

DAFTAR PUSTAKA

- Ampong, K., Thilakaranthna, M.S., and Gorim, L.Y., 2022, Understanding the role of humic acids on crop performance and soil health, *Frontiers in Agronomy*, 4, 848621.
- Angelico, R., Colombo, C., Di Iorio, E., Brtnický, M., Fojt, J., and Conte, P., 2023, Humic Substances: From Supramolecular Aggregation to Fractal Conformation— Is There Time for a New Paradigm, *Applied Sciences (Switzerland)*, 13, 13-14.
- Arvianto, R.I., 2019, Preparasi Humus Sintetik Kaya Nitrogen dan Sulfur dari Limbah Rumah Pemotongan Ayam, *Skripsi*, Universitas Gadjah Mada, Yogyakarta.
- Bai, P., Siepmann, J.I., and Deem, M.W., 2013, Adsorption of Glucose into Zeolite Beta from Aqueous Solution, *AlChE J.*, 59(9), 3523-3529.
- Benito, P.H., Eko, H., and Erin, D., 2023, Accumulation Levels of Available Cu and Cu Absorption in Corn in Ultisolss and Alfisolss After the Addition of Fly Ash and Organic Materials, *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands*, 12(1), 11–26.
- Bronick, C.J., and Lal, R., 2005, Soil structure and management: A review, *Geoderma*, 124(1–2), 3–22
- Chang, R.R., Mylotte, R., Hayes, M.H.B., McLnerney, R., and Tzou, Y.M., 2014, A Comparison of The Compositional Differences Between Humic Fractions Isolated by The IHSS and Exhaustive Extraction Procedures, *Naturwissenschaften*, 101, 197–209.
- Chen, J., Wang, Y., and Chen, X., 2024, Advances of the mechanism for copper tolerance in plants, *Plant Science*, 350, 112299.
- Chia, J.C., Zavodna, T.O., Shatokhina, H., Kavulych, Y., and Vatamaniuk, O.K., 2025, Copper connections: Coordinating transport, sensing and systemic signalling in plants, *Quantitative Plant Biology*, 6.
- Chu, K.H., Hashim, M.A., and Basirun, A.A., 2026, Pseudo-First-Order Kinetics in Water Contaminant Adsorption: A Cautionary Note, *Water, Air, Soil, Pollution*, 237, 55.
- Dey, A., Srivastava, P.C., Pachauri, S.P., and Shukla, A.K., 2019, Time-dependent release of some plant nutrients from different organic amendments in a laboratory study, *International Journal of Recycling of Organic Waste in Agriculture*, 8(Suppl 1), 173–188.
- Dimmas, G.P., Afandi, dan Sri, Y., 2022, Pengaruh Aplikasi Asam Humat Terhadap Nisbah Dispersi Dan Daya Menahan Air Tanah Pada Tanah

- Ultisol Di PT. Great Giant Pineapple (GGP) Lampung Tengah, *Jurnal Agrotek Tropika*, 10(2), 269–277.
- Eso, R., Tufaila, and Arman, 2025, Using FTIR analysis to investigate the mineralogical composition of Ultisols and Alfisols in Southeast Sulawesi, Indonesia, *Indonesian Journal of Applied Physics*, 15(1).
- Falco, G., Griffiths, P., Coutouly, C., Fustin, C.A., and Baeza, G.P., 2020, Supramolecular Superparamagnetic Nanocomposites based on a Magnetite Filled Unentangled Terpyridine Functionalized Polymer, *Macromolecules*, 53, 5361–5370.
- FAO, 2017, *The future of food and agriculture: Trends and challenges*, Food and Agriculture Organization of the United Nations.
- Fatimah, S.D., Kuncaka, A., and Roto, 2024, Characterization of Synthetic Humin from Solid Hydrolysate and Biochar from Hydrothermal Carbonization Products of Chicken Feather Waste, *Indones. J. Chem.*, 24 (1), 1 – 12.
- Hayes, M.H.B., and Graham, C.L., 2000, *Procedures for the Isolation and Fractionation of Humic Substances*. Dalam Ghabbour, E. A., Davies, G., *Humic Substance: Versatile Components of Plants, Soil, and Water*, RSC, Cambridge.
- Hayes, M.H.B., Swift, R.S., Bryne, C.M., Song, G., and Simpson, A.J., 2010, The Isolation and Characterization of Humic Substance and Humin from Grey Brown Podzolic and Grey Grassland Soil, *19th world congress of soil science, soil solution for changing world*, 1-6 Agustus 2010, Brisbane.
- Hayes, M.H.B., Swift, R.S., and Malcolm, R.L., 2010), Humic substances and supramolecular associations, *Advances in Agronomy*, 106, 1–48.
- Ho, Y.S., and McKay, G., 1999, Pseudo-second order model for sorption processes, *Process Biochemistry*, 34(5), 451–465.
- Indrawati, 2018, Peran Biochar Untuk Memperbaiki Sifat Kimia Gambut Ombrogen dan Peningkatan Hasil jagung, *Disertasi*, Fakultas Pertanian, Universitas Gadjah Mada, Yogyakarta, Indonesia.
- Kleber, M., Eusterhues, K., Keiluweit, M., Mikutta, C., Mikutta, R., and Nico, P.S., 2015, Mineral–organic associations: Formation, properties, and relevance in soil environments, *Advances in Agronomy*, 130, 1–140.
- Klučáková, M., Krouská, J., and Kalina, M., 2024, Physico-chemical aspects of metal–fulvic complexation, *Processes*, 12(5), 989.
- Kinniburgh, D.G., Van Riemsdijk, W.H., Koopal, L.K., Borkovec, M., Benedetti, M.F., and Avena, M.J., 1999, Ion binding to natural organic matter: Competition, heterogeneity, stoichiometry and thermodynamic consistency, *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 151(1–2), 147–166.

- Krivoshein, P.K., Volkov, D.S., Rogova, O.B., and Proskurnin, M.A., 2022, FTIR Photoacoustic and ATR Spectroscopies of Soils with Aggregate Size Fractionation by Dry Sieving, *ACS Omega*, 7(2), 2177–2197.
- Kulikova, N.A., and Perminova, I.V., 2021, *Interactions of humic substances in environmental systems*, Molecules.
- Kuncaka, A., 2014, Metode Memproduksi Pupuk Organik Paramagnetik Pelepasan Lambat (Slow Release Organic Paramagnetic), Paten Indonesia, P00201401530.
- Kuncaka, A., 2015, Humus Sintetis/Pupuk Srop sebagai Mesin Penjerap Carbon (Modeling Adsorpsi Glukosa), *Prosiding Seminar Nasional Hasil-hasil Penelitian Pascasarjana, PPS UNDIP*, Program Pascasarjana Universitas Diponegoro, Semarang, 25 November 2015.
- Kuncaka, A., Arvianto, R.I., Latifa, A.S.R.B., Rambe, M.R., Suratman, A., and Triono, S., 2021, Analysis and characterization of solid and liquid organic fertilizer from hydrothermal carbonization (Htc) of chicken feather and blood waste, Indones. *J. Chem.*, 21, 651–658.
- Lakshani, N., Wijerathne, H.S., Sandaruwan, C., Kottegoda, N., and Karunarathne, V., 2023, Release Kinetic Models and Release Mechanisms of Controlled-Release and Slow-Release Fertilizers, *ACS Agric. Sci. Technol*, 3(11), 939–956.
- Lehmann, J., 2009, Terra Preta de Indio, *Encyc. Of Soil Sci.*, 1, 1-4.
- Lehmann, J., and Kleber, M., 2015, The contentious nature of soil organic matter, *Nature*, 528(7580), 60–68.
- Liu, L., Wang, Y., Yan, X., Li, J., Jiao, N., and Hu, S., 2017, Biochar amendments increase the yield advantage of legume-based intercropping systems over monoculture, *Agric, Ecosyst, Environ.*, 237, 16–23.
- Madejová, J., 2003), FTIR techniques in clay mineral studies, *Vibrational Spectroscopy*, 31(1), 1–10.
- Maffia, A., Oliva, M., Marra, C., Mallamaci, C., Nardi, S., and Adele M., 2025, Humic Substances: Bridging Ecology and Agriculture for a Greener Future, *Agronomy*, 15, 410.
- Mansyur, N.I., dan Eiddieansyah, M.N., 2022, Pemupukan Terpadu Anorganik dan Organik Berbasis Asam Humat-Fulvat ada Lahan Marginal, *Jurnal Ilmiah Respati*, 13(2), 151-159.
- Maratun, S., Afiah, H., dan Akhmad, S.R., 2023, Pengaruh Pemberian Kotoran Walet terhadap pH , KTK , C-organik , N- mineral , dan P-tersedia pada Tanah Ultisol, *Acta Solum*, 2(1), 47–52.
- Nardi, S., Pizzeghello, D., Schiavon, M., and Ertani, A., 2017, Plant biostimulants: Physiological responses induced by protein

hydrolyzed-based products and humic substances in plant metabolism, *Scientia Agricola*, 73(1), 18–23.

- Nikodemus, P.L.D., Uska, J.P., dan Lusua, L.D., 2021, Pengaruh Bahan Organik Terhadap Daya Ikat Air Pada Ultisol lahan Kering, *Jurnal Tanah Dan Sumberdaya Lahan*, 8(2), 327–332.
- Pan, X., Xu, R., Nkoh J., Lu, H., Hua, H., and Guan, P., 2020, Effects of straw decayed products of four crops on the amelioration of soil acidity and maize growth In two acidic Ultisols, *Environ. Sci. Pollut. Res.*, 28, 5092–5100.
- Pan, D., Wu, X., Chen, P., Zhao, Z., Fan, F., Wang, Youxue, Zhu, M., Xue, J., and Wang, Yi, 2021, New Insights Into The Interactions Between Humic Acid and Three Neonicotinoid Pesticides, with Multiple Spectroscopy Technologies, Two Dimensional Correlation Spectroscopy Analysis and Density Functional Theory, *Science of the Total Environment*, 798.
- Pertusatti, J., and Prado, A.G.S., 2007, Buffer capacity and acid–base properties of humic acid, *Journal of Colloid and Interface Science*, 314(1), 484–489.
- Piccolo, A., 2002, The supramolecular structure of humic substances: A novel understanding of humus chemistry and implications in soil science, *Advances in Agronomy*, 75, 57–134.
- Pratamaningsih, M.M., Hati, D.P., Erwinda, E., Muslim, R.Q., Hikmat, M., and Purwanto, S., 2024, Soil characteristics and management of Ultisols derived from claystones of Sumatra, *Journal of Tropical Soils*, 29(3), 115–125.
- Ririn, A., Bambang, S., and Zainal, M., 2024, Improvement of Selected Soil Physical Properties and Mustard Yield After the Application of Tithonia Compost in Ultisols, *Terra: Journal Of Land Restoration*, 7(2), 66–71.
- Rong, X., Xie, G., Ongena, M., Zhong, K., Huang, H., Li, C., Zhang, C., Nong, X., 2020, Humic acid reduces the available cadmium, copper, lead, and zinc in soil and their uptake by tobacco, *Applied Sciences*, 10(3), 1077
- Roslina, E., Arman, and Tufaila, 2025, Using FTIR Analysis To Investigate The Mineralogical Composition Of Ultisols And Alfisol In Southeast East Sulawesi, Indonesia, *Indonesian Journal of Applied Physics (IJAP)*, 15(1), 84–97.
- Rowley, M.C., Grand, S., Verrecchia, É.P., and Henderson, G.S., 2018, Metal cation–organic matter interactions in soils: Mechanisms and environmental implications, *Soil Biology and Biochemistry*, 122, 107–119.
- Setiawan, B., 1996, Karakterisasi Permeabilitas dan Sorpsi-Desorpsi Bentonit sebagai Bahan Penyangga (Buffer Material) hlm. 347-353 dalam *Prosiding Presentasi Ilmiah Daur Bahan Bakar Nuklir II*, PEBN-Batan, Jakarta.
- Sevilla, M., and Fuertes, A.B., 2009, The production of carbon materials by hydrothermal carbonization of cellulose, *Carbon*, 47(9), 2281–2289.

- Shabtai, I.A., Wilhelm, R.C., Schweizer, S.A., Höschen, C., Buckley, D.H., and Lehmann, J., 2023, Calcium promotes persistent soil organic matter by altering microbial transformation of plant litter, *Nature Communications*, 14, 6609.
- Six, J., Bossuyt, H., Degryze, S., and Denef, K., 2004, A history of research on the link between (micro)aggregates, soil biota, and soil organic matter dynamics, *Soil and Tillage Research*, 79(1), 7–31
- Song, G.X., Novotny, E.H., Simpson, A.J., Clapp, C.E., and Hayes, M.H.B., 2008, Sequential Exhaustive Extraction of a Mollisol Soil, and Characterizations of Humic Components, Including Humin, by Solid and Solution State NMR, *Eur. J. Soil Sci.*, 59, 505-516.
- Sparks, D.L., 2003, *Environmental Soil Chemistry* (2nd ed.). Academic Press.
- Stevenson, F.J., 1982, *Extraction, Fractionation and General Chemical Composition of Soil Organic Matter. In. Stevenson, F.J. (Ed.) Humus Chemistry. Genesis, Composition, Reactions*, John Wiley and Sons, New York.
- Stevenson, F.J., 1994, *Humus Chemistry: Genesis, Composition, Reaction*, 2 Ed., John Wiley & Sons, New York.
- Tesfaye, T., Sithole, B., Ramjugernath, D., and Chunilall, V., 2017, Valorisation of chicken feathers: Characterisation of chemical properties, *Waste Management*, 68, 626–63.
- Tian, R., Liu, X., Gao, X., Li, R., and Li, H., 2021, Observation of specific ion effects in humus aggregation process, *Pedosphere*, 31, 736–745.
- Tipping, E., 2002, *Cation Binding by Humic Substances*, Cambridge University Press.
- UNESCO, 2024, *Widespread soil degradation alarms Unesco*.
- Wang, C., Xu, C., Ma, R., Li, Q., Hu, F., Zhao, S., and Bol, R., 2025, Comparison for colloidal stability and aggregation behavior of fulvic and humic acids: Effects of cations and pH, *Frontiers in Soil Science*, 5, 1452870.
- Wang, T., Zhai, Y., Zhu, Y., Li, C., and Zeng, G., 2018, A Review of Hydrothermal Carbonization of Biomass Waste for Hydrochar formation: Process Conditions, Fundamentals, and Physicochemical Properties, *Renew. Sust. Energ. Rev.*, 90, 223-247.
- Xu, F., Zhu, J., Zhang, B., Fu, Q., Chen, J., Hu, H., and Huang, Q., 2019, Sorption and immobilization of Cu and Pb in a red soil (Ultisol) after different long-term fertilizations, *Environmental Science and Pollution Research*, 26, 1716–1722.

- Yang, X., Wang, L., Gao, B., and Wang, H., 2021, Interactions between soil humic substances and metal cations: Mechanisms and environmental implications, *Science of the Total Environment*, 764, 142857.
- Yang, M., Zhou, D., Hang, H., Chen, S., Liu, H., Su, J., Lv, H., Jia, H., and Zhao, G., 2024, Effects of balancing exchangeable cations Ca, Mg, and K on the growth of tomato seedlings based on increased soil cation exchange capacity, *Agronomy*, 14(3), 629.
- Yuyun, M., Namriah, Sitti, L., Darwis, Syamsu, A., dan Resman, 2023, Variabilitas Kandungan C-Organik Pada Tanah Ultisol Yang Diberi Berbagai Jenis Bahan Organik Untuk Pertumbuhan Tanaman Sawi, *AGRONU: JURNAL AGROTEKNOLOGI VARIABILITAS*, 2(2), 82–90.
- Zeng, X., Sootahar, M.K., Su, S., Wang, Y., Bai, L., Zhang, Y., Li, T., and Zhang, X., 2019, Molecular structure and reactivity of fulvic acid: Insights into environmental behavior, *Molecules*, 24(8), 1535.
- Zhou, S., Liang, W., Zeng, T., Liu, X., Meng, L., and Bi, X., 2021, Ca saturation determines crop growth in acidic Ultisols derived from different parent materials, *Eurasian Soil Science*, 54, 1215–1227.
- Zhu, Y., Cao, Y., Fu, B., Wang, C., Shu, S., Zhu, P., Wang, D., Xu, H., Zhong, N., and Cai, D., 2024, Waste milk humification product can be used as a slow release nano-fertilizer, *Nature Communications*, 15, 128.