Evaluation of the potential for adaptation of *"Lippia berlandieri"* in soils contaminated with heavy metals.

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ABSTRACT

The negative effects produced by contaminated sites, with heavy metals, as a result of mining activity in arid, and semi-arid zones, lead us to explore new inexpensive alternatives that could allow us to explore, and diversify the applications to the natural resources, characteristic of these regions.

Mexican oregano, "Lippia berlandieri Shauer", is a versatile plant with many uses and a high potential for adaptation, to which you can add value by extracting its essential oil. To assess the possibility of using the oregano as a surface coverage of tailings, and mitigate the emission of particulate material containing heavy metals to the atmosphere, an experiment was conducted comparing the growth rates of the plant in 4 different substrates: tailings, compost, soil of the region and a mixture of "tailings plus compost". Statistical analysis shows a significant difference between the 4 substrates. The substrate with the highest growth rate was "Soil", with values ranging between 40 and 55 cm, for a period of approximately six months, exceeding that observed in the substrate "tailings" for 291.17%, 217.70% at the "compost" and 203.98% to the mixture of "tailings plus compost". The low permeability of the tailings affects the growth and adaptation of oregano, however, when mixing the tailings with another type of substrate, such as compost or soil of the region, increases the possibilities of adaptation of the plant. Given the characteristics of the medium, the oregano can be classified as phyto-stabilizer, expanding the possibility of being used as a surface coverage, using a top layer of substrate composed as a supporting means for its implementation.

INTRODUCTION

Mexico has several communities with great development in mining industry, one of them the city of Parral Chihuahua. The study of these activities, and processes in general, which may represent a potential detrimental to the environment, have become more important in recent years, because of the impact cause to the health of human beings, and their environment, as some authors make it evident in their research [1, 2, 3, 4].

Mining is one of the biggest contributors to the economic development of Mexico [5]. The mining industry is mostly based on extraction of metals such as, copper, zinc, silver and lead [6].

Mining creates various sources of pollution. The primary process, and waste dumps, knows as tailings, in mine activity, represent two of the most critical pollution sources.
The chemical composition of the tailings, makes them toxic for living organisms; particularly cyanide tailings [7].

The damage to soils after mining is considerable, causing anomalies such as absence of presence of low soil structure, chemical properties anomalous presence of toxic compounds, among others [8].

With more than three centuries of history, mining in Parral has not only brought prosperity, in aspects of economic and urban development [9], but also an environmental issue that has been latent since the beginning of operation of one of the major mines in the area, La Prieta mine. With production of about 1500 tons of pure mineral daily, waste generated on the date cover an area of approximately 80 ha on whose soil lie waste more than three centuries of operation [10].

Past studies in the area make evident the concentrations of heavy metals present in topsoil of the urban area, which exceeded the limits set by national and international organizations, which suggests that the tailings are a major source of heavy metals. [11].

The potential risk of harm to the health of the population [12, 13] and its environment [14, 15], besides being one of the main emission sources of particulate matter with heavy metal content to the town and its surroundings, motivates the search for strategies to mitigate the adverse effects of particle emissions containing heavy metals into the atmosphere, and that these, are available to be inhaled, ingested or deposited in the skin of the surrounding population to deposits.

Oregano has been used since ancient times in various application areas ranging from alternative medicine [16, 17, 18] to pharmaceutical and food industry [19, 20, 21].

The versatility of the plant, and its resistance to harsh environmental conditions, poor soils and extreme climates, makes us think that it is a plant that has the potential to grow in soils with high content of heavy metals, and behave as a surface coverage.

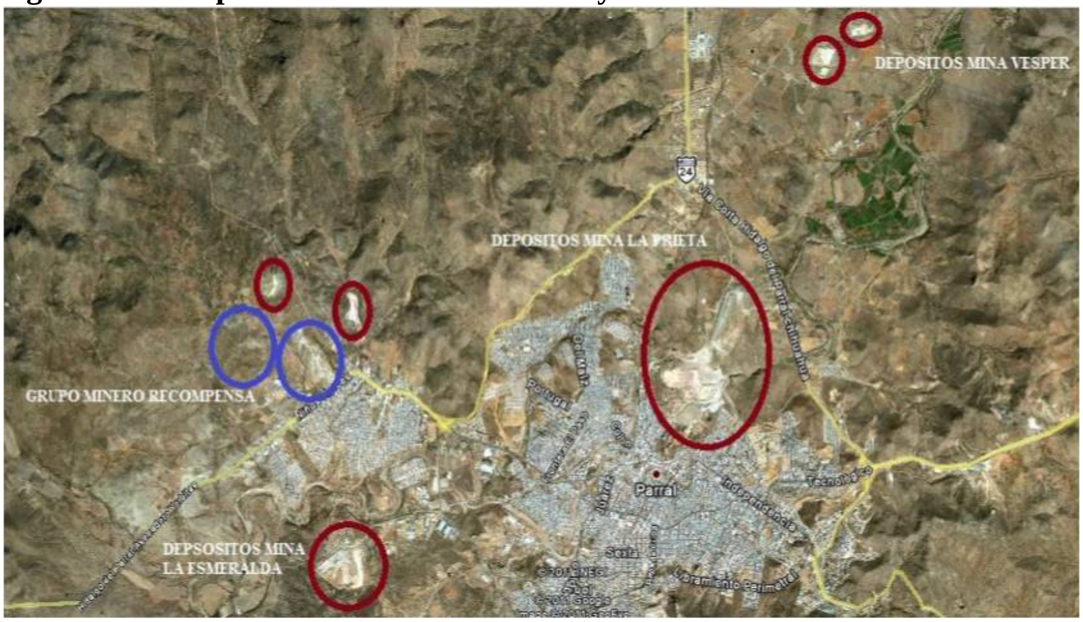
OVERVIEW

Experimental Methods

Characterization of the area under study

The location of the tailings, not only of the La Prieta mine, whose deposits were characterized recently, and which present elements and concentrations similar to those in other areas of Mexico by the type of deposits that are extracted and the beneficial minerals [22, 23, 24], but other tailings from different mines in the City, is located within the urban area as shown in Figure 1. This is a determining factor in the shape and magnitude of the potential impact that can generate such deposits in the ecosystem.

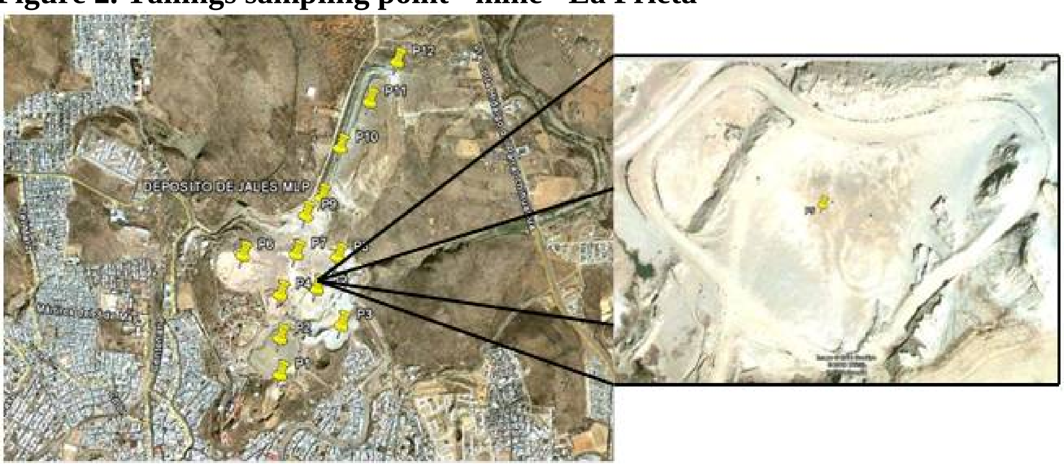
Figure 1. Description of the area under study



Heavy dust storms generated by winds ranging from moderate to strong, ranging between 21 and 50 km / h according to the Beaufort scale, take greater relevance because the main source of which are generated (The tailings from mines in Parral). Tailings can be airlifted to different areas and distances from the emission source; it can become a problem of regional type depending on the degree of intensity and direction wind.

Sampling Plan

Figure 2. Tailings sampling point - mine "La Prieta"

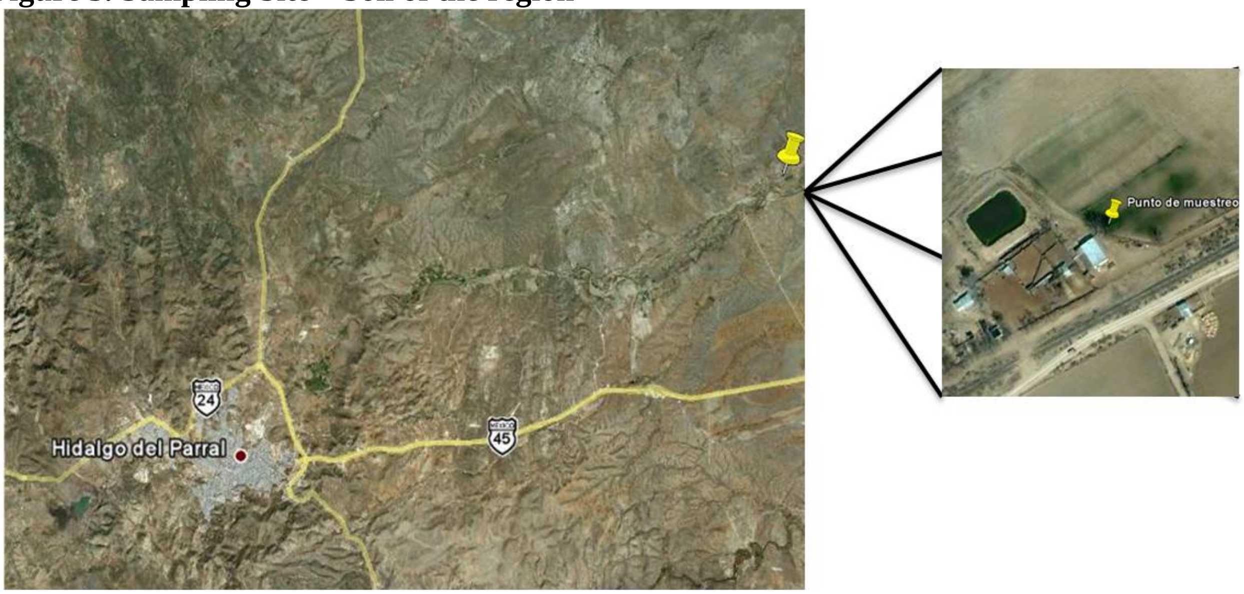


Tailings samples were collected and soil of the region, plus vermicompost, as substrates for the formation of the experimental units where was carried out the monitoring process of growth and adaptation of oregano.

It took into account previous studies on tailings from the mine La Prieta, to choose the point with the highest concentration of heavy metals, for experimentation with oregano looking to be used as surface coverage tailings and their possible identification as phyto-remedial or phyto-stabilizing. Point 5 is located at 26.9422º Lattitud, -105.6603º Longitude; Elevation 1743 masl, as shown in Figure 2.

The soil sample was taken from the region at a point away from the tailings deposits, as shows in Figure 3, to reduce error and alteration of the samples collected. Samples were collected, according to the guidelines established in the standard "NMX-AA-132-SCFI-2006".

Figure 3. Sampling Site – Soil of the region



Pre-treatment of the samples collected

Prior to analysis by atomic absorption and X-ray diffraction techniques, the samples were drying and screening to obtain the fine particle fraction (<75 microns, named silt), according to the provisions of ASTM C136.

Characterization of the samples collected

It performed the determination of elements such as As, Pb, Cd, Cr, Zn, Ag, Fe and Cu by the technique of atomic absorption Spectrophotometry, using the methods 3010, and 7000 B of the EPA on a equipment model Avanta Σ GBC brand, coupled with a hydride generator model HG300 GBC brand.

Permeability coefficient

The determination of the permeability coefficient was performed according to the specification provided by Angelone Silva in his paper "Geology and Geotechnical – Soil Permeability, 2006"

Experimental Units

For the formation of experimental units were used potted with a capacity of 5Kg of sample capacity, approximately, which are distributed as follows: 10 for the tailings substrate, 10 for the soil substrate, 5 for vermicompost, and 5 for the composite substrate (tailings plus vermicompost).

Care and observation of oregano in the 4 experimental substrates

Seed germination for generating oregano plants was conducted, which were then transplanted into experimental units. Were poured 200 ml of water every third day, to each experimental unit, according to the recommendations made by staff of the Research Center for Natural Resources (CIRENA). The monitoring process lasted approximately 6 months, during which measurements were made weekly for height and foliar diameter.

Results and Discussion

The figures shown below demonstrate the differences between the growth behavior of the oregano plant in different substrates provided for this experiment, reflecting a marked difference between the behavior presented in "Soil" and the findings of the results obtained for the substrate called "Tailings". It is further observed that the differences between the growth of oregano, in the substrates of "vermicompost" and "tailings plus compost tailings" are relatively small, as shown in Figures 4, 5, 6 and 7 to the substrates described, respectively.

Figure 4. Monitoring growth of oregano plant, in the substrate "Soil"

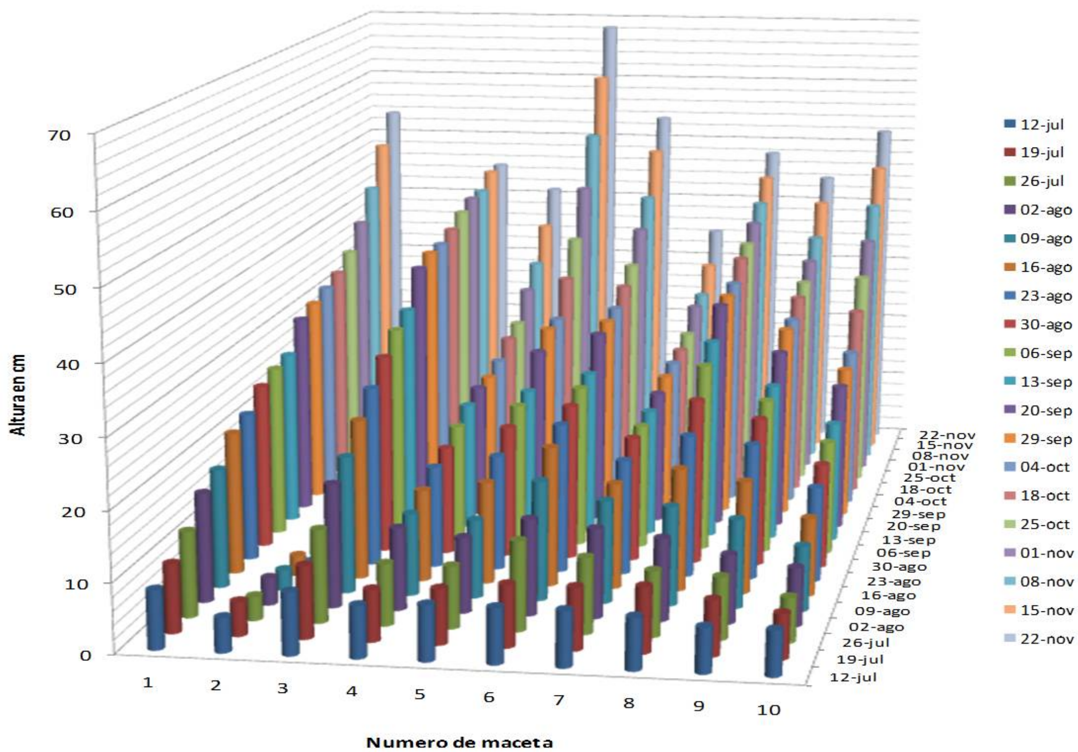


Figure 5. Monitoring growth of oregano plant, in the substrate "Tailings"

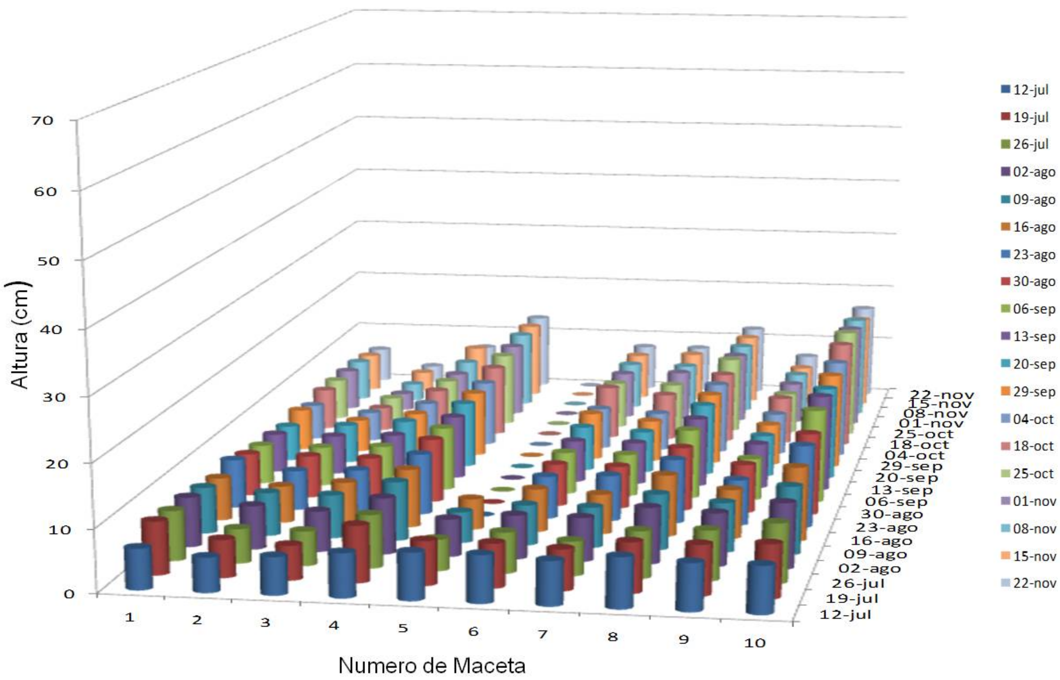


Figure 6. Monitoring growth of oregano plant, in the substrate "Vermicompost"

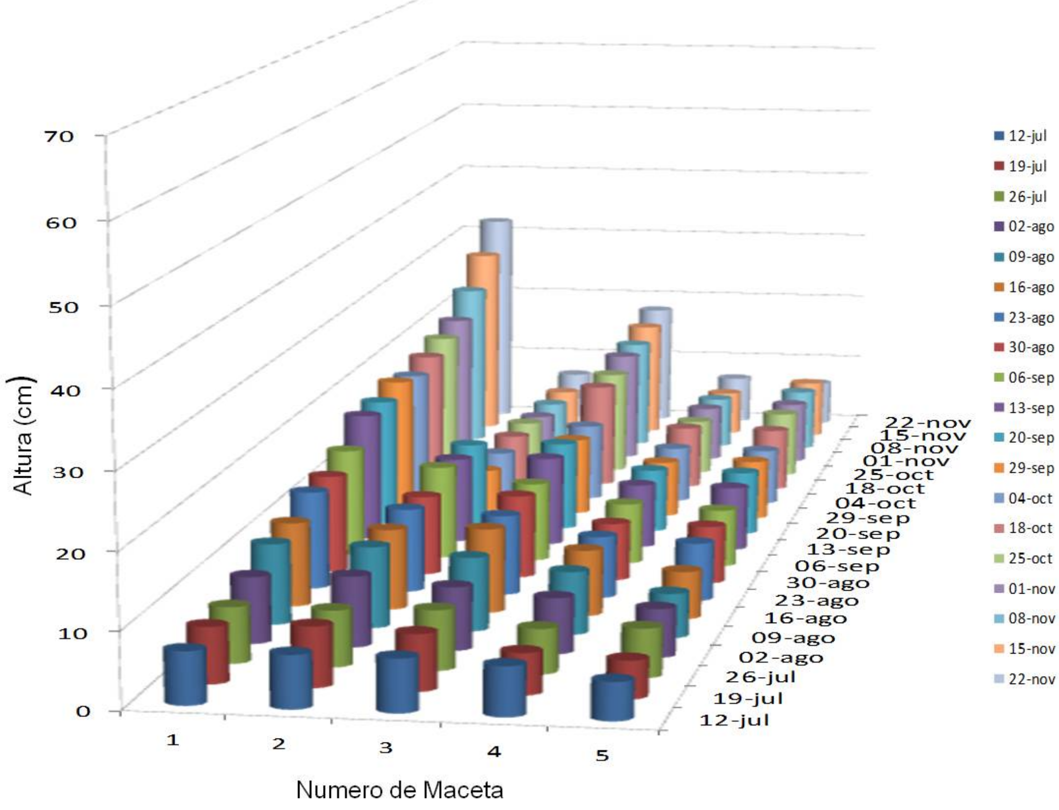
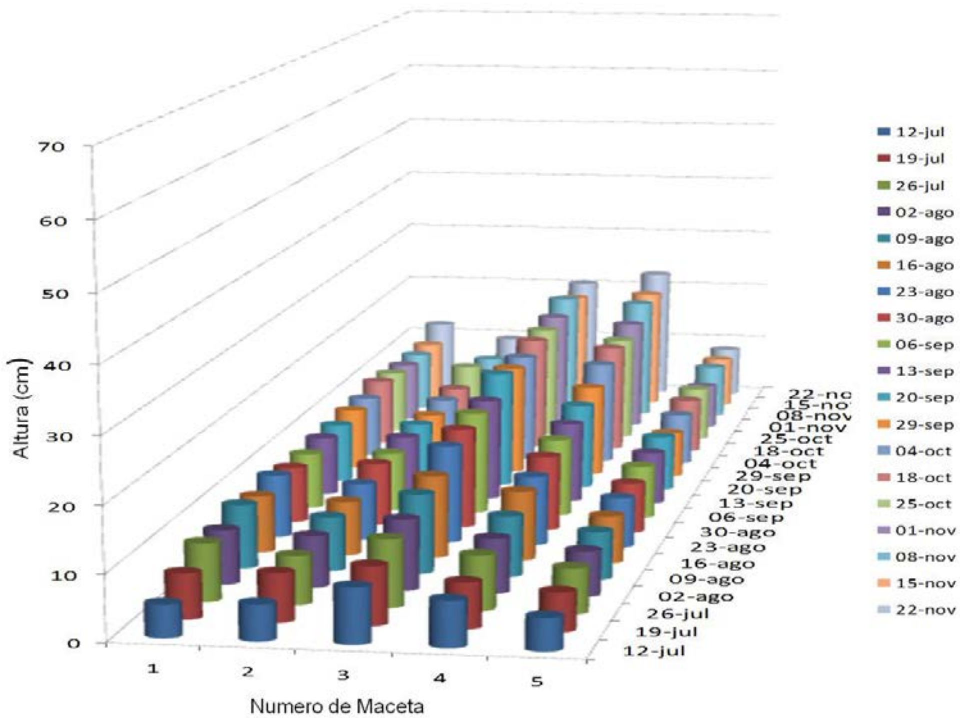


Figure 7. Monitoring growth of oregano plant, in the substrate "Tailings plus Vermicompost"



The results were processed by analysis of variance (ANOVA) using the Minitan ® Sorftware. The data were processed to a confidence level of 95% (significance level of 5%), which are shown in the following report.

Unidireccional ANOVA: Height Soil, Height Tailings, Height Vermicompost, Height Tailings+vermicompost

Source	GL	SC	CM	F	P
Factor	3	25492.9	8497.6	109.73	0.000
Error	596	46156.7	77.4		
Total	599	71649.7			

S = 8.800   R-Sqrt. = 35.58%   R-Sqrt.(adjusted) = 35.26%

Level	N	Average	Std.Dev.
Height Soil	200	22.968	14.053
Height Tailings	200	7.888	3.648
Height Vermicompost	100	10.550	4.901
Height Tailings+vermicompost	100	11.260	4.300

ICs of 95% individual for the averagepara
based on Std.Dev. grouped

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Level                          -------+---------+---------+---------+--
Height Soil                                                (--*-)
Height Tailings                (--*-)
Height Vermicompost                    (--*---)
Height Tailings+vermicompost             (---*--)
                               -------+---------+---------+---------+--
                                    10.0      15.0      20.0      25.0
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Grouped Std.Dev. = 8.800

Grouping information using the method of Fisher

	N	Average	Group
Height Soil	200	22.968	A
Height Tailings	100	11.260	B
Height Vermicompost	100	10.550	B
Height Tailings+vermicompost	200	7.888	C

The averages not sharing a letter are significantly different.
Fisher's confidence intervals Individual of 95%

The initial hypothesis established for the analysis of the four substrates, argues that "the oregano plant has the same behavior on all substrates used, i.e. $\mu 1=\mu 2=\mu 3=\ldots=\mu a$", the alternative hypothesis, however argues that "at least one of the behaviors observed in the substrates is different, i.e. $\mu i \neq \mu j$." The value of the Fisher distribution of the observed data ($F = 109.73$ and $P >> 0.05$) in the results produced by the program exceeds the critical value of the Fisher distribution ($Fc = 2.6$) obtained from tables to a level of significance of 5% ($\alpha = 0.05$), 3 degrees of freedom of the factor (a-1) and the degrees of freedom for error greater than 120. Therefore, we reject the initial hypothesis ($\mu 1=\mu 2=\mu 3=\ldots=\mu a$), and accepted the alternative hypothesis ($\mu i \neq \mu j$), indicating that there is significant difference for at least a couple of treatments.

Permeability and pH

The first approaches of the the permeability coefficient (K) in samples taken from the tailings of La Prieta mine, result in a value of 2.55 E-4 cm / s, placing the substrate analyzed in the region "impermeable soils, modified by the vegetation or decomposition, ranging from 1E-7 to 1E-2", according to the established by Karl Terzaghi and PeckRaphen 1973 at his table permeability coefficient values in different soils.

The process of determining the pH in water samples "Tailings", and substrate called "Land" was performed by the method AS-02 from the NOM-021-SEMARNAT-2000, showing an average value of 7.7 ± 0.01

SUMMARY

Monitoring results of plant growth of oregano in different substrates provided for this experiment show a clear difference. The substrate with the highest rate of growth was the "Soil", as shown in Figure 4 with values ranging between 40 and 55 cm, exceeding that observed in the substrate "tailings" for 291.17% , 217.70% at the "compost" and 203.98% to the mixture of "tailings plus compost", being the best substrate and therefore used as a reference for the evaluation the potential for plant growth in the other substrates.

Analysis of variance showed enough evidence to conclude that there is a significant difference between at least one pair of treatments (substrates), the most significant for the interests of our analysis is that observed between plant growth in soil and tailings. Growth in the tailings is so poor compared to growth at the soil substrate, which could rule out the oregano for use as surface coverage. However, the use of a composite substrate such as "tailing plus vermicompost", enables its implementation.

The low performance showing the oregano plant tailings, is mainly attributed to low permeability coefficient calculated for this substrate even when the plants were watered with the same amount of water, the permeability coefficient for each of the substrates is determining factor for the performance of the plant.

It confirm the data obtained in the previous characterization process on La Prieta mine where point 5 is one of the highest concentration of heavy metals ranging from 800-900ppm for arsenic, 7-18ppm for chromium, 97-102ppm for cadmium, 5200-6800ppm for lead, 1700ppm 14000 for Zinc, 870-990ppm for copper, 21000-29000ppm for iron, and 36-45ppm for silver.

Although the plant does not growth directly on tailings, it survives and grows reasonably on a composite substrate, "vermicompost plus tailings", which remains a substrate with high heavy metal content, given the characteristics of the tailings. Therefore, oregano can be classified as phyto-stabilizer, having an acceptable development in the contaminated soil, without translocating heavy metals.

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KEYWORDS

Oregano, heavy metals, tailings, phito-stabilaizer.