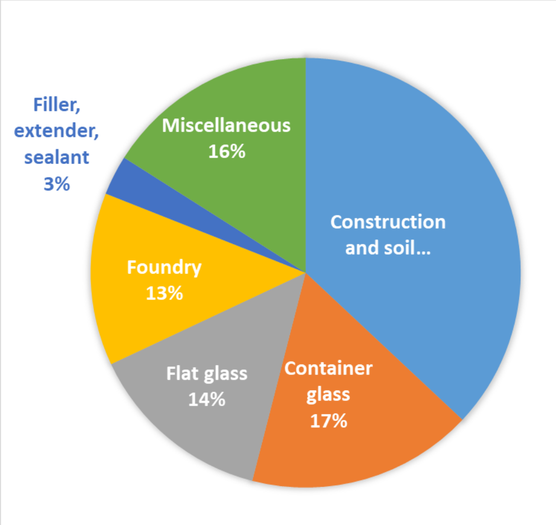

Figure 4: EU uses of silica sand

Substitution: Silica sands are not routinely substituted as any potential substitute would lead to an increase in cost, or a loss in performance (leading to a decrease in the benefit/cost ratio). This is particularly true for glass, where silica is the major component and plays the irreplaceable function of glass network former.

Table 2. Uses and possible substitutes

Use	Percentage*	Substitutes	Sub share	Cost	Performance
Construction and soil	37%	Aggregates	28%	Similar or lower costs	Reduced
Glass	31%	No substitute			
Foundry	13%	Zircon	9%	Very high costs (more than 2 times)	Similar
		Olivine	1%	Slightly higher costs (up to 2 times)	Similar
Filler, extender, sealant	3%	Lime (calcium carbonate)	10%	Slightly higher costs (up to 2 times)	Similar
		Talc	5%	Similar or lower costs	Similar
		Wollastonite	10%	Similar or lower costs	Similar
		Kaolin	5%	Similar or lower costs	Similar
		Mica	5%	Similar or lower costs	Similar
		Pyrophyllite	5%	Similar or lower costs	Similar
		Feldspar	10%	Similar or lower costs	Similar

*Estimated end use shares of silica sand (SCRREEN Experts Validation Workshop (2022).

Other issues: Crystalline silica placed on the market is subject to the classification obligation under (Regulation EC 1272/2008), while crystalline silica dust generated by a work process is not placed on the market and therefore is not classified in accordance with that Regulation (IMA-Europe, 2018b). Sand is among the most extracted minerals in the world and the significant volumes extracted at rapid rates are associated with social risks, including crime, as well as environmental risks. Several organisations described as 'sand mafias' have emerged in multiple locations around the world, stealing large quantities of the valuable commodity, reselling it to unscrupulous buyers and undermining efforts to use sand sustainably.

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MARKET ANALYSIS, TRADE AND PRICES

GLOBAL MARKET

Table 3. Silica sand supply and demand in metric tonnes, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
237.94 Mtonnes	USA 41% China 8% India 5% Turkey 5% Germany 4% France 4%	51.1 Mtonnes	21.5%	Tunisia 25% Egypt 13% UK 5%	0%

The world annual production of silica is about 238 Million tonnes. The European production of silica is around 51 million tonnes. In Europe, silica sand is produced in Sweden, Latvia, Slovakia, Hungary, Denmark, Portugal, Slovenia, Finland, Romania, Greece, Lithuania, Estonia, Germany, France, Bulgaria, Spain, Poland, Netherlands, Italy, Bulgaria, Austria, and the Czech Republic. Key players are SCR-Sibelco N.V., Mitsubishi Corporation, U.S. Silica, Chongqing Changjiang River Moulding Material (Group) Co., Ltd., Quarzwerke GmbH, JFE Mineral Company, Ltd, Hi-Crush Inc.

The global silica minerals mining market has been growing in the last 10 years. This has been driven mainly by the glass industry, since silica is the primary component in glass, glass demand is increasing in the construction and automotive sectors, especially in developing and transition countries. The main end-uses for silica sand are construction and soil (37%), container glass (17%), flat glass (14%), foundry casting (13%), ceramics, filtration, sports and leisure and other uses.

- Silica sand is used in different types of glass. Glass uses silica sand to produce bottles and jars. Flat glass is also an important end-use and encompasses glass in windows in buildings and vehicles, and mirrors. Other glass applications include lighting glass for light bulbs use, tableware for drinking glass, electronic goods, fibreglass, and optical glass.
- Silica is also used in foundry casting as it is used to make moulds used to pour molten metals for aerospace, military and automotive application. In ceramic glazes, silica sand is a major component and can be found in tableware, sanitaryware, wall and floor tiles, and ornaments.
- Silica sand can also be used to filter and extract solids from potable and wastewater in the food and water industry.
- In construction, silica sand is utilised to produce high-end concrete, mortar, glues, grouts, etc. as well as composite silica-resin kitchen-tops, equestrian surfaces, sport soils, silica gravel and traction sand, and asphalt.
- Further silica applications encompass filler in plastics, polymers and rubber; extender in paints and adhesives; ingredient of ceramics (silicate and carbides), abrasives, and refractories; filtration sands; chemicals; and in fluidized bed incinerator plants.

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The glass industry is driving the growth of the silica sand market, due to an increased use of glass in diverse industries, such as solar panels. (Expert Market Research, 2022). From 2023 to 2028, the market is projected to grow at a compound annual growth rate of 3.20%. (Expert Market Research, 2022).

EU TRADE

For this assessment, silica sand is evaluated at extraction stage.

Table 4. Relevant Eurostat CN trade codes for silica sand.

Mining	
CN trade code	**title**
25051000	Silica sand and quartz sands, whether or not coloured

Figure 5 shows the import and export trend of silica sand from 2000-2021. In 2000-2014, the EU imports were higher than the exports. The EU exports volumes began to exceed the imports in 2014-2020. The year 2021 saw a decline in the exports and an increase in imports. On the average of 2000-2021, the EU imports stayed at 1,388,522 tonnes/year and the exports were 937,538 tonnes/year. Transportation of silica sand over long distances is not affordable, so trade exchanges of silica sands are small with extra-EU countries (European Commission, 2020). The major suppliers of this silica sands to the EU in the 2016-2020 period of time are Tunisia (25%), Egypt (13%) and UK (5%) (Figure 6). There was no export prohibition, export tax, nor export quota measure in place according to OECD's database - Export restrictions on Industrial Raw Materials (OECD, 2022) in 2022.

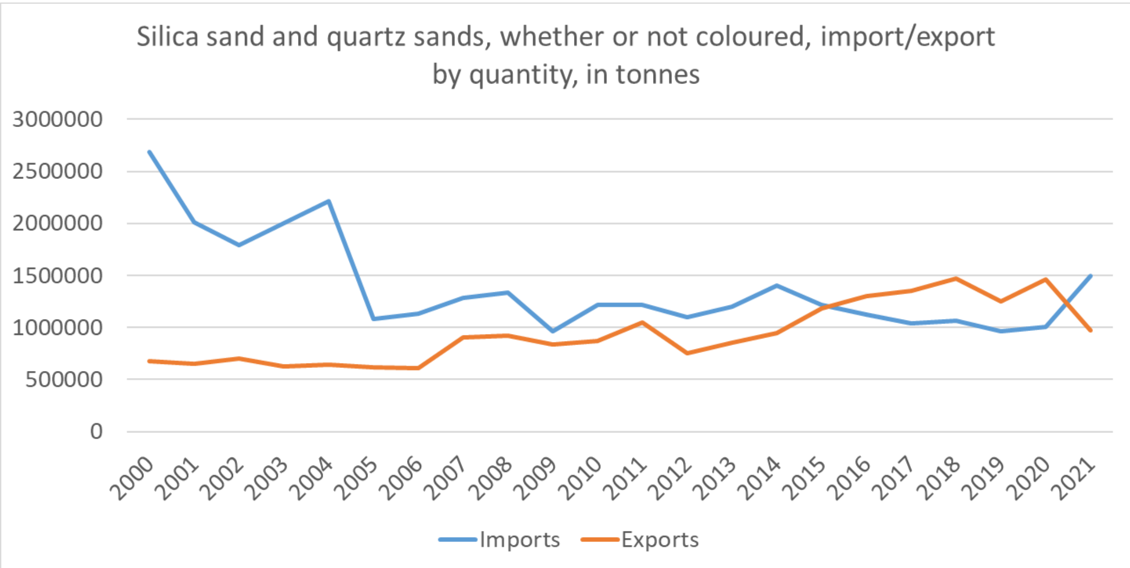

Figure 5. EU trade flows of silica sand and quartz sands, whether or not coloured (CN 250510) from 2000 to 2021 (Eurostat, 2022)

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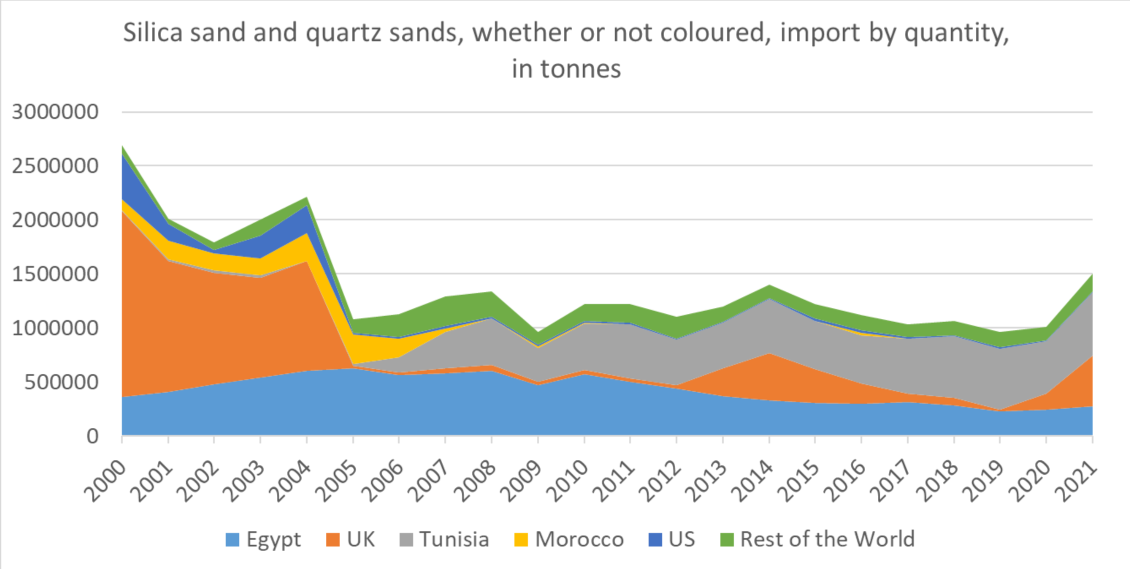

Figure 6. EU imports of silica sand and quartz sands, whether or not coloured (CN 250510) by country from 2000 to 2021 (Eurostat, 2022)

PRICE AND PRICE VOLATILITY

Between 2014 and 2020, quartz crystal (as-grown cultured quartz) prices ranged from USD 200 per kilogram to USD 300 per kilogram. The vast majority is sold on the open market and only small amounts are traded on annual contracts (EC, 2020). Silica sand prices depend widely on location of the mine and delivery location.

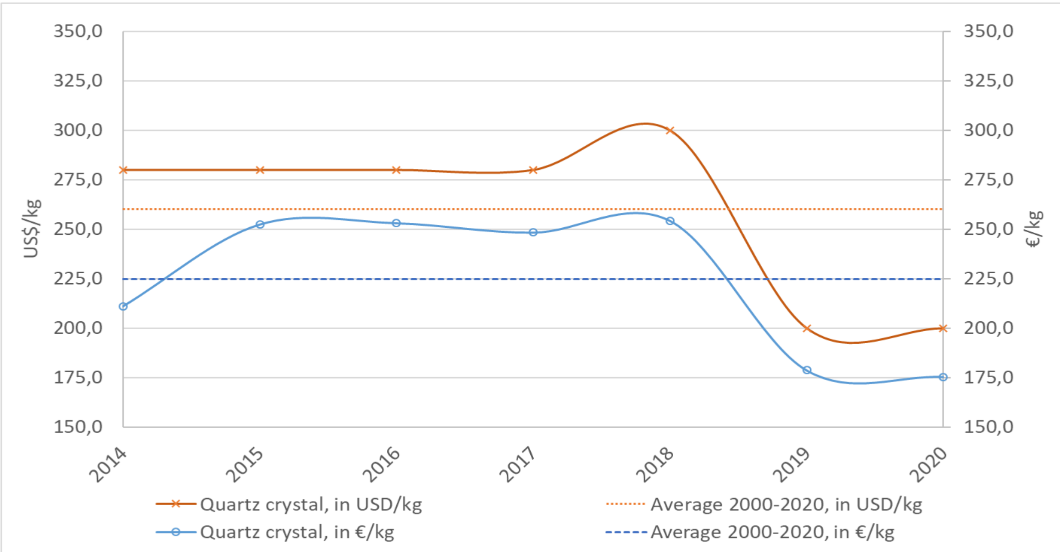

Figure 7. Annual average price of quartz crystal (as-grown cultured quartz) between 2014 and 2020, in US$/kg and €/kg[3]. Dash lines indicate the average price for 2000-2020 (USGS, 2022)

[3] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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DEMAND

GLOBAL AND EU DEMAND AND CONSUMPTION

The world market of silica sand in 2018 was about 315 million tonnes worth around EUR 3,000 million, expected to keep steady by 2020. Approximately 32 million tonnes of silica sand were produced and consumed in the EU on average between 2012 and 2016 (IMA-Europe, 2018a). However, as calculated from the various sources listed below, the EU consumption for 2016-2020 is considerably lower at around 4 million tonnes.

Silica sand EU consumption is assessed at extraction stage. Silica sand extraction stage EU consumption is presented by HS code CN 25051000 - Silica sands and quartz sands, whether or not coloured. Import and export data is extracted from Eurostat Comext (2022). Production data is extracted from various sources including BGS (2022), GTK (2022), MCS (2022), ISTAT (2022), USGS (2000-2022), PGI (2022), DGEG (2022), GEUS (2022) and GSS (2022).

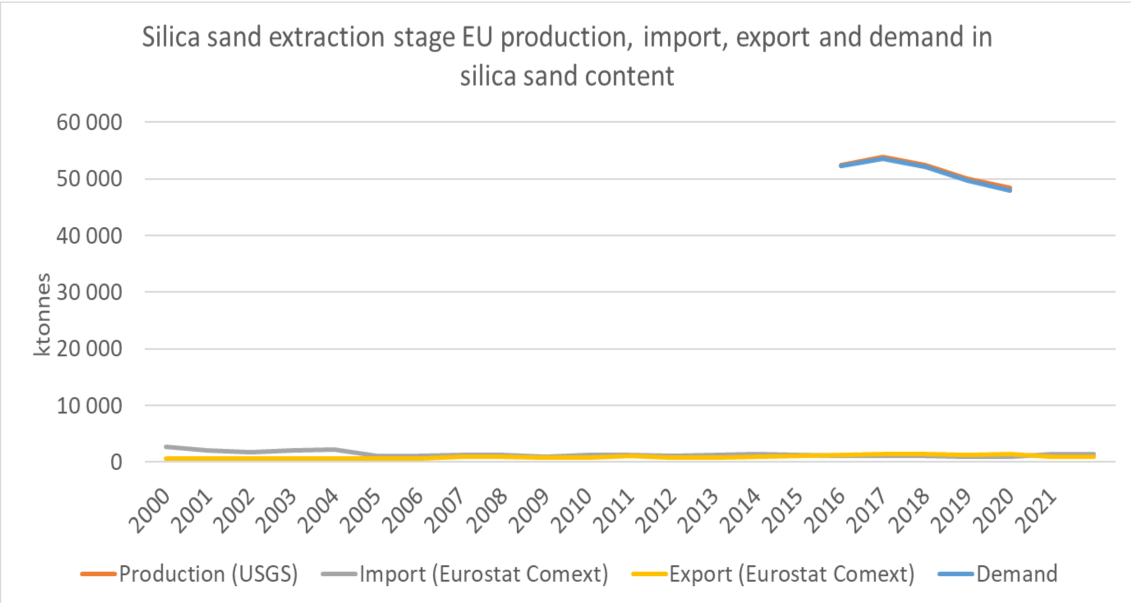

Figure 8. Silica sand (25051000) extraction stage apparent EU consumption. Production data is available from various sources stated above and is available for 2016-2020. Consumption is calculated in silica sand content (EU production+import-export).

Average import reliance of silica sand at extraction stage is 0 % for 2016-2020.

EU USES AND END-USES

The major end-uses of silica sand averaged over 2012-2016, both at the global and European level, are displayed in Figure 9.

In the EU, there are three major end users (construction and soil 37%, glass manufacture 21%, and foundries 13%) plus a range of different applications accounting for the remaining applications.

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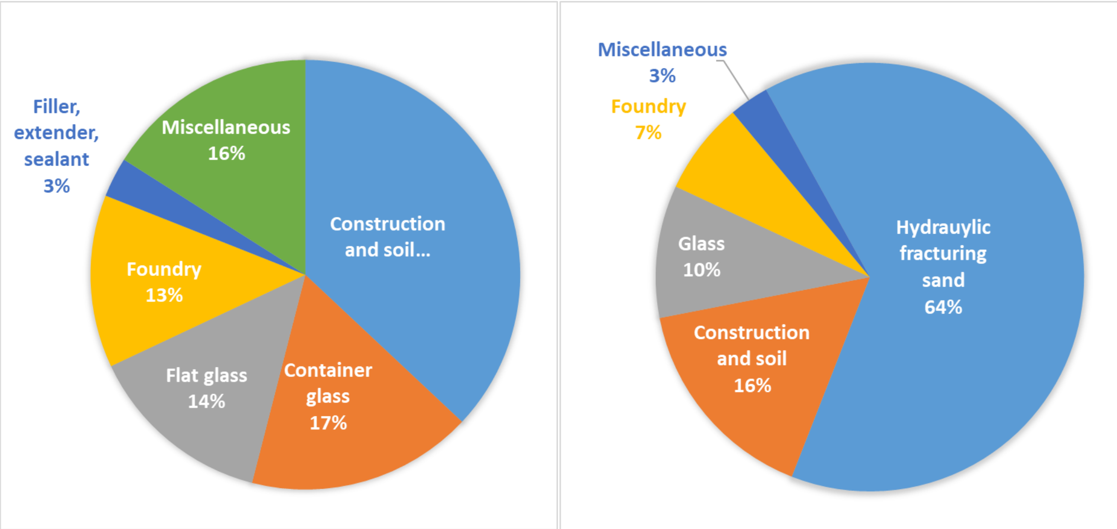

Figure 9. EU uses (left, IMA-Europe, 2018a; SCRREEN experts 2022) and global uses (right, USGS, 2020) of silica minerals (2012-2016).

The calculation of economic importance is based on the use of the NACE 2-digit codes and the value added at factor cost for the identified sectors. The value-added data correspond to 2019 figures

Table 5. Silica sand applications (IMA-Europe, 2018a), 2-digit and associated 4-digit NACE sectors, and value added per sector (Eurostat, 2021)

Applications	2-digit NACE sector	Value added of NACE 2 sector (millions €) - 2019	4-digit NACE sectors
Construction and Soil	C23 - Manufacture of other non-metallic mineral products	72,396	23.61, 23.64; 20.52, 23.69; 23.99; 43.99; 42.10
Glass	C23 - Manufacture of other non-metallic mineral products	72,396	23.11, 23.13, 23.14
Foundry and metallurgy	C24 - Manufacture of basic metals	63,700	24.10, 24.5
Filler, extender and sealant	C22 - Manufacture of rubber and plastic products	94,767	22.1, 22.2, 20.3, 20.52

APPLICATIONS OF SILICA SAND IN THE EU:

CONSTRUCTION

Silica sand is used to produce high-end concrete, mortar, glues and grouts, composite silica-resin kitchen-tops, equestrian surfaces, sport soils, silica gravel and traction sand.

Low-end by-products of silica, used for asphalt and road construction, are not considered here.

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GLASS

Silica sand is the major ingredient in the manufacture of different kinds of glass (flat, hollow, fiberglass) and technical glassware.

Jars and containers are the main glass products, followed by flat glass (windows, mirrors), tableware, glass fibre (composite reinforcing and insulation material) and special uses such as plasma screens and optical glass.

FOUNDRIES

Silica sand is used is as casting moulds for both ferrous and non-ferrous metallurgy. Silica has a higher melting point than iron, copper and aluminium and can be used at the temperatures required to melt the metals. These casts form an essential part of the engineering and manufacturing industries.

OTHER (SUMMARISED)

Other silica applications include:

- As filler in plastics, polymers and rubber.
- As and extender in paints and adhesives.
- As an ingredient of ceramics (silicate and carbides), abrasives, and refractories.
- As filtration sands; chemicals; and in fluidised bed incinerator plants.
- As proppant for hydraulic fracturing, and well packing/cementing.
- Quartz is used for precision casting for products such as jewellery and aviation turbines.

SUBSTITUTION

Table 6. Uses and possible substitutes

Use	Percentage*	Substitutes	Sub share	Cost	Performance
Construction and soil	37%	Aggregates	28%	Similar or lower costs	Reduced
Glass	31%	No substitute			
Foundry	13%	Zircon	9%	Very high costs (more than 2 times)	Similar
		Olivine	1%	Slightly higher costs (up to 2 times)	Similar
Filler, extender, sealant	3%	Lime (calcium carbonate)	10%	Slightly higher costs (up to 2 times)	Similar
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		Feldspar	10%	Similar or lower costs	Similar

*Estimated end use shares of silica sand (SCRREEN Experts Validation Workshop (2022).

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Silica sands are not routinely substituted as any potential substitute would lead to an increase in cost, or a loss in performance (leading to a decrease in the benefit/cost ratio). This is particularly true for glass, where silica is the major component and plays the irreplaceable function of glass network former.

In other sectors, substitution possibilities include:

- **bauxite or kaolin** - as raw materials for oil proppants (designed to keep open an intended hydraulic fracture).
- **zircon or olivine** - as constituents of casting moulds in foundries).
- **calcium carbonate, talc, wollastonite, kaolin, mica, pyrophyllite, feldspar** - as fillers, extenders, and sealants.
- **Feldspar or perlite** - in the formulation of some high-end concrete, mortar, glues, grouts, or composite silica-resin kitchen-tops.
- **Low-end by-products or common sand and gravel** - to produce equestrian surfaces, sport soils, silica gravel and traction sand along with asphalt and road construction.

SUPPLY

EU SUPPLY CHAIN

Silica sand extraction is taking place in EU at a significant extent. The average annual production during the period 2016-2020 was 51 Mt representing 21.6% of the world production. Denmark, Finland, Hungary, Slovakia, Slovenia and Sweden are the main EU producers. At the same period 1 Mt of Silica sands quartz sands (HS Code 25051000) were annually imported mainly from Tunisia, Egypt and United Kingdom, while 1.3 Mt were annually exported to third countries. United Kingdom, Switzerland and Turkey are the most important trade partners. The EU recycling rate in EU is estimated at 17% (taking into account the end-of-life recycling of glass (Eurostat, 2021).

SUPPLY FROM PRIMARY MATERIALS

GEOLOGICAL OCCURRENCE

Quartz makes up approximately 12% by weight of the lithosphere, making it the second most common mineral in the Earth's crust. Quartz is found in igneous, metamorphic and sedimentary rocks but it is particularly concentrated in some sedimentary types (quartz sand and the lithified counterpart quartzarenite), given its high resistance to physical and chemical weathering, and their metamorphic equivalents (quartzite). Since quartz is almost ubiquitous, deposits of silica sand and quartzite are found in all continents, even if those able to provide industrial sand of suitable purity at affordable cost are not widespread. Quartz crystals are almost pure silicon dioxide, containing low quantities of impurities. For industrial purposes, silica sand with a purity of at least 95% is usually required. High-technology applications for quartz require extreme quality, with specific low-ppm or sub-ppm requirements for maximum concentrations of certain trace metals (European Commission, 2017b).

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Table 7. Resource data for Europe compiled in the European Minerals Yearbook of the Minerals4EU website (Minerals4EU, 2019)

Country	Reporting code	Quantity	Unit	Grade	Code Res. Type
Norway	None	157	Mt	quartz and quartzite	Estimated
UK	None	40,000	Mt	silica sand	Estimated
Latvia	-	18.8 2.6	? ?	moulding sand glass sand	Stock of deposits
Poland	Nat.Rep.Code	352.89	Mt	quartz sands	A+B+C1
Slovakia	none	10.662 0	Mt Mt Mt	foundry sands glass sands quartz	Verified Z1
Czech Republic	Nat.Rep.Code	147,412 145,040	kt kt	foundry sand glass sand	Potentially economic
Ukraine	Russian class.	38,924	kt	quartz sand	P2
Slovenia	Nat.Rep.Code	168.68	Mt	quartz sand	National
Serbia	JORC	65.63	Mt	quartz sand silicious rocks	Total
Kosovo	Nat. rep. code	13	Mt	quartzite sand	Hist. Res. Estimates
Macedonia	Yugoslavian	5,081,465	m^3	quartz	B
Albania	Nat.Rep.Code	100	million m^3	silica sands	A
Greece	USGS	75 3	Mt Mt	quartz silica sand	Indicated

Reserve data for some countries in Europe are also available in the Minerals4EU website. However, these data cannot be summed as they are partial and they do not use the same reporting code.

Table 8. Reserve data for Europe compiled in the European Minerals Yearbook of the Minerals4EU website (Minerals4EU, 2019)

Country	Reporting code	Quantity	Unit	Grade	Reserve Type
Denmark	None	24.1	million m^3	pure quartz sand	e
Ukraine	Russian classification	41,130 14,007 11,521	ktkt kt	foundry sand glass sand quartz/quartzite for	A
Poland	Nat. rep. code	20.45 144.54	Mt Mt	foundry sands glass sands	-
Czech Republic	Nat. rep. code	127,937 84,755	ktkt	foundry sand glass sand	Economic explored
Slovakia	None	10.662 0	Mt Mt	foundry sands glass sands	Verified Z1
Slovenia	UNFC	16.44	Mt	quartz sand	Proved
Croatia	Nat.Rep.Code	33,035.77	kt	silica sands	-

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Kosovo	Nat.Rep.Code	2,312,614	m^3	quartzite sand	A+B
Macedonia	Yugoslavian	5,081,465	m^3	quartz	B

PRODUCTION OF SILICA SAND:

The exact amount of mined silica sand and quartz sand worldwide can hardly be identified due to the lack of provided data by various geological surveys. USGS factsheets provides silica sand data into the “sand and gravel” general group of materials. Figure 10 shows the produced amounts of silica sand by the major producer-countries from 2000 to 2020 according to USGS data and additional sources for 2016-21020. The total worldwide produced silica amount in 2020 was 216.8 million tonnes.

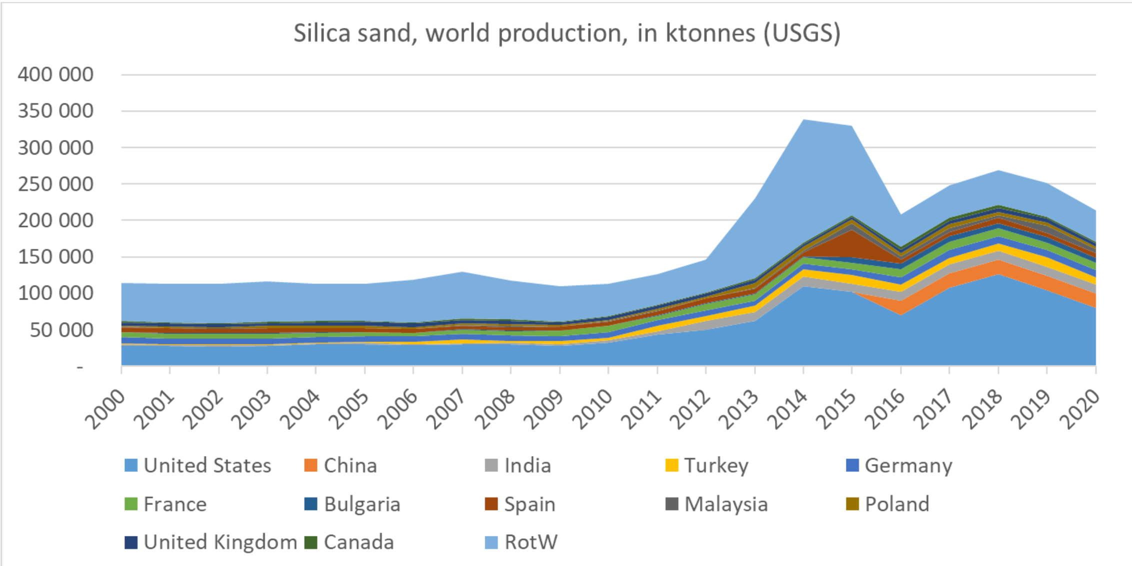

Figure 10. Annual world production of silica sand. Data from 2000 to 2015 from USGS Silica Minerals Yearbook; data from 2016 to 2020 from USGS and other sources, used for criticality assessment.

OUTLOOK FOR SUPPLY

The last decades the identification of high purity quartzite deposits that can be used for the synthesis of high purity Si for photovoltaic panels has a crucial importance. The beginning of exploitation of significant high-purity silica deposits is expected in Australia in short term. Galalar, which is considered as one of the world’s purest silica sands deposits, will be exploited by Diatreme Resources Company. Galalar silica sand reserves are estimated at 32.5 Mt with >98.50% SiO_2 content, while the respective resources are estimated at 75.5 Mt with a 99.1% SiO_2 content (Diatreme Resources, 2022). Arrowsmith North Silica Sand project is also scheduled to commence in 2023. Arrowsmith North resources are huge, estimated at 771 Mt with 98% average SiO_2 content (vrxsilica, 2022a). Further silica sand project are expected to begin in Australia in medium term including: (a) the Muchea project near Perth city which contains an extra high purity silica reserve (18.7 Mt with 99.9 SiO2 content) (vrxsilica, 2022b) and (b) the exploitation of Multiphase high purity sand dunes located 20-50km northeast of Hope Vale in Far North Queensland which is considered as the world’s largest silica sand deposit (Diatreme Resources, 2022).

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SUPPLY FROM SECONDARY MATERIALS

Silica sands cannot be recovered after use in the oil field. Silica utilized in construction and as filler is retained within the matrix of concrete, mortar, rubber, plastics, etc., thus cannot be recycled as silica source. Silica in glass and ceramics is melted and recycled as a whole product. Recycling rates in the EU are on average: hollow glass 74%, flat glass 15%; foundry 79%; ceramics 2%. Silica consumption is 10% foundry, 11% hollow glass and 10% flat glass, 1% ceramics. Thus, the overall recycling rate (EoL-RIR), weighted for the application shares, is 17.5% (IMA-Europe, 2018a; SCRREEN workshops, 2019). It has been estimated that, taking into consideration the whole life cycle of glass production, about 580 kg of CO_2 are saved for every tonne of cullet re-used in container glass manufacture. Flat glass is recycled into glass containers, glass fibre and rolled plate glass. Flat glass is highly sensitive to contamination during the recycling process. For this reason window glass is not taken from demolition sites because of the risk of contamination, although the potential for recovery of this type of glass is being considered. The industry does however, utilise flat glass cullet recovered from downstream fabricators, such as the automobile industry and double-glazing manufacturers, where better quality control is feasible (BGS, 2020).

PROCESSING OF SILICA

Silica sand is commonly produced from loosely consolidated sedimentary deposits or by crushing weakly cemented sandstones or processing quartzite, and quartz containing rocks, such as granite. High grade quartz can also be produced by processing naturally pure vein quartz (Kogel, 2019). Quartz is valued for both its chemical and physical properties; each application must have a specific set of these properties and consistency in quality is of critical importance. These include high silica content and low content of impurities, such as iron and aluminium oxide, heavy metals and other metals such as chromium. Specific size distribution of the grains is also an essential requirement for certain applications. The shape of the grains (rounded vs sharp grains) is also important. Given the specificity of the properties for each application, the use of different types of silica sand is not interchangeable. Processing distinguishes industrial sand from common construction sand, because beneficiation is directly related to the purity of the final product. Quartz sands are always washed (to remove clay and other fine-grained minerals), then dewatered (by surge piles or cyclones) prior to a coarse separation (by hydrosizing or wet screening). Further steps may consist in (Kogel, 2019): attrition scrubbing (to remove clay minerals, iron oxides, and surface coatings on the sand grains), flotation (to get high-purity quartz) and drying (fluid bed or rotary dryer). Figure 2 provides the simplified flowsheet of the silica sand processing.

The purification of the silica sand through chemical processing is necessary in case the silica product will be used for the construction of high purity silicon for PVs. The selection of the acid mean is determined in respect of the chemical composition of the impurities. Oxalic acid, H_3PO_4 and H_2SO_4 are the most widely used leaching means. The application of ultrasound can enhance the decontamination process (Boussaa et al. 2017).

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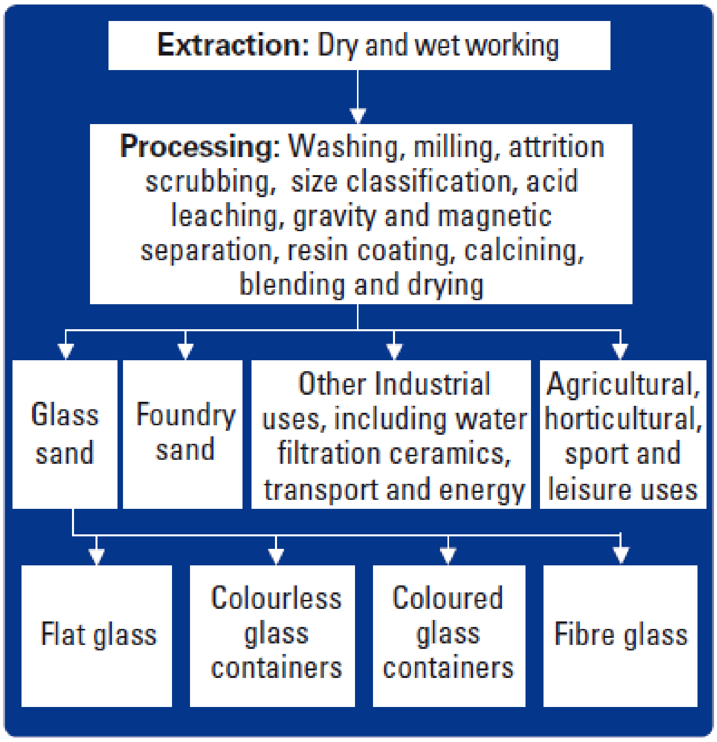

Figure 11. Simplified flowsheet of silica sand processing aiming to the production of various products (BGS, 2020).

OTHER CONSIDERATIONS

HEALTH AND SAFETY ISSUES

Crystalline silica placed on the market is subject to the classification obligation under (Regulation EC 1272/2008), while crystalline silica dust generated by a work process is not placed on the market and therefore is not classified in accordance with that Regulation (IMA-Europe, 2018b). Several silicate compounds are subject to labelling, for example due to acute toxicity, skin irritation, aquatic toxicity, etc. (CLP 2023)

Working with silica sand poses a risk to human health if not handled carefully. Inhalation of crystalline silica dust can cause silicosis, a form of pneumoconiosis. The contraction of this incurable fibrogenic lung disease can be prevented by limiting exposure. The (EU Directive 2017/2398) implements legal limits on exposure, e.g. to respirable crystalline silica (0.1 mg/m³) that is known to be carcinogenic and causing lung diseases in workers who are exposed high levels of it regularly for many years. Other countries have also set limits for the exposure to these particles in the work place, e.g. 0.1 mg/m³ for respirable silica. In the USA, the threshold limit is 0.05 mg/m³ (IFA 2023).

In order to prevent the risk of contracting such an illness, the employees and employers of several industrial European sectoral associations that make use of or produce silica sand have signed the Social Dialogue "Agreement on Workers' Health Protection Through the Good Handling and Use of Crystalline Silica and

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Products Containing it" on 25 April 2006. This social dialogue, known as the European Network for Silica (NEPSI), is the first multisector agreement in this field. (OSHA EU 2022)

ENVIRONMENTAL ISSUES

The fast extraction of silica damages the environmental quality of a region. Taking Shankargarh region as a case, out of 57 mining sites are in this area, one third of the mines are situated in three villages and these villages are at highest threat from environmental point of view. Although State Government has given Mining lease over only 206 acre land but during field survey the author noticed the illegal mining over area more than 2,000 acres. Such large scale silica mining has changed the land cover and land use pattern of the region. (Mishra 2015)

NORMATIVE REQUIREMENTS

No specific issues identified.

SOCIO-ECONOMIC AND ETHICAL ISSUES

ECONOMIC IMPORTANCE OF SILICA SAND FOR EXPORTING COUNTRIES

Table 9 lists the countries for which the economic value of silica sand exports represents more than 0.1 % in the total value of their exports.

Table 9: Countries with highest economic shares of silica sand exports in their total exports

Country	Export value (USD)	Share in total exports (%)
Gambia	46,727	0.18

Source: COMTRADE (2023), based on data for 2021

Gambia is the only country for which the value of silica sand exports accounts for more than 0.1 % of the total value of exports.

SOCIAL AND ETHICAL ASPECTS

Sand is among the most extracted minerals in the world and the significant volumes extracted at rapid rates are associated with social risks, including crime, as well as environmental risks. The extraction process engenders negative impacts on rivers, marine ecosystems and biodiversity, and is linked to greater risks of enhanced salt-wedge intrusion in delta channels, as well as coastal and delta erosion. Alongside these environmental impacts, the sand supply chain can attract criminal organisations which operate with impunity and in some cases threaten, intimidate, injure and kill civilians. Several organisations described as ‘sand mafias’ have emerged in multiple locations around the world, stealing large quantities of the valuable commodity, reselling it to unscrupulous buyers and undermining efforts to use sand sustainably. Ordinary people can find themselves becoming unintended victims of the trade, as buildings built with poor-quality, or too much, sand, all too often collapse. (Levin Sources 2019)

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RESEARCH AND DEVELOPMENT TRENDS

RESEARCH AND DEVELOPMENT TRENDS FOR LOW-CARBON AND GREEN TECHNOLOGIES

- Utilization of fly ash as an alternative to silica sand for green sand mould casting process (Sadarang et al. 2023)

The investigation evaluates the power plant fly ash (F-type) suitability as an alternative material to silica sand for Indian foundry industries. The sand mould properties such as permeability, hardness, compressive and shear strength, and compactibility are evaluated as per the standard (American Foundry Society (AFS)). The fly ash is added to silica sand at a different weight percentage (5 wt %, 10 wt %, 15 wt % and 20 wt %) and made the sand mould specimen. The results revealed that up to 15 wt % of fly ash can be added to silica sand mould to meet the desired physical and mechanical properties of green sand mould castings. It is observed that the fusion point of fly ash is below 1,350 °C and suitable for nonferrous sand casting. The utilization of power plant fly ash in green sand mould casting reduces environmental pollution and minimizes the scarcity of silica sand in Indian foundry industries.

- Hydrophobic silica sand ceramic hollow fiber membrane for desalination via direct contact membrane distillation (Alftessi et al 2022)

A porous hollow fibre ceramic membrane derived from silica sand and fabricated by combine phase inversion and sintering technique followed by fluoroalkylsilane (FAS17) grafting to improve its hydrophobicity was produced. The performance of the silica sand ceramic hollow fibre membrane (SSCHFM) in a desalination performance test via direct contact membrane distillation (DCMD) was evaluated on a salt solution for 32 h at different NaCl concentrations (8,16, 24, 32 and 40) g/L, feed flow rates and feed temperatures. The results indicate that the hydrophobic hollow fibre ceramic membranes derived from silica sand have significant potential to be developed for membrane distillation application in water purification and reclamation.

OTHER RESEARCH AND DEVELOPMENT TRENDS

- The influence of the proportion of silica sand on cement mortar during laser irradiation (Seo et al., 2023)

Cement mortars with different mixed ratios of cement and silica sand are utilized to be cut by a high-power laser beam. The influence of the silica sand content on the cut profile including melting width, kerf width, and penetration depth was clarified. Furthermore, the investigation of the glassy layer produced on the cut surface was investigated. The results show that the effect of laser scanning speed and silica sand contents on melting and kerf widths was indistinctly observed, but the difference in the penetration depth was certainly revealed. In addition, the relationship between the thickness of the glassy layer and the proportion of silica sand was established.

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- Mechanical characterization of low temperature thermomechanically treated AA6061-silica sand composites (Sadanand et al. 2023)

In the present work efforts are made to confirm the effects of reinforcement and thermomechanical treatment on the mechanical properties of aluminium matrix composite (AMC) produced through stir casting technique. Silica sand particles with varying weight percentages were used to fabricate the composites and the extracted particle analysis revealed the retention of a minimum of 97 % of reinforcement particles. The composites are subjected to conventional age hardening and low temperature thermomechanical treatment (LTMT) to enhance their mechanical properties. The mechanical characterization of the composites subjected to heat treatment processes include hardness and tensile tests. Nearly 20–30 % increase in peak hardness, 30 % decrease in aging time and 15 % increase in ultimate tensile strength (UTS) was observed in LTMT treated composites as compared to age hardened composites. The best results of peak hardness and UTS of 139.76 HV and 274 MPa respectively were achieved by composite containing 6 wt. % silica sand reinforcement subjected to 15 % deformation and aged at 100 °C.

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