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DAFTAR PUSTAKA

Abbas, S., Zulfiqar, S., Arshad, M., Khalid, N., Hussain, A., & Ahmed, I. (2025). Molecular characterization of heavy metal-tolerant bacteria and their potential for bioremediation and plant growth promotion. Frontiers in Microbiology, 16, 1644466.

Adnan, M., Xiao, B., Ali, M. U., Xiao, P., Zhao, P., Wang, H., & Bibi, S. (2024). Heavy metals pollution from smelting activities: A threat to soil and groundwater. Ecotoxicology and Environmental Safety, 274, 116189.

Ahemad, M. (2019). Remediation of metalliferous soils through the heavy metal resistant plant growth promoting bacteria: paradigms and prospects. Arabian Journal of Chemistry, 12(7), 1365-1377.

Alengebawy, A., Abdelkhalek, S. T., Qureshi, S. R., & Wang, M. Q. (2021). Heavy metals and pesticides toxicity in agricultural soil and plants: Ecological risks and human health implications. Toxics, 9(3), 42.

AL-Huqail, A. A., Taher, M. A., Širić, I., Goala, M., Adelodun, B., Choi, K. S., Kumar, P., Kumar, V., Kumar, P., & Eid, E. M. (2023). Bioremediation of Battery Scrap Waste Contaminated Soils Using Coco Grass (*Cyperus rotundus* L.): A Prediction Modeling Study for Cadmium and Lead Phytoextraction. Agriculture, 13(7), 1411.

Asaf, S., Numan, M., Khan, A. L., & Al-Harrasi, A. (2020). *Sphingomonas*: from diversity and genomics to functional role in environmental remediation and plant growth. Critical Reviews in Biotechnology, 40(2), 138-152.

Badan Standardisasi Nasional. (2021). SNI 8910:2021: Kualitas lingkungan—Cara uji kadar logam dalam contoh uji limbah padat, sedimen, dan tanah dengan metode destruksi asam. BSN.

Bai, X., Bol, R., Chen, H., Cui, Q., Qiu, T., Zhao, S., & Fang, L. (2024). A meta-analysis on crop growth and heavy metals accumulation with PGPB inoculation in contaminated soils. Journal of Hazardous Materials, 471, 134370.

Bakshe, P., & Jugade, R. (2023). Phytostabilization and rhizofiltration of toxic heavy metals by heavy metal accumulator plants for sustainable management of contaminated industrial sites: A comprehensive review. Journal of Hazardous Materials Advances, 10, 100293.

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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Baruah, N., Gogoi, N., Roy, S., Bora, P., Chetia, J., Zahra, N., Ali, N., Gogoi, P., & Farooq, M. (2023). Phytotoxic responses and plant tolerance mechanisms to cadmium toxicity. Journal of Soil Science and Plant Nutrition, 23(4), 4805-4826.

Bortoloti, G. A., & Baron, D. (2022). Phytoremediation of toxic heavy metals by *Brassica* plants: A biochemical and physiological approach. Environmental Advances, 8, 100204.

Chen, L., Luo, S., Li, X., Wan, Y., Chen, J., & Liu, C. (2014). Interaction of Cd-hyperaccumulator *Solanum nigrum* L. and functional endophyte *Pseudomonas* sp. Lk9 on soil heavy metals uptake. Soil Biology and Biochemistry, 68, 300-308.

Cui, J. L., Zhao, Y. P., Chan, T. S., Zhang, L. L., Tsang, D. C., & Li, X. D. (2020). Spatial distribution and molecular speciation of copper in indigenous plants from contaminated mine sites: Implication for phytostabilization. Journal of Hazardous Materials, 381, 121208.

Emmeline, D. I., Alexandra, L., Hervé, C., Pierre, G., Jean-Yves, C., & Thierry, L. (2022). Effect of *Pseudomonas putida*-producing pyoverdine on copper uptake by *Helianthus annuus* cultivated on vineyard soils. Science of the Total Environment, 809, 152113.

Feigl, G., Kumar, D., Lehotai, N., Pető, A., Molnár, Á., Rácz, É., Ördög, A., Erdei, L., Kolbert, Z., & Laskay, G. (2015). Comparing the effects of excess copper in the leaves of *Brassica juncea* (L. Czern) and *Brassica napus* (L.) seedlings: Growth inhibition, oxidative stress and photosynthetic damage. Acta Biologica Hungarica Acta Biologica Hungarica, 66(2), 205-221.

Ferret, C., Sterckeman, T., Cornu, J. Y., Gangloff, S., Schalk, I. J., & Geoffroy, V. A. (2014). Siderophore-promoted dissolution of smectite by fluorescent *Pseudomonas*. Environmental microbiology reports, 6(5), 459-467.

Gangga, Y. E. (2021). Kemampuan dan Mekanisme Bakteri *Sphingomonas* sp. dan *Pseudomonas* sp. dalam Perubahan Kelarutan Tembaga Divalen (Cu^{2+}) dalam Medium Pertumbuhannya. Fakultas Pertanian. Universitas Gadjah Mada. Skripsi.

Glick, B. R. (2014). Bacteria with ACC deaminase can promote plant growth and help to feed the world. Microbiological Research, 169(1), 30–39.

Haribabu, T., Latha, S., Lavanya, G., Rekha, A., Sudhakar, K., Suresh, R., Ansar, A., & Sudha, P. (2024). Phytoextraction of heavy metals: Assessing the potential of *Brassica juncea* in

Pengaruh Inokulasi Pseudomonas sp. dan Sphingomonas sp. terhadap Pertumbuhan serta Serapan Cu pada
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

heavy metals (copper and cadmium) from contaminated soils. Asian Journal of Chemistry, 36(12), 2961–2966.

He, L. Y., Zhang, Y. F., Ma, H. Y., Su, L. N., Chen, Z. J., Wang, Q. Y., & Sheng, X. F. (2010). Characterization of copper-resistant bacteria and assessment of bacterial communities in rhizosphere soils of copper-tolerant plants. Applied Soil Ecology, 44(1), 49-55.

Islam, F., Yasmeen, T., Ali, Q., Mubin, M., Ali, S., Arif, M. S., Hussain, S., Riaz, M., & Abbas, F. (2016). Copper-resistant bacteria reduces oxidative stress and uptake of copper in lentil plants: Potential for bacterial bioremediation. Environmental Science and Pollution Research, 23(1), 220–233.

Ju, W. L., Liu, L., Jin, X. L., Duan, C. J., Cui, Y. X., Wang, J., & Fang, L. (2020). Co-inoculation effect of plant-growth-promoting rhizobacteria and rhizobium on EDDS-assisted phytoremediation of Cu-contaminated soils. Chemosphere, 254, 126724.

Kamal, M. A., & Alali, A. F. (2025). Kinetic modeling of heavy metal uptake and translocation in *Brassica juncea* L. for phytoremediation engineering. Discover Environment, 3(1), 296.

Lan, M. M., Liu, C., Liu, S. J., Qiu, R. L., & Tang, Y. T. (2020). Phytostabilization of Cd and Pb in highly polluted farmland soils using ramie and amendments. International Journal of Environmental Research and Public Health, 17(5), 1661.

Lewandowski, Z., & Beyenal, H. (2014). Fundamentals of Biofilm Research (2nd ed.). CRC Press.

Li, B., Ma, Y., & Yang, J. (2017). Is the computed speciation of copper in a wide range of Chinese soils reliable? Chemical Speciation & Bioavailability, 29(1), 205–215.

Ma, Y., Rajkumar, M., Rocha, I., Oliveira, R. S., & Freitas, H. (2015). Serpentine bacteria influence metal translocation and bioconcentration of *Brassica juncea* and *Ricinus communis* grown in multi-metal polluted soils. Frontiers in Plant Science, 5, 757.

Mir, A. R., Pichtel, J., & Hayat, S. (2021). Copper: Uptake, toxicity and tolerance in plants and management of Cu-contaminated soil. Biometals, 34(4), 737–759.

Mir, A. R., Siddiqui, H., Alam, P., & Hayat, S. (2022). Melatonin modulates photosynthesis, redox status, and elemental composition to promote growth of *Brassica juncea*—A dose-dependent effect. Plant Physiology and Biochemistry, 185, 244–259.

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Pengaruh Inokulasi Pseudomonas sp. dan Sphingomonas sp. terhadap Pertumbuhan serta Serapan Cu pada Brassica juncea di Regosol
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Motshumi, K. K., Mbangi, A., Van Der Watt, E., & Khetsha, Z. P. (2025). Phytoremediation Potential of Silicon-Treated *Brassica juncea* L. in Mining-Affected Water and Soil Composites in South Africa: A Review. Agriculture, 15(15), 1582.

Panhwar, Q. A., Naher, U. A., Jusop, S., Othman, R., Latif, M. A., & Ismail, M. R. (2014). Biochemical and molecular characterization of potential phosphate-solubilizing bacteria in acid sulfate soils and their beneficial effects on rice growth. PloS one, 9(10), e97241.

Pemerintah Republik Indonesia. (2021). *Peraturan Pemerintah (PP) Nomor 22 Tahun 2021 tentang Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup*. Lembaran Negara RI Tahun 2021 Nomor 32. Jakarta: Sekretariat Negara.

Poria, V., Dębiec-Andrzejewska, K., Fiodor, A., Lyzohub, M., Ajijah, N., Singh, S., & Pranaw, K. (2022). Plant growth-promoting bacteria (PGPB) integrated phytotechnology: A sustainable approach for remediation of marginal lands. Frontiers in Plant Science, 13, 999866.

Rehman, M., Maqbool, Z., Peng, D., & Liu, L. (2019). Morpho-physiological traits, antioxidant capacity and phytoextraction of copper by ramie (*Boehmeria nivea* L.) grown as fodder in copper-contaminated soil. Environmental Science and Pollution Research, 26, 5851–5861.

Riaz, U., Athar, T., Mustafa, U., & Iqbal, R. (2022). Economic feasibility of phytoremediation. Phytoremediation (pp. 481-502). Academic Press.

Rob, M. M., Akhter, D., Islam, T., Bhattacharjya, D. K., Khan, M. S. S., Islam, F., & Chen, J. (2024). Copper stress in rice: Perception, signaling, bioremediation and future prospects. Journal of Plant Physiology, 302, 154314.

Sa'ad, N. S., Artanti, R., & Dewi, T. (2009). Fitoremediasi untuk rehabilitasi lahan pertanian tercemar kadmium (Cd) dan tembaga (Cu). Jurnal Tanah dan Iklim, 30, 59-66.

Santoso, A. R. 2019. Potensi Isolat Bakteri Toleran Merkuri dari Sisa Pengolahan Bijih Mineral Pertambangan Emas sebagai Bioremediator. Fakultas Pertanian. Universitas Gadjah Mada. Skripsi.

Shahid, M., Singh, U. B., Khan, M. S., Singh, P., Kumar, R., Singh, R. N., et al. (2023). Bacterial ACC deaminase: Insights into enzymology, biochemistry, genetics, and potential role in amelioration of environmental stress in crop plants. Frontiers in Microbiology, 14, 1132770.

Pengaruh Inokulasi Pseudomonas sp. dan Sphingomonas sp. terhadap Pertumbuhan serta Serapan Cu pada
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Sharma, N., Sharma, G., Kour, S., Chadha, B. S., & Ohri, P. (2024). Unravelling the role of plant growth promoting rhizobacteria in boosting plant growth and phytoremediation of heavy metals. Applied Soil Ecology, 199, 105416.

Sharma, S., & Saraf, M. (2024). Rhizobacteria-*Pseudomonas guguanensis* isolated from mines area assists green-remediation of cadmium by *Brassica juncea*: a promising environment sustainable approach. Acta Biologica Slovenica, 67(1), 1-15.

Sheng, X., He, L., Wang, Q., Ye, H., & Jiang, C. (2008). Effects of inoculation of biosurfactant-producing *Bacillus* sp. J119 on plant growth and cadmium uptake in a cadmium-amended soil. Journal of Hazardous Materials, 155(1-2), 17-22.

Sultana, R., Islam, S. M. N., Sriti, N., Ahmed, M., Shuvo, S. B., Rahman, M. H., & Jashim, A. I. I. (2024). *Sphingomonas panaciterrae* PB20 increases growth, photosynthetic pigments, antioxidants, and mineral nutrient contents in spinach (*Spinacia oleracea* L.). Heliyon, 10, e25596.

Syarifuddin, D. W. (2020). Penurunan Konsentrasi Merkuri Divalen (Hg^{2+}) oleh Bakteri *Sphingomonas* sp. dan *Pseudomonas* sp. Tahan Merkuri. Fakultas Pertanian. Universitas Gadjah Mada. Skripsi.

Tan, P., Zeng, C., Wan, C., Liu, Z., Dong, X., Peng, J., Lin, H., Li, M., Liu, Z., & Yan, M. (2021). Metabolic profiles of *Brassica juncea* roots in response to cadmium stress. Metabolites, 11(6), 383.

Wang, Y., Narayanan, M., Shi, X., Chen, X., Li, Z., Natarajan, D., & Ma, Y. (2022). Plant growth-promoting bacteria in metal-contaminated soil: Current perspectives on remediation mechanisms. Frontiers in Microbiology, 13, 966226.

Yu, T., Qin, M., Shao, Z., Zhao, Y., & Zeng, X. (2024). Isolation of highly copper-resistant bacteria from deep-sea hydrothermal fields and description of a novel species *Marinobacter metalliresistant* sp. nov. Frontiers in Microbiology, 15, 1390451.

Zboralski, A. A., & Filion, M. F. (2023). *Pseudomonas* spp. can help plants face climate change. Frontiers in Microbiology, 14, 1198131.

Zeremski, T., Ranđelović, D., Jakovljević, K., Marjanović Jeromela, A., & Milić, S. (2021). *Brassica* species in phytoextractions: real potentials and challenges. Plants, 10(11), 2340.