Chapter 4
Chemical and Biological Processes for Nutrients Removal and Recovery

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ABSTRACT

This chapter gives an overview on the main technologies for nutrient removal from industrial wastewater by focusing on principles and operational parameters of real applications. A plethora of technologies can achieve the nutrients removal from wastewater depending mainly on their concentration and forms; however, biological nitrification and denitrification and chemical precipitation are the most common processes used today to remove nitrogen and phosphorus, respectively. Stripping, adsorption and membrane based processes for nutrients recovery can be economically viable only when nitrogen concentration is higher than 1.5-2 gN/L. On the other hand, phosphorus recovery should always be pursued and struvite crystalization is the most common option that should be evaluated together with biological phosphorus accumulation in sludge or plants for the following post-processing and valorization.

INTRODUCTION

Nitrogen and phosphorus are essential elements of life, however, the continuous release of excess nitrogen and phosphorus into the environment during naturally occurring processes (e.g. weathering, leaching, erosion) and anthropogenic activities (e.g. surface run-off from agricultural and livestock activities, wastewater treatment plants, etc.), which may lead to eutrophication (i.e. algae bloom and oxygen depletion

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in aqueous systems) in natural water systems. The eutrophication problem is expected to increase due to the increasing population, agricultural intensification and industrialization. Nevertheless, eutrophication can be reversed by reducing the nutrients load to water bodies. One such solution is to decrease the load of nutrients discharged from wastewater treatment plants. Thus, efficient and reliable nutrients removal and/or recovery technologies are required. Nitrogen and phosphorus removal/recovery from wastewater can be achieved by biological or physical-chemical processes. The selection of nutrients removal/recovery technologies is determined by the nitrogen and phosphorus concentrations, and consequently the cost-effectiveness of the process. The nutrients removal/recovery technologies can be classified into three concentrations ranges (Mulder, 2003):

- Diluted wastewater with phosphorus concentration <40 mg P/L and ammonium concentration <0.1 g N/L. In this nutrients concentration range, biological nutrients removal is the preferable process based on cost-effectiveness. In addition, chemical phosphorus precipitation can be an option for phosphorus removal from diluted wastewater.
- Concentrated wastewater with phosphorus concentration >60 mg P/L and ammonium concentration in the range 0.1-5 g N/L. Chemical phosphorus precipitation processes are identified as interesting alternatives for the simultaneous recovery of phosphorus and nitrogen as an agricultural fertilizer (struvite) or phosphorus recovery as a raw material for the phosphorus industry (calcium phosphates). For nitrogen, biological treatment processes are also to be preferred.
- Concentrated wastewater with ammonium concentration >5 g N/L. In this range, the physical-chemical process for ammonium removal can be technically and economically feasible (e.g. ammonia stripping, selective ion exchange and breakpoint chlorination).

Thus, this chapter summarizes the methods and technologies commonly used for nitrogen and phosphorus removal/recovery from wastewater. While the processes for nutrients removal, such as biological nutrients removal or chemical phosphorus precipitation from diluted wastewater, have been widely adopted in nutrient removal plants, strategies for its recovery are still being studied. One such technology is the phosphorus recovery by struvite crystallization from wastewater streams with high phosphorus concentration. Moreover, ammonium removal from concentrated wastewater by ammonia stripping can be used because of its simple operation and high efficiency.

NITROGEN AND PHOSPHORUS IN INDUSTRIAL WASTEWATER

The characteristics of industrial wastewater vary essentially with the type of industry and the type of industrial process used (Table 1). Agro-industrial effluents, like piggery effluents or fishery discharges, slaughterhouses and meat processing, food processing, frequently combine high concentration both in ammonium, phosphorus and organic matter. For many industrial wastewaters, especially in chemical and petrochemical industry, reduction of effluent total nitrogen is difficult because of batch production operations and the refractory nature of many complex organic nitrogen compounds in process chemicals.

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