

Potential for the use of duckweed-based pond systems in Zimbabwe

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Abstract

Duckweed systems are a form of natural wastewater treatment method that is ideal for developing countries. They demand less in terms of financial resources for construction and maintenance, manpower sophistication, electricity requirements, and machinery. This paper looks at the duckweed technology as a new phenomenon in Zimbabwe, reviews its requirements and problems, and finally explores its potential in the Zimbabwean environment. A simple spreadsheet model was developed to assess a water and nutrient balance of an ideal duckweed system. It was concluded that under ideal or optimum operating conditions, duckweed systems could achieve the required Zimbabwean nutrient standards of 10 mg·ℓ⁻¹ total nitrogen and 1 mg·ℓ⁻¹ total phosphorus. Duckweed systems would suit areas of moderate to high water consumption to avoid toxicity problems and also to increase the surface area available for duckweed growth. It was recommended that further experiments be carried out locally to improve and validate the model developed and used in this paper.

Keywords: duckweed, mass balance model, nutrient recovery, pollution control, reuse options, wastewater treatment

Introduction

The management of wastewater has traditionally focused on the reduction of organic loading, nutrient removal, and pathogen elimination. The approach has been to address these through technological options, most of them high-tech. Land requirements and the need to dispose of high quantities of industrial, commercial, and domestic sewage have so far favoured this direction. However, the emergence of smaller urbanising areas of predominantly poor and middle-class populations reduces the economy of scale advantages and has often made such technologies uneconomical and unsustainable. It is debatable whether land is a genuine constraint in most developing countries, especially in small towns and growth points. Another factor that brings into question the traditional approach is whether the growth momentum of the past decades will be sustained. This is important since designs are made for a certain design period and operation and financial problems are likely to be faced if the plants continue to be under-utilised. It is in this view that modern researchers are now advocating for natural treatment methods coupled with recovery and reuse of water and nutrients in a decentralised approach to wastewater management (USEPA, 1997; Venhuizen, 1997; RMI, 2000; Lens et al., 2001). The popular natural treatment methods include waste stabilisation ponds (WSP), duckweed-based pond systems (DPSs), and constructed wetlands (CW).

The current cost of wastewater treatment in Zimbabwe is very high and almost unaffordable (Nhapi et al., 2002). In such a scenario, environmental sustainability, investment and operational efficiency are three important goals. The first goal implies that the

current environmental integrity is preserved or improved for future generations and it involves meeting set environmental quality standards. Investment efficiency is a powerful argument for getting funding support, while operational efficiency helps ensure that available resources are used to expand coverage as widely as possible. These goals can be best achieved by constructing small sewage treatment plants for each development with treatment particular to the type of wastewater generated.

The recent application of duckweed technology in wastewater treatment vs. recent shift in approaches to wastewater management is quite interesting and revealing. Some researchers believe that the best solution to problems of centralised (offsite) treatment is to go for household-centred sanitation (DLG, 1998; King, 2000). Despite this, the handling of combined wastewater remains an attractive option where retrofitting is difficult for economic, social (acceptability) and other reasons. Duckweed systems are one of the options that have been widely applied for combined handling of wastewater with the nutrients used for poultry and aquacultural projects (Gijzen and Kondker, 1997; FAO, 1999; Nhapi et al., 2001). The pollutant removal efficiency of duckweed-based pond systems varies widely depending on retention time, water depth, initial nutrient concentration, duckweed density, used genera type, and harvesting regimes. Some figures are: Nitrogen 34 to 99%, phosphorus 12 to 92%, and BOD₅ 65 to 90% (Oron et al., 1984; FAO, 1999).

This paper is based on a literature review of duckweed technology and case studies of duckweed-based pond systems in Zimbabwe. It looks at critical parameters that would determine duckweed growth and the problems that would likely arise. The actual problems that would be expected in Zimbabwe are examined through case studies with the latter part of this paper dealing with potential results if duckweed systems are optimally managed. This was achieved by developing a simple spreadsheet model based on literature values and local figures.

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