ORTHOPHOSPHATE ADSORPTION ON MORDENITE AND ITS CALCINATION EFFECT

INTRODUCTION

Nowadays, human beings use water for several activities such as washing, taking a bath, and in industry. Certainly, wastewater from various sources including domestic, agricultural, and industrial uses has different kinds and quantities of contaminants, for example, domestic, and agricultural wastewaters have nitrogen and phosphorus compounds as contaminants (Boari and Liberty, 1975). The textiles, printing, dyeing, food, and paper-making industries have dyes, such as methyl violet, nutrients (nitrogen and phosphate) as contaminants (Doğan and Alkan, 2003). Many industries, like tanneries, metal plating facilities and mining operations have also heavy metal contaminants, especially Cu^{2+}, Fe^{3+} and Cr^{3+} (Inglezakis *et al.*, 2003). Therefore, the contaminants' removal from different aqueous solution is many ways, for instance, Cu^{2+}, Fe^{3+} and Cr^{3+} removal through ion exchange on natural clinoptilolite (Inglezakis *et al.*, 2003), methylene blue removal by adsorption onto perlite (Doğan *et al.*, 2004), and nitrogen and phosphorus removal by biological treatment in anaerobic/anoxic and aerobic sequencing batch reactor with separated biofilm nitrification, denitrification, and bio-phosphorus removal (Bortone *et al.*, 1994). The human feces in domestic wastewater and from the detergents used in households produce phosphorus compounds. The population correction factor is 3.5 g P per person per day, with 30 to 50% resulting from detergents (Fresenius *et al.*, 1989). In addition, phosphorus is introduced into the sewage plant through industrial and agricultural wastewater and uncontrolled inflowing rainwater.

The phosphorus compounds have an important effect on the dynamics of metabolism. It is one of the most important elements and is the main factor responsible for eutrophication (Fresenius *et al.*, 1989), which leads to short- and long-term environmental and aesthetic problems in lakes, coastal areas, and other confined water bodies. For this reason, phosphorus must be removed from wastewater before it is discharged into the environment or retained as far as this is possible under engineering and economic conditions. In general, the total amount of phosphorus present in domestic wastewater is typically of the order of 10 to 25 mg-P/L (Henri, 1996). Phosphorus compounds in wastewater and in natural waters are mostly in the form of three types of phosphate. These forms are commonly classified into orthophosphates, condensed phosphates, and organically bound phosphates (Andrew, 1995). Phosphorus is essential to the growth of organisms and can be the nutrient of aquatic plants such as java weed and lemnaceae that limit the productivity of a body of water. Consequently, phosphorus must be removal from several wastewaters in order to control the amount of it as low as minimum in the range of 0.10-2.0 mg-P/L depending on wastewater treatment plant location and potential impact on receiving water (Burton and Stensel, 2003). Consequently, there has been an interest among the academic community in environmental issues and research on ways to treat phosphorus problems. Considerable research and development efforts are devoted to wastewater treatment, to find new methods, and for the most efficient methods. There are several routes for phosphorus treatment; biological, chemical, and physicochemical treatments.

Biological treatment for phosphorus removal is inexpensive cost. This process depends on the role of microorganisms. This method can transform and remove specific trace organic constituents, compounds and nutrients such as nitrogen and phosphorus (Burton and Stensel, 2003). The phosphate concentration in the wastewater is reduced, mainly by its introduction into biological cell mass, by adsorption to activated sludge, and by biogenous precipitation phenomena (Fresenius *et al.*, 1989). However, phosphorus removal by biological treatment is difficult to operate. In chemical treatment process for phosphorus removal is very effective but it is quit expensive. The phosphorus removal from wastewater involves the incorporation of phosphate into suspended solids (TSS) and the subsequent removal of those solids. The reagents are used to precipitate phosphorus such as calcium, aluminum, and iron (Burton and Stensel, 2003). Physicochemical treatment is a process to co-eliminate contaminants from wastewater by physical and chemical treatment. Methods are used to eliminate contaminants such as ion exchange, ultrafiltration, reverse osmosis, electrodialysis, and adsorption. However, precipitation and adsorption are a major process to remove phosphorus. The researchers used different materials to ion exchanger for wastewater treatment. For instance, polyacrylonitrile fiber has been used to remove fluoride, arsenate, and phosphate ions (Liu *et al*., 2002), clinoptilolite in its Na form and Kastal A 510 in its Cl form to remove eutrophic species such as chloride, sulphate, bicarbonate, ammonium, and phosphate (Liberti and Passino, 1981).

Adsorption has become an important method for phosphorus removal. Even though the adsorption process has not been used extensively in wastewater treatment, demands for a better quality of treated wastewater effluent, have led to an intensive examination and use of the process of adsorption. There are many materials used to adsorb, for example, activated carbon, silica powders and gels, activated alumina, titanium oxide, magnesium oxide, clay, and natural zeolite. Materials such as soils, slags, and zeolite have been used as adsorbent for eliminating phosphorus (Sakadevan and Bavor, 1998).

The most industrially important natural zeolites are mordenite, clinoptilolite, chabazite, and erionite (Dyer, 1988). In this work, mordenite was used to study adsorption due to its low cost and available material. Because many zeolites have evident channels and cavities within their structure, molecular dimensions, their size, and configuration are intrinsic properties of the particular crystalline framework. Moreover, the local electrostatic fields, which emanate from the exchangeable cations, are to a large extent responsible for the strong affinity for water and other polar molecules. Natural zeolites are indirect results from volcanic activity. They are formed by hydrothermal transformation of basalt, volcanic ash, and pumice which can be found e.g. in basalt cavities and in large sedimentary deposits. For this reason, phosphorus removal by natural zeolite adsorption comes to one's interest.

In order to improve the ability of materials to adsorb other ions, thermal treatment is one of the major methods to dislodge aluminum from framework to non-framework positions in zeolite. From the relationship between the unit cell shrinkage and the micropore volume decrease, it is suggested that the non-framework position goes to the pores. Upon increasing the calcination temperature, the number of non-framework position species increases while the total number of aluminum atoms stays the same (Hong, 1995). Upon calcination, structures of mordenite would be altered leading to the change in its adsorption capability. In this study, orthophosphate adsorption in mordenite frameworks after calcinations was determined by UV/visible spectrophotometry, and their structures as well as the adsorption behavior were investigated.

The purposes of this study were:

1. To study the effect of calcination temperatures of natural zeolite on the orthophosphate adsorption.

2. To study the effects of orthophosphate concentrations and shaking periods on the natural zeolite adsorption.

3. To investigate the behavior of phosphorus adsorption on natural zeolite after calcination at various temperatures.

Scope of Research:

1. To focus on the temperature of calcination from 0°C to 900°C.

2. To study the orthophosphate concentration of 5, 10, 20, and 30 mg-P/L and shaking time of 20, 40, 60, 120, 180, and 240 minutes.

3. Materials used to study the orthophosphate adsorption were natural adsorbents including natural zeolite, diatomite, perlite, ball clay, and kaolin.