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ENHANCED NUTRIENT REMOVAL IN DOMESTIC WASTEWATER TREATMENT USING MODIFIED DUCKWEED PONDS

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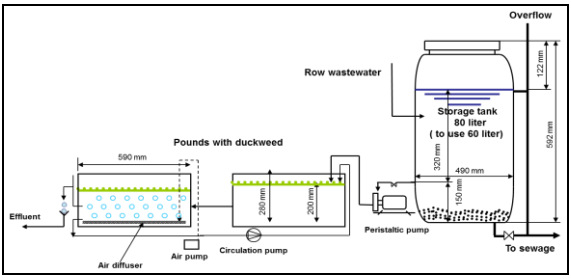
Introduction

Wastewater treatment in natural systems is a simple process based on natural processes with little engineering intervention and reduced operating expenses. One of the applications of these systems is the use of Duckweed that have high nutrient removal capabilities while producing oxygen which is used by microorganisms to degrade organic matter. Due to the strict regulations in many places around the world, such systems sometimes need to be upgraded by internal changes (as demonstrated in this study) or by the addition of advanced treatment processes depending on the type of wastewater and the efficiency of the treatment.



Materials and methods

Three pilot scale Duckweed based wastewater treatment systems were constructed to treat domestic wastewater of a small community, for the purpose of examining the effect of aeration and circulation on treatment efficiency. Each system consisted of two duckweed ponds in series. All systems received domestic wastewater from a common container. The first system was "natural" and included Duckweed plants only (DWCN). The second system included plants and aeration in the second pond (DWAE), and the third system included plants, aeration and circulation of the water from the second pond to the first (DWAC). Three study periods took place, in which the concentration of the wastewater was increased by reducing the dilution in tap water. In the second half of the third period the circulation rate in system DWAC increased. A comparison between the systems was conducted in terms of chemical

and physical parameters (pH, DO, water Temp. and EC), treatment efficiency (COD_T, BOD_T, NH_4^+, PO_4^{3-} and TSS), and Duckweed growth rate.

Results and conclusions

DO levels were always lower in the first ponds in comparison with the second ponds, in all systems. In the first ponds DO levels decreased with the increase of wastewater concentration, while in the second pond DO levels remained high throughout the experiment. No relation was found between DO levels and organic load. DO was inversely related to NH_4^+ load and to water temperature. It seems that oxygen-demanding nitrification processes may have influenced DO levels in ponds no. 1, where ammonium levels were high. Water temperature may also have affected DO levels, decreasing oxygen solubility with increasing temperatures in summer. No differences were found between the systems regarding DO levels, and the supplemental aeration had no effect on DO. COD_T removal was high in the first study period, (60-80%), but decreased in ponds DWCN-2 and DWAE-2 from the second study period onward. Apparently, algae growth in these ponds caused the reduction in COD_T removal. BOD_T removal was very high (80-97%). Effluent levels were very close to the Israeli standard for unlimited reuse in agriculture and for use in river rehabilitation, in all systems and all study periods. NH_4^+ removal was very high throughout the experiment (96-99%), and effluent levels were always beneath the Israeli standard for unlimited reuse in agriculture and for use in river rehabilitation. PO_4^{3-} removal was high in the first and second study periods (85-89%). After that removal decreased but was still high. However, effluent levels were higher than the reuse standard for TP throughout the experiment. This means that the current system is unable to remove phosphorus in a satisfactory manner, and efforts should be made to investigate the means of improving removal. Aeration and circulation did not influence PO_4^{3-} removal until the second part of the third study period, when it seemed that increasing the circulation rate had a negative effect on removal efficiency. TSS removal was high in all the systems before the algae growth commenced (80-85%). Duckweed yield was very high in the first and second study periods (74-135 g/m^2-d). After that the yield decreased. The growth rate in system DWAC decreased considerably less than in the other systems, and the plants recovered more rapidly towards the end of the experiment. Ammonium concentration was the main factor influencing Duckweed yield.

Main conclusions: The systems can treat domestic pre-settled wastewater to a secondary treatment level. Algae growth prevented two of the systems from achieving good results in terms of COD_T and TSS removal. The reasons for the algae growth are unclear and should be investigated further, to prevent such an occurrence. It may be that effluent circulation in the third system (DWAC) helped to prevent algae growth, and improved effluent quality regarding COD_T and TSS. Supplemental aeration had no effect on DO levels and pollutants removal efficiency. For the current system design it seems unnecessary to include aeration. The circulation had almost no influence on BOD_T and NH_4^+ removal. Increasing circulation rate had a negative influence on PO_4^{3-} removal, and a positive influence on TSS removal. The circulation improved the condition and growth rate of the Duckweed plants, especially during high wastewater concentration levels.