

DAFTAR PUSTAKA

- Afrozi, A.S., 2010, Sintesis dan karakterisasi katalis nanokomposit berbasis titania untuk produksi hidrogen dari gliserol dan air, *Skripsi*, Departemen Teknik Kimia, Universitas Indonesia, Depok.
- Alfina, B.T., Wardhani, S., and Triandi, R.T., 2015, Sintesis TiO₂-N/zeolit untuk degradasi metilen biru, *Kimia Student Journal*, 1, 599–605.
- Ali, A.G., Dejene, B.F., and Swart, H.C., 2016, The influence of different species of gases on the luminescent and structural properties of pulsed laser-ablated Y₂O₂S:Eu³⁺ thin films, *Appl. Phys. A*, 122, 534.
- Ali, S., Mehmood, A., and Khan, N., 2021, Uptake, translocation, and consequences of nanomaterials on plant growth and stress adaptation, *J. Nanomater.*, 2021, 1–17.
- Amalia, D.U., 2023, Fe-doped TiO₂ nano-anatase to accelerate photosynthesis in *Alternanthera sissoo* plants, Universitas Gadjah Mada, Yogyakarta.
- Amananti, W., 2016, Aktivitas fotokatalis TiO₂ dan TiO₂/ZnO yang dideposisikan di atas substrat kaca menggunakan metode sol-gel spray coating, *Pancasakti Science Education Journal*, 1, 78–85.
- Amole, S., Awodele, M. K., Adedokun, O., Jain, M., and Awodugba, A. O., 2019, Sol-gel spin coating synthesis of TiO₂ nanostructure and its optical characterization, *Journal of Materials Science and Chemical Engineering*, 7(6), 23-34.
- Anjali, G.K., and Zainul, R., 2024, Fotokatalis titanium oksida (TiO₂) doping tembaga (Cu) menggunakan metode sol gel untuk fototransformasi zat warna methylene blue, *Masaliq*, 4, 285–293.
- Ansari, S.A., Khan, M.M., Ansari, M.O., and Cho, M.H., 2016, Nitrogen-doped titanium dioxide (N-doped TiO₂) for visible light photocatalysis, *New J. Chem.*, 40, 3000–3009.
- Bartee, L., Shriner, W., and Creech, C., 2017, Principles of biology, *Open Oregon Educational Resources*.
- Benčina, M., Iglič, A., Mozetič, M., and Junkar, I., 2020, Crystallized TiO₂ nanosurfaces in biomedical applications, *Nanomaterials*, 10, 1121.
- Bibi, S., Shah, S.S., Muhammad, F., Siddiq, M., Kiran, L., Aldossari, S.A., Sheikh Saleh Mushab, M., and Sarwar, S., 2023, Cu-doped mesoporous TiO₂

photocatalyst for efficient degradation of organic dye via visible light photocatalysis, *Chemosphere*, 339, 139583.

- Budiharto, W., 2019, Inovasi digital di industri smart farming: Konsep dan implementasi, 4-5 September, Palembang.
- Byers, H. L., McHenry, L. J., & Grundl, T. J., 2019, XRF techniques to quantify heavy metals in vegetables at low detection limits, *Food Chemistry: X*, 1, 100001.
- Calone, R., Sanoubar, R., Lambertini, C., Speranza, M., Vittori Antisari, L., Vianello, G. and Barbanti, L., 2020, Salt tolerance and Na allocation in Sorghum bicolor under variable soil and water salinity. *Plants*, 9(5), 561.
- Chen, J.-Y., Yan, J.-K., and Gan, G.-Y., 2019, The effect of Cu doping on the transformation from rutile to anatase and Cu occupation tendency in TiO₂ solid solution, *J. Spectrosc.*
- Chen, X., Shen, S., Guo, L., and Mao, S.S., 2010, Semiconductor-based photocatalytic hydrogen generation, *Chem. Rev.*, 110, 6503–6570.
- Choudhury, B., Dey, M., and Choudhury, A., 2013, Defect generation, d–d transition, and band gap reduction in Cu-doped TiO₂ nanoparticles, *Int. Nano Lett.*, 3, 25.
- Christophe, N.N. and Veronica, N.J., 2025, Evaluation of physico-chemical characteristics of biochar produced from red bell pepper waste biomass, *Clean Technol. Environ. Policy*.
- Damayanti, C.A., Wardhani, S., and Purwonugroho, D., 2014, Pengaruh konsentrasi TiO₂ dalam zeolit terhadap degradasi methylene blue secara fotokatalitik, *Pros. Sem. Nas. Tek. Kim.*
- Diban, N., Pacuła, A., Kumakiri, I., Barquín, C., Rivero, M.J., Urtiaga, A., and Ortiz, I., 2021, TiO₂–zeolite metal composites for photocatalytic degradation of organic pollutants in water, *Catalysts*, 11, 1367.
- Dubey, N., Rayalu, S.S., Labhsetwar, N.K., Naidu, R.R., Chatti, R.V., and Devotta, S., 2006, Photocatalytic properties of zeolite-based materials for the photoreduction of methyl orange, *Appl. Catal. A Gen.*, 303, 152–157.
- Eidsvåg, H., Bentouba, S., Vajeeston, P., Yohi, S., and Velauthapillai, D., 2021, TiO₂ as a photocatalyst for water splitting—An experimental and theoretical review, *Molecules*, 26, 1687.

- Ellya, H., Nurlaila, N., Sari, N.N., Apriani, R.R., Mulyawan, R., Purba, F., and Fithria, S., 2021, Pendampingan introduksi bayam Brazil sebagai sayur pekarangan di Kota Banjarbaru, *Logista J. Ilm. Pengabd. Masy.*, 5, 253–258.
- Esgin, H., Caglar, Y., and Caglar, M., 2022, Photovoltaic performance and physical characterization of Cu-doped ZnO nanopowders as photoanode for DSSC, *J. Alloys Compd.*, 890, 161848.
- Fatimah, I. and Wijaya, K., 2005, Sintesis TiO₂/zeolit sebagai fotokatalis pada pengolahan limbah cair industri tapioka secara adsorpsi–fotodegradasi, *Teknoin*, 10, 26–31.
- Flexas, J., DIAZ-ESPEJO, A.N.T.O.N.I.O., Galmés, J., Kaldenhoff, R., Medrano, H. and RIBAS-CARBO, M.I.Q.U.E.L., 2007, Rapid variations of mesophyll conductance in response to changes in CO₂ concentration around leaves. *Plant, Cell & Environment*, 30(10), 1284-1298.
- Furqonita, A., Aritonang, A.B., and Wibowo, M.A., 2021, Sintesis TiO₂ terdoping Bi³⁺ dan uji aktivitas fotokatalisis antibakteri *E. coli* dengan bantuan sinar tampak, *Indones. J. Pure Appl. Chem.*, 4, 69–75.
- Gao, F., Hong, F., Liu, C., Zheng, L., Su, M., Wu, X., Yang, F., Wu, C., and Yang, P., 2006, Mechanism of nano-anatase TiO₂ on promoting photosynthetic carbon reaction of spinach: Inducing complex of Rubisco–Rubisco activase, *Biol. Trace Elem. Res.*, 111, 239–254.
- Ghaly, M.Y., Jamil, T.S., El-Seesy, I.E., Souaya, E.R., and Nasr, R.A., 2011, Treatment of highly polluted paper mill wastewater by solar photocatalytic oxidation with synthesized nano TiO₂, *Chem. Eng. J.*, 168, 446–454.
- Giuliani, R., Koteyeva, N., Voznesenskaya, E., Evans, M.A., Cousins, A.B., and Edwards, G.E., 2013, Coordination of leaf photosynthesis, transpiration, and structural traits in rice and wild relatives (genus *Oryza*), *Plant Physiol.*, 162, 1632–1651.
- Gong, T., Chen, L., Wang, X., Qiu, Y., Liu, H., Yang, Z., and Walther, T., 2025, Recent developments in transmission electron microscopy for crystallographic characterization of strained semiconductor heterostructures, *Crystals*, 15, 192.
- Gultom, F., 2015, Preparation of Sarulla natural nanozeolite as a filler for polyuratane foam, *Polymer*, 19, 190–195.

- Handayani, I.S., Sutanty, M., and Ismawati, I., 2023, Analisis efisiensi penggunaan faktor-faktor produksi pada usaha tani padi di Kabupaten Sumbawa, *J. Ekon. Bisnis*, 11, 40–51.
- Handoko, P. and Fajariyanti, Y., 2013, Pengaruh spektrum cahaya tampak terhadap laju fotosintesis tanaman air *Hydrilla verticillata*, *Pros. Semin. Nas. X Pendidik. Biol. FKIP UNS*, 10, 1–9.
- Harahap, N.I.P., Silvia, C., Fadilla, A., Rahma, A., Wulandari, D.R., and Fachrizal, A., 2024, Perbandingan pengaruh cahaya tampak terhadap laju fotosintesis tumbuhan *Hydrilla verticillata*, *J. Pendidik. Sains Dan Teknol.*, 3, 440–447.
- Hardjowigeno, S., 2003, *Ilmu Tanah*, Akademika Pressindo, Jakarta.
- Hasan, F., 2010, Peran luas panen dan produktivitas terhadap pertumbuhan produksi tanaman pangan di Jawa Timur, *J. Tan. Pangan*, 7.
- Hoffmann, M.R., Martin, S.T., Choi, W., and Bahnemannt, D.W., 1995, Environmental applications of semiconductor photocatalysis, *Chem. Rev.*, 95, 69–96.
- Hong, F., Zhou, J., Liu, C., Yang, F., Wu, C., Zheng, L., and Yang, P., 2005, Effect of nano-TiO₂ on photochemical reaction of chloroplasts of spinach, *Biol. Trace Elem. Res.*, 105, 269–280.
- Iriyani, D. and Nugrahani, 2014, Kandungan klorofil, karotenoid, dan vitamin C beberapa jenis sayuran daun pada pertanian periurban di Kota Surabaya, *J. Mat.*, 15.
- Irving, L., 2015, Carbon assimilation, biomass partitioning and productivity in grasses, *Agriculture*, 5, 1116–1134.
- Ismawati, R., 2018, Zeolite: structure and potential in agriculture, *J. Pena Sains*, 5, 57.
- Jaafar, S.N.H., Minggu, L.J., Arifin, K., Kassim, M.B., and Wan, W.R.D., 2017, Natural dyes as TiO₂ sensitizers with membranes for photoelectrochemical water splitting: an overview, *Renew. Sustain. Energy Rev.*, 78, 698–709.
- Jiang, D., Otitoju, T.A., Ouyang, Y., Shoparwe, N.F., Wang, S., Zhang, A., and Li, S., 2021, A review on metal ions modified TiO₂ for photocatalytic degradation of organic pollutants, *Catalysts*, 11, 1039.
- Kamegawa, T., Ishiguro, Y., Kido, R., and Yamashita, H., 2014, Design of composite photocatalyst of TiO₂ and Y-zeolite for degradation of 2-

propanol in the gas phase under UV and visible light irradiation, *Molecules*, 19, 16477–16488.

Khafifudin, B., 2017, Sintesis dan karakterisasi fotokatalis titanium dioksida (TiO₂) anatas dengan metode sonikasi variasi suhu dan waktu kalsinasi, Skripsi, Universitas Islam Negeri Maulana Malik Ibrahim Malang.

Khan, H. and Berk, D., 2013, Sol–gel synthesized vanadium doped TiO₂ photocatalyst: physicochemical properties and visible light photocatalytic studies, *J. Sol-Gel Sci. Technol.*, 68, 180–192.

Khan, M.Z.H., Islam, M.R., Nahar, N., Al-Mamun, M.R., Khan, M.A.S., and Matin, M.A., 2021, Synthesis and characterization of nanozeolite based composite fertilizer for sustainable release and use efficiency of nutrients, *Heliyon*, 7, e06091.

Koohestani, H., Hassanabadi, M., Mansouri, H., and Pirmoradian, A., 2019, Investigation of photocatalytic performance of natural zeolite/TiO₂ composites, *Micro Nano Lett.*, 14, 669–673.

Kozai, T., 2018, Smart plant factory: the next generation indoor vertical farms, Springer, Singapore.

Krisdianto, Y.W., Suhardjono, H., and Makhziah, 2022, Pengaruh penggunaan daya lampu LED (light emitting diode) dan media tanam secara indoor terhadap pertumbuhan dan hasil tanaman bayam merah (*Amaranthus tricolor L.*), *J. Agrotech*, 12, 95–100.

Kumar, S.G. and Devi, L.G., 2011, Review on modified TiO₂ photocatalysis under UV/visible light: selected results and related mechanisms on interfacial charge carrier transfer dynamics, *J. Phys. Chem. A*, 115, 13211–13241.

Kusiak-Nejman, E., Wanag, A., Kapica-Kozar, J., Kowalczyk, Ł., Zgrzebnicki, M., Tryba, B., Przepiórski, J., and Morawski, A.W., 2020, Methylene blue decomposition on TiO₂/reduced graphene oxide hybrid photocatalysts obtained by a two-step hydrothermal and calcination synthesis, *Catal. Today*, 357, 630–637.

Lakitan, B., 2010, Dasar-dasar fisiologi tumbuhan, Raja Grafindo Persada.

Lee, C., Monteith, S., Ferguson, R., and Seybold, C, 2025, Energy Dispersive X-Ray Fluorescence Spectrometry Using a Matrix Corrected Fundamental Parameters Algorithm vs. Acid Digestion with ICP-AES: A Comparison of Two Methods for Soil Elemental Analysis, *Communications in Soil Science and Plant Analysis*, 56(3), 348-362.

- Lei, Z., Mingyu, S., Chao, L., Liang, C., Hao, H., Xiao, W., Xiaoqing, L., Fan, Y., Fengqing, G., and Fashui, H., 2007, Effects of nanoanatase TiO₂ on photosynthesis of spinach chloroplasts under different light illumination, *Biol. Trace Elem. Res.*, 119, 68–76.
- Liang, Q., Liu, X., Zeng, G., Liu, Z., Tang, L., Shao, B., Zeng, Z., Zhang, W., Liu, Y., Cheng, M., Tang, W., and Gong, S., 2019, Surfactant-assisted synthesis of photocatalysts: Mechanism, synthesis, recent advances and environmental application, *Chem. Eng. J.*, 372, 429–451.
- Liao, G., He, W., and He, Y., 2019, Investigation of microstructure and photocatalytic performance of a modified zeolite supported nanocrystal TiO₂ composite, *Catalysts*, 9, 502.
- Liao, G., He, W., and He, Y., 2019, Investigation of microstructure and photocatalytic performance of a modified zeolite supported nanocrystal TiO₂ composite, *Catalysts*, 9, 502.
- Loveless, A.R., Kartawinata, K., Danimiharja, S., and Soetisna, 1989, Prinsip-prinsip biologi tumbuhan untuk daerah tropik, Gramedia, Jakarta.
- Lykiema, J., Sing, K.S.W., Haber, J., Kerker, M., Wolfram, E., Block, J.H., Churaev, N.V., Everett, D.H., Hansen, R.S., Haul, R.A.W., Hightower, J.W., and Hunter, R.J., 1985, Reporting physisorption data for gas/solid systems with special reference to the determination of surface area and porosity, *Pure and Applied Chemistry*, 57(4), 603–619.
- Ma, S., He, F., Tian, D., Zou, D., Yan, Z., Yang, Y., Zhou, T., Huang, K., Shen, H., and Fang, J., 2018, Variations and determinants of carbon content in plants: A global synthesis, *Biogeosciences*, 15, 693–702.
- Macedo, A.F., Leal-Costa, M.V., Tavares, E.S., Lage, C.L.S. and Esquibel, M.A., 2011, The effect of light quality on leaf production and development of in vitro-cultured plants of *Alternanthera brasiliana* Kuntze. *Environmental and experimental botany*, 70(1), 43-50.
- Macedo, O.B.D., Oliveira, A.L.M.D., and Santos, I.M.G.D., 2022, Zinc tungstate: A review on its application as heterogeneous photocatalyst, *Cerâmica*, 68, 294–315.
- Maftukhah, M., Turrohmah, U.U., Sholikhah, N.I., and Fawaida, U.U., 2023, Pengaruh cahaya terhadap proses fotosintesis pada tanaman naungan dan tanaman terpapar cahaya langsung, *J. Pengabd. Masy. MIPA dan Pendidik. MIPA*, 7, 51–55.

- Mahil, E.I.T. and Kumar, B.N.A., 2019, Foliar application of nanofertilizers in agricultural crops – A review, *J. Farm Sci.*, 32(3), 239–249.
- Mahreni, R. and Saepudin, A., 2021, Aplikasi katalis kerangka logam organik pada fotokatalis, Lembaga Penelitian dan Pengabdian kepada Masyarakat UPN Veteran Yogyakarta, Yogyakarta.
- Martín-Gómez, J., Reca-Expósito, S., López-Tenllado, F.J., Hidalgo-Carrillo, J., Marinas, A., and Urbano, F.J., 2023, Synthesis of Fe-TiO₂ and Cu-TiO₂ based materials by olive leaves biotemplating—Application to hydrogen production from glycerol photoreforming, *Nanomaterials*, 13, 664.
- Mastinu, A., Kumar, A., Maccarinelli, G., Bonini, S.A., Premoli, M., Aria, F., Gianoncelli, A., and Memo, M., 2019, Zeolite clinoptilolite: Therapeutic virtues of an ancient mineral, *Molecules*, 24, 1517.
- McCree, K.J., 1971, The action spectrum, absorptance and quantum yield of photosynthesis in crop plants. *Agricultural Meteorology*, 9, 191-216.
- Mingyu, S., Xiao, W., Chao, L., Chunxiang, Q., Xiaoqing, L., Liang, C., Hao, H., and Fashui, H., 2007, Promotion of energy transfer and oxygen evolution in spinach photosystem II by nano-anatase TiO₂, *Biol. Trace Elem. Res.*, 119, 183–192.
- Mishra, V., Mishra, R.K., Dikshit, A., and Pandey, A.C., 2014, Interactions of nanoparticles with plants, *Emerg. Technol. Manag. Crop Stress Toler.*, 159–180.
- Mohammadi, H., Kazemi, Z., Aghaee, A., Hazrati, S., Golzari Dehno, R., and Ghorbanpour, M., 2023, Unraveling the influence of TiO₂ nanoparticles on growth, physiological and phytochemical characteristics of *Mentha piperita* L. in cadmium-contaminated soil, *Sci. Rep.*, 13, 22280.
- Muda, S.A., Lakitan, B., Wijaya, A., and Susilawati, S., 2022, Response of Brazilian spinach (*Alternanthera sissou*) to propagation planting material and NPK fertilizer application, *Pesqui. Agropecuária Trop.*, 52, e72730.
- Mulyo, J.H., Sugiyarto, S., and Widada, A.W., 2016, Ketahanan dan kemandirian pangan rumah tangga tani daerah marginal di Kabupaten Bojonegoro, *Agro Ekon.*, 26, 121.
- Narayan, M.R., 2011, Review: dye sensitized solar cells based on natural photosensitizers, *Renew. Sustain. Energy Rev.*, S1364032111003959.
- Nasralla, N., Yeganeh, M., Astuti, Y., Piticharoenphun, S., Shahtahmasebi, N., Kompany, A., Karimipour, M., Mendis, B.G., Poolton, N.R.J., and Šiller, L.,

- 2013, Structural and spectroscopic study of Fe-doped TiO₂ nanoparticles prepared by sol–gel method, *Scientia Iranica*, 20(3), 1018–1022.
- Nimir, N.E.A., and Guisheng, Z., 2018, Photosynthesis and carbon metabolism, in: Cañedo, J.C.G. and Lizárraga, G.L.L. (eds.), *Photosynthesis - from its evolution to future improvements in photosynthetic efficiency using nanomaterials*, InTech.
- Nio Song, A., and Banyo, Y., 2011, Konsentrasi klorofil daun sebagai indikator kekurangan air pada tanaman, *J. Ilm. SAINS*, 15, 166.
- Nogueira, R.F.P., and Jardim, W.F., 1993, Photodegradation of methylene blue: using solar light and semiconductor (TiO₂), *J. Chem. Educ.*, 70, 861.
- Nurmaeli, R.E., and Taifur, Moh., 2015, Analisis penentuan kandungan gas oksigen (O₂) fotosintesis tanaman gelombang cinta (*Anthurium* sp) pada variasi daya lampu, *Taman Vokasi*, 1.
- Oliveira, R.N., Mancini, M.C., Oliveira, F.C.S.D., Passos, T.M., Quilty, B., Thiré, R.M.D.S.M., and McGuinness, G.B., 2016, FTIR analysis and quantification of phenols and flavonoids of five commercially available plants extracts used in wound healing, *Matér. Rio Jan.*, 21, 767–779.
- Othman, S.H., Abdul Rashid, S., Mohd Ghazi, T.I., and Abdullah, N., 2011, Fe-doped TiO₂ nanoparticles produced via MOCVD: synthesis, characterization, and photocatalytic activity, *J. Nanomater.*, 2011, 1–8.
- Palupi, E., 2006, Degradasi methylene blue dengan metode fotokatalisis dan fotoelektrokatalisis menggunakan film TiO₂, Departemen Fisika FMIPA Institut Pertanian Bogor, Bogor.
- Pambudi, A.B., Kurniawati, R., Iryani, A., and Hartanto, D., 2018, Effect of calcination temperature in the synthesis of carbon doped TiO₂ without external carbon source, Presented at THE 3RD INTERNATIONAL SEMINAR ON CHEMISTRY: Green Chemistry and its Role for Sustainability, Surabaya, Indonesia, 020074.
- Pasieczna-Patkowska, S., Cichy, M., and Flieger, J., 2025, Application of Fourier Transform Infrared (FTIR) Spectroscopy in Characterization of Green Synthesized Nanoparticles, *Molecules*, 30(3), 684.
- Pei, Z.F., Ming, D.F., Liu, D., Wan, G.L., Geng, X.X., Gong, H.J., and Zhou, W.J., 2010, Silicon improves the tolerance to water-deficit stress induced by polyethylene glycol in wheat (*Triticum aestivum* L.) seedlings, *J. Plant Growth Regul.*, 29, 106–115.

- Pitre, S.P., Yoon, T.P., and Scaiano, J.C., 2017, Titanium dioxide visible light photocatalysis: surface association enables photocatalysis with visible light irradiation, *Chem. Commun.*, 53, 4335–4338.
- Pratiwi, E., Harlia, H., and Aritonang, A.B., 2020, Sintesis TiO₂ terdoping Fe³⁺ untuk degradasi rhodamin B secara fotokatalisis dengan bantuan sinar tampak, *POSITRON*, 10, 57.
- Prihatiningsih, P., 2012, Sintesis dan karakterisasi Cu-doped titanium dioksida sebagai model fotokatalis responsif sinar tampak, Universitas Gadjah Mada, Yogyakarta.
- Pujiati, S., Pertiwi, A., Silfia, C.C., Ibrahim, D.M., and Nur Hafida, S.H., 2020, Analisis ketersediaan, keterjangkauan dan pemanfaatan pangan dalam mendukung tercapainya ketahanan pangan masyarakat di Provinsi Jawa Tengah, *J. Sos. Ekon. Pertan.*, 16, 123.
- Putranto, V.H., Kusumastuti, E., and Jumaeri, J., 2015, Pemanfaatan zeolit dari abu sekam padi dengan aktivasi asam untuk penurunan kesadahan air, *J. MIPA Unnes*, 38, 150–159.
- Putri, S.E., and Side, S., 2021, The effect of ratio zeolite and TiO₂ toward the particle size of zeolite/TiO₂ composites, *J. Phys. Conf. Ser.*, 1899, 012036.
- Rafique, R., Arshad, M., and Fahim Khokhar, M., 2014, Growth response of wheat to titania nanoparticles application, *NUST J. Eng. Sci.*, 7, 42–46.
- Raguram, T., and Rajni, K.S., 2022, Synthesis and characterisation of Cu-doped TiO₂ nanoparticles for DSSC and photocatalytic applications, *Int. J. Hydrog. Energy*, 47, 4674–4689.
- Ramadhana, A.K.K., Wardhani, S., and Purwonugroho, D., 2013, Fotodegradasi zat warna methyl orange menggunakan TiO₂-zeolit dengan penambahan ion persulfat, Brawijaya Univ., 168–174.
- Rianto, L.B., Amalia, S., and Khalifah, S.N., 2013, Pengaruh impregnasi logam titanium pada zeolit alam Malang terhadap luas permukaan zeolit, *Alchemy*, 2(1), 58-67.
- Rice, S.B., Chan, C., Brown, S.C., Eschbach, P., Han, L., Ensor, D.S., Stefaniak, A.B., Bonevich, J., Vladár, A.E., Walker, A.R.H., Zheng, J., Starnes, C., Stromberg, A., Ye, J., and Grulke, E.A., 2013, Particle size distributions by transmission electron microscopy: an interlaboratory comparison case study, *Metrologia*, 50, 663–678.

- Riyani, K., 2012, Sintesis dan karakterisasi fotokatalis TiO₂-Cu aktif sinar tampak, *Molekul*, 10(2), 104-111.
- Rizal, H., Abidin, Z., and Hiedayati, N., 2022, Sintesis komposit zeolit X/oksida perak dan tembaga melalui reaksi Tollens serta aplikasinya sebagai adsorben, *J. Ilmu Tanah dan Lingkung.*, 24, 87–95.
- Roslani, R., and Sumarni, N., 2005, Budidaya tanaman sayur dengan sistem hidroponik, Balai Penelitian Tanaman Sayur Pusat Penelitian dan Pengembangan Hortikultura Badan Penelitian dan Pengembangan Pertanian, Bandung.
- Sağlam, A., Yetişsin, F., Demiralay, M., and Terzi, R., 2016, Copper stress and responses in plants, in: *Plant Metal Interaction*, Elsevier, 21–40.
- Salisbury, F.B., and Ross, C.W., 1992, *Plant physiology*, 4th ed., Ancestry Publishing.
- Santoso, J., Suhardjono, H., and Wattimury, A., 2020, The study of color spectrum curs value against sunlight color and artificial light for plant growth, in: *Nusantara Science and Technology Proceedings*, presented at the Seminar Nasional Magister Agroteknologi Fakultas Pertanian UPN “Veteran” Jawa Timur, *Galaxy Science*, 11–22.
- Sari, Z.G.L.V., Younesi, H., and Kazemian, H., 2015, Synthesis of nanosized ZSM-5 zeolite using extracted silica from rice husk without adding any alumina source, *Appl. Nanosci.*, 5, 737–745.
- Schmidt, H., 1988, Chemistry of material preparation by the sol-gel process, *J. Non-Cryst. Solids*, 100, 51–64.
- Seeda, A., Abou El-Nour, E., Mervat, G., and Zaghloul, S., 2020, Interaction of copper, zinc, and their importance in plant physiology: review, acquisition and transport, *Middle East J. Appl. Sci.*, 10, 407–434.
- Setiadji, S., Sundari, C.D.D., Aprilia, V., Sumiyanto, E., Novianti, I., and Ivansyah, A.L., 2019, Synthesis of zeolite NaX using elephant grass (*Pennisetum purpureum*) as a silica source and its characterization, *J. Phys. Conf. Ser.*, 1402, 066016.
- Setiawan, A., Sugiarto, C., Mayangsari, N.E., Ari, M., and Santiasih, I., 2023, Sintesis dan karakterisasi komposit TiO₂/zeolit sebagai fotokatalis pada degradasi amonia di dalam air limbah, *J. Teknol.*, 15.

- Setiawan, Y., Mahatmanti, F.W., and Harjono, 2018, Preparasi dan karakterisasi nanozeolit dari zeolit alam Gunungkidul dengan metode top-down, *Indo. J. Chem. Sci.*, 7, 43–49.
- Setyanti, Y.H., Anwar, S., and Slamet, Y., 2013, Karakteristik fotosintetik dan serapan fosfor hijauan alfalfa (*Medicago sativa*) pada tinggi pemotongan dan pemupukan nitrogen yang berbeda, *Anim. Agric. J.*, 2, 86–96.
- Shabbir, A., Khan, M.M.A., Ahmad, B., Sadiq, Y., Jaleel, H., and Uddin, M., 2019, Efficacy of TiO₂ nanoparticles in enhancing the photosynthesis, essential oil and khusimol biosynthesis in *Vetiveria zizanioides* L. Nash, *Photosynthetica*, 57, 599–606.
- Sharma, V., Javed, B., Byrne, H., Curtin, J., and Tian, F., 2022, Zeolites as carriers of nano-fertilizers: From structures and principles to prospects and challenges, *Appl. Nano*, 3, 163–186.
- Shull, T.E., Kurepa, J., and Smalle, J.A., 2019, Anatase TiO₂ nanoparticles induce autophagy and chloroplast degradation in thale cress (*Arabidopsis thaliana*), *Environ. Sci. Technol.*, 53, 9522–9532.
- Siddiqui, M.H. and Al-Wahaibi, M.H., 2014, Role of nano-SiO₂ in germination of tomato (*Lycopersicon esculentum* seeds Mill.), *Saudi J. Biol. Sci.*, 21, 13–17.
- Singh, A., Agrawal, S., Rajput, V.D., Ghazaryan, K., Yesayan, A., Minkina, T., Zhao, Y., Petropoulos, D., Kriemadis, A., Papadakis, M., and Alexiou, A., 2024, Nanoparticles in revolutionizing crop production and agriculture to address salinity stress challenges for a sustainable future, *Discov. Appl. Sci.*, 6, 317.
- Somma, S., Cherdthong, A., Suntara, C., So, S., Wanapat, M., and Polyorach, S., 2021, In vitro fermentation characteristics and methane mitigation responded to flavonoid extract levels from *Alternanthera sissoo* and dietary ratios, *Fermentation*, 7, 109.
- Sun, J., Liu, N., Zhai, S., Xiao, Z., An, Q., and Huang, D., 2014, Gold-titanium/protonated zeolite nanocomposite photocatalysts for methyl orange degradation under ultraviolet and visible irradiation, *Mater. Sci. Semicond. Process.*, 25, 286–293.
- Suryani, O., Higashino, Y., Sato, H., and Kubo, Y., 2019, Visible-to-near-infrared light-driven photocatalytic hydrogen production using dibenzo-BODIPY and phenothiazine conjugate as organic photosensitizer, *ACS Appl. Energy Mater.*, 2, 448–458.

- Sutiyoso, Y., 2006, Hidroponik ala Yos, *Penebar Swadaya*, Jakarta.
- Suyatman, S., 2021, Menyelidiki energi pada fotosintesis tumbuhan, *INKUIRI J. Pendidik. IPA*, 9, 134.
- Tapken, W., Ravet, K., and Pilon, M., 2012, Plastocyanin controls the stabilization of the thylakoid Cu-transporting P-type ATPase PAA2/HMA8 in response to low copper in *Arabidopsis*, *J. Biol. Chem.*, 287, 18544–18550.
- Tauc, J., 1968, Optical properties and electronic structure of amorphous Ge and Si, *Mater. Res. Bull.*, 3, 37–46.
- Teatrawan, I.A., Madyaningrana, K., Ariestanti, C.A., and Prihatmo, G., 2022, Pemanfaatan limbah ampas *Coffea canephora* sebagai pupuk pendukung pertumbuhan *Alternanthera sissoo*, *BIOMA J. Biol. Dan Pembelajaran Biol.*, 7, 90–104.
- Teodoro, V., Longo, E., Zaghete, M.A., and Perazolli, L.A., 2022, Influence of Cu-doped TiO₂ on its structural and photocatalytic properties, *Eclética Química J.*, 47, 130–140.
- Thommes, M., Kaneko, K., Neimark, A.V., Olivier, J.P., Rodriguez-Reinoso, F., Rouquerol, J., and Sing, K.S.W., 2015, Physisorption of gases, with special reference to the evaluation of surface area and pore size distribution (IUPAC Technical Report), *Pure Appl. Chem.*, 87, 1051–1069.
- Tian, L., Guan, X., Dong, Y., Zong, S., Dai, A., Zhang, Z., and Guo, L., 2023, Improved overall water splitting for hydrogen production on aluminium-doped SrTiO₃ photocatalyst via tuned surface band bending, *Environ. Chem. Lett.*, 21, 1257–1264.
- Trisunaryanti, W., 2006, Buku ajar: Kimia Zat Padat, FMIPA UGM, Yogyakarta.
- Trivana, L., Sugiarti, S., and Rohaeti, R., 2015, Sintesis zeolit dan komposit zeolit/TiO₂ dari kaolin serta uji adsorpsi fotodegradasi, *ALCHEMY*, 11, 147–162.
- Wang, C. and Li, Y., 2014, Synthesis, characterisation and photocatalytic activity of natural zeolite supported Fe/S and Cr/S codoped nanoTiO₂ photocatalysts, *Mater. Technol.*, 29, 372–376.
- Wang, K., Xiong, D., and Niu, Y., 2014, Novel lubricated surface of titanium alloy based on porous structure and hydrophilic polymer brushes, *Applied surface science*, 317, 875–883.

- Wang, X.H., Li, J.-G., Kamiyama, H., Moriyoshi, Y., and Ishigaki, T., 2006, Wavelength-sensitive photocatalytic degradation of methyl orange in aqueous suspension over iron(III)-doped TiO₂ nanopowders under UV and visible light irradiation, *J. Phys. Chem. B*, 110, 6804–6809.
- Wang, Y., Duan, W., Liu, B., Chen, X., Yang, F., and Guo, J., 2014, The effects of doping copper and mesoporous structure on photocatalytic properties of TiO₂, *J. Nanomater.*, 2014, 178152.
- Wardhani, S., Rahman, M.F., Purwonugroho, D., Tjahjanto, R.T., Damayanti, C.A., and Wulandari, I.O., 2016, Photocatalytic degradation of methylene blue using TiO₂-natural zeolite as a photocatalyst, *J. Pure Appl. Chem. Res.*, 5, 19–27.
- Wibawani, A.I. and Laily, A.N., 2015, Identifikasi tanaman berdasarkan tipe fotosintesis pada beberapa spesies anggota genus *Ficus* melalui pengamatan anatomi daun, *el-Hayah*, 5, 43.
- Wibowo, A.Y. and Putra, A., 2013, Pengaruh ukuran partikel batu apung terhadap kemampuan serapan cairan limbah logam berat, *J. Teknol. Lingkung.*, 2, .
- Wiraatmaja, I.W., 2017, *Bahan ajar fotosintesis*, Unipress UNUD, Bali.
- Xu, R., Pang, W., Yu, J., Huo, Q., and Chen, J., 2007, *Chemistry of zeolites and related porous materials*, Wiley, Singapore.
- Yama, D.I. and Kartiko, H., 2020, Pertumbuhan dan kandungan klorofil pakcoy (*Brassica rapa* L) pada beberapa konsentrasi AB mix dengan sistem wick, *J. Teknol.*, 12.
- Yang, H., Yang, B., Chen, W., and Yang, J., 2022, Preparation and photocatalytic activities of TiO₂-based composite catalysts, *Catalysts*, 12, 1263.
- Yang, Z., Li, J.L., Liu, L.N., Xie, Q. and Sui, N., 2020, Photosynthetic regulation under salt stress and salt-tolerance mechanism of sweet sorghum, *Frontiers in plant science*, 10, 1722.
- Yustiningsih, M., 2019, Intensitas cahaya dan efisiensi fotosintesis pada tanaman naungan dan tanaman terpapar cahaya langsung, *Bio-Edu J. Pendidik. Biol.*, 4, 44–49.
- Zainul, R., Alif, A., Aziz, H., Arief, S., and Darajat, S., 2015, Modifikasi dan karakteristik I–V sel fotovoltaik Cu₂O/Cu-gel Na₂SO₄ melalui iluminasi lampu neon, *J. Fis. Indones.*, 2, 50-59.

- Zannah, H., 2023, Peran cahaya matahari dalam proses fotosintesis tumbuhan, *J. Penelit.*, 7(1), 204-214.
- Ze, Y., Liu, C., Wang, L., Hong, M., and Hong, F., 2011a, The regulation of TiO₂ nanoparticles on the expression of light-harvesting complex II and photosynthesis of chloroplasts of *Arabidopsis thaliana*, *Biol. Trace Elem. Res.*, 143, 1131–1141.
- Ze, Y., Liu, C., Wang, L., Hong, M., and Hong, F., 2011b, The regulation of TiO₂ nanoparticles on the expression of light-harvesting complex II and photosynthesis of chloroplasts of *Arabidopsis thaliana*, *Biol. Trace Elem. Res.*, 143, 1131–1141.
- Zhang, H. and Banfield, J.F., 2000, Understanding polymorphic phase transformation behavior during growth of nanocrystalline aggregates: Insights from TiO₂, *J. Phys. Chem. B*, 104, 3481–3487.
- Zhang, H., Wang, M., and Xu, F., 2020, Generating oxygen vacancies in Cu²⁺-doped TiO₂ hollow spheres for enhanced photocatalytic activity and antimicrobial activity, *Micro Nano Lett.*, 15, 535–539.
- Zhang, Y., Liu, N., Wang, W., Sun, J., and Zhu, L., 2020, Photosynthesis and related metabolic mechanism of promoted rice (*Oryza sativa* L.) growth by TiO₂ nanoparticles, *Front. Environ. Sci. Eng.*, 14, 103.