มีการอ้างอิงบทความวิจัย "Artificial Neural Network Model to Prediction of Eutrophication and Microcystis Aeruginosa Bloom" ตั้งแต่ 1 ตุลาคม 2568 – 28 กุมภาพันธ์ 2569 จำนวน 1 บทความ

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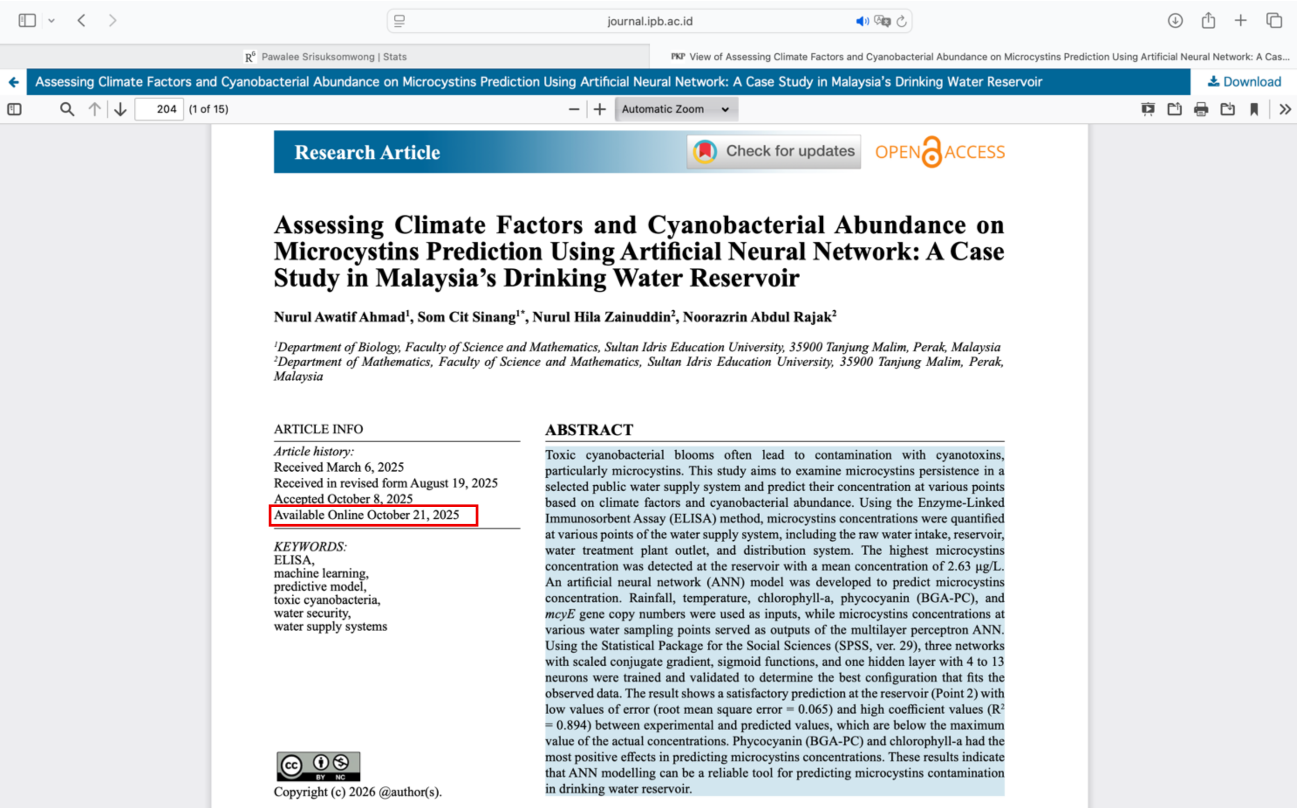

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Assessing Climate Factors and Cyanobacterial Abundance on Microcystins Prediction Using Artificial Neural Network: A Case Study in Malaysia's Drinking Water Reservoir

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ARTICLE INFO

Article history:
Received March 6, 2025
Received in revised form August 19, 2025
Accepted October 8, 2025
Available Online October 21, 2025

KEYWORDS:
ELISA,
machine learning,
predictive model,
toxic cyanobacteria,
water security,
water supply systems

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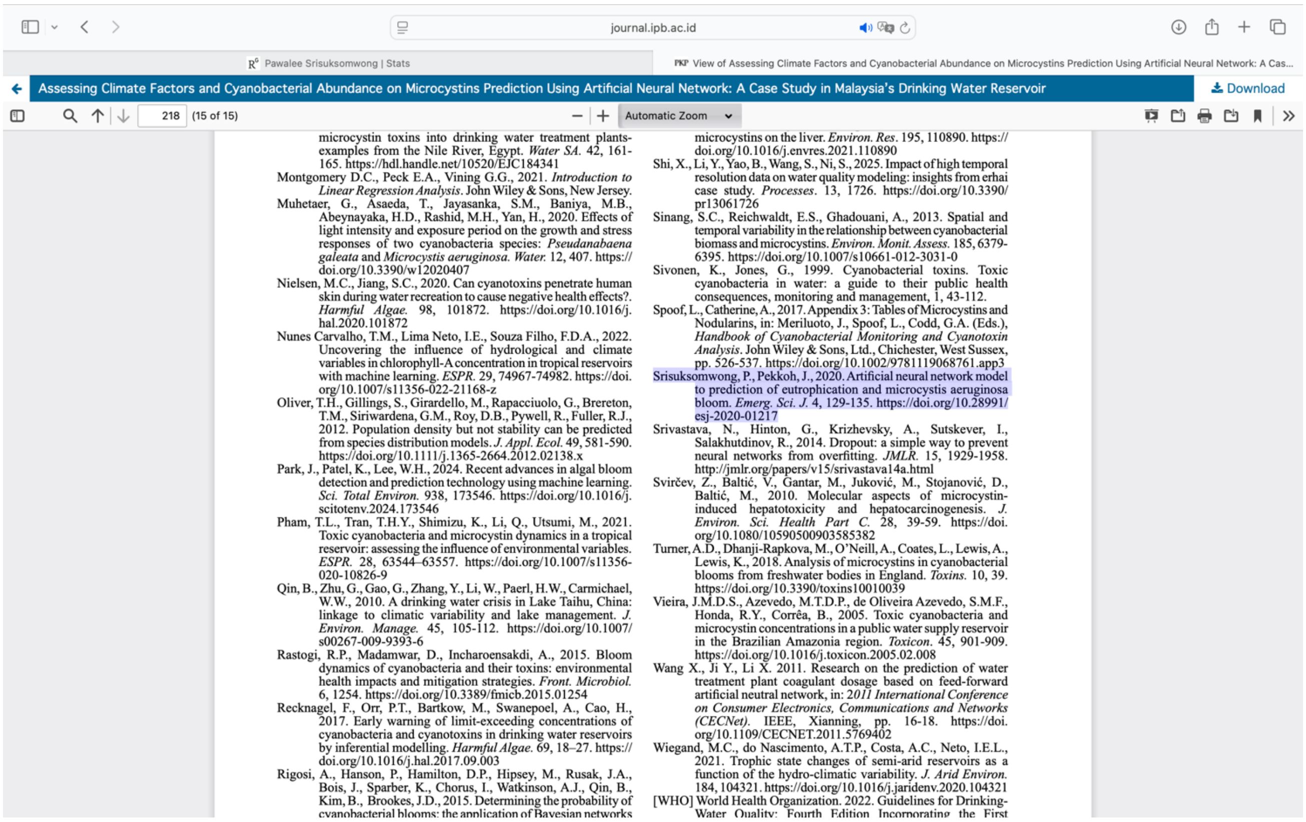
ABSTRACT

Toxic cyanobacterial blooms often lead to contamination with cyanotoxins, particularly microcystins. This study aims to examine microcystins persistence in a selected public water supply system and predict their concentration at various points based on climate factors and cyanobacterial abundance. Using the Enzyme-Linked Immunosorbent Assay (ELISA) method, microcystins concentrations were quantified at various points of the water supply system, including the raw water intake, reservoir, water treatment plant outlet, and distribution system. The highest microcystins concentration was detected at the reservoir with a mean concentration of 2.63 µg/L. An artificial neural network (ANN) model was developed to predict microcystins concentration. Rainfall, temperature, chlorophyll-a, phycocyanin (BGA-PC), and *mcyE* gene copy numbers were used as inputs, while microcystins concentrations at various water sampling points served as outputs of the multilayer perceptron ANN. Using the Statistical Package for the Social Sciences (SPSS, ver. 29), three networks with scaled conjugate gradient, sigmoid functions, and one hidden layer with 4 to 13 neurons were trained and validated to determine the best configuration that fits the observed data. The result shows a satisfactory prediction at the reservoir (Point 2) with low values of error (root mean square error = 0.065) and high coefficient values (R^2 = 0.894) between experimental and predicted values, which are below the maximum value of the actual concentrations. Phycocyanin (BGA-PC) and chlorophyll-a had the most positive effects in predicting microcystins concentrations. These results indicate that ANN modelling can be a reliable tool for predicting microcystins contamination in drinking water reservoir.



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microcystin toxins into drinking water treatment plants-examples from the Nile River, Egypt. *Water SA*. 42, 161-165. https://hdl.handle.net/10520/EJC184341
Montgomery D.C., Peck E.A., Vining G.G., 2021. *Introduction to Linear Regression Analysis*. John Wiley & Sons, New Jersey.
Muhetaer, G., Asaeda, T., Jayasanka, S.M., Baniya, M.B., Abeynayaka, H.D., Rashid, M.H., Yan, H., 2020. Effects of light intensity and exposure period on the growth and stress responses of two cyanobacteria species: *Pseudanabaena galeata* and *Microcystis aeruginosa*. *Water*. 12, 407. https://doi.org/10.3390/w12020407
Nielsen, M.C., Jiang, S.C., 2020. Can cyanotoxins penetrate human skin during water recreation to cause negative health effects?. *Harmful Algae*. 98, 101872. https://doi.org/10.1016/j.hal.2020.101872
Nunes Carvalho, T.M., Lima Neto, I.E., Souza Filho, F.D.A., 2022. Uncovering the influence of hydrological and climate variables in chlorophyll-A concentration in tropical reservoirs with machine learning. *ESPR*. 29, 74967-74982. https://doi.org/10.1007/s11356-022-21168-z
Oliver, T.H., Gillings, S., Girardello, M., Rapacciuolo, G., Brereton, T.M., Siriwardena, G.M., Roy, D.B., Pywell, R., Fuller, R.J., 2012. Population density but not stability can be predicted from species distribution models. *J. Appl. Ecol*. 49, 581-590. https://doi.org/10.1111/j.1365-2664.2012.02138.x
Park, J., Patel, K., Lee, W.H., 2024. Recent advances in algal bloom detection and prediction technology using machine learning. *Sci. Total Environ*. 938, 173546. https://doi.org/10.1016/j.scitotenv.2024.173546
Pham, T.L., Tran, T.H.Y., Shimizu, K., Li, Q., Utsumi, M., 2021. Toxic cyanobacteria and microcystin dynamics in a tropical reservoir: assessing the influence of environmental variables. *ESPR*. 28, 63544–63557. https://doi.org/10.1007/s11356-020-10826-9
Qin, B., Zhu, G., Gao, G., Zhang, Y., Li, W., Paerl, H.W., Carmichael, W.W., 2010. A drinking water crisis in Lake Taihu, China: linkage to climatic variability and lake management. *J. Environ. Manage*. 45, 105-112. https://doi.org/10.1007/s00267-009-9393-6
Rastogi, R.P., Madamwar, D., Incharoensakdi, A., 2015. Bloom dynamics of cyanobacteria and their toxins: environmental health impacts and mitigation strategies. *Front. Microbiol*. 6, 1254. https://doi.org/10.3389/fmicb.2015.01254
Recknagel, F., Orr, P.T., Bartkow, M., Swanepoel, A., Cao, H., 2017. Early warning of limit-exceeding concentrations of cyanobacteria and cyanotoxins in drinking water reservoirs by inferential modelling. *Harmful Algae*. 69, 18–27. https://doi.org/10.1016/j.hal.2017.09.003
Rigosi, A., Hanson, P., Hamilton, D.P., Hipsey, M., Rusak, J.A., Bois, J., Sparber, K., Chorus, I., Watkinson, A.J., Qin, B., Kim, B., Brookes, J.D., 2015. Determining the probability of cyanobacterial blooms: the application of Bayesian networks
microcystins on the liver. *Environ. Res*. 195, 110890. https://doi.org/10.1016/j.envres.2021.110890
Shi, X., Li, Y., Yao, B., Wang, S., Ni, S., 2025. Impact of high temporal resolution data on water quality modeling: insights from erhai case study. *Processes*. 13, 1726. https://doi.org/10.3390/pr13061726
Sinang, S.C., Reichwaldt, E.S., Ghadouani, A., 2013. Spatial and temporal variability in the relationship between cyanobacterial biomass and microcystins. *Environ. Monit. Assess*. 185, 6379-6395. https://doi.org/10.1007/s10661-012-3031-0
Sivonen, K., Jones, G., 1999. Cyanobacterial toxins. Toxic cyanobacteria in water: a guide to their public health consequences, monitoring and management, 1, 43-112.
Spoof, L., Catherine, A., 2017. Appendix 3: Tables of Microcystins and Nodularins, in: Meriluoto, J., Spoof, L., Codd, G.A. (Eds.), *Handbook of Cyanobacterial Monitoring and Cyanotoxin Analysis*. John Wiley & Sons, Ltd., Chichester, West Sussex, pp. 526-537. https://doi.org/10.1002/9781119068761.app3
Srisuksomwong, P., Pekkoh, J., 2020. Artificial neural network model to prediction of eutrophication and microcystis aeruginosa bloom. *Emerg. Sci. J*. 4, 129-135. https://doi.org/10.28991/esj-2020-01217
Srivastava, N., Hinton, G., Krizhevsky, A., Sutskever, I., Salakhutdinov, R., 2014. Dropout: a simple way to prevent neural networks from overfitting. *JMLR*. 15, 1929-1958. http://jmlr.org/papers/v15/srivastava14a.html
Svirčev, Z., Baltić, V., Gantar, M., Juković, M., Stojanović, D., Baltić, M., 2010. Molecular aspects of microcystin-induced hepatotoxicity and hepatocarcinogenesis. *J. Environ. Sci. Health Part C*. 28, 39-59. https://doi.org/10.1080/10590500903585382
Turner, A.D., Dhanji-Rapkova, M., O'Neill, A., Coates, L., Lewis, A., Lewis, K., 2018. Analysis of microcystins in cyanobacterial blooms from freshwater bodies in England. *Toxins*. 10, 39. https://doi.org/10.3390/toxins10010039
Vieira, J.M.D.S., Azevedo, M.T.D.P., de Oliveira Azevedo, S.M.F., Honda, R.Y., Corrêa, B., 2005. Toxic cyanobacteria and microcystin concentrations in a public water supply reservoir in the Brazilian Amazonia region. *Toxicon*. 45, 901-909. https://doi.org/10.1016/j.toxicon.2005.02.008
Wang X., Ji Y., Li X. 2011. Research on the prediction of water treatment plant coagulant dosage based on feed-forward artificial neutral network, in: *2011 International Conference on Consumer Electronics, Communications and Networks (CECNet)*. IEEE, Xianning, pp. 16-18. https://doi.org/10.1109/CECNET.2011.5769402
Wiegand, M.C., do Nascimento, A.T.P., Costa, A.C., Neto, I.E.L., 2021. Trophic state changes of semi-arid reservoirs as a function of the hydro-climatic variability. *J. Arid Environ*. 184, 104321. https://doi.org/10.1016/j.jaridenv.2020.104321
[WHO] World Health Organization. 2022. Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First