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The Utilization of Water Spinach (*Ipomoea reptans* Poir) as a Phytoremediation Agent for Heavy Metals in Growing Media

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ABSTRACT: The results showed that the combination of ex-mining soil with Belega compost (J2K4) produced the highest plant height (38.00 cm) and the greatest number of leaves (42). The best reduction of heavy metals was observed in the treatment of social forest soil with Jagapati compost (J1K2), namely As 10.29 ppm, Hg 0.24 ppm, and Mn 83.61 ppm. These findings indicate that water spinach is effective as a phytoremediation plant. This study aimed to investigate the effects of land-use type and compost sources from TPS 3R on the growth and capacity of water spinach (*Ipomoea reptans* Poir.) to reduce heavy metal content in the growing media. The experiment was arranged in a factorial Completely Randomized Design (CRD) with two factors, namely land type (social forest soil and ex-mining soil from C excavation) and compost source from TPS 3R (Kesiman, Jagapati, Belega, Darmasaba). The observed parameters included plant height, number of leaves, fresh and dry weight, as well as the reduction of heavy metals (As, Hg, Mn).

KEYWORDS: Water spinach, phytoremediation, heavy metals, compost from TPS 3R, social forest land

INTRODUCTION

Phytoremediation is a process that utilizes plants, both herbaceous (e.g., *Thlaspi caerulescens*, *Brassica juncea*, *Helianthus annuus*) and woody (e.g., *Salix* spp., *Populus* spp.), due to their ability to remove, absorb, or transform hazardous contaminants such as heavy metals [1]. Water spinach (*Ipomoea reptans* Poir) has been reported as an effective phytoremediation species, to absorb and accumulate cadmium (Cd) from the soil in the roots, stems, and leaves, with respective concentrations of 0.4303 ppm, 0.1513 ppm, and 0.1667 ppm [2]. This ability highlights its potential application for heavy metal remediation in contaminated soils.

Compost derived from TPS 3R been used for agricultural crops requires careful consideration, as in addition to serving as a nutrient source, it may also affect crop quality. Compost originating from household waste raises concerns regarding the presence of hazardous metals, which could negatively impact environmental quality and reduce agricultural productivity. Waste from landfills (TPA) and TPS analyzed has been reported to contain heavy metal levels exceeding the standards established by the Soil Research Institute-Balitan 2005 for compost quality requirements from domestic organic waste (SNI 19-7030-2004) [3]. Meanwhile, ex C-mining soil from excavation sites is obtained from former mining activities of sand, gravel, rocks, clay, and backfill soil. Such ex-mining soils can increase the risk of heavy metal accumulation, including lead (Pb), cadmium (Cd), and mercury (Hg), which may contaminate crops and pose negative impacts on human health. In contrast, social forestry land refers to marginal drylands managed under sustainable forest management systems within state-owned forests or customary forests by local communities or indigenous groups, with the objectives of improving welfare, maintaining environmental balance, and supporting social dynamics [4]. This study was conducted to evaluate the effects of land type and TPS 3R compost sources on the growth of water spinach (*Ipomoea reptans* Poir) and its capacity to reduce heavy metal concentrations.

RESEARCH METHODS

This research was conducted in Bali from December 2024 to January 2025 at the Experimental Garden of the Faculty of Agriculture, Udayana University. The study employed a two-factor Completely Randomized Design (CRD), consisting of land-use type and compost source, with twelve treatment combinations: J_0K_1 (Experimental Garden soil + TPS 3R Kesiman), J_0K_2 (Experimental Garden soil + TPS 3R Jagapati), J_0K_3 (Experimental Garden soil + TPS 3R Darmasaba), J_0K_4 (Experimental Garden soil + Belega), J_1K_1 (Social forest soil + TPS 3R Kesiman), J_1K_2 (Social forest soil + TPS 3R Jagapati), J_1K_3 (Social forest soil + TPS 3R

Darmasaba), J_1K_4 (Social forest soil + Belega), J_2K_1 (Ex-C excavation soil + TPS 3R Kesiman), J_2K_2 (Ex-C excavation soil + TPS 3R Jagapati), J_2K_3 (Ex-C excavation soil + TPS 3R Darmasaba), and J_2K_4 (Ex-C excavation soil + Belega). Each treatment was replicated three times. Data were analyzed using analysis of variance (ANOVA), followed by the Least Significant Difference (LSD) test at the 5% significance level.

This study consisted of several stages, begins with with survey, sampling of compost from TPS 3R and land-use types, preparation of materials, greenhouse setup, preparation of planting media, heavy metal analysis, and data collection. Compost samples were collected from four TPS 3R facilities located in three regencies: TPS 3R Kesiman Kertalangu (Denpasar), TPS 3R Jagapati (Badung), TPS 3R Belega (Gianyar), and TPS 3R Darmasaba (Badung). Soil samples were obtained from Sebudi Village, Karangasem Regency.

The equipment used included 40 × 40 cm polybags, hoes, shovels, sacks, plastic, and a Portable Heavy Metal Analyzer. The materials consisted of compost from TPS 3R, ex-C excavation soil, social forest soil in Bali, and water spinach (Ipomoea reptans Poir) seedlings. The planting media were prepared by mixing 1,000 g of compost with either ex-C excavation soil or social forest soil, and then placed into polybags with a diameter of 15 cm.

The observed parameters included plant height, number of leaves, and reduction of heavy metal content. Measurements of plant height and number of leaves were carried out at 7-day intervals.

RESULTS

Reduction in Heavy Metal Content of As, Hg, and Mg (ppm) After Phytoremediation

Based on the laboratory analysis, all samples showed Mn concentrations well below the critical threshold established for soils and growing media (1,500–3,000 ppm). The most significant reduction in Mn concentration was observed in the J_1 TPS 3R Jagapati treatment (ex-C excavation soil), where Mn levels decreased from 135.54 ppm to 54.22 ppm after the phytoremediation process. Other treatments, such as J_0 Jagapati and J_0 Darmasaba, also demonstrated effective Mn uptake, with final respective concentrations of 15.54 ppm and 29.79 ppm.

Ex-C excavation soil exhibited relatively safe conditions in terms of heavy metal content, with arsenic and manganese undetected, and mercury levels remaining within the critical threshold (3.998 ppm, compared to the standard range of 0.3 –5 ppm). These findings indicate that ex-C excavation soil tends to contain relatively low levels of heavy metal contaminants.
The reduction in concentrations of heavy metals (As, Hg, Mn; ppm) is presented in Table 1.

Table 1. Reduction in Heavy Metal Content of As, Hg, and Mg (ppm) After Phytoremediation

Land Resources	Compost Source	Heavy Metal Content (ppm)		
		As	Hg	Mn
Experimental Garden of the Faculty of Agriculture, Udayana University	Kesiman	71.25	11.53	182.25
	Jagapati	0	0	15.54
	Belega	027.24	0	51.99
	Dharmasaba	0	0	29.79
Social Forest Land	Kesiman	21.95	3.38	149.16
	Jagapati	10.29	0.24	83.61
	Belega	13.54	0	47.84
	Dharmasaba	10.52	2.47	60.04
Ex-C Excavation Soil	Kesiman	26.51	0	132.13
	Jagapati	12.10	0	54.22
	Belega	14.58	0	72.09
	Dharmasaba	2.29	0.07	59.32
Critical limits of heavy metals for soil		Critical Limit 20-50	Critical Limit 0.3-5	Critical Limit 1500-3000
Source	Critical Limit Data from Alloway, B. J., Heavy Metal in Soils Blackie Academic and Professional [5].			

The Effect of Land Use Type and Origin of TPS3R Compost on Plant Height

The average plant height (cm) under different treatments was observed at 7, 14, 21, and 28 days after planting (DAP). The treatments consisted of two factors, namely land-use type (J) and compost source from TPS 3R (K). For the land-use type treatments, the highest plant height was recorded in treatment J1 at 28 DAP, while for the compost treatments, the highest plant height was observed in treatment K4 at 28 DAP (Table 2). The interaction table of plant height (cm) in several different treatments (7, 14, 21, and 28 DAP). There are two treatment groups, namely Land Use Type (J) and TPS 3R Compost (K). The highest combination treatment was the J2K4 treatment at 28 DAP (Table 3).

Table 2. Average Plant Height on The Influence of Land Use Type and Origin of TPS 3R Compost

Treatment	7 DAP	14 DAP	21 DAP	28 DAP
J_0	6,37a	14,87a	26,78a	35,50b
J_1	6,96a	15,52a	27,44a	37.44a
J_2	7,38a	15,88a	27,46a	37,43ab
BNT 5%	0,99	0,98	1,23	1,78
K_1	6,90a	15,40a	26,89a	35,19b
K_2	6,67a	15,16a	27,04a	37,04a
K_3	7,10a	15,60a	27,54a	37,54a
K_4	6,93a	15,52a	27,42a	37,42a
BNT 5%	0,86	0,85	1,07	1,55

Note: The means followed by the same letter at the same row and column are not significantly different according to LSD (Least Significant Different) test at alpha 5%.

Table 3. Interaction of Plant Height with The Influence of Land Use Type and Origin of TPS 3R Compost

Treatment	K1	K2	K3	K4
J_0	30.67c	36.20a	37.77a	37.37a
J_1	37,77a	37,47a	36,87a	38,43a
J_2	36,47a	37,47a	38.00a	37,80a
BNT 5%		3,17		

Note: The means followed by the same letter at the same row and column are not significantly different according to LSD (Least Significant Different) test at alpha 5%.

The Effect of Land Use Type and Origin of TPS3R Compost on the Number of Leaves

The number of leaves of water spinach under different treatments was observed at 7, 14, 21, and 28 days after planting (DAP). The treatments consisted of two factors, namely land-use type (J) and compost source from TPS 3R (K). For the land-use type treatments, the highest number of leaves was recorded in treatment J1 at 28 DAP, while for the compost treatments, the highest number of leaves was observed in treatment K4 at 28 DAP (Table 4). The interaction table of leaf number in several different treatments (7, 14, 21, and 28 DAP) consists of two treatment groups: Land use type (J) and TPS 3R compost (K). In this treatment, the highest combination was found in treatment J2K4 at 28 DAP (Table 5).

Table 4. Average Number of Leaves on the Influence of Land Use Type and Origin of TPS 3R Compost

Treatment	7 DAP	14 DAP	21 DAP	28 DAP
J_0	3,17a	9,67a	22,67a	39.58a
J_1	4,00a	9,75a	22,75a	40.75a
J_2	3,67a	9,67a	22,67a	40.58a
BNT 5%	1,48	1,57	1,57	1,60
K_1	3,56a	9,33a	22,33a	38,67b
K_2	3,56a	10,00a	23,00a	40,56a
K_3	3,11a	9,22a	22,22a	40,11a
K_4	4,22a	10,22a	23,22a	41,22a
BNT 5%	1.28a	1,36	1,57	1,36

Note: The means followed by the same letter at the same row and column are not significantly different according to LSD (Least Significant Different) test at alpha 5%.

Table 5. Interaction of Plant Height with The Influence of Land Use Type and Origin of TPS 3R Compost

Treatment	K1	K2	K3	K4
J_0	35,33c	41,00a	39,33c	41,00a
J_1	40,67b	39,67c	40,67b	42,00a
J_2	40,00b	41,00b	40,33b	40,67b
BNT 5%		1,31		

Note: The means followed by the same letter at the same row and column are not significantly different according to LSD (Least Significant Different) test at alpha 5%.

DISCUSSION

The use of water spinach (*Ipomoea reptans* Poir.) in phytoremediation has been proven effective in reducing heavy metal concentrations. Water spinach is categorized as a hyperaccumulator plant that can efficiently absorb and accumulate heavy metals such as lead (Pb), cadmium (Cd), arsenic (As), and mercury (Hg) through phytoextraction and rhizofiltration mechanisms [6]. Plants cultivated under control treatments, the combination of social forest soil with compost from TPS 3R, as well as the combination of ex-C excavation soil with compost from TPS 3R, were shown to effectively reduce the concentrations of heavy metals (As, Hg, and Mn). This reduction is presumably due to the ability of water spinach to absorb, accumulate, or transform hazardous environmental contaminants through heavy metal uptake mechanisms. The process begins with the absorption of heavy metals by the roots, followed by translocation to other plant parts after penetrating the root endodermis . Subsequently, metal ions or other xenobiotic compounds are transported along the transpiration stream to the aerial organs via the vascular tissues (xylem and phloem), thereby distributing the metals throughout the plant [7].

The most effective reduction of heavy metals was observed in the treatment of social forest soil combined with Jagapati compost (J_1K_2), with final concentrations of As at 10.29 ppm, Hg at 0.24 ppm, and Mn at 83.61 ppm. These findings confirm that water spinach is effective as a phytoremediation species. On plant height and number of leaves, the treatment of land use type and TPS 3R compost at the age of 7 DAP, 14 DAP, and 21 DAP did not have a significant effect. This was due to the incomplete decomposition of the compost and the high concentrations of heavy metals in the growing media. The TPS 3R compost used as a soil amendment was still in the decomposition stage. Nutrients from the compost require time to break down into forms available for plant uptake. As the decomposition process occurs gradually, the release of nutrients is not immediately accessible to plants [8]. The slow decomposition process delayed the availability of essential nutrients, and this condition was further aggravated by the high concentrations of heavy metals such as arsenic and mercury. These metals not only inhibited nutrient availability through ion binding to organic fractions but also exerted toxic effects on the root system [9]. Water spinach (*Ipomoea reptans* Poir) has been shown to absorb mercury up to approximately 1.06 mg/kg in the roots and 0.12 mg/kg in the leaves from contaminated soil [10]. However at 28 DAP, the treatments significantly affected plant height and number of leaves. The best growth performance was observed in the J_1K_4 combination, which was attributed to the relatively high content of soil organic matter (SOM) in social forest soil, derived from leaf litter, twigs, and other plant residues, as well as its favorable soil structure. The addition of compost further improved soil structure and enhanced nutrient availability, thereby supporting better plant growth.

CONCLUSIONS

This study demonstrated that the combination of social forest soil and compost from TPS 3R improved the quality of the growing media and supported the growth of water spinach. The improvement in soil conditions was attributed to the high organic matter content of social forest soil, while the TPS 3R compost contributed to enhancing soil structure and increasing nutrient availability. Water spinach was proven effective in reducing the concentrations of heavy metals such as arsenic (As), mercury (Hg), and manganese (Mn) through phytoextraction and rhizofiltration mechanisms. This process occurs as the roots absorb heavy metals and subsequently translocate them to the aerial parts of the plant through the xylem and phloem tissues.

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REFERENCES

1) Ramzi, F. (2022). Phytoremediation of Heavy Metal Iron (Fe) Using Water Spinach (*Ipomoea reptans* Poir) on Soil Contaminated by Leachate at the Blang Bintang Regional Landfill. Undergraduate Thesis. Faculty of Science and Technology, UIN Ar-Raniry.
2) Suhaeni, & Wardi, R. Y. (2016). Analysis of Heavy Metal Cadmium (Cd) Levels in Water Spinach (*Ipomoea reptans* Poir). *Dinamika*, 7(2), 1–8.
3) Balitan (Soil Research Institute). (2005). Chemical Analysis of Soil, Plants, Water, and Fertilizers. Bogor, West Java.
4) Heriyanto, N. M., & Suharti, S. (2019). Water quality, soil fertility, and heavy metal content in the mangrove forest of Nusa Penida, Bali. Journal of Forest Research and Nature Conservation, 16(1), 25–33.
5) Alloway, B. J. (Ed.). (1995). Heavy Metals in Soils (2nd ed.). London: Blackie Academic.
6) Wulandari, I. A., Prasetyo, B. H., & Astuti, D. (2021). Phytoextraction Potential of *Ipomoea reptans* Poir for Heavy Metal Removal in Contaminated Soil. Indonesian Journal of Environmental Science and Technology, 8(1), 23–31.
7) Priyanti, & Yunita, E. (2013). Test of the Absorption Capacity of Genjer (*Limnocharis flava*) for Heavy Metals Iron (Fe) and Manganese (Mn). Proceedings of the Semirata, Faculty of Mathematics and Natural Sciences, University of Lampung.
8) Juang, K., & Suhendra, H. (2020). Benefits of Using Compost in Improving Soil Quality and Agricultural Yield. Scientific Journal of Agriculture, 15(3), 150–160.
9) Kabata-Pendias, A. (2011). Trace Elements in Soils and Plants (4th ed.). CRC Press.
10) Yeanchon, W., Phusantisampan, T., & Chuthong, B. (2021). Phytoremediation of Mercury-Contaminated Soil by Water Spinach (*Ipomoea aquatica* Forssk.). Environmental Science and Pollution Research, 28(3), 3281–3291.
11) Suhendra, H., & Rachman, A. (2020). Land Management in Social Forestry Areas: Opportunities and Challenges. Journal of Natural Resources and Environmental Management. 9(1), 34–44.