9th International Interdisciplinary Congress on Renewable Energies, Industrial Maintenance, Mechatronics and Informatics

Booklets

RENIECYT Registro Nacional de Instituciones y Empresas Científicas y Tecnológicas 1702902 CONAHCYT

RENIECYT - LATINDEX - Research Gate - DULCINEA - CLASE - Sudoc - HISPANA - SHERPA UNIVERSIA - Google Scholar DOI - REDIB - Mendeley - DIALNET - ROAD - ORCID - V|LEX

Title: Bioremediation through the use of composting

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ROR Universidad Politécnica de Cuautitlán Izcalli KYU-8461-2024 0009-0003-8078-7172 2052292
ROR Universidad Politécnica de Cuautitlán Izcalli 0009-0004-4589-6012 2062626
ROR Universidad Politécnica de Cuautitlán Izcalli LDF-5108-2024 0009-0007-9094-0547 2062215
ROR Universidad Politécnica de Cuautitlán Izcalli LBI-3522-2024 0009-0005-5151-5471 1196052

Editorial label ECORFAN: 607-8695
BCIERMMI Control Number: 2024-01
BCIERMMI Classification (2024): 241024-0001
RNA: 03-2010-032610115700-14
Pages: 14

CONAHCYT classification:
Area: Biotechnology and Agricultural Sciencess
Field: Agricultural Sciences
Discipline: Agronomy
Subdiscipline: Soil fertility

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INTRODUCTION

Bioremediation is an innovative and sustainable approach to restoring contaminated environments, using the natural ability of living organisms to degrade, transform or stabilize pollutants. This technique, which combines biology and technology, offers an effective and environmentally friendly solution to address soil, water and air pollution.

Through bioremediation, microorganisms such as bacteria, fungi and plants work to break down and remove contaminants such as hydrocarbons, pesticides, heavy metals and other harmful chemicals. This process not only eliminates the source of contamination, but also promotes the recovery of ecosystems and the restoration of environmental well-being.

In a world where pollution is a growing problem, bioremediation emerges as a promising solution, capable of offering benefits to both the environment and society.

There are several types of bioremediation, classified according to the type of organism used, the environment treated and the technique applied. However, the different types of bioremediation are divided into 2 categories; in situ and ex situ. In situ bioremediation is a cleanup process, which is carried out directly at the site where the contaminant is found, without the need to excavate or transport the contaminated materials; its approach uses microorganisms found naturally in the environment or introduced specifically to degrade or transform the contaminants. On the other hand, ex situ bioremediation is a cleanup process that takes place at a location other than the contaminated site. This approach involves excavation and transport of contaminated materials to a controlled treatment site, where bioremediation is applied.

INTRODUCTION

There are four methods of in situ bioremediation: natural attenuation, bioventing, biostimulation and bioaugmentation. There are also four ex situ bioremediation methods: landfarming, composting, biopiles and bioreactors.

In the present work, ex situ bioremediation, specifically composting, is carried out. Composting refers to a process of organic waste degradation based on anaerobic microbial metabolism that is generally carried out at temperatures between 55-65°C. These temperatures are due to the product of the composting process. These temperatures are due to the product of biological activity (Das, 2014).

Within the ex situ composting technique, different methods can be found, for example, the "Takakura", this is an optimized composting technique based on microorganisms, which consists of preparing a previous substrate called "seed" and a fermentation bed, This provides the optimal conditions for a large number and variety of microorganisms that quickly and efficiently decompose the organic waste, and thanks to the transformation that they carry out, the fungus Aspergillus Fumigatus is generated, which has the function of bioremediating the soil low in nutrients.

To decompose organic waste, the Takakura method uses mainly aerobic microorganisms. This transformation is strengthened by the constant movement of the compost, i.e. the movement gives more strength to the aerobes and minimizes the action of anaerobes in the soil, promoting favourable soil conditions.

INTRODUCTION

Soil is the layer of fertile material (earth) that covers the earth's surface and is the natural medium in which plants develop through their roots. It is a complex system composed of minerals, organic matter, water, air and living things that interact with each other to create an environment conducive to plant growth.

Soil has three basic properties to be considered fertile and functional. These properties are chemical, physical and biological. The chemical properties are responsible for providing the non-organic minerals that nourish the soil. The physical properties determine the rigidity and strength of the soil, the ease of root penetration, aeration, soil permeability, plasticity and nutrient retention, among other characteristics. Biological properties refer to those microorganisms that favor soil quality.

Good soil is essential for a good harvest. The soil must have all the nutrients necessary for plant growth, and a structure that keeps plants firm and upright. The soil structure must ensure sufficient air and water for plant roots but must avoid excess water through good drainage.

The importance of bioremediation through the use of compost lies in being a possible solution to improve the quality of life of all living beings, as it can increase biodiversity by creating a habitat conducive to microorganisms and plants, reduce the amount of waste sent to landfills by using it as raw material for bioremediation and help reduce the emission of greenhouse gases by promoting carbon absorption by plants.

METHODOLOGY

The methodology is divides into four phases in order to obtain the results to optimize the parameters.

Preparation of the Takakura Compost → **Microorganism confirmation (*Aspergillus Fumigatus*)** → **Application to the soil** → **Physicochemical tests**

METHODOLOGY

Preparation of the Takakura Compost

The process begins with the preparation of the compost, which consists of two stages: the cultivation of microorganisms and the assembly of the fermentation bed. The cultivation of microorganisms has the function of allowing the development of microorganisms that will work on the waste to generate composting and the production of the fungus Aspergillus Fumigatus, for this two substrates must be prepared, one sweet and one salty, which will ferment and facilitate the decomposition of organic waste. They are left to rest under the protection of the sun for 3 to 5 days.

Once both substrates are fermented, the fermentation bed is assembled, which has the function of providing optimal conditions for the fungus and being the basis of the compost. This is left to rest for 3 to 5 days. During this period of time, it should begin to be covered with a white mold (*Aspergillus Fumigatus*), this will be the guideline that indicates that it is ready to be used.

Figure 1. Fermentation bed

METHODOLOGY

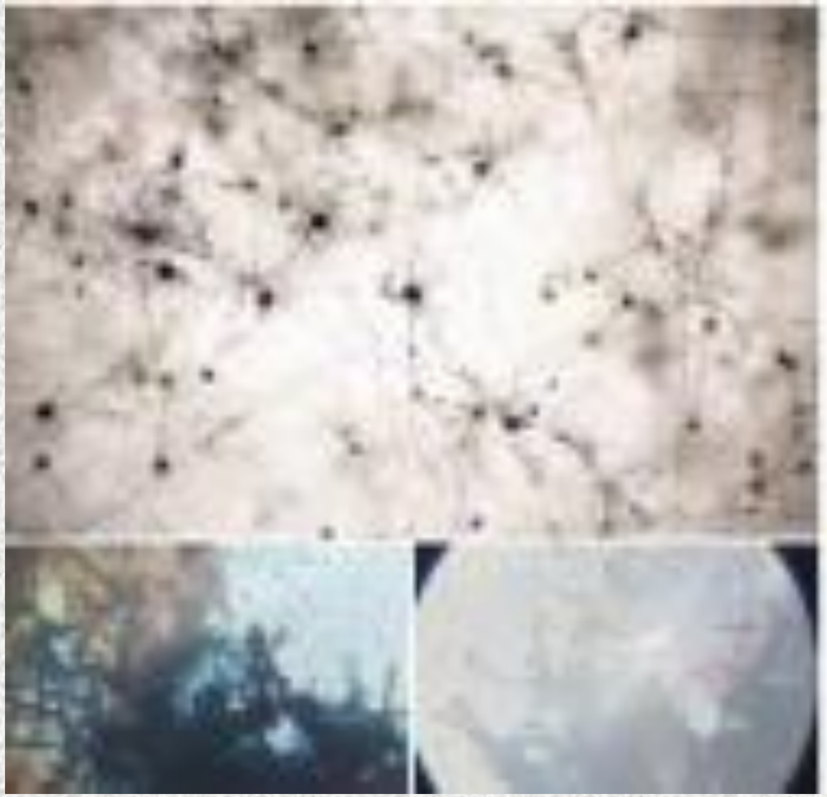

Figure 2. Comparison of the fungus Aspergillus Fumigatus obtained with a paper.

Microorganism confirmation (*Aspergillus Fumigatus*)

Once the fungus is available, a sample of the fungus is taken with two objectives: to perform staining tests in order to identify and confirm the species of the fungus (*Aspergillus Fumigatus*) and to perform a culture on ADS agar to reproduce it in a more accelerated manner.

For the first objective, a sample of the fungus is taken and three stains are performed: Gram, Malachite Green and Methylene Blue. Consequently, it is placed under the microscope to observe the result and compare it with different papers to ensure that it is the desired fungus.

Once the identity of the fungus is confirmed, a sample of the fungus is taken and a massive sowing is done in ADS agar and it is put in the incubator until it has a growth.

METHODOLOGY

Application to the soil

Areas of soil with low nutrients are selected and measurements are taken of humidity, pH, consistency, temperature and the color of the soil. Samples of the soil are taken and placed on a scale to determine their weight and, according to this, compost is added in different proportions.

Mix the compost with fungus and the soil with low nutrients in different proportions. To do this, the initial weight of the soil must be considered. The proportions must be 50% compost and 50% soil with low nutrients; 40% compost and 60% soil with low nutrients and finally 30% compost and 70% soil with low nutrients. Once the different mixtures are obtained, different types of plants are placed in them and their measurements are taken. In the same way, another section of soil is taken as a target to analyse its development more thoroughly.

Figure 3. Low nutrient soil

METHODOLOGY

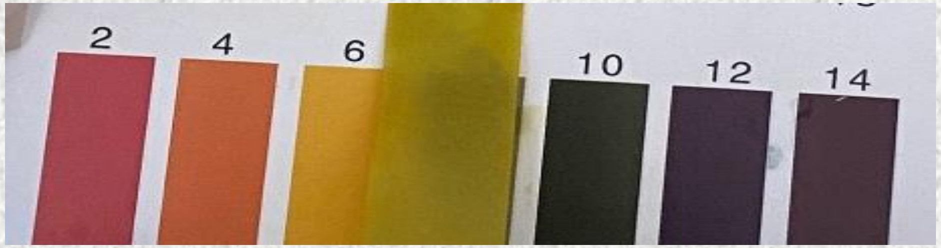

Figure 4. pH test parameter

Figure 5. Total Carbon test

Figure 6. Total Phosporus test

Physicochemical tests

Different physicochemical tests are carried out using previously established methodologies and compared with the results of optimal parameters.

The physicochemical tests performed are colour using the Munsell method, humidity determined by a gravimetric method established in the Analytical Methods Manual of the IGA Soil Laboratory, texture by the Bouyoucos Hydrometer-Densimeter method, pH by the potentiometer method described by NTC 5264, salinity determined by the conductivity meter method, total Nitrogen established in the Micro-Kjeldahl method, total carbon by the Mehlich methodology, available phosphorus determined by the Bray method described in NTC 5350 and the quantification of organic matter by the Walkley-Black method.

RESULTS

Tests with plants and compost

Compost was used in soil with low nutrients and a sandy consistency in different proportions, as well as compost without soil to house the plants. The compost improved the consistency and texture of the soil, which went from having a sandy consistency to a sandy-clayey one, allowing a notable change in color, in addition to improving humidity, pH and nutrient supply.

This generated that the soil had the necessary conditions to keep the plants alive and to help them develop within it, having the appearance of roots, leaves, branches and flowers.

These results are attributed to different factors, soil with a sandy consistency has a poor structure, consistency and fertility, in addition to not being able to retain water, the fungus absorbed the contaminants that it could have and over time this became unified with the soil, allowing the compost to provide the nutrients, returning the soil with a poor structure, but with adequate consistency and good fertility.

Figure 7. Color change in the soil

RESULTS

Physicochemical tests

Samples of soil with low nutrient content were taken to be used as a blank, in addition to analysing the evolution of the conditions and characteristics of the soil once the compost was applied. Analysing the approximate time of its evolution. The result of the tests was an increase in the fertility and general conditions of the soil as shown in the table below.

Physicochemical test	Soil without compost (white)	Soil with compost (1 month)	Soil with compost (5 months)
Physic Tests			
Color			
Humidity	18.24%	23.57%	44%
Texture	Sandy	Clayey sand	Sandy loam
Chemical Tests			
Total Carbon	19.8 mg/kg	23.48 mg/kg	32.18 mg/kg
Disponible Phosporus	17.2 mg/kg	20.5 mg/kg	48 mg/kg
Organic Matter	13%	26%	47%
Total Nitrogen	7.67 mg/kg	10.6 mg/kg	27.25 mg/kg
pH	4.6	5.4	6.6
Salinity	3	3	2

Chart 1. Results of physicochemical tests

CONCLUSION

Compost provides different macronutrients such as N, P and K and micronutrients that benefit plant growth, as well as improving the physical, chemical and biological properties of the soil, as it increases soil moisture retention and cation exchange capacity, improving its fertility and structure and thus preventing erosion and degradation. Meanwhile, the fungus mobilizes or immobilizes the contaminants found in the soil, mitigating the impact of these contaminants. In addition, the amount of organic waste generated is reduced, returning valuable nutrients to the soil.

Some chemical nutrients in the soil are stable (phosphorus) while others are lost or consumed very easily (nitrogen). With this method, regular application of these nutrients can be maintained while the crop grows. Poor soil can become productive if it is well managed.

Compost is very easy to prepare and is very useful, which makes it a common factor in bioremediation due to the nutrients it contains and provides to the soil, restoring them with living microorganisms such as bacteria and fungi, while these organisms develop their life and provide a very useful service by helping to maintain the quality of the soil while the fungus *Aspergillus Fumigatus* adapts to the soil helping to eliminate undesirable harmful substances.

This method generates the conditions that plants need to develop, such as water and certain minerals. They absorb them from the soil through their roots thanks to the compost made from organic waste.

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