

"IMPLEMENTATION OF ACTIVATED BIOGARDENS FOR SUSTAINABLE WASTEWATER MANAGEMENT IN TACNA, PERU"

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ABSTRACT:

In the face of climate change and the severe shortage of water resources in Tacna, the reuse of treated wastewater for the irrigation of parks, gardens, public areas, football fields, and even construction projects represents a sustainable alternative, to displace the indiscriminate utilization of the drinkable water that is given for these ends at present. These conditions lead to the proposal of an experimental implementation of ACTIVATED BIOGARDENS for the natural purification of wastewater with low operating and maintenance costs. The proposal stems from principles applied in constructed wetlands with the addition of the direct application of heterotrophic microorganisms, isolated and produced with recycled products from naturally purified sludge, which, once isolated and enriched, are applied to the roots of plants and biofiltrate beds, constituting a conjoined ecosystem of mixed symbiotic purification, which is complimented by an ornamental vegetative cover.

INTRODUCTION:

Due to its desert climate, the city of Tacna is particularly affected by climate change. Worsening water supply problems are exacerbated by accelerated population growth, and a lack of cultural sensitivity to Tacna's water issues. Potable water is used, for instance, for the irrigation of parks, gardens, avenues, football pitches and construction projects. Potable water is simply not highly valued.

In the face of current and projected problems, the reuse of wastewater becomes necessary. This research proposal suggests the creation of a system that would contribute to the sustainable management of wastewater in the city of Tacna by improving wastewater management, as well as reducing its environmental impact on local ecosystems through the application of ecotechnology. ACTIVATED BIOGARDENS are a sustainable and economically viable alternative, principally intended for the irrigation of parks and gardens (Metcalf & Eddy, 1996).

METHODS:

Bacterial purifiers were isolated and produced using fully composted sludge obtained from different aquatic ecosystems, which were enriched with nutrients from sewage, sugar residues, residues of soft herbs, and rotten fruits. Twenty-five days of fermentation yielded a concentrate that is rich in lactic bacteria and heterotrophic microorganisms.

The obtained microorganisms were applied by sprinkler on the sand and gravel media in the biogarden system, as well as on the roots of ornamental plants used therein. Water quality was evaluated following the standards outlined in Eaton et al (Methods 9222 B, 9222 D y 9215 D) (Standard Methods, 2005).

RESULTS AND DISCUSSIONS:

The implementation of a system of Activated Biogardens would build upon the system of constructed wetlands in Ilo (Moquegua), which considered a flow rate of 0.03 L/s (up to 3.5 L/s) and consists of facultative ponds and processing by surface and subsurface flow through the wetland. The principal results of the Ilo experiment appear in **Table 1**:

Table 1: Microbiological results of wastewater wetland system sampling.

Parameter	M1 (Raw Water)	M3 (Outlet Wetland1)	M4 (Outlet Wetland2)
Temperature (°C)	21.7	22.3	21.9
Turbidity (NTU)	572.6	145.0	74.4
Total Coliforms (NMP/100 mL)	2.0 E12	3.6E09	1.2E09
Thermotolerant Coliforms (NMP/100mL)	2.0E10	5.4E09	7.6E06
DBO5 (mg/L)	419.4	242.6	55.8

Source: Author's own work

The following images depict the development of the constructed wetland in Ilo, Moquegua, Peru.



Fig. 1: Wetland 2 de FSP in Ilo.

Fig. 2: Wetland Growth (6 months)

Fig. 3: Quality of effluents in Wetland 2

The use of potable water in Tacna is indiscriminate. **Table 2** outlines the use of water on a given day by the simultaneous irrigation of just three small plazas in a district of Tacna, it can be estimated that up to 23.3 m³ of potable water is wasted. This number is equivalent to three cisterns being dumped in eight hours.

Table 2: Evaluation of potable water waste in the Pocollay district (Tacna)

Description	Hose Diameter	Hours Irrigated	Approximate Volume Flow	Area Irrigated	Volume Used
Gardener 1	3/4"	8 hrs	0.27 L/s	Plaza F. A. Zela	7.78 m ³
Gardener 2	3/4"	8 hrs	0.27 L/s	Plaza 28 de agosto	7.78 m ³
Gardener 3	3/4"	8 hrs	0.27 L/s	Plaza de la mujer	7.78 m ³
			Total:		23.33 m ³

Source: Author's own work



Fig 4: Irrigation of parks by hose



Fig 5: Irrigation of plaza F. A. Zela, Pocollay

In some areas, advanced irrigation techniques, such as sprinklers, are used, in others, however, responsible gardeners use hoses of between 3/4" and 1" diameters, which lower water pressure in the surrounding area. In some cases, the use of 1" hoses restricts the domestic use of water in areas surrounding the parks, causing complaints against the utility.

One answer to these problems is the use of Activated Biogardens for the sustained and comprehensive treatment of domestic wastewater for reuse in the irrigation of parks and gardens in the city of Tacna. This innovative, green initiative has low operating and maintenance costs for the utility.

The technology stems from principles applied in biofilters and constructed wetlands (Salas R.J et al, 2010). It adds the application of bacterial cleaners, which were selected, isolated, and produced with recycled materials or organic waste, and were subsequently applied to the roots of plants and biofiltrate beds. This constitutes an enormous tool for the symbiotic purification of wastewater. The activation of plant roots by injecting bacteria constitutes the process called ACTIVATED BIOGARDENS.

The following images depict some projected applications of activated biogardens:



Fig 6: Isolation of bacterial cleaners



Fig 7: Biofilters in Lima, Peru



Fig 8: Existing green areas in treatment plants



Fig.9: Projected application in Magollo

Fig.10: Projected application 2

Fig.11: Projected application 3

CONCLUSIONS:

The proposed experimental investigation of ACTIVATED BIOGARDENS in the treatment of wastewater, in order to reduce the **indiscriminate use of potable water** in the irrigation of parks and gardens in the city of Tacna, as well as reduce pollution and contamination, constitutes an **innovative** ecological alternative. The low-cost system is ideal for small communities and represents an environmental solution to water scarcity issues in the city of Tacna.

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