Nutrient recovery from dairy cattle wastewater

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Highlights:

- Sanitation solutions for dairy farms
- Economic viability assessment of sustainable rural wastewater system
- Nutrient recovery and environmental impact mitigation

Keywords: wastewater treatment; circular economy; economic feasibility study

INTRODUCTION

The increasing demand for food has led to greater environmental impacts. Farming activities, such as milk production, generate a large volume of nutrient-rich wastewater, which is usually discarded untreated, causing degradation of water bodies and contributing to eutrophication. In intensive crop production, the demand for fertilizers is always necessary, leading to increased production costs. Nutrient cycling can be an alternative to intensive agriculture. On dairy farms, treating wastewater from the milking parlor through high-rate ponds can enable the production of biomass with fertilizer characteristics and effluent with a lower nutrient load.

This study aimed to assess the economic viability of the costs of production and application of microalgae biofertilizer in pasture, from the treatment of wastewater from dairy cattle. For this, an economic feasibility study was conducted on the implementation of a wastewater treatment system with biomass production on a dairy farm.

METHODOLOGY

To quantify the generated residual water, as well as the areas used for fertilization, a small rural property from Brazilian family farming was utilized. This property spans an area of 70 hectares, housing 30 lactating Dutch cows raised in a semi-intensive system. During the day, the cows are confined in the resting area without access to pasture, while they graze at night, producing an average of 340 liters of milk per day through two milkings. The cleaning of the milking parlor generates approximately 1,500 liters of residual water daily, which is discharged without any treatment.

The basic diet of the herd consists of sorghum silage, mombaca, and brachiaria grass, supplemented with a dry feed (corn, soybean, and urea). Roughage grasses are produced on the farm itself, occupying an area of 2.3 hectares. The paddock system is rotated, with a stocking rate of 1.38 samples per square meter. Fertilization of paddocks occurs whenever the cattle are removed from them. A uniform cut is made using a brush cutter, followed by fertilization with nitrogen. Approximately 150 kg of nitrogen fertilizers are consumed per month, with an expense of $80.00 per month.

Given the impacts caused by dairy cattle and the challenges faced by small farmers, an economic feasibility study (EFS) was conducted considering two scenarios: one where the producer continues with the current production system (PS) and another where the producer implements a wastewater treatment plant in HRAPs for the milking parlor (WTP), resulting in treated effluent and the production of microalgae biomass, which can be used as a fertilizer source for pasture. In the WTP scenario, investments consider project implementation, and operating expenses are included in maintenance costs.

The indices used for analysis were: net present value (NPV), internal rate of return (IRR), payback, and cost-benefit ratio. To calculate these indices, estimated values were used for the implementation of the wastewater treatment unit. An investment source was created from milk production income, the primary financial resource on this type of farm.

RESULTS AND CONCLUSIONS

The production cost of the biomass characterized in Table 1 was around U$ 2.8 (two dollars and eighty cents) per kilo produced. The chosen biomass supplied the demand for pasture fertilization, not counting which effluent can be used for irrigation

A IRR and NPV were used to evaluate the project against the RMA, determining the acceptance of the accept the proposal (Azevedo Filho, 1995; Ross; Westerfield; Jaffe, 1996). Azevedo Filho (1995) suggests that a project becomes economically unfeasible if NPV is less than zero, and the greater the NPV, the more attractive the project. The cost-benefit ratio was also evaluated, being greater than 1 for the WTP, demonstrating its viability according to Azevedo Filho (1995).

Given the economic context, implementing a wastewater treatment plant would positively impact costs and the environment by transforming waste. Using biomass from milking room wastewater treatment can meet the property's nitrogen fertilizer needs, helping to reduce environmental impacts by treating all wastewater and allowing for irrigation without using clean water. Proper fertilizer application can reduce nutrient needs over time. Implementing this proposal involves treating dairy cattle wastewater in HRAPs, applying harvested algal biomass, and monitoring soil and pasture.

While microalgae biomass production costs aren't yet competitive with mineral fertilizers, their use is environmentally beneficial.

Table 1 – Resources and trace elements.

Resources	
P	1992 mg L^{-1}
NTK	1657,42 mg L^{-1}
TOC	67.38 mg L^{-1}
Humidity	97.34%
pH	8.4
As	<0.01 mg L^{-1}
Ba	1.32 mg L^{-1}
B	0.55 mg L^{-1}
Cd	0.001 mg L^{-1}
Pb	0.022 mg L^{-1}
Cu	0.52 mg L^{-1}
Cr	0.097 mg L^{-1}
Hg	<0.0002 mg L^{-1}
Mo	<0.050 mg L^{-1}
Ni	0.075 mg L^{-1}
Zn	0.005 mg L^{-1}

Table 2 – EFS result.

Parameters	30 cows	
	Mineral Fertilizer	Microalgae Biomass
RMA (%)	6,5	6,5
IIR (%)	14,79	9,96
NPV (R$)	U$ 26,218	U$ 25,097
Vida útil projeto (anos)	15	15
Cost-benefit ratio	1,2	0,77
***Payback* period (years)**	6	7

MRA – minimum rate of attractiveness, IIR – internal rate of return, NPV – net present value.

IWA the international water association
ABES
UFPR UNIVERSIDADE FEDERAL DO PARANÁ
INCT – Instituto Nacional de Ciência e Tecnologia ETEs Sustentáveis
SANEPAR
Sistema Fiep FIEP SESI SENAI IEL

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