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REMOVAL OF MERCURY (Hg) FROM TAILINGS WASTE CONTAMINATED SOIL BY PHYTOREMEDIATION USING VETIVER (*Vetiveria zizanioides L.*)

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ABSTRACT

Mercury waste from unlicensed gold mining (PETI) is absorbed by the soil, so that the soil contains Mercury (Hg). This will cause environmental pollution. The Hg waste treatment method using the phytoremediation method has been able to bind Hg contained in the soil. However, phytoremediation of Hg waste from tailings soil using vetiver plants (Vetiveria zizanioides L.) has never been specifically studied. This study aims to determine the removal of Hg from soil contaminated with traditional gold mining tailings waste to determine the effect of Hg levels in the soil on the growth of Vetiveria zizanioides L. Vetiveria zizanioides L. plants in the soils that previously had heavy metal Hg as a pollutant with concentration variations of 1.8816 ppm and 1.9113 ppm and harvest variations of 7,14, and 21 days. The results showed that Vetiveria zizanioides L. can accumulate Hg in the roots, soil, and leaves. The highest Hg accumulation in the roots of all types of concentration variations of 1.8816 ppm and 1.9113 ppm were 1.52 µg/g, 1.52 µg/g and 1.32 µg/g; 1.254 µg/g, 0.6813 µg/g and 0.59 µg/g on stems; while 1.02 µg/g, 0.49 µg/g and 0.04 µg/g on the soil. From the data that has been presented, it can be seen that the sample of Vetiveria zizanioides L. is able and effective in reducing the concentration levels of contaminants contained in tailings waste soil. The results of a simple linear regression test for Hg waste treatment showed that there was an effect of time/day on the decrease in the levels of the test parameters. The results indicate the use of Vetiveria zizanioides L has the potential to be used in the treatment of Hg-contaminated waste soil.

Keywords: Phytoremediation, Mercury (Hg), Fragrant Root

ABSTRAK

Limbah merkuri yang berasal dari Pertambangan Emas Tanpa Izin (PETI) diserap oleh tanah, sehingga mengandung merkuri (Hg). Hal ini akan menyebabkan pencemaran lingkungan. Metode pengolahan limbah Hg dengan menggunakan metode fitoremediasi mampu untuk mengikat Hg yang terdapat di dalam tanah. Namun fitoremediasi limbah Hg dari tanah tailing dengan menggunakan tanaman Akar Wangi (Vetiveria zizanioides L.) belum pernah secara khusus dikaji. Penelitian ini bertujuan untuk mengetahui penyisihan Hg dari tanah terkontaminasi limbah tailing pertambangan emas tradisional guna menentukan pengaruh kadar Hg di dalam tanah terhadap pertumbuhan Vetiveria zizanioides L. Tanaman Vetiveria zizanioides L. yang berada pada tanah yang sebelumnya sudah terdapat logam berat Hg sebagai pencemar dengan variasi

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konsentrasi 1,8816 ppm dan 1,9113 ppm dan variasi pemanenan 7, 14, 21 hari. Hasil penelitian menunjukkan Vetiveria zizanioides L. dapat mengakumulasi Hg pada bagian akar, tanah dan daun. Akumulasi Hg tertinggi pada bagian akar dari semua jenis variasi konsentrasi 1,8816 ppm dan 1,9113 ppm dengan nilai sebesar 1,52 µ/g, 1,52 µ/g dan 1,32 µ/g; pada batang 1,254 µ/g, 0,6813 µ/g dan 0,59 µ/g; sedangkan pada tanah 1,02 µ/g, 0,49 µ/g dan 0,04 µ/g. Dari data yang telah disajikan maka dapat dilihat bahwa sampel Vetiveria zizanioides L. mampu dan efektif dalam menurunkan kadar konsentrasi zat pencemar yang terdapat dalam tanah limbah tailing. Hasil uji regresi linear sederhana untuk pengolahan limbah Hg menunjukkan adanya pengaruh waktu/hari terhadap penurunan kadar parameteryang diuji. Hasil mengindikasikan penggunaan Vetiveria zizanioides L berpotensi untuk digunakan dalam pengolahan tanah limbah tercemar Hg.

Kata kunci: *Fitoremediasi, Merkuri (Hg), Akar Wangi*

Introduction

Nagan Raya Regency is one of the regencies located in Aceh Province with many mining and quarrying businesses, especially gold and coal mining (BPT, 2009). Gold mining in Nagan Raya is one of the illegal gold mines in Indonesia because it does not have a license. Illegal mining is carried out by communities around Beutong Subdistrict using simple tools and some of the communities use tools such as bulldozer, suction machines and sluice box machines (Ramadi, 2019).

Gold processing activities in Beutong District, Nagan Raya are still carried out traditionally using the amalgamation method or the use of mercury (Hg). The use of mercury will have a major adverse impact on the environment and also on humans (Sumatri et al., 2014). So, it is necessary to overcome post-mining soil contaminated with mercury using biological agents because it is more environmentally friendly and cost-effective than chemically which requires more expensive work.

Phytoremediation is a method of removing, transferring, stabilizing and destroying pollutants including organic and inorganic compounds. According (Garbisu et al., 2002), phytoremediation requires plants, not all plants can be used, because not all plants metabolize, evaporate and accumulate all contamination with similar techniques. Identification of plants that can be used for phytoremediation research are plants with the following characteristics: fast growth, can consume a lot of water in a short time, can repair more than one contaminant and there is a high tolerance with contaminants (Morel et al., 2006).

One of the plants that can be used in phytoremediation of soil polluted with heavy metals is the Vetiver Root Plant *(Vetiveria Zizanioides L*) which has hyper accumulator properties so that vetiver plants effectively absorb heavy metals Cu and Pb (Chen et al., 2004). Vetiver plants do not require special conditions to live and can develop well and have a massive root system (Aini et al., 2010). Based on the background of the above problems, the author is interested in further research so that research is carried out with the title "Removal of soil that has contained mercury (Hg) by utilizing vetiver plants (*Vetiveria Zizanioides* L) as an agent that becomes a phytoremediator around traditional mining sites in Nagan Rayan".

Methods

The sampling location in this study was in Agoy Village, Beutong Sub-district, Nagan Raya. Sampling was done randomly to make it easier to determine

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mercury in the soil. The sampling process was carried out at 4 points on an area of 100 m^2. Of the fourth soil points, there are 2 points that contain the most mercury, so the soil point of sample two and sample three are analyzed in this study, in the table below the sample point soil is marked with sample A and sample B. The tools and materials used in this research are vetiver plants, scales, polybags, shoes, gloves and masks.

This study was conducted by planting vetiver for 7, 14, and 21 days in sample A containing mercury (Hg) of 1.8816 ppm and sample B containing 1.9113 ppm of 3 kg of polluted soil. Furthermore, observe physiological changes in plants including stem height, leaf color, and watering twice a day in the morning and evening. After the phytoremediation process was completed, continued with mercury testing on stems and roots at the age of 7, 14, and 21 days.

Results and Discussion

Polluted soil concentrations of vetiver plants were phytoremediated using vetiver plants with variations in polluted soil concentrations of 1.8816 ppm and 1.9113 ppm and permanent variations in vetiver plants of 7, 14, and 21. Table 1 shows the absorption or accumulation of mercury metal in the roots and stems.

Table 1. Phytoremediation Experiment Results of Vetiver Plants

Initial Concentration	Time (hari)	Label Sample	Total New Leaves	Initial Stem Height (cm)	Final Stem Height (cm)	Hg Root (µg/g)	Hg Root (µg/g)	Hg Soil (µg/g)	Hg Root + Stem	TF	BCF
A = 1.8816 ppm	7	A7	2	41	48	0.62	0.254	0.076	1.874	0.002	0.246
	14	A14	9	41	51.5	1.52	0.36	0	1.88	0.234	1.88
	21	A21	1	41	111	1.55	0.32	0.04	1.87	0.206	46.7
B = 1.91113 ppm	7	B7	0	41	54	0.79	0.23	1.02	1.02	0.291	1
	14	B14	14	41	56	1.23	0.6813	0	1.9113	0.553	1.9113
	21	B21	6	41	68	1.32	0.59	0.49	1.91	0.446	0.389

TF = Translocation factor value
BCF = Contaminant Value

From the analysis results, it can be seen that in sample A there was an increase in mercury absorption in the roots of vetiver plants on day 14 by 0.9 µg/g from 0.62 µg/g on day seven, but on day 21 it only increased by 0.03 µg/g. Meanwhile in sample B there was an increase in mercury absorption in the roots of vetiver plants on day 14 by 0.44 µg/g from 0.79 µg/g on day seven, but on day 21 it only increased by 0.09 µg/g. This is due to the hot room temperature and excess water during the rainy season.

The vetiver plant stem absorbed mercury from sample A as much as 1.254 µg/g while on day 14 and day 21 there was a decrease in absorption of 0.894 µg/g and 0.04 µg/g. In sample B, there was an increase in mercury absorption in the

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vetiver stem on day 14 as much as 0.45 µg/g, but decreased on day 21. Based on the results of both sample analysis, it can be seen that, the vetiver leaves will decrease day by day, absorbing mercury influenced by the watering process and room temperature and evaporating into the air with safer compounds. This is in accordance with the statement (Hansi et al., 2014) which states that variations in the number of plants affect the decrease in copper heavy metal levels in soil.

After phytoremediation for 7,14, and 21 days, there was growth in the leaves and stem height in sample A and sample B. Sample A showed growth of 2 leaves and 48 cm of stem height on day 7, on day 14 there were 9 leaves growth, and the stem height became 51.5 cm. While on day 21 there was leaf loss occurred leaving 1 leaf, but the stem height increased to 111 cm. Sample B began to experience leaf and stem growth on day 14 with 14 leaves which a stem height of 56 cm, but on day 21 there was leaf loss occurred leaving only 6 leaves. This is due to the process of changing the height of the stem which reached 61 cm in sample B.

Based on the analysis that has been carried out for 21 days, mercury in vetiver plants along with the length of the harvest period used in the phytoremediation process to facilitate the absorption of heavy metals contained in the soil. The treatment carried out for 21 days caused an increase in mercury levels in every week session which was influenced by root absorption.

From the phytoremediation treatment using vetiver plants for 21 days, there were significant changes in mercury parameters which can be seen in Table 1. This change is influenced by time, where the longer the remediation time, the greater the concentration of metals absorbed and vice versa. Vetiver plants are more suitable as mercury stabilization in soil than phytoextraction. The root part plays a role in the absorption of inorganic substances, while the leaf part plays a role in the absorption of lipophilic substances with metals absorbed through translocation and localization mechanisms (Handayanto, 2017).

Despite physical changes in vetiver plants, such as leaves which turn yellow and stems which turn dry, the absorption of mercury levels by these plants showed a significant effect on the soil. Statistical tests showed a strong relationship (R = 1.000) between the roots of vetiver plants and mercury absorption with a coefficient of determination (R Square) of sample A of 1.000 and sample B of 0.215. Similarly, the influence of stem and height growth also affects the absorption of mercury in the soil with statistical test results showing a significant relationship (R>0.05) and the coefficient of determination that shows a significant relationship (Santoso, 2012). While the effect of leaf growth also affects mercury absorption with a coefficient of determination value that shows a significant relation (Santoso, 2012).

The translocation factor (TF) value in vetiver plants showed low mercury translocation from roots to stems with increasing values from the first week (0.022 ppm) to the third week (0.206 ppm). This is due to the roots accumulating more mercury than being translocated to the stem. At higher contaminated soil concentrations mercury translocation from the stem to the roots increases, suggesting phytostabilization where plants release chemical compounds to immobilize heavy metals in the roots (Hashimoto et al., 2011).

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Conclusion

Based on the results of the study, it can be concluded that *Vetiveria zizanioides L* is effective in removing Hg in the soil on day 14. Based on the calculation of the translocation factor (TF) in the translocation of metal in vetiver plant stem mercury <1 (less than one), which shows that the translocation of mercury metal is greater to the roots of the plant compared to the stem of the plant. So that the mechanism that occurs in the process of absorption of heavy metal mercury is Phyto stabilization or the process of attaching certain contaminants to the roots that are unlikely to be absorbed into the plant stem. Concentration value (BCF) which greater than 1 can be found in vetiver plants. Based on the table, it can be found that the concentration value in the vetiver plant is >1. This shows that the vetiver plant in the roots contains a lot of heavy metals from the soil.

References

Aini, R., & Indris, M. K. (2010). Penggunaan Tanaman Akar Wangi *(Vetiveria zizanioides)* untuk Penyisihan Logam Timbal Studi Kasus: Leuwigajah, Kota Cimahi. *Jurnal Teknik Lingkungan*, 16 (1).

Balai Penelitian Tanah. (2009). Petunjuk Teknis Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. Badan Penelitian dan Pengembangan Pertanian.

Chen, Y., Shen, Z., & Li, X. (2004). The use of vetiver grass (Vetiveria zizanioides) in the phytoremediation of soils contaminated with heavy metals. *Applied Geochemistry*, *19* (10), 1553–1565.

Garbisu, C., Hernández-Allica, J., Barrutia, O., Alkorta, I., & Becerril, J. M. (2002). Phytoremediation: A technology using green plants to remove contaminants from polluted areas. *Reviews on Environmental Health*, *17*(3), 173–188.

Hansi, M., Weidenhamer, J. D., & Sinkkonen, A. (2014). Plant growth responses to inorganic environmental contaminants are density-dependent: Experiments with copper sulfate, barley and lettuce. *Environmental Pollution*, *184*, 443–448.

Hashimoto, Y., Takaoka, M., & Shiota, K. (2011). Enhanced Transformation of Lead Speciation in Rhizosphere Soils Using Phosphorus Amendments and Phytostabilization: An X-ray Absorption Fine Structure Spectroscopy Investigation. *Journal of Environmental Quality*, *40*(3), 696–703.

Handayanto, E., Tanah, J., Pertanian, F., & Brawijaya, U. (2017). Potensi Tiga Varietas Tanaman Sawi Sebagai Akumulator Merkuri pada Tanah. *Jurnal Tanah dan Sumberdaya Lahan*. (4).

Morel R, Navaro PedrenoJ, Gomez I, Mataix J. (1995). "Effects of Chromium on The

Element Content and Morphology of tomatoes. *Journal Plant Nutrition*.18.

Ramadi, P. (2019). Profil Penambangan Emas di Kecamatan Beutong Kabupaten Nagan Raya.

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ISSN 3046-885X

Santoso, S (2012). Panduan lengkap SPSS Versi 20. Jakarta PT : Elex Media Komputindo.

Sumatri, A., Laelasari, E., Junita, N. R., dan Nasrudin, N. (2014). Logam Merkuri pada Pekerja Penambangan Emas Tanpa Izin. *Kesmas: National Public Health Journal*, 8 (8), 398.