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Crescimento de Vetiver submetidos a diferentes concentrações de chorume

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Resumo

O objetivo deste trabalho foi avaliar a variação morfológica de raízes e seu crescimento, e a incorporação de alguns metais em *Vetiveria zizanoides*, quando expostos a diferentes concentrações de chorume. Os níveis de metais foram analisados por meio de espectrofotometria de absorção atômica em forno de grafite (Cu, Cd, Ni e Pb). A análise de variância de parte aérea e comprimento radicular mostraram uma diferença significativa ($p \leq 0,01$) entre a planta após a exposição a diferentes concentrações de chorume. O teste de significância (teste de Tukey) mostrou que a parte aérea da planta teve um aumento significativo quando exposto a 25% de lixiviado ($p \leq 0,05$) em comparação ao controle (0% de lixiviados), e concentrações dos lixiviados de 75% e 100%, porém foi semelhante para a concentração de 50%. Para o comprimento das raízes, o teste utilizado para significância (teste Buferroni) mostrou que as raízes cresceram melhor nas concentrações mais baixas (0% e 25%). Os resultados para peso seco da planta total obtido no final do período de 21 dias de exposição ao lixiviado, também mostram que a concentração de chorume 25% apresentou o maior crescimento, em comparação com todas as outras concentrações. Para as concentrações elevadas (50%, 75% e 100%) foi observada redução no crescimento das plantas e a consequente perda de massa da folha (parte aérea) e raízes devido à morte das plantas. Concluímos que a fitorremediação com vetiver pode ser uma estratégia viável para otimizar a descarga de lixiviados em aterros controlados.

Palavras-Chave: fitoremediação, poluição, chorume

Vetiver growth under different slurry concentrations. The objective of this work is to evaluate morphological root structure variations and some metals build-upin *Vetiver zizanoides* exposed to different leachate concentrations. The metals were analyzed in an atomic absorption spectrophotometer in graphite oven (Cu, Cd, Ni and Pb). The variance analysis of aerial part height and root length showed a significant difference ($p \leq 0.01$) between plant exposures to different leachate concentrations. The mean test (Tukey test) showed that the plant aerial partheight at 25% leachate was significantly larger ($p \leq 0.05$) than the control (0% leachate), and the highest leachate concentrations (75% and 100%), but was similar to the 50% concentration. For root length, the mean test utilized (Buferroni test) showed that the roots grew better in the lower concentrations (0% and 25%.leachate) with the 0% leachate being superior to 25% ($p \leq 0.01$). The results for total plant dry weight obtained in the end of 21 days period of exposition to leachate also show that the 25% leachate concentration presented the highest plant weight, compared with all other concentrations. At high concentrations (50%, 75%, and 100%), it was observed a reduction in plant growth and the consequent loss of leaf mass (aerial part) and roots due to plant death. We conclude that phytoremediation with vetiver may be a good strategy to optimize the leachate discharge of the controlled landfill.

Key-words: phytoremediation, leachate pollution.

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1. Introduction

Leachate from municipality's landfills represents a potential health risk to both surrounding ecosystems and human populations (SALEM et al., 2008). Leachate is an organic matter decomposition liquid residue. It has high amounts of dissolved total solids, high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), varying pH values, and usually a dark color tending to black (JOHNS; BAUDER, 2007). Leachate is frequently produced in large amounts in sanitary landfills close to urban areas and the inadequate implementation of dumps without proper soil impermeabilization and handling makes them potential polluting agents. The main steps of leachate formation involve the chemical and microbiological decomposition of dump residues. The decomposition of solid residues in open-air waste dumps and sanitary landfills are extremely changeable according to the nature, the deposit time, and the climatic changes (BILGILI et al., 2006). As it has highly soluble substances, leachate may contaminate underground water and rivers close to landfills, which may result in hazards for human welfare, the environment, and the communities located close to landfills (BECK, 2005).

In fact, inadequate waste disposal is a world problem and the search for alternatives to depollute leachate-contaminated areas has favored solutions that emphasize the improvement of decontamination efficiency, operation simplicity, time requirements, and cost reduction. In this context, the interest in the use of phytoremediation, characterized by the use of plants to remove wastewater impurities (SUSARLA et al., 2002), has increased. It In most, the commonly tested plant parameters are biomass increase, chlorophyll concentration, photosynthesis rate, death, size, and the functional size of some organs (KAPITONOVA, 2002).

Vetiver (*Vetiveria zizanoides*), a grass and one of the vegetables used with relative success in phytoremediation tests, has been known since 1995 for its absorbing characteristics suitable for leachate removal from sanitary landfills and/or sewage and used in several parts of the world (TRUONG; BAKER, 1997; ROONGTANAKIAT et al., 2003; PERCY; TRUONG, 2005; TRUONG, 2006). With increasing use of municipal solid waste landfills for solid waste disposal, municipal landfill leachate has become a serious concern for aquatic environments. Manaus, the capital of Amazonas State, has approximately 1.7 million inhabitants. For nearly two decades now, Manaus controlled landfill has received all kinds of urban wastes, domestic, commercial, industrial, and from hospitals. It is estimated that it receives a daily average of 2.800 tons of waste, which has caused waste-related environmental problems and problems to the local population. In the present study, were evaluated the root structure anatomical variations and metal build-up in *V. zizanoides* exposed to different leachate concentrations.

2. Material e Methods

2.1. Leachate sampling and analysis

The leachate used in the experiments was collected at Manaus City controlled landfill located at km 19 of the Manaus-Itacoatiara road. After collection, leachate was taken to the toxicology laboratory of CUNL (Centro Universitário Nilton Lins) for measurement of total dissolved solid content (TS) by APHA 2540B method. For that, 100 mL leachate was transferred to a beaker and previously heated and cooled in oven to about 103-105 ºC for 1 h. The liquid phase was evaporated at around 90 ºC and the beaker was weighed after total evaporation and heated again at least 6 times until weight stabilization. Chloride analysis was carried out by colorimetric method (APHA 4500-Cl E). Measurements were carried out in duplicate in a spectrophotometer (Gênese) at 480 nm wavelength. The other metals (Cu, Cd, Pb, and Ni) were analyzed in an atomic absorption spectrophotometer in graphite oven (Perkin Elmer Analyst 800) at the respective wavelength, thermal pretreatment temperatures and atomization temperatures: cadmium, 288.8 nm, 700 ºC and 1400 ºC; copper, 324.8 nm, 1200 ºC and 1900 ºC; plumb, 283.3 nm, 850 ºC and 1500 ºC; nickel, 232.2 nm, 1100 ºC and 2300 ºC. Simultaneously, leachate aliquots taken in appropriate containers were fixed and sent for hydrocarbon and mercury analysis by a qualified analysis company.

Plant preparation and exposure to leachate

Vetiveria zizanoides seedlings were collected at Centro Universitário Nilton Lins plant garden. The plant ends (roots and leaves) were pruned after cleaning with running water at set aerial part (30 cm) and root (10 cm) lengths, The plants were exposed to leachate for 21 days (from May 25 to June 15, 2007). The plants were kept in 75-L plastic containers with different leachate concentrations, 0% (water), 25%, 50%, 75%, and 100%.

The experiment was carried out in a sheltered area to avoid leachate solution dilution and with light period of 12 h at room temperature. After exposure, the plants were measured (new leaves and root shoots) and new roots were counted. In the beginning of the experiment, ten plants were collected for average weight measurement (aerial part and roots) after remaining in oven at 60 ºC for 24 h. At the end of the experiment, the dry weight of five plants of each treatment was measured to evaluate the effect of leachate on plant biomass. Next, the aerial part and roots were separated for metal content analysis as described above.

3. Results and discussion

The landfill of the city of Manaus is located at Km 19 of the AM-010 highway, which are dumped, approximately 56,000 tons of waste each month (1 kg / person / day). Of this total, half is composed of organic matter and the rest for paper, cardboard, metal, plastic, cloth, wood and glass (SANTOS et al., 2006). By the year 2007, the slurry from the controlled landfill of the city of Manaus was not channeled and therefore was released directly into water bodies of the Tarumã Basin region. From 2007, they were installed deposition pools for this slurry.

The dissolved solid concentration on the raw leachate collected at the Manaus-AM sanitary landfill was 190 mg L^{-1}. The leachate and plant contents of Cd, Cu, Ni and Pb are shown in Figure 1. Concentrations of Cd and Pb in the leachate were close to zero before (Figure 1A) and after (Figure 1B) the exposure period. This reflects the negligible concentration of these elements in the rocks and the lack anthropogenic sources related to processes industrial drainage basin (SILVEIRA et al., 2014). In contrast, Ni concentrations were proportional to the leachate solution concentration increase.

Figure 1C and 1D presents the leaf and root metal analysis results: cadmium (leaves, 0.004 ± 0.001, roots, 0.049 ± 0.074) and plumb (leaves, not detected, roots, 0.015 ± 0.019) levels remained close to zero. However, nickel build-up was larger in roots than in leaves for all experimental concentrations (leaves, 0.297 ± 0.149, roots, 1.597 ± 1.29). Copper build-up predominated in leaves from 75% leachate on (leaves, 2.88 ± 0.12, roots, 2.07 ± 0.573). Interestingly, cooper concentration in roots was larger than in leaves of plants not exposed to leachate (leaves, 3.202, root, 5.408) comparatively to the other treatment plants (leaves, 2.693 ± 0.513, roots, 2.76 ± 0.760), suggesting that vetiver looses copper to the environment.

Table I shows the parameters analyzed for the effect of leachate in several concentrations on the vegetative development of *V. zizanoides*. The variance analysis of aerial part height and root length showed a significant difference ($p \leq 0.01$) between plant exposures to different leachate concentrations (table I). The mean test (Tukey test) showed that the plant aerial part height at 25% leachate was significantly larger ($p \leq 0.05$) than the control (0% leachate), and the highest leachate concentrations (75% and 100%), but was similar to the 50% concentration. For root length, the mean test utilized (Buferroni test) showed that the roots grew better in the lower concentrations (0% and 25%.leachate) with the 0% leachate being superior to 25% ($p<0.01$). The results for total plant dry weight obtained in the end of 21 days period of exposition to leachate, also show that the 25% leachate concentration presented the highest plant weigth (table I), compared with all other concentrations. These results suggest that at 25% concentration, leachate still has some amount of organic matter and minerals that hence the plants growth.

At high concentrations (50%, 75%, and 100%), it was observed a reduction in plant growth and the consequent loss of leaf mass (aerial part) and roots due to plant death. It was observed that the roots became dark with the increase in the leachate solution concentration. The roots did not develop as much in high leachate concentrations as in its absence. These results suggest that high leachate concentrations (over 50%) inhibit *Vetiveria zizanoides* L. root growth and causes root morphological deformations (Figure 2).

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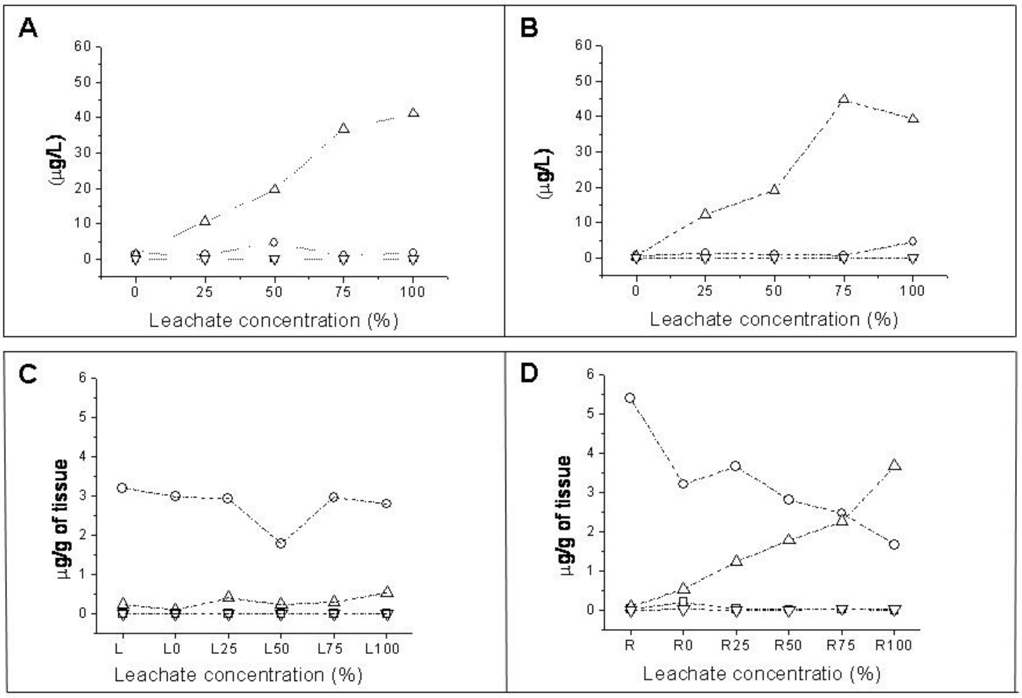

Figure 1: □-Cu; O-Cd; △-Ni; ▽-Pb. Analyze for the effect of leachate in several concentrations on the vegetative development of *V. zizanoides*. A - Leachate Concentration (%), Control. B - After exposure of *V. zizanoides* to different concentrations of leachate for 21 days. C - Concentration, Metals, distribution profile of aerial part of *V. zizanoides* grown in different leachate concentrations for 21 days. D - Concentration, Metals, distribution profile of roots part of *V. zizanoides* grown in different leachate concentrations for 21 days.

Table 1. Vegetative development of *V. zizanoides* exposed to different leachate concentration for 21 days.

Leachate concentration (%)	Aerial part height (cm)	Root length (cm)	shoot out roots (#)	Total Plant dry weight (g)
0	51.2bc	22.6[a]	12.6ns	96.51c
25	61.4a	17.6b	14.1ns	131.57a
50	57.7ab	2.3c	11.7ns	107.70b
75	43.1c	1.5cd	12.6ns	82.75d
100	47.0c	0.9d	12.3ns	90.26c

Different letters indicate significant differences in Tukey tests for aerial part height and total plant dry weight ($P < 0.05$) and in Buferroni test for root length ($P < 0.01$).

Figure 2. Root deformation in *Vetiveria zizanoides* L. exposed to different leachate concentrations for 21 days.

Merkl et al., (2005) grew grass in a raw oil-contaminated environment in a similar experiment. They observed that biomass was reduced and that the root structure changed as well. Likewise et al. (2000) compared vetiver plants to other species grown in hydroponics system with leachate water collected directly at the landfill and physically treated and released to oxidation ponds. They observed that raw leachate affected vetiver vegetative development in relation to tiller and root weight, plant height, root length, and total number of tillers negatively the most.

Roongtanakiat et al., (2003) evaluated vetiver plants grown in vases and watered with different concentrations of leachate (0, 50, 70, and 100%) and observed that plant growth reduced with increasing leachate concentration. Plants watered with 100% leachate did not survive over 80-85 days. The results found by Guangke Li et al., (2005) confirm that components of leachate may be genotoxic in plant cells and imply that long exposure to leachate at low concentrations in the aquatic environment may pose a potential genotoxic risk to organisms. In contrast, Lavania et al., (2004) and Truong (2006) observed that the plants can tolerate polluted environments very well.

The leachate metal analysis values found in this work were lower than the limits set by CONAMA regulation No. 357/2005, which regulates direct and indirect liquid waste discharges of the main polluting activities in countryside surface waters. The low metal ion concentrations found in this work may be attributed to their low solubility in the experimental conditions, alkaline pH and high total dissolved solids, as also observed by Sisinno and Moreira (1996). However, the amount of chloride in leachate was nearly 10-fold higher than the regulation limit.

Mercury concentration was below the limit of detection (0.0002 mgHg/L) and of all hydrocarbons analyzed, only naphthalene was detected (0.08 µg/L), but below the CONAMA nº 357/2005 limit. The other hydrocarbons were below the limit of detection. Although the difference observed was significant only for 100% leachate concentration, it was possible to notice root growth inhibition with increasing leachate concentration. The use of phytoremediation as a technique to reduce the impact of polluting agents such as hydrocarbons, metals, oils, and excess organic matter has been extensively discussed. Among the favorable aspects of the use of phytoremediation, we can cite its low cost, low implementation energy consumption, improved environment aesthetics, good toxic compound degradation results and absorption of metals and other toxic agents (SUSARLA et al., 2002).

One limitation is its application only to surface waters, sediments, and soils. The high concentration of toxic compounds may be hazardous to plants and soil and weather may affect plant development. The biomass produced has limited application and the toxicity of the products biodegraded by the plants is unknown yet (SUSARLA et al., 2002). Despite these disadvantages, some authors have considered phytoremediation an excellent alternative to reduce the impact of toxic agents (MEAGHER, 2000; PILON-SMITS, 2005; LEWANDOWSKI et al., 2006; YOSHIDA et al., 2006).

4. Conclusion

We conclude that phytoremediation with vetiver may be a good strategy to optimize the leachate discharge of the controlled landfill of Manaus to the aquatic environment. However, vegetative growth limiting factors must be taken into consideration for high leachate concentrations.

Divulgação

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