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Application of water hyacinth (*Eichhornia crassipes*) for phytoremediation of ammoniacal nitrogen: A review

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ABSTRACT

Water eutrophication is a serious global issue that needs urgent attention. Ammoniacal nitrogen (AN) is present in both domestic and industrial wastewater which acts as one of the main contributors of eutrophication. There is a need to reduce AN to permissible levels as enforced by local authorities before final discharge. Phytoremediation has been recommended as an alternative solution to other conventional physiochemical and biological methods to treat wastewater with high AN content due to its cost-effective, environmental friendly and sustainable characteristics. Water hyacinth (*Eichhornia crassipes*) is a free-floating macrophyte, which is known as the most noxious weed in the world that shows characteristics of fast growth rate, adaptability to a wide range of environmental conditions and high nutrient uptake capacity. These capabilities contribute to the wide applications of water hyacinth for phytoremediation purpose. This paper provides extensive review on the technical advantages and limitations of phytoremediation as compared to other nitrogen removal technologies, as well as the insight for the development of phytoremediation technology using water hyacinth to treat wastewater with high AN content. This paper also provides fundamental knowledge on the AN removal mechanisms and necessary considerations in selecting the operating conditions of water hyacinth-based phytoremediation system, which may facilitate the design of industrial scale phytoremediation system for effluent treatment. Overall, phytoremediation technology assisted by water hyacinth has been shown to be promising for AN removal, which can be a potential solution in the future for various industries to reduce the AN level in their effluent discharge.

1. Introduction

Nitrogen is the fundamental element of organisms' protein and nucleic acids [1]. Naturally, nitrogen exists in several forms according to various oxidation states [2]. In wastewater treatment, there are several principal nitrogen types of concern, which include total nitrogen (TN), total Kjeldahl nitrogen (TKN), ammoniacal nitrogen (AN), organic nitrogen (org-N), nitrate (NO_3^-)and nitrite (NO_2^-). AN is a significant common nitrogen form that is highly present in agricultural, domestic and industrial wastewater [3,4]. The instances of industrial wastewater characterized with high AN content include effluent from semiconductor industry, tannery industry, colouring agent manufacturing industry, explosive industry and winery industry [3]. For nitrogen content of industrial wastewater, AN and nitrates are the most problematic nitrogen compounds to deal with before their discharge to waterbodies to prevent eutrophication. Notably there are certain wastewater sources which contain significantly higher AN concentration as compared to other nitrogen forms (i.e. nitrates and nitrites), thus making AN treatment process necessary [5–10].

Eutrophication is one of the serious environmental issues worldwide in recent years [11]. Excessive nutrients deposition, including nitrogen (N) and phosphorus (P), is the main contributor which triggers water eutrophication [12–15]. The phenomenon of water eutrophication is induced by both external and internal pollution [11]. The external pollution is caused by anthropogenic activities, for instance, municipal, industrial and agricultural sources. In contrast, the internal pollution is related to the natural sedimentation process in lakes, reservoirs, rivers and bays. Eutrophication leads to algal blooms, spread of invasive aquatic macrophytes, depletion of oxygen level and loss of species [12,14–16].

AN removal from wastewater is necessary due to three main reasons as stated by Culp and Culp [17]: i) depletion of oxygen level in water stream due to existence of AN, ii) excessive AN contributes to toxicity towards biological life in waterbodies, and iii) formation of chloramine by reaction between AN and chlorine which can interfere with disinfection. Phytoremediation technology has been recommended as the

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