

DAFTAR PUSTAKA

- Adamcová, D., Radziemska, M., Zloch, J., Dvořáčková, H., Elbl, J., Kynický, J., Brtnický, M., & Vaverková, M. D. (2018). SEM analysis and degradation behavior of conventional and bio-based plastics during composting. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 66(2), 349-356. <https://doi.org/10.11118/actaun201866020349>.
- Afianti, N. F., Rachman, A., Hatmanti, A., Yogaswara, D., Anggiani, M., Fitriya, N., & Darmayati, Y. (2022). Microbial biofilm of plastic in tropical marine environment and their potential for bioremediation of plastic waste. *Journal of Ecological Engineering*, 23(4). <https://doi.org/10.12911/22998993/145463>.
- Akhtar, K., Khan, S. A., Khan, S. B., & Asiri, A. M. (2018). Scanning electron microscopy: Principle and applications in nanomaterials characterization. *Springer International Publishing*, 113-145. https://doi.org/10.1007/978-3-319-92955-2_4.
- Akihary, C. V., & Kolondam, B. J. (2020). Pemanfaatan gen 16S rRNA sebagai perangkat identifikasi bakteri untuk penelitian-penelitian di Indonesia. *Pharmacon*, 9(1), 16-22. <https://doi.org/10.35799/pha.9.2020.27405>.
- Alazazi, E. A., Ahmed, S., & Murtey, M. D. (2023). Negative staining: a forgotten technique in microbiology. *Advancements in Life Sciences*, 10(3), 309-313. ISSN: 2310-5380.
- Ali, N. S., Huang, F., Qin, W., & Yang, T. C. (2022). Identification and characterization of a new *Serratia proteamaculans* strain that naturally produces significant amount of extracellular laccase. *Frontiers in Microbiology*, 13, 878360. <https://doi.org/10.3389/fmicb.2022.878360>.
- Ali, S., Bukhari, D. A., & Rehman, A. (2023). Call for biotechnological approach to degrade plastic in the era of COVID-19 pandemic. *Saudi Journal of Biological Sciences*, 30(3), 103583. <https://doi.org/10.1016/j.sjbs.2023.103583>.
- Amanda, K. (2019). Optimasi suhu annealing proses PCR Amplifikasi gen shv bakteri *Escherichia coli* pasien ulkus diabetik. *Jurnal Mahasiswa Farmasi Fakultas Kedokteran UNTAN*, 4(1).
- Anggiani, M., Kristanti, R. A., Hadibarata, T., Kurniati, T. H., & Shiddiq, M. A. (2024). degradation of polypropylene microplastics by a consortium of bacteria colonizing plastic surface waste from Jakarta Bay. *Water, Air, & Soil Pollution*, 235(5), 1-11. <https://doi.org/10.1007/s11270-024-07113-5>.

- Antosik, A. K., Kowalska, U., Stobińska, M., Dzięcioł, P., Pieczykolan, M., Kozłowska, K., & Bartkowiak, A. (2021). Development and characterization of bioactive polypropylene films for food packaging applications. *Polymers*, 13(20), 3478. <https://doi.org/10.3390/polym13203478>.
- Artati, D. (2016). Sensitivitas gel red sebagai pewarna DNA pada gel elektroforesis. *Buletin Teknik Litkayasa Akuakultur*, 11(1), 11-14. <http://dx.doi.org/10.15578/blta.11.1.2013.11-14>.
- Astina, D., Nugroho, T. T., & Linggawati, A. (2017). Penentuan aktivitas enzim laccase *Rhus vernicifera* menggunakan guaiacol sebagai substrat. *Jurnal Penelitian Farmasi Indonesia*, 5(2), 55-62. <https://ejurnal.stifarriau.ac.id/index.php/jpfi/article/view/6>.
- Atanasova, N., Stoitsova, S., Paunova-Krasteva, T., & Kambourova, M. (2021). Plastic degradation by extremophilic bacteria. *International Journal of Molecular Sciences*, 22(11), 5610. <https://doi.org/10.3390/ijms22115610>.
- Auta, H. S., Emenike, C. U., & Fauziah, S. H. (2017). Screening of *Bacillus* strains isolated from mangrove ecosystems in Peninsular Malaysia for microplastic degradation. *Environmental Pollution*, 231, 1552-1559. <https://doi.org/10.1016/j.envpol.2017.09.043>.
- Auta, H. S., Emenike, C. U., Jayanthi, B., & Fauziah, S. H. (2018). Growth kinetics and biodeterioration of polypropylene microplastics by *Bacillus* sp. and *Rhodococcus* sp. isolated from mangrove sediment. *Marine Pollution Bulletin*, 127, 15-21. <https://doi.org/10.1016/j.marpolbul.2017.11.036>.
- Auta, S. H., Emenike, C. U., & Fauziah, S. H. (2017). Screening for polypropylene degradation potential of bacteria isolated from mangrove ecosystems in Peninsular Malaysia. *International Journal of Bioscience, Biochemistry, and Bioinformatics*, 4(4). <https://doi.org/10.17706/ijbbb.2017.7.4.245-251>.
- Azubuike, C. C., Chikere, C. B., & Okpokwasili, G. C. (2016). Bioremediation techniques—classification based on site of application: principles, advantages, limitations and prospects. *World Journal of Microbiology and Biotechnology*, 32, 1-18. <https://doi.org/10.1007/s11274-016-2137-x>.
- Bajt, O. (2021). From plastics to microplastics and organisms. *FEBS Open bio*, 11(4), 954-966. <https://doi.org/10.1002/2211-5463.13120>.
- Basri, K., Syaputra, E. M., & Handayani, S. (2021). Microplastic pollution in waters and its impact on health and environment in Indonesia: a review. *Journal of Public Health for Tropical and Coastal Region*, 4(2), 63-77. <https://doi.org/10.14710/jphtcr.v4i2.10809>.

- Beal, J., Farny, N. G., Haddock-Angelli, T., Selvarajah, V., Baldwin, G. S., Buckley-Taylor, R., Geshater, M., Kiga, D., Marken, J., Sanchania, V., Sison, A., & Workman, C. T. (2020). Robust estimation of bacterial cell count from optical density. *Communication biology*, 3(512). <https://doi.org/10.1038/s42003-020-01127-5>.
- Bora, R. R., Wang, R., & You, F. (2020). Waste polipropilena plastic recycling toward climate change mitigation and circular economy: energy, environmental, and technoeconomic perspectives. *ACS Sustainable Chemistry & Engineering*, 8(43), 16350-16363. <https://dx.doi.org/10.1021/acssuschemeng.0c06311>.
- Chandra, R., & Chowdhary, P. (2015). Properties of bacterial laccases and their application in bioremediation of industrial wastes. *Environmental Science: Processes & Impacts*, 17(2), 326-342. <https://doi.org/10.1039/C4EM00627E>.
- Chauhan, P. S., Goradia, B., & Saxena, A. (2017). Bacterial laccase: recent update on production, properties and industrial applications. *3 Biotech*, 7(5), 323. <https://doi.org/10.1007/s13205-017-0955-7>.
- Cizmar, P., & Yuana, Y. (2017). Detection and characterization of extracellular vesicles by transmission and cryo-transmission electron microscopy. *Extracellular Vesicles: Methods and Protocols*, 221-232. https://doi.org/10.1007/978-1-4939-7253-1_18.
- Colthup, N. B. (2003). Infrared spectroscopy. *Encyclopedia of Physical Science and Technology*, 793-816. <https://doi.org/10.1016/B0-12-227410-5/00340-9>.
- Cortese, I. J., Castrillo, M. L., Onetto, A. L., Bich, G. Á., Zapata, P. D., & Laczeski, M. E. (2021). De novo genome assembly of *Bacillus altitudinis* 19RS3 and *Bacillus altitudinis* T5S-T4, two plant growth-promoting bacteria isolated from *Ilex paraguariensis* St. Hil.(yerba mate). *PloS One*, 16(3), e0248274. <https://doi.org/10.1371/journal.pone.0248274>.
- Da Costa, J. P., Nunes, A. R., Santos, P. S., Girao, A. V., Duarte, A. C., & Rocha-Santos, T. (2018). Degradation of polyethylene microplastics in seawater: insights into the environmental degradation of polymers. *Journal of Environmental Science and Health, Part A*, 53(9), 866-875. <https://doi.org/10.1080/10934529.2018.1455381>.
- De Villalobos, N. F., Costa, M. C., & Marín-Beltrán, I. (2022). A community of marine bacteria with potential to biodegrade petroleum-based and biobased microplastics. *Marine Pollution Bulletin*, 185, 114251. <https://doi.org/10.1016/j.marpolbul.2022.114251>.

- Desalle, R., & Goldstein, P. (2019). Review and interpretation of trends in DNA barcoding. *Frontiers in Ecology and Evolution*, 7, 302. <https://doi.org/10.3389/fevo.2019.00302>.
- Devi, K. N., Raju, P., Santhanam, P., Kumar, S. D., Krishnaveni, N., Roopavathy, J., & Perumal, P. (2021). Biodegradation of low-density polyethylene and polypropylene by microbes isolated from Vaigai River, Madurai, India. *Archives of Microbiology*, 203, 6253-6265. <https://doi.org/10.1007/s00203-021-02592-0>.
- Dhiman, K., & Shirkot, P. (2015). Bioprospecting and molecular characterization of laccase producing bacteria from paper mills of Himachal Pradesh. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 85, 1095-1103. <https://doi.org/10.1007/s40011-015-0541-x>.
- Dini, M. R., Nurcholis, M., Ulfah, M., Sabbathini, G. C., Wulandari, S. R., & Helianti, I. (2024). The Potential of *Bacillus altitudinis* B538 and *Alcaligenes faecalis* B947 in PET and PCL plastic degradation. *HAYATI Journal of Biosciences*, 31(4), 621-629. <https://doi.org/10.4308/hjb.31.4.621-629>.
- Dos Santos, H. R. M., Argolo, C. S., Argôlo-Filho, R. C., & Loguerio, L. L. (2019). A 16S rDNA PCR-based theoretical to actual delta approach on culturable mock communities revealed severe losses of diversity information. *BMC Microbiology*, 19, 1-14. <https://doi.org/10.1186/s12866-019-1446-2>.
- Dussud, C., & Ghiglione, J. F. (2014). Bacterial degradation of synthetic plastics. In *CIESM Workshop Monogr*, 46, 49-54.
- Emenike, C., Adelugba, A., MacDonald, M., Asiedu, S. K., Ofoe, R., & Abbey, L. (2025). A combined effect of mixed multi-microplastic types on growth and yield of tomato. *Microplastics*, 4(1), 5. <https://doi.org/10.3390/microplastics4010005>.
- Evode, N., Qamar, S. A., Bilal, M., Barceló, D., & Iqbal, H. M. (2021). Plastic waste and its management strategies for environmental sustainability. *Case Studies in Chemical and Environmental Engineering*, 4, 100142. <https://doi.org/10.1016/j.cscee.2021.100142>.
- Fitria, A. N., & Zulaika, E. (2019). Aklimatisasi pH dan pola pertumbuhan *Bacillus cereus* S1 pada medium MSM modifikasi. *Jurnal Sains dan Seni ITS*, 7(2), 39-41. <https://doi.org/10.12962/j23373520.v7i2.36788>.
- Fukuda, K., Ogawa, M., Taniguchi, H., & Saito, M. (2016). Molecular approaches to studying microbial communities: targeting the 16S ribosomal RNA

- gene. *Journal of UOEH*, 38(3), 223-232. <https://doi.org/10.7888/juoeh.38.223>.
- Gani, M. A., Tallei, T. E., & Fatimawali, F. (2019). Identifikasi bakteri asam laktat dari hasil fermentasi selada romain (*Lactuca sativa* var. *longifolia* Lam.) menggunakan gen 16S rRNA. *Pharmacon*, 8(1), 57-64. <https://doi.org/10.35799/pha.8.2019.29237>.
- Gao, S., Jin, W., Quan, Y., Li, Y., Shen, Y., Yuan, S., Yi, L., Wang, Y., & Wang, Y. (2024). Bacterial capsules: Occurrence, mechanism, and function. *npj Biofilms and Microbiomes*, 10(1), 21. <https://doi.org/10.1038/s41522-024-00497-6>.
- Garibyan, L., & Avashia, N. (2013). Research techniques made simple: polymerase chain reaction (PCR). *The Journal of Investigative Dermatology*, 133(3), e6. <https://doi.org/10.1038/jid.2013.1>.
- Gewert, B., Plassmann, M. M., & MacLeod, M. (2015). Pathways for degradation of plastic polymers floating in the marine environment. *Environmental Science: Processes & Impacts*, 17(9), 1513-1521. <https://doi.org/10.1039/c5em00207a>.
- Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, 3(7), e1700782. <https://doi.org/10.1126/sciadv.1700782>.
- Giacomucci, L., Raddadi, N., Soccio, M., Lotti, N., & Fava, F. (2019). Polyvinyl chloride biodegradation by *Pseudomonas citronellolis* and *Bacillus flexus*. *New Biotechnology*, 52, 35-41. <https://doi.org/10.1016/j.nbt.2019.04.005>.
- Goyal, T., Singh, S., Das Gupta, G., & Verma, S. K. (2023). Microplastics in environment: a comprehension on sources, analytical detection, health concerns, and remediation. *Environmental Science and Pollution Research*, 30(54), 114707-114721. <https://doi.org/10.1007/s11356-023-30526-4>.
- Gupta, R. S., Patel, S., Saini, N., & Chen, S. (2020). Robust demarcation of 17 distinct *Bacillus* species clades, proposed as novel Bacillaceae genera, by phylogenomics and comparative genomic analyses: description of *Robertmurraya kyonggiensis* sp. nov. and proposal for an emended genus *Bacillus* limiting it only to the members of the *Subtilis* and *Cereus* clades of species. *International Journal of Systematic and Evolutionary Microbiology*, 70(11), 5753-5798. <https://doi.org/10.1099/ijsem.0.004475>.
- Habib, S., Iruthayam, A., Shukor, M. Y. A., Alias, S. A., Smykla, J., & Yasid, N. A. (2020). Biodeterioration of untreated polypropylene microplastic

- particles by antarctic bacteria. *Polymers*, 12(11), 1–12. <https://doi.org/10.3390/polym12112616>.
- Hakulinen, N., & Rouvinen, J. (2015). Three-dimensional structures of laccases. *Cellular and Molecular Life Sciences*, 72, 857-868. <https://doi.org/10.1007/s00018-014-1827-5>.
- Harrison, J. P., Boardman, C., O'Callaghan, K., Delort, A. M., & Song, J. (2018). Biodegradability standards for carrier bags and plastic films in aquatic environments: a critical review. *Royal Society Open Science*, 5(5), 171792. <https://doi.org/10.1098/rsos.171792>.
- Heins, A., & Harder, J. (2023). Particle-associated bacteria in seawater dominate the colony-forming microbiome on ZoBell marine agar. *FEMS Microbiology Ecology*, 99(1), 151. <https://doi.org/10.1093/femsec/fiac151>.
- Hernández-González, I. L., Moreno-Hagelsieb, G., & Olmedo-Álvarez, G. (2018). Environmentally-driven gene content convergence and the *Bacillus* phylogeny. *BMC Evolutionary Biology*, 18, 1-15. <https://doi.org/10.1186/s12862-018-1261-7>.
- Hidayat, I., Laili, N., Agustiyani, D., & Antonius, S. (2019). PCR-based specific detection of *Bacillus* in liquid organic fertilizer. *Journal of Microbial Systematics and Biotechnology*, 1(1), 44-47. <https://doi.org/10.37604/jmsb.v1i1.21>.
- Horiike, T. (2016). An introduction to molecular phylogenetic analysis. *Reviews in Agricultural Science*, 4, 36-45. https://doi.org/10.7831/ras.4.0_36.
- Hossain, M. T., Shahid, M. A., Mahmud, N., Habib, A., Rana, M. M., Khan, S. A., & Hossain, M. D. (2024). Research and application of polypropylene: a review. *Discover Nano*, 19(1), 2. <https://doi.org/10.1186/s11671-023-03952-z>.
- Hossain, S., Shukri, Z. N. A., Waiho, K., Ibrahim, Y. S., Kamaruzzan, A. S., Rahim, A. I. A., Draman, A. S., Wahab, W., Khatoon, H., & Kasan, N. A. (2024). Biodegradation of polyethylene (PE), polypropylene (PP), and polystyrene (PS) microplastics by floc-forming bacteria, *Bacillus cereus* strain SHBF2, isolated from a commercial aquafarm. *Environmental Science and Pollution Research*, 1-21. <https://doi.org/10.1007/s11356-024-33337-3>.
- Huang, H., Wang, F., Ma, S., Yuan, X., Li, J., Chen, H., Yuan, R., Luo, S., & Gai, N. (2024). The Aquatic Plasticsphere: Methodology, Biofilm Formation Mechanism, and Microbial Diversity. *Reviews of Environmental Contamination and Toxicology*, 262(1), 15. <https://doi.org/10.1007/s44169-024-00063-3>.

- Jain, K., Bhunia, H., & Sudhakara Reddy, M. (2018). Degradation of polipropilena-poly-L-lactide blend by bacteria isolated from compost. *Bioremediation Journal*, 22(3-4), 73-90. <https://doi.org/10.1080/10889868.2018.1516620>.
- Jeon, J. M., Park, S. J., Choi, T. R., Park, J. H., Yang, Y. H., & Yoon, J. J. (2021). Biodegradation of polyethylene and polypropylene by *Lysinibacillus* species JJY0216 isolated from soil grove. *Polymer Degradation and Stability*, 191, 109662. <https://doi.org/10.1016/j.polymdegradstab.2021.109662>.
- Johnson, J. S., Spakowicz, D. J., Hong, B. Y., Petersen, L. M., Demkowicz, P., Chen, L., Leopold, S. R., Hanson, B. M., Agresta, H. O., Gerstein, M., Sodergrenz E., & Weinstock, G. M. (2019). Evaluation of 16S rRNA gene sequencing for species and strain-level microbiome analysis. *Nature Communications*, 10(1), 5029. <https://doi.org/10.1038/s41467-019-13036-1>.
- Kaur, J. (2021). Interferring Evolutionary Distance Using Kimura's Two Parameter Method. *International Journal of Research in Engineering and Science (IJRES)*, 9(10), 75-81. ISSN: 2320-9364.
- Khalaj, M. J., Ahmadi, H., Lesankhosh, R., & Khalaj, G. (2016). Study of physical and mechanical properties of polypropylene nanocomposites for food packaging application: Nano-clay modified with iron nanoparticles. *Trends in Food Science & Technology*, 51, 41-48. <https://doi.org/10.1016/j.tifs.2016.03.007>.
- Khan, S. I., Sahinkaya, M., Colak, D. N., Zada, N. S., Uzuner, U., Belduz, A. O., Canakci, S., Khan, A. Z., Khan, S., Badshah, M., & Shah, A. A. (2024). Production and characterization of novel thermostable CotA-laccase from *Bacillus altitudinis* SL7 and its application for lignin degradation. *Enzyme and Microbial Technology*, 172, 110329. <https://doi.org/https://doi.org/10.1016/j.enzmictec.2023.110329>.
- Khandare, S. D., Chaudhary, D. R., & Jha, B. (2021). Marine bacterial biodegradation of low-density polyethylene (LDPE) plastic. *Biodegradation*, 32(2), 127-143. <https://doi.org/10.1007/s10532-021-09927-0>.
- Khoironi, A., Hadiyanto, H., Anggoro, S., & Sudarno, S. (2020). Evaluation of polipropilena plastic degradation and microplastic identification in sediments at Tambak Lorok coastal area, Semarang, Indonesia. *Marine Pollution Bulletin*, 151, 110868. <https://doi.org/10.1016/j.marpolbul.2019.110868>.
- Kurniati, T. H., Syahbani, N., & Rahayu, S. (2024). Screening and identification of exopolysaccharide-producing bacteria from pickled fruit. In *AIP*

- Conference Proceedings*, 2982(1), 050016.
<https://doi.org/10.1063/5.0184140>.
- Lin, Z., Jin, T., Zou, T., Xu, L., Xi, B., Xu, D., He, J., Xiong, L., Tang, C., Peng, J., Zhou, Y., & Fei, J. (2022). Current progress on plastic/microplastic degradation: Fact influences and mechanism. *Environmental Pollution*, 304, 119159. <https://doi.org/10.1016/j.envpol.2022.119159>.
- Liu, H., Tian, L., Qu, M., & Wang, D. (2021). Acetylation regulation associated with the induction of protective response to polystyrene nanoparticles in *Caenorhabditis elegans*. *Journal of Hazardous Materials*, 411, 125035. <https://doi.org/10.1016/j.jhazmat.2020.125035>.
- López-Aladid, R., Fernández-Barat, L., Alcaraz-Serrano, V., Bueno-Freire, L., Vázquez, N., Pastor-Ibáñez, R., Palomeque, A., Oscanoa, P., & Torres, A. (2023). Determining the most accurate 16S rRNA hypervariable region for taxonomic identification from respiratory samples. *Scientific Reports*, 13(1), 3974. <https://doi.org/10.1038/s41598-023-30764-z>.
- Lv, S., Li, Y., Zhao, S., & Shao, Z. (2024). Biodegradation of typical plastics: from microbial diversity to metabolic mechanisms. *International Journal of Molecular Sciences*, 25(1), 593. <https://doi.org/10.3390/ijms25010593>.
- Mirzaei, M. (2020). Hydrogen bond interactions of nucleobases: a quick review. *Lab-in-Silico*, 1(2), 61-66. <https://doi.org/10.22034/labinsilico20012061>.
- Maity, S., Banerjee, S., Biswas, C., Guchhait, R., Chatterjee, A., & Pramanick, K. (2021). Functional interplay between plastic polymers and microbes: a comprehensive review. *Biodegradation*, 32(5), 487-510. <https://doi.org/10.1007/s10532-021-09954-x>.
- Manalu, A. A., Hariyadi, S., & Wardiatno, Y. (2017). Microplastics abundance in coastal sediments of Jakarta Bay, Indonesia. *Aquaculture, Aquarium, Conservation & Legislation*, 10(5), 1164-1173.
- Markowicz, F., & Szymańska-Pulikowska, A. (2021). Assessment of the decomposition of Oxo-and Biodegradable packaging using FTIR spectroscopy. *Materials*, 14(21), 6449. <https://doi.org/10.3390/ma14216449>.
- Minami, M., & Takase, H. (2017). Comparative investigation of alternative negative staining reagents in bacterial morphological study. *Journal of Biosciences and Medicines*, 5(10), 17-24. <https://doi.org/10.4236/jbm.2017.510002>.

- Mohan, A. J., Sekhar, V. C., Bhaskar, T., & Nampoothiri, K. M. (2016). Microbial assisted high impact polystyrene (HIPS) degradation. *Bioresource Technology*, 213, 204-207. <https://doi.org/10.1016/j.biortech.2016.03.021>.
- Mohanan, N., Montazer, Z., Sharma, P. K., & Levin, D. B. (2020). Microbial and enzymatic degradation of synthetic plastics. *Frontiers in Microbiology*, 11, 580709. <https://doi.org/10.3389/fmicb.2020.580709>.
- Moka, W. (2020). Pentingnya pendekatan molekuler dalam pengelolaan sumberdaya perairan. *Jurnal Pengelolaan Perairan*, 3(2). e-ISSN: 2620-6552.
- Montazer, Z., Habibi Najafi, M. B., & Levin, D. B. (2020). Challenges with verifying microbial degradation of polyethylene. *Polymers*, 12(1), 123. <https://doi.org/10.3390/polym12010123>.
- Mosolygó, T., Laczi, K., Spengler, G., & Burján, K. (2022). A practical approach for quantitative polymerase chain reaction, the gold standard in microbiological diagnosis. *Sci*, 4(1), 4. <https://doi.org/10.3390/sci4010004>.
- Moumen, A., Laabid, Z., Lakhdar, A., & Mansouri, K. (2021). Prediction of the mechanical properties of polypropylene reinforced with snail shell powder with a deep neural network model and the finite element method. *IOP Conference Series: Materials Science and Engineering*, 1126(1), 012009. <http://dx.doi.org/10.1088/1757-899X/1126/1/012009>.
- Moyes, R. B., Reynolds, J., & Breakwell, D. P. (2009). Preliminary staining of bacteria: negative stain. *Current protocols in microbiology*, 15(1), A-3F. <https://doi.org/10.1002/9780471729259.mca03fs15>.
- Mulchandani, N., & Narayan, R. (2023). Redesigning Carbon–Carbon Backbone Polymers for Biodegradability–Compostability at the End-of-Life Stage. *Molecules*, 28(9), 3832. <https://doi.org/10.3390/molecules28093832>.
- Nakano, Y., Domon, Y., & Yamagishi, K. (2023). Phylogenetic trees of closely related bacterial species and subspecies based on frequencies of short nucleotide sequences. *Plos One*, 18(4), e0268847. <https://doi.org/10.1371/journal.pone.0268847>.
- Nasreen. (2022). Ocean Salinity. *International Journal for Modern Trends in Science and Technology*, 8, 296-302. <https://doi.org/10.46501/IJMTST0801052>.
- Nestorov, J., Matić, G., Elaković, I., & Tanić, N. (2013). Gene expression studies: How to obtain accurate and reliable data by quantitative real-time RT

- PCR. *Journal of Medical Biochemistry*, 32(4), 325-338.
<https://doi.org/10.2478/jomb-2014-0001>.
- Newell, P. D., Fricker, A. D., Roco, C. A., Chandrangs, P., & Merkel, S. M. (2013). A small-group activity introducing the use and interpretation of BLAST. *Journal of Microbiology & Biology Education*, 14(2), 238-243. <https://doi.org/10.1128/jmbe.v14i2.637>.
- Nimkande, V. D., Sivanesan, S., & Bafana, A. (2023). Screening, identification, and characterization of lipase-producing halotolerant *Bacillus altitudinis* Ant19 from Antarctic soil. *Archives of Microbiology*, 205(4), 113. <https://doi.org/10.1007/s00203-023-03453-8>.
- Noer, S. (2021). Identifikasi Bakteri secara Molekular Menggunakan 16S rRNA. *EduBiologia: Biological Science and Education Journal*, 1(1), 1-6. <http://dx.doi.org/10.30998/edubiologia.v1i1.8596>.
- Nwaokorie, F. O., Ameh, P. O., Ayanbadejo, P. O., & Atat, P. U. (2020). 16S rRNA gene sequence analysis of anaerobic streptococcal isolates from patients with chronic periodontitis. *African Journal of Biomedical Research*, 23(3), 343-350. e-ISSN: 1119-5096.
- Oliynyk, R. T., & Church, G. M. (2022). Efficient modification and preparation of circular DNA for expression in cell culture. *Communications Biology*, 5(1), 1393. <https://doi.org/10.1038/s42003-022-04363-z>.
- Ong, G. H., Kee, W. K., Ahmed, R. D. A. H., Ying, J. K. N. Z., Rui, W. R., Er, L. K., & Tanee, T. (2024). Degradation of Polipropilena Using Fungal Enzyme As A Sustainable Approach To Management Plastic Waste. *Malaysian Applied Biology*, 53(2), 93-100. <https://doi.org/10.55230/mabjournal.v53i2.2819>.
- Othman, A. R., Hasan, H. A., Muhamad, M. H., Ismail, N. I., & Abdullah, S. R. S. (2021). Microbial degradation of microplastics by enzymatic processes: a review. *Environmental Chemistry Letters*, 19, 3057-3073. <https://doi.org/10.1007/s10311-021-01197-9>.
- Pal, A. K., Singh, J., Soni, R., Tripathi, P., Kamle, M., Tripathi, V., & Kumar, P. (2020). The role of microorganism in bioremediation for sustainable environment management. In *Bioremediation of Pollutants*, 227-249. <https://doi.org/10.1016/B978-0-12-819025-8.00010-7>.
- Pangestika, Y., Budiharjo, A., & Kusumaningrum, H. P. (2015). Analisis filogenetik *Curcuma zedoaria* (temu putih) berdasarkan gen *internal transcribed spacer* (ITS). *Jurnal Akademika Biologi*, 4(4), 8-13. <https://ejournal3.undip.ac.id/index.php/biologi/about/editorialPolicies#openAccessPolicy>.

- Poursat, B. A., van Spanning, R. J., de Voogt, P., & Parsons, J. R. (2019). Implications of microbial adaptation for the assessment of environmental persistence of chemicals. *Critical Reviews in Environmental Science and Technology*, 49(23), 2220-2255. <https://doi.org/10.1080/10643389.2019.1607687>.
- Pramila, R., & Ramesh, K. V. (2011). Biodegradation of low density polyethylene (LDPE) by fungi isolated from marine water a SEM analysis. *Afr J Microbiol Res*, 5(28), 5013-5018. <https://doi.org/10.5897/AJMR11.670>.
- Raddadi, N., & Fava, F. (2019). Biodegradation of oil-based plastics in the environment: existing knowledge and needs of research and innovation. *Science of the Total Environment*, 679, 148-158. <https://doi.org/10.1016/j.scitotenv.2019.04.419>.
- Rahman, M. T., Uddin, M. S., Sultana, R., Moue, A., & Setu, M. (2013). Polymerase chain reaction (PCR): a short review. *Anwer Khan Modern Medical College Journal*, 4(1), 30-36. <https://doi.org/10.3329/akmmcj.v4i1.13682>.
- Rampazzo, F., Calace, N., Formalewicz, M., Noventa, S., Gion, C., Bongiorni, L., Lazzari, A. D., Causin, V., & Berto, D. (2023). An FTIR and EA-IRMS Application to the Degradation Study of Compostable Plastic Bags in the Natural Marine Environment. *Applied Sciences*, 13(19), 10851. <https://doi.org/10.3390/app131910851>.
- Rana, A. K., Thakur, M. K., Saini, A. K., Mokhta, S. K., Moradi, O., Rydzkowski, T., Alsanie, W. F., Wang, Q., Grammatikos, S., & Thakur, V. K. (2022). Recent developments in microbial degradation of polipropilena: Integrated approaches towards a sustainable environment. *Science of The Total Environment*, 826, 154056. <https://doi.org/10.1016/j.scitotenv.2022.154056>.
- Ray, A. S., Rajasekaran, M., Uddin, M., & Kandasamy, R. (2023). Laccase driven biocatalytic oxidation to reduce polymeric surface hydrophobicity: an effective pre-treatment strategy to enhance biofilm mediated degradation of polyethylene and polycarbonate plastics. *Science of The Total Environment*, 904, 166721. <https://doi.org/10.1016/j.scitotenv.2023.166721>.
- Ratzke, C., & Gore, J. (2018). Modifying and reacting to the environmental pH can drive bacterial interactions. *PLoS biology*, 16(3), e2004248. <https://doi.org/10.1371/journal.pbio.2004248>.
- Roohi, Bano, K., Kuddus, M., Zaheer, M. R., Zia, Q., Khan, M. F., Ashraf, G. M., Anamika, G., & Aliev, G. (2017). Microbial enzymatic degradation of

- biodegradable plastics. *Current Pharmaceutical Biotechnology*, 18(5), 429-440. <https://doi.org/10.2174/138920101866170523165742>.
- Ru, J., Huo, Y., & Yang, Y. (2020). Microbial degradation and valorization of plastic wastes. *Frontiers in Microbiology*, 11, 507487. <https://doi.org/10.3389/fmicb.2020.00442>.
- Russo, C. A. D. M., & Selvatti, A. P. (2018). Bootstrap and rogue identification tests for phylogenetic analyses. *Molecular Biology and Evolution*, 35(9), 2327-2333. <https://doi.org/10.1093/molbev/msy118>.
- Saeed, Z. K., Abbas, B. A., & Othman, R. M. (2020). Molecular identification and phylogenetic analysis of lactic acid bacteria isolated from goat raw milk. *Iraqi Journal of Veterinary Sciences*, 34(2), 259-263. <https://doi.org/10.33899/ijvs.2019.125896.1176>.
- Santosa, A. I., Hilmany, T., Dewi, N. A., Rahmawati, N. E., Putri, E. A., Hafidsya, T., Setyaningrum, A. V., Dewi, R. E., Sari, G. N. P., Nubatonis, M. B. F. M., Widyawan, A., & Widyawan, A. (2024). Cross amplification of 16S rRNA bacterial primer 27F/1492R on horticultural crop chloroplast genome. *Agricultural Science*, 7(2), 172-183. <https://doi.org/10.55173/agriscience.v7i2.132>.
- Sari, G. L., Kasasiah, A., Utami, M. R., & Trihadiningrum, Y. (2021). Microplastics contamination in the aquatic environment of Indonesia: a comprehensive review. *Journal of Ecological Engineering*, 22(10), 127-140. <https://doi.org/10.12911/22998993/142118>.
- Sekhar, V. C., Nampoothiri, K. M., Mohan, A. J., Nair, N. R., Bhaskar, T., & Pandey, A. (2016). Microbial degradation of high impact polystyrene (HIPS), an e-plastic with decabromodiphenyl oxide and antimony trioxide. *Journal of Hazardous Materials*, 318, 347-354. <https://doi.org/10.1016/j.jhazmat.2016.07.008>.
- Shvartsman, E., Richmond, M. E., Schellenberg, J. J., Lamont, A., Perciani, C., Russell, J. N., Poliquin, V., Burgener, A., Jaoko, W., Sandstrom, P., & MacDonald, K. S. (2022). Comparative analysis of DNA extraction and PCR product purification methods for cervicovaginal microbiome analysis using cpn 60 microbial profiling. *Plos One*, 17(1), e0262355. <https://doi.org/10.1371/journal.pone.0262355>.
- Simon, C. (2022). An evolving view of phylogenetic support. *Systematic Biology*, 71(4), 921-928. <https://doi.org/10.1093/sysbio/syaa068>.
- Speight, J. G. (2020). Monomers, polymers, and plastics. *Handbook of Industrial Hydrocarbon Processes*, 499-537.

- Sun, X. L., Xiang, H., Xiong, H. Q., Fang, Y. C., & Wang, Y. (2023). Bioremediation of microplastics in freshwater environments: a systematic review of biofilm culture, degradation mechanisms, and analytical methods. *Science of The Total Environment*, 863, 160953. <https://doi.org/10.1016/j.scitotenv.2022.160953>.
- Tamnou, E. B. M., Arfao, A. T., Nougang, M. E., Metsopkeng, C. S., Ewoti, O. V. N., Moungang, L. M., Nana, P. N., Takang-Rtta, L. R. A., Perriere, F., Sime-Ngando, T., & Nola, M. (2021). Biodegradation of polyethylene by the bacterium *Pseudomonas aeruginosa* in acidic aquatic microcosm and effect of the environmental temperature. *Environmental Challenges*, 3, 100056. <https://doi.org/10.1016/j.envc.2021.100056>.
- Thakur, B., Singh, J., Singh, J., Angmo, D., & Vig, A. P. (2023). Biodegradation of different types of microplastics: Molecular mechanism and degradation efficiency. *Science of The Total Environment*, 877, 162912. <https://doi.org/10.1016/j.scitotenv.2023.162912>.
- Umar, A., & Ahmed, S. (2022). Optimization, purification and characterization of laccase from *Ganoderma leucocontextum* along with its phylogenetic relationship. *Scientific Reports*, 12(1), 2416. <https://doi.org/10.1038/s41598-022-06111-z>.
- Viel, T., Manfra, L., Zupo, V., Libralato, G., Cocca, M., & Costantini, M. (2023). Biodegradation of plastics induced by marine organisms: future perspectives for bioremediation approaches. *Polymers*, 15(12), 2673. <https://doi.org/10.3390/polym15122673>.
- Vertommen, M. A. M. E., Nierstrasz, V. A., Van Der Veer, M., & Warmoeskerken, M. M. C. G. (2005). Enzymatic surface modification of poly (ethylene terephthalate). *Journal of Biotechnology*, 120(4), 376-386. <https://doi.org/10.1016/j.jbiotec.2005.06.015>.
- Waechter, C., Fehse, L., Welzel, M., Heider, D., Babalija, L., Cheko, J., Mueller, J., Poling, J., Braun, T., Pankweit, S., Weihe, E., Kinscherf, R., Schieffer, B., Luesebrink, U., Soufi, M., & Ruppert, V. (2023). Comparative analysis of full-length 16s ribosomal RNA genome sequencing in human fecal samples using primer sets with different degrees of degeneracy. *Frontiers in Genetics*, 14, 1213829. <https://doi.org/10.3389/fgene.2023.1213829>.
- Weinstein, J.E., Crocker, B.K., Gray, A.D., 2016. From macroplastics to microplastics: degradation of high-density polyethylene, polypropylene and polystyrene in a salt marsh habitat. *Environ. Toxicol. Chem.* 35(7), 1632–1640. <http://dx.doi.org/10.1002/etc.3432>.
- Widyadnyana, D. G. A., Sukrama, I. D. M., & Suardana, I. W. (2015). Identifikasi bakteri asam laktat isolat 9A dari kolon sapi bali sebagai probiotik melalui

- analisis gen 16S rRNA. *Jurnal Sains Veteriner*, 33(2). <https://doi.org/10.22146/jsv.17923>.
- Wijayanti, M., Jubaedah, D., Suhada, J. A., Yuliani, S., Saraswati, N., Syaifudin, M., & Widjajanti, H. (2018). DNA barcoding of swamp sediment bacterial isolates for swamp aquaculture probiotic. In *E3S Web of Conferences*, 68, 01023. <https://doi.org/10.1051/e3sconf/201868010>.
- Wittmeier, P., & Hummel, S. (2022). Agarose gel electrophoresis to assess PCR product yield: comparison with spectrophotometry, fluorometry and qPCR. *Biotechniques*, 72(4), 155-158. <https://doi.org/10.2144/btn-2021-0094>.
- Wróbel, M., Szymańska, S., Kowalkowski, T., & Hrynkiewicz, K. (2023). Selection of microorganisms capable of polyethylene (PE) and polypropylene (PP) degradation. *Microbiological Research*, 267, 127251. <https://doi.org/10.1016/j.micres.2022.127251>.
- Wu, X., Gu, Y., Wu, X., Zhou, X., Zhou, H., Amanze, C., Shen, L., & Zeng, W. (2020). Construction of a tetracycline degrading bacterial consortium and its application evaluation in laboratory-scale soil remediation. *Microorganisms*, 8(2), 292. <https://doi.org/10.3390/microorganisms8020292>.
- Xiang, P., Zhang, T., Wu, Q., & Li, Q. (2023). Systematic review of degradation processes for microplastics: Progress and prospects. *Sustainability*, 15(17), 12698. <https://doi.org/10.3390/su151712698>.
- Yuan, J., Ma, J., Sun, Y., Zhou, T., Zhao, Y., & Yu, F. (2020). Microbial degradation and other environmental aspects of microplastics/plastics. *Science of the Total Environment*, 715, 136968. <https://doi.org/10.1016/j.scitotenv.2020.136968>.
- Yuenleni, Y. (2019). Langkah – langkah optimasi PCR. *Indonesian Journal of Laboratory*, 1(3), 51-56. <https://doi.org/10.22146/ijl.v1i3.48723>.
- Zeenat, Elahi, A., Bukhari, D. A., Shamim, S., & Rehman, A. (2021). Plastics degradation by microbes: a sustainable approach. *Journal of King Saud University-Science*, 33(6), 101538. <https://doi.org/10.1016/j.jksus.2021.101538>.
- Zhang, N., Ding, M., & Yuan, Y. (2022). Current advances in biodegradation of polyolefins. *Microorganisms*, 10(8), 1537. <https://doi.org/10.3390/microorganisms10081537>.
- Zhang, Y., Pedersen, J. N., Eser, B. E., & Guo, Z. (2022). Biodegradation of polyethylene and polystyrene: From microbial deterioration to enzyme

discovery. *Biotechnology Advances*, 60, 107991.
<https://doi.org/10.1016/j.biotechadv.2022.107991>.

Ziani, K., Ioniță-Mîndrican, C. B., Mititelu, M., Neacșu, S. M., Negrei, C., Moroșan, E., Drăgănescu, D., & Preda, O. T. (2023). Microplastics: a real global threat for environment and food safety: a state of the art review. *Nutrients*, 15(3), 617. <https://doi.org/10.3390/nu15030617>.

