REMOVAL AND RECOVERY OF METALS FROM DILUTE SOLUTIONS:
Applications of Flotation Techniques

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ABSTRACT. Dilute aqueous solutions, generated or used by mineral industry, generally contain several metal species; the latter are known to be non-biodegradable substances. For this reason, various processes suitable for metal ions removal from water and effluents will be briefly reviewed, among them the conventional ones such as precipitation, sorption and ion exchange. Nevertheless, attention will be mainly paid to the application of innovative processes, particularly aiming for metals recovery. In today's world of water shortage, water reuse in the mineral processing plants is also of great importance. Stress will be given to the necessary solid-liquid separation technique applied downstream, following the metals removal. The important aspect of applying industrial by-products (i.e. mineral fines, etc.) as efficient sorbents, including the biosorbents, will be discussed. Finally, the chemistry of pyrite flotation will be reported.

1. Introduction

Treatability studies have indicated that wastes often contain a fraction of toxic and non-biodegradable matter, which generally limits the implementation of a conventional biological treatment process. Therefore, an in-plant control programme, including waste segregation and process-specific pretreatments was proposed [1].

The mining, mineral processing and metallurgical industries are known to generate annually billions of tons of wastes, which include gases, dusts, solutions and a variety of massive mineral materials, such as tailings and slags. Some of the metal and mineral constituents of these wastes have potential economic value and their recovery can augment the primary mineral and metal resource supply base. This constitutes one of the aims of the present review.
For instance, the resource potential of wastes generated by the iron and steel, aluminum, clay, phosphate, copper, coal mining and processing, nonmetallic, and selected secondary metals industries was identified [2]. Every operation in the materials cycle generates wastes, but the extent to which a material is truly waste, depends upon many factors involved in the overall process. The importance of pollution prevention by the application of clean technologies, instead of remediation, was also reported [3]; industrial waste management foresees an evolution from an end-of-pipe treatment mentality to source reduction as the preferred option.

The World Commission on Environment and Development has argued on the concept of sustainable development [4]; this suits well with the renewable resources utilization, but its application to non-renewable resources, such as the minerals, is less clear. Effluent permits are subject to modification in the light of "best available technology" concept, which however might not be commercially proven technology. The Environmental Protection Agency of USA is especially interested in evaluating technologies for their capability to recover metals from sludges and wastewaters [5], because the disposal of hazardous wastes in or on the land is restricted.

Also, EPA offers many informational resources to aid in screening and selecting innovative technologies for waste site remediation [6]. Methods of processing mining wastes include: (i) mine fill, landfill and road ballast (the usual ones), (ii) building bricks, ceramic tiles, etc. (not so obvious), and (iii) the recovery of valuable metals. An alternative way for facing the mineral waste problem is to suggest its further utilization.

1.1. FLOTATION

Flotation is a well known selective separation process in mineral processing. The importance of froth flotation to the economy of the whole industrial world is considered to be enormous. However, flotation has been also successfully applied to water and wastewater treatment, usually as a solid/liquid separation technique, i.e. total removal by flotation of the suspended matter. The differences between flotation of mineral particles and its application to water treatment were recently enlightened [7].

A comparison between sedimentation and flotation was attempted [8]; the key to successful pretreatment of industrial wastewaters was argued to be an efficient solid/liquid separation process. Apart from the conventional dispersed-air flotation, another bubbles generation method is dissolved-air flotation, usually denoted as DAF[9]. The application of the recycle concept from the chemical reactor theory can be also applied here [10]. The difference in cell hydrodynamics between these two different bubble-generating techniques is