Chapter 1

Introductory Chapter: Lanthanides - A Quest for Solutions

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Additional information is available at the end of the chapter

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1. Introduction

Lanthanides are a family of high electropositive metals that intervene between the *s* and *b* blocks. They are sometimes known as the rare earth metals, where rarity reflects the difficulty in obtaining an element in its pure form, which has been a challenging task to achieve due to similarity in their properties, the original isolation, and identification of the lanthanides. The cheap prices encourage scientists to use lanthanides in various applications. The coordination chemistry of lanthanides has shown promising opportunities to use lanthanide-based reagents or catalysts in the preparation and study of broad spectrum of applications to new materials in various fields [1].

Lanthanides have been the subject of many applications, such as, misch metals (alloy), removal of the impurities of sulfur and oxygen from different industrial applications, and as catalysts in the conversion of crude oil into a lot of products. Furthermore, the industry of ceramics uses oxides of lanthanide to color glasses and ceramics as well as optical lenses that used lanthanum oxide in binoculars and cameras. The most important application of lanthanides related to the nuclear applications is that they are used as control rods *via* absorption of neutrons to shut down the nuclear reactors. Lanthanides are considered promising materials as shielding for γ- and X-rays produced from the fission product in reactors.

Many researchers and scientists have come with conclusions that more efforts are needed to expand their quest toward the multidisciplinary character of the lanthanide research. Therefore, it is expected that these efforts will stimulate researchers to explore many more exciting discoveries in a variety of fronts to expand the body of knowledge available on lanthanide materials and explore new ways for their utilization in modern and futuristic applications. Hence, this book is going to give an insight into some of the applications taking place within the lanthanide research in recent times. It is a small effort to show interesting results of

some valuable studies carried out by bright scientists and researchers in different parts of the world. We thank the authors for having agreed to participate in this book with their excellent contributions.

2. Summary of the book

The book is going to be divided into six chapters. The first one is going to be a short introduction to explain the nature and purpose of the book and the logic and significance of its contents. The second one is going to discuss the recovering and recycling of the rare earth elements (REE) and the economical importance for Poland, in particular, and the EU economy [2]. The chapter is going to focus on the fundamental actions aimed at ensuring continuity of REE supply, that is, exploration and exploitation of new deposits, reduction of the consumption of these precious metals in technological processes, and their recovery from waste, which are very important from an economic point of view. In addition, the chapter shows different methods and processes of separating and obtaining the rear earth elements from raw materials such as REEs ores, waste electronic equipment (WEEE), coal fly ash (CFA), and other resources. Some of these recovery techniques have shown a promising high purity extraction.

The third chapter describes the development of life cycle inventory (LCI) to rare earth elements (REEs) based on the secondary sources, conducted according to ISO 14040 (2006) guidelines. Monte Carlo (MC) simulation with the Crystal Ball (CB) spreadsheet-based software was employed to stochastic modeling of life cycle inventory. This chapter comes with many figures and charts to point out many aspects referring to uncertainty in the input parameters used to create LCI of REEs recovery processes from secondary sources performed. The focus of this study is defined in the goal and scope and developed using the primary and secondary data, and with uncertainty analysis, a final result is obtained in the form of value range. The results from this study suggest that MC simulation is an effective method for quantifying parameter uncertainty in LCA studies. The analyzed parameters are assigned with log-normal distribution. It is concluded that uncertainty analysis offers a well-defined procedure for LCI studies; early phase of LCA as deterministic analysis does not include uncertainty in the input data [3].

In the fourth chapter, attention is going to be directed to another important field of lanthanide science that addresses the lanthanide elements or rare earth elements (REEs) as an active soil science research area, given their usage as micro-fertilizers, documented cases of environmental impact attributed to industry/mining, and their ability to identify lithologic discontinuities and reveal active soil processes. In soil science, the uniqueness and importance of the rare earth elements (REEs) arise because their respective concentrations as a function of atomic number have been employed to (i) assess soil genesis, (ii) augment soil fertility, (iii) evaluate anthropogenic impacts, and (iv) are sufficiently mobile to infer the intensity of key pedogenic processes [4]. Rare earth element abundances in soils are influenced by (i) parent materials and organic matter contents, (ii) soil texture, (iii) pedogenic processes, and (iv) anthropogenic activities [5].

The fifth chapter describes a new study on the effect of lanthanides content in soddy-calcareous soils under anthropogenic impact at a different distance from the Cherepovets steel mill

(Vologda region, Russia). The study has shown that in soils near the steel mill, an increased content of Pr and Tb was found, while the content of other light lanthanides (from La to Gd inclusive) was less increased. The study concludes that the comparison of distribution diagrams of lanthanides constructed with used indicators allows deriving both qualitative and sometimes quantitative differences in the behavior of these elements and in the technogenic contamination of soils with lanthanides. Further, the soils of the investigated territory are contaminated with lanthanides due to the Cherepovets steel mill (CSM) activities. Moreover, a significantly increased content of praseodymium and terbium was found in soils near CSM. In these soils, less increase in the content of other light lanthanides, from lanthanum to gadolinium, was determined. Technogenic contamination also leads to an increase in the amount and to changes in extraction degree of acid-soluble forms of lanthanides from soils [6, 7].

The sixth chapter discusses ecological and physiological impacts of lanthanides on algae as primary producers in aquatic environments. This study summarizes knowledge of positive and toxic effects of lanthanides on algae in order to better elucidate their biological roles. Various applications and methods of use, including the possibility of remediation and lanthanide recycling are also suggested [8–10]. The study arrived at a brief conclusion, which stated that algae are very important, being at the very beginning of the food chain. Their relationships with metals therefore affect other living organisms. Their ability to accumulate lanthanides may have an impact on the surrounding environment, representing both a threat and an opportunity, with the potential for further study and use, as bioaccumulation abilities and beneficial or toxic effects of lanthanides differ in individual algal strains. Algae in combination with lanthanides offer a wide variety of applications. They can be used as bioindicators, fertilizers, toxin detectors, or for phytoremediation and recycling. Therefore, understanding the relationships between algae and lanthanides is very important, once we understand the molecular mechanisms of their effects.

3. Conclusion

Although the presented book is not providing a comprehensive treatment by any means to its topics, it is still a very important tool to direct attention to some of the advanced trends of the lanthanide research. This book will encourage readers, researchers, and scientists to look further into the frontier topics of lanthanides applications and uses to reach the needed efforts to develop their quest toward the multidisciplinary character of lanthanide research.

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