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Introductory Chapter: Montmorillonite Clay Consumption Trend in Industry

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1. Introduction

Clay is the material of choice in the 21st century. The value of natural environment and sustainability is now recognized as more demanding at social, political, and public levels. The realization of these two prime influencers has resulted in an increased demand for montmorillonite consumption. The performance features in montmorillonite clay in meeting the application requirement for a variety of materials is the foundation for the continual interest in production, consumption, and research studies.

Clay utilization from grave flooring to pottery and construction of bricks, with origin traced several thousand years back, is breathing to date in human society. Increasing interest and realization in saving the natural environment, through using environment-friendly material, will apparently capture the motivation and attention of researchers and industrialists to value the clay consumption in products and structure of materials.

The earliest examples of clay consumption as a product or constituent material can be seen in the oldest human civilization. The abundant presence of clay in the natural environment is a vital source of directing the interest in using the clay as a product and as an effective material component in a composite structure.

Presently, the study of montmorillonite clay structure and properties [1], industrial applications, composite materials, and testing and evaluation are active areas for research and development studies.

More importantly, the sustainability, environment-friendly character, cost-effectiveness, and ease of processing are continually supporting an enhanced interest in consuming clay for the development of a variety of products (**Figure 1**).

The study can be seen presenting an overview of montmorillonite clay structure and properties, and addressing its effects in selected materials [2]. Important aspects of montmorillonite clay utilization for the industry are discussed in terms of natural sources, chemical structure, and physical and chemical properties. The useful properties for industrial application include, however, not limited to, particle size and layered structure, molecular structure and cation exchange effect, barrier property, and water sorption.

It is fascinating to see clay as the oldest material consumed in human civilization, and in the 21st century, it appears to be the latest material in modern human society.

Clay as a material has an extensive variety of uses and application [3–6]. Many of the uses of clay are traditional; however, an increasing interest in clay research and innovation is providing continuous breathing to its global market consumption.

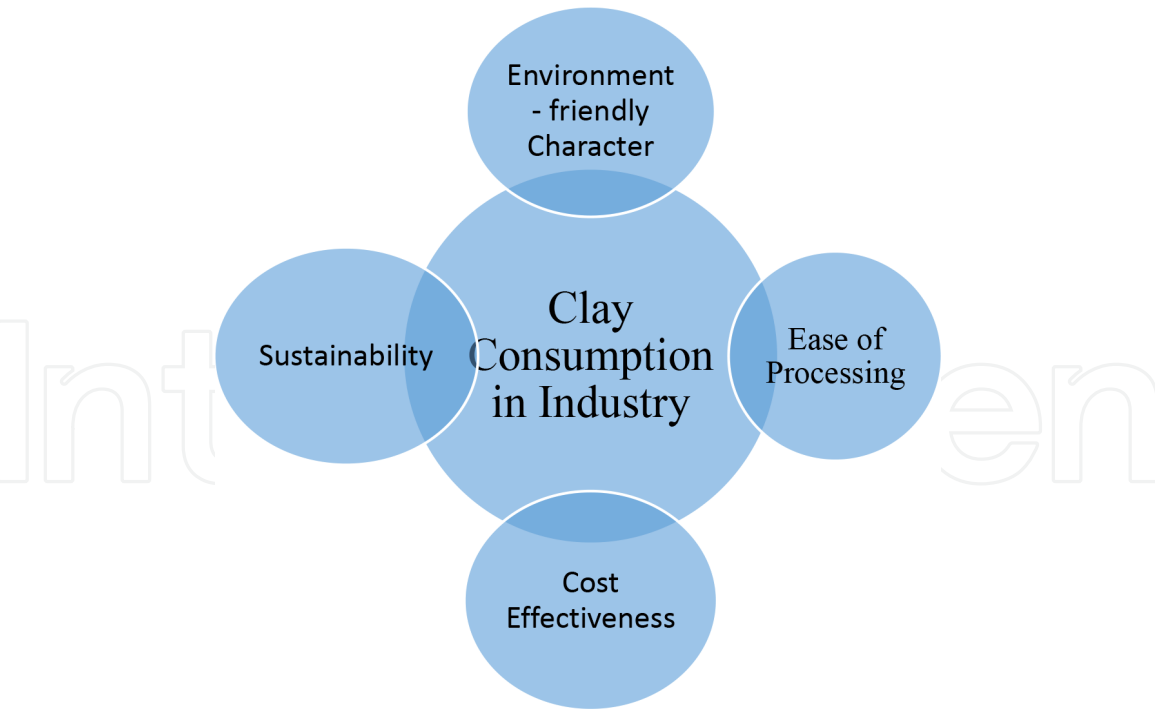


Figure 1.
Important driving factors leading the clay consumption in the industry.

The interesting clay consumption in traditional sectors including civil structure, paint, construction products, plastic, etc., coupled with more specialized uses in medical, healthcare, and industrial applications demonstrate the current and future viability of clay consumption.

The study of clay consumption in the research studies can be seen for particular application materials and products. However, any quantified information available on clay consumption in the industrial market is mainly seen in the progress studies of industrial products. This chapter provides an overview of the montmorillonite clay consumption mainly based on the reports produced by the market studies, where necessary reference is made to the research studies that direct the particular use or consumption of montmorillonite.

2. Montmorillonite clay producers

The consumption of clay in the industry is presented in reports by various study groups on a commercial basis. These reports demonstrate the clay consumption in various industrial sectors in terms of quantity and value. Montmorillonite clay is generally represented by sodium bentonite and calcium bentonite in the industrial sector.

Undoubtedly, commercially available industrial clay is a chemical composition that generally comprises minerals, metal oxide, and organic traces [7]. The industrial market studies are showing the growth in montmorillonite clay consumption over the period of 2012–2030. The main known producers of montmorillonite clay around the world are apparently the same; they can be seen in **Table 1**. The influence of the COVID-19 pandemic has not affected the presence of producers; however, depending upon the country or region, the variation in production is obviously possible.

It can be seen that for the last almost two decades, the main montmorillonite clay producers for the industry are there in different study reports. These producers are mainly located in the USA, China, India, and Turkey (countries with more than

Montmorillonite clay producers	Projected year	Reference
Amcol (Minerals Technologies); Bentonite Performance Minerals LLC (US); Wyo-Ben Inc. (US); Black Hills Bentonite (US); Tolsa Group (Spain); Imerys (S&B) (France); Clariant (Switzerland); Bentonite Company LLC (Russia); Laviosa Minerals (Italy); LKAB Minerals (Netherlands); Ashapura (India); Star Bentonite Group (India); Kunimine Industries (South America); Huawei Bentonite (China); Fenghong New Material (China); Chang'anRenheng (China); LiufangziBentonite (China); BentonitUniao (Brazil); Castiglioni (Argentina), Canbensan (Turkey)	2021–2030	https://www.marketwatch.com/press-release/montmorillonite-clay-market-consumption-companies-and-industry-report-2021-2030-marketbiz-2021-06-18 [8]
Amcol (Minerals Technologies); Bentonite Performance Minerals LLC(US); Wyo-Ben Inc. (US); Black Hills Bentonite (US); Tolsa Group (Spain); Imerys (SandB) (France); Clariant (Switzerland); Bentonite Company LLC (Russia); Laviosa Minerals (Italy); LKAB Minerals (Netherlands); Ashapura (India); Star Bentonite Group (India); Kunimine Industries (South America); Huawei Bentonite (China); Fenghong New Material (China); Chang'anRenheng (China); LiufangziBentonite (China); BentonitUniao (Brazil); Castiglioni (Argentina); Canbensan (Turkey); Aydin Bentonit (Turkey); KarBen (Turkey); G and W Mineral Resources (South Africa); NingchengTianyu (China)	2021–2026	https://www.wboc.com/story/43563723/montmorillonite-clay-market-2021-is-estimated-to-clock-a-modest-cagr-of-40nsdpduring-the-forecast-period-2021-2026-with-top-countries-data [9]
Amcol (Minerals Technologies); Bentonite Performance Minerals LLC (US); Wyo-Ben Inc. (US); Black Hills Bentonite (US); Tolsa Group (Spain); Imerys (S&B) (France); Clariant (Switzerland); Bentonite Company LLC (Russia); Laviosa Minerals SpA (Italy); LKAB Minerals (Netherlands); Ashapura (India); Star Bentonite Group (India); Kunimine Industries (South America); Huawei Bentonite (China); Fenghong New Material (China); Changan Renheng (China); Liufangzi Bentonite (China); Bentonit Uniao (Brazil); Castiglioni Pesy Cia (Argentina); Canbensan (Turkey); Aydn Bentonit (Turkey); KarBen (Turkey); G & W Mineral Resources (South Africa); NingchengTianyu (China)	2020–2027	https://www.marketresearchintellect.com/product/global-montmorillonite-clay-bentonites-consumption-market-size-and-forecast/ [10]
Amcol (Minerals Technologies); Bentonite Performance Minerals LLC (US); Wyo-Ben Inc. (US); Black Hills Bentonite (US); Tolsa Group (Spain); Imerys (S&B) (France); Clariant (Switzerland); Bentonite Company LLC (Russia); Laviosa Minerals SpA (Italy); LKAB Minerals (Netherlands); Ashapura (India); Star Bentonite Group (India); Kunimine Industries (South America); Huawei Bentonite (China); Fenghong New Material (China); Changan Renheng (China); LiufangziBentonite (China); Bentonit Uniao (Brazil); Castiglioni Pesy Cia (Argentina); Canbensan (Turkey); AydinBentonit (Turkey); KarBen (Turkey); G & W Mineral Resources (South Africa); NingchengTianyu (China)	2012–2022	https://www.marketresearch.com/QYResearch-Group-v3531/Global-Montmorillonite-Clay-Bentonites-Research-11763149/ [11]

Table 1.
The main producers of montmorillonite clay around the world over the period 2012–2030.

one producing company). Countries severely affected by the COVID-19 pandemic including Italy, India, Spain, and the USA may be having some variation in the production capacity. The main influence of the COVID-19 pandemic is possible on the demand, production, and supply chain of montmorillonite clay.

3. Variety of industrial clay

Naturally occurring bentonite is essentially comprising montmorillonite. Bentonite contains exchangeable cations including Ca^{2+} , Mg^{2+} , Na^+ , or Li^+ . The dominant presence of a particular cation in bentonite provided important application properties. Sodium bentonite can swell in water. It has good binding property and is generally used in its natural state. However, calcium bentonite has a non-swelling character. The binding property in calcium bentonite is achievable through a chemical reaction with soda ash to introduce sodium-exchanged bentonite at outer and inner surfaces, resulting in an increased ability to bind water. Calcium bentonite can also be treated with acid to obtain bleaching clay. Li bentonite is called hectorite; however, it is not mined at a commercial level like sodium or calcium bentonite [12].

4. Montmorillonite clay applications

The variety of montmorillonite clay applications is significantly diverse. It is applied in areas of catalysis, wastewater treatment, food additive, antibacterial function, polymer, sorbent, etc. Some more specific applications include pelletizing (production of iron-ore pellets, civil engineering and construction work, drilling, impurities removal in oils, animal feed, producing paste composition in pharmaceutical, cosmetics and medical products, detergents, papers, etc. [13].

The significant development in the use and application of montmorillonite is seen in recent times. This chapter provides an overview of montmorillonite's structure and properties and particularly discusses its recent utilization in important materials. Montmorillonite is introduced in terms of its natural sources, chemical structure, physical and chemical properties, and functional utilization. The important physical and chemical properties are summarized as particle and layered structure, molecular structure and cation exchange effect, barrier property, and water sorption. This is followed by the important functional utilizations of montmorillonite based on the effects of its chemical structure. The important functional utilization of montmorillonite includes use as food additive for health and stamina, for antibacterial activity against tooth and gum decay, as sorbent for nonionic, anionic, and cationic dyes, and the use as a catalyst in organic synthesis. In terms of healthcare, the effects of montmorillonite clay are observed for body detoxification, resisting skin allergy and dermatitis, treatment of organism leading to diarrhea, antibacterial effects (killing large spectrum of bacteria), assisting renal health, providing drug delivery for cancer treatment, etc. [14].

The environmental concerns, to date, do not indicate the adversity for particles used as additives. Studies will be useful that are clearly based on any montmorillonite structure to describe environmental effects.

The broader application categories described in the market studies include molding sands, iron-ore pelletizing, pet litter, drilling mud, civil engineering, and agriculture.

5. Montmorillonite market

For the last two decades, the trend in the industrial consumption of montmorillonite clay is progressive, and there are reports indicating the continuity of this trend for the next decade.

Montmorillonite clay market is divided into the United States, Mexico, Canada, Germany, Singapore, the U.K., Italy, Russia, France, Spain, China, India, Japan, South

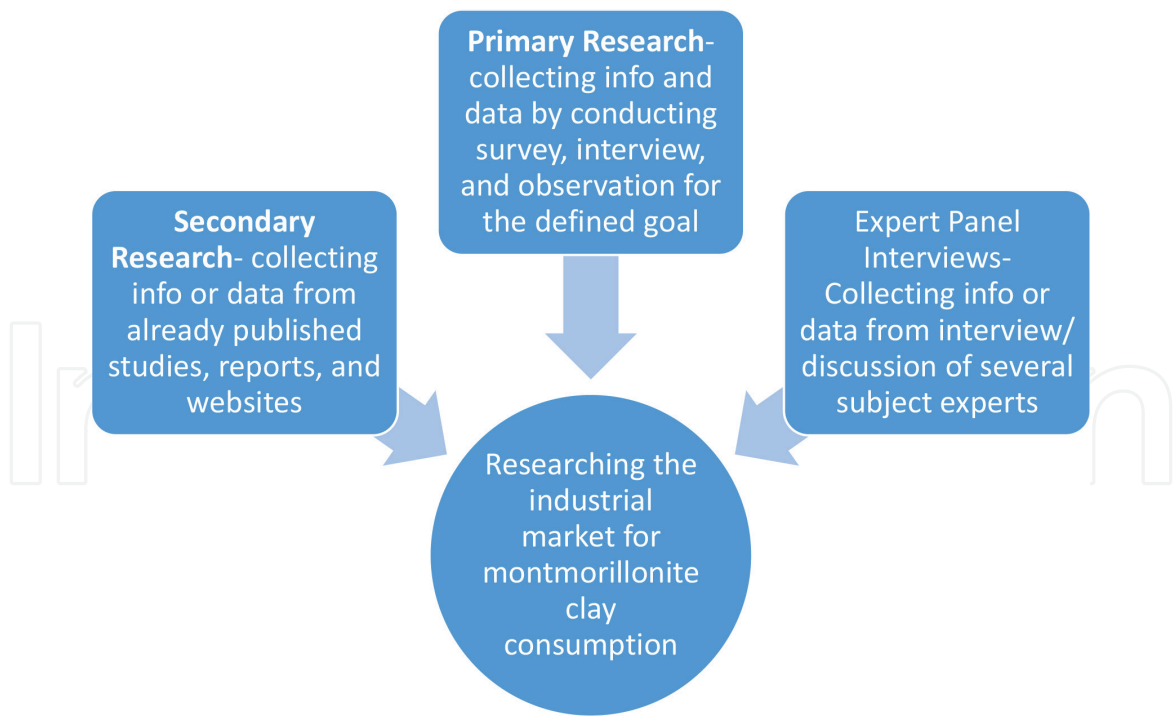


Figure 2.
Sources for the study of industrial market study.

Korea, Australia, Brazil, Colombia, Paraguay, Saudi Arabia, South Africa, Egypt, the UAE, and ASEAN countries. The details info and data can be seen in the market study reports, covering the worldwide montmorillonite clay (bentonites) market, the competitiveness of suppliers, market share, size, development rate, future patterns, etc. The discussion for future market trends and the factors that are driving the montmorillonite clay market are provided [15].

The study of the industrial market is based on research methodology that covers three important sources including primary research, secondary research, and expert panel reviews. Where secondary research utilized the sources including press releases, company annual reports, and research papers of the concerned industry. The study is refined using the associated sources of industry magazines, trade journals, websites of related government departments, and the trade associations [10].

The worldwide montmorillonite clay market, for period of 2020–2027, is estimated to move from USD 1238.7 million (2020) to USD 1630 million by 2027; the growth is forecasted at a CAGR of 4.0% (**Figure 2**) [16].

Reducing consumption trend in montmorillonite clay was seen in 2008–2009. However, start recovering the market in 2010. For example, global production of bentonite was reduced by a further 5% in 2010 relative to 2009, and a reduction of 9% in 2009 relative to 2008. The fall was perceived as the decreased demand by the end-user market.

In the following year, the consumption was recovering. Therefore, bentonite production of more than 11 million tons was globally observed in 2011. US Geological Survey estimated the worldwide reserves to be over 10 billion tons [17].

6. Conclusion

Montmorillonite clay is an important material to produce a large variety of products for the industrial consumption around the world. In addition to meeting the requirement for the environment and sustainability, the montmorillonite clay is known for its inexpensive, abundance, and natural character. It is fascinating to see

clay as the oldest material consumed in human civilization, and in the 21st century, it appears to be the latest material in modern human society.

Clay as a material has an extensive variety of uses and application. Many of the uses of clay are traditional; however, an increasing interest in clay research and innovation is providing continuous breathing to its global market consumption. The interesting clay consumption in traditional sectors including civil structure, paint, construction products, plastic, etc., coupled with more specialized uses in medical, healthcare, and industrial applications demonstrate the current and future viability of clay consumption.

The reported research literature introduced the use of montmorillonite clay in particular application, or demonstrate its effect in specific material. The data on the consumption of montmorillonite clay is based on products categorized by the industrial application. Therefore, this chapter provides an overview of montmorillonite clay consumption using the market research reports. It indicates the important market regions, suppliers, industrial product areas and applications of montmorillonite clay. If necessary the discussion is supported with the particular research study.

Conflict of interest

There is no conflict of interest in the publication of this manuscript.

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