Environmental zeolites and aqueous media: examples of practical solution Edited by Eva Chmielewska, Bentham Science Publishers, Sharjah, 2014

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During the eighteenth century, the department of Mineralogist from Sweden (Axel F. Cronstedt) invented the name of a new mineral. It was known as “stone that boils” which in Greeks means “ζέιν”, to boil, and “λίθος” to stone, describes perfectly the mineral which finally received the Greek name “zeolite”. This behavior, (Chapter 2) “stone that boils”, was due to the fact that under fast heating conditions, when the zeolite seems to boil, a rapid water loss is observed.

Unexceptionably, zeolites can be characterized as one of the main natural resources which can be used in any industrial process including medicine, food process, oil industry, water treatment, and more others and this is because of the unique physicochemical properties which the mineral presents and made them the most interesting class of minerals for scientists since their first known description. The Group of zeolites (Ζεόλιθος) is among the 75% that encompasses the earth crust known as testosilicates or more commonly silicates which have a three-dimensional framework of silicate tetrahedra with SiO2 or a 1:2 ratio and with the exception of the quartz group are aluminosilicates. The group of zeolites counts more than 60 different natural species with the clinoptilolite, chabazite, analcime, mordenite, erionite, ferrierite, and philipsite (Chapter 3) to be the most known species as well as until now there are more than 200 zeolite topologies. However, Clinoptilolite (Cli) is considered to be the zeolite species with the largest amount in the world and with unique purity.

Zeolite is an inorganic microporous mineral of volcanic origin (most of the natural zeolites were formed from volcanic ashes or other pyroclastics mainly from the chemical reaction of the amorphous aluminisilicate glasses with the water, Chapter 3), with highly regular structure of pores and chambers. The crystalline substance with a structure (detailed presentation in Chapter 3 mainly for Sodalite, Linde Type A, Faujasite, Erionite, Clinoptilolite) characterized by a framework of linked composed of TO4 tetrahedra (T = Si, Al) with O atoms connecting neighboring tetrahedra. The composition of Zeolite can be described as follows:

\[ M^{m+}_{n/m} \cdot [Si_{1-n}Al_nO_2] \cdot nH_2O \]

extraframework cations framework sorbed phase

and its formation more or less depends on the composition of the glass and surrounding conditions.

Moreover, most of the zeolites have been prepared synthetically (1.4 milion metric t/y—Chapter 2) mainly for commercial use as well as for several scientists in order to investigate their chemical properties (Chapter 1). Also, there is evidence that zeolite tuff may have already been used by the ancient Romans as well as Indians in 2000 BC mainly for infrastructures (like roads, houses, pyramids, etc.). Through Chapter 2 a unique historical trip about the zeolites formation, usages as well as about its characteristic behavior (regarding natural zeolite) to act as molecular sieves are well presented. A specific statement on zeolites environmental
properties and application is defined. Chapter 2 clearly mentioned the main properties of zeolite which is ion exchange and the importance of this property. This property makes zeolite available to be used in several processing like soil, water, and air treatment as well as in the treatment of heavy polluted waste (removing and/or uptake NH₃, metals and other pollutants) like manure, sewage sludge, waste water, etc. (Chapter 2). Moreover, Chapter 2 mentioned several implementations of Zeolites in agricultural, in water treatment, animal nutrition, energy production, etc.

The market of zeolite is well defined and discussed, and natural zeolite mineral used for ion-exchange applications are usually sold as screened products in the 10–50 mesh (2–0.3 mm respectively) size range (Chapter 3). Zeolites large scale use is mainly due to minerals availability at low cost. During 1980, the total production of the natural mineral was more than 280,000 t, while in 2010 was more than 2.8 million t. From this production in several states in the USA, used the mineral for animal feed, odor control, water purification, wastewater treatment, aquaculture, agricultural use, etc. The total price in the USA varies from 30 to 900$/t. In Europe, the main player for the production of zeolite remain Slovakia (90,000 t/y) and mainly produce clinoptilolite. Moreover, the domestic clinoptilolite-rich tuff is available in the market from 15 to 40/t, while montmorillonite range from 30 to 80/t, slovakite is up to 700/t (Chapter 5).

Chapter 4 presents several outcomes from the implementation of Zeolite in aqueous solution due to the ion-exchange property. Through Chapter 4 is identified the general aspects of adsorb ion and how zeolites can be used in the treatment of radioactive waste worldwide; which are extremely difficult to treat. Moreover, a fundamental approach of the usage of the zeolite in aqueous solution of some environmental pollutants is well described. More specifically, in the framework of radioactive waste the book presents several case studies with specific measurable results like the removal of cesium from highly radioactive liquid waste as well as several results are present which strongly related with the chernobyl accident during 1986. The use of zeolite tuff (clinoptilolite) in that case reduced radiocesium (137) by 95% and radiostrontium by 50–60%.

Humans and mainly agricultural and even though mining activities are the main intentions why the most of our water bodies suffer from the eutrophication phenomenon and also affect the quality of our waters. Through Chapter 5 emphasis is given on the removal of phosphate using natural adsorption materials. For example, the implementation of Slovakian clinoptilolite effectively removed phosphate ions from waters. Also, through this Chapter the reader can easily recognize that natural zeolites have been considered as the most common and low-cost alternative adsorbents to be used for water clean-up. Also, other adsorbents are presented (Al–Mg-montmorillonite-tuff, domestic clinoptilolite-rich tuff, Chinese zeolite, granulated ferric hydroxide, slovakite, alginate fossil, calsit-synthetic zeolite type 5A, etc.) which were used for phosphate removal as well as numerous properties for several zeolites species are presented like bulking density, surface area, porosity, shipping weight as well as kinetic studies and isotherms calculation (for phosphate adsorption onto several zeolites).

Industrial application of zeolites is presented clearly (Chapter 6) covering also some of the retrospectives applications, especially in water clean-up process. The subject of the removal of ammonia, which is the most commonly occurring nitrogenous pollutant in any water bodies, is detailed covered and natural clinoptilolite seems to be the most cost-effective and environmental-friendly solution. Furthermore, the implementation of zeolites in the treatment of wastewaters is also presented. Moreover, the laboratory data, that are presented, focus on, how a clinoptilolite column can be designed and it is very important. Hence, the efficiency of the mineral in the removal of metals as well as in usage of drinkable water is covered. Generally, Chapter 6 provides a fundamental research approach regarding the numerous implementations of zeolites in aqueous media and how the quality of the water could be improved. Extremely important is the combination of natural zeolite filter followed by water UV-light to control quality of the water and destroyed pathogen micro-organism like cryptosporidium and giardia.
Chapter 7 presents ongoing research on adsorption phenomena. Through this Chapter, a detailed complementary analytical methods for the characterization of hydrophobized, pelletized, carbonized, and clinoptilolite-rich tuff using several techniques like X-ray, NMR, SIMS, XPS, thermogravimetry, DTA, etc. Moreover, emphasis is given on the implementation of clinoptilolite and carbonized-rich tuff and for the removal of other inorganic anions (fluoride, bromide, iodide, chloride, nitrate, sulfate, phosphate). Furthermore, the efficiency of the clinoptilolite-rich tuff, on the removal from aqueous media, of some other pollutants like azodydes (acid red 18 and indigotine) and cefazoline (prophylaxis antibiotic), is also presented with very important and significant scientific evidences. A very interesting task is the implementation of carbonized clinoptilolite-rich tuff than other adsorption techniques (like active cook) for the removal of phenol compounds with impressing results.

Concluding, Eva Chmielewska’s Book is well researched with almost every possible scientific data and information regarding the environmental application of zeolites in aqueous media. The book is very ambitious and the fact that the preface is being signed by Professor Alan Dyer is a huge honor for this book, which guarantees its acceptance from the scientific community. It reminds me of the pride that I received when Prof. Dyer made the honor (to me and my Coauthor) also to sign the preface of my book entitled “Handbook of Natural Zeolites.”

The strength of the book is that it covers all the possible aspects from the environmental side of view regarding the numeral applications of zeolites in aqueous media as well as it presents historical aspects, market trends, kinetic, and thermodynamic case studies, analytical methods for the characterization of some species and also design parameters foe zeolite columns. The Chapters provide an extended detail of the all the above and have addressed all the research narrowly in the scientific field of the implementation of zeolites in aqueous media.

Moreover, the impact of this book in the scientific community is extremely high and will be useful for academics, students, engineers as well as for scientists around the world who have been working for many years with this mineral as the book presents in a very smart way and at the same time in a clear, understandable way the importance of this mineral in the section of environmental science and engineering with emphasis on aqueous media providing qualitative and quantitative results. I personally enjoyed reading this book.

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