

**Biomonitoring Aktif Ekosistem Sungai Code, Daerah Istimewa Yogyakarta:
Akumulasi Mikroplastik dan Logam pada Ikan Nila *Oreochromis niloticus*
(Linnaeus, 1758) dan *Integrated Biomarker Response***

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INTISARI

Sungai Code merupakan salah satu sungai penting di Yogyakarta yang banyak dimanfaatkan oleh masyarakat sekitar untuk berbagai keperluan. Aktivitas manusia di sekitar sungai menyebabkan berbagai jenis pencemar seperti logam dan mikroplastik masuk ke sungai sehingga mempengaruhi kualitas air sungai. Biomonitoring aktif melalui pendekatan multimarker dapat memberikan gambaran kondisi kekosistem secara komprehensif, sehingga dapat diidentifikasi biomarker yang sensitif dan spesifik terhadap keberadaan jenis pencemar tertentu. Penelitian ini bertujuan untuk mengevaluasi kesehatan ekosistem Sungai Code melalui analisis akumulasi mikroplastik dan karakteristiknya, konsentrasi Cu, aktivitas enzim superoxide dismutase (SOD), katalase (CAT), dan asetilkolinesterase (AChE), konsentrasi metallothionein (MT), dan kerusakan DNA pada ikan *O. niloticus* yang ditransplantasikan di Sungai Code. Ikan dipaparkan dalam keramba di tiga stasiun (S1, S2, dan S3) sepanjang Sungai Code dan dikoleksi pada hari ke-0, 3, 7, 14, 21, dan 28. Evaluasi biomarker dilakukan dengan *Integrated Biomarker Response* (IBR). Hasil penelitian menunjukkan bahwa seluruh stasiun di Sungai Code telah tercemar mikroplastik dan Cu. Peningkatan kandungan mikroplastik dan Cu dalam saluran pencernaan, otot, dan insang ikan sejalan dengan durasi paparan oleh pencemar dan berkorelasi positif dengan akumulasinya, serta tidak ada perbedaan antar stasiun. Paparan berbagai pencemar di sungai sangat meningkatkan aktivitas SOD dan CAT di ketiga organ ikan pada awal paparan di semua stasiun, dengan tertinggi di S3. Aktivitas AChE sangat terhambat di saluran pencernaan ikan di S3. Konsentrasi MT sedikit meningkat dan peningkatan tertinggi terjadi di insang ikan di S3. Kerusakan DNA lebih parah terjadi di S2 dan S3. Hasil analisis IBR menunjukkan bahwa aktivitas CAT, AChE, dan konsentrasi MT merupakan biomarker yang responsif terhadap pencemaran Sungai Code dan diketahui bahwa tingkat pencemaran Sungai Code di S2 dan S3 lebih tinggi dibandingkan S1. Penelitian ini memberikan bukti efektivitas penggunaan pendekatan biomonitoring dengan multimarker pada ikan *O. niloticus* untuk memantau pencemaran di sungai.

Keywords: aktivitas enzim, biomarker, comet assay, mikroplastik, *Oreochromis niloticus*, tembaga

Active Biomonitoring of Code River Ecosystem, Special Region of Yogyakarta: Accumulation of Microplastics and Metals in Tilapia Fish *Oreochromis niloticus* (Linnaeus, 1758) and Integrated Biomarker Response

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ABSTRACT

Code River is one of the important rivers in Yogyakarta which is widely used by the local community for various purposes. Human activities around rivers cause various types of pollutants such as metals and microplastics to enter rivers, thereby affecting river water quality. Active biomonitoring through a multimarker approach can provide a comprehensive picture of ecosystem conditions, so that biomarkers that are sensitive and specific for the presence of certain types of pollutants can be identified. This study aims to evaluate the health of the Code River ecosystem through analysis of microplastic accumulation and its characteristics, Cu concentration, superoxide dismutase (SOD), catalase (CAT), and acetylcholinesterase (AChE) enzyme activity, metallothionein (MT) concentration, and DNA damage in *O. niloticus* were transplanted in Code River. Fish were exposed in cages at three stations (S1, S2, and S3) along the Code River and collected on days 0, 3, 7, 14, 21, and 28. Biomarker evaluation was carried out using Integrated Biomarker Response (IBR). The research results show that all stations in the Code River have been contaminated with microplastics and Cu. The increase in microplastic and Cu content in digestive tract (GIT), muscles, and gills of fish was in line with the duration of exposure to pollutants and was positively correlated with their accumulation, and there were no differences between stations. Exposure to various pollutants in the river greatly increased SOD and CAT activities in all three fish organs at the beginning of exposure at all stations, with the highest at S3. AChE activity was severely inhibited in GIT of fish at S3. MT concentration increased slightly and the highest increase occurred in gills of fish in S3. More severe DNA damage occurred in S2 and S3. The results of the IBR analysis show that CAT activity, AChE, and MT concentration are responsive biomarkers for Code River pollution and it is known that the Code River pollution level in S2 and S3 is higher than S1. This research provides evidence of the effectiveness of using a biomonitoring approach with multimarkers on *O. niloticus* fish to monitor pollution in rivers.

Keywords: biomarker, comet assay, copper, enzyme activity, microplastics, *Oreochromis niloticus*