

PREDIKSI RISIKO KESEHATAN AKIBAT KONTAMINASI MIKROPLASTIK PADA RANTAI MAKANAN DI TPST SINDU MANDIRI

ABSTRAK

Latar Belakang: Mikroplastik telah menjadi ancaman lingkungan yang signifikan, dengan bukti kontaminasi pada berbagai komponen ekosistem, termasuk rantai makanan manusia. Salah satu jalur kontaminasi potensial adalah melalui konsumsi ikan yang dibudidayakan menggunakan pakan berbasis limbah. TPST Sindu Mandiri di Daerah Istimewa Yogyakarta merupakan salah satu fasilitas pengelolaan sampah terpadu yang memanfaatkan sampah organik untuk budidaya maggot sebagai pakan ikan lele.

Tujuan: Untuk memprediksi risiko kesehatan akibat pajanan mikroplastik pada manusia dari konsumsi ikan lele hasil produksi TPST Sindu Mandiri.

Metode: Kuantitatif dengan desain *cross sectional*. Metode Analisis Risiko Kesehatan Lingkungan (ARKL) diterapkan untuk mengidentifikasi bahaya, menilai dosis respon, paparan, dan karakterisasi risiko. Simulasi Monte Carlo dilakukan dengan perangkat lunak *Oracle Crystal Ball* untuk memodelkan ketidakpastian dan menghasilkan distribusi probabilitas risiko. Sampel terdiri dari 30 ekor ikan lele dari tiga kolam berbeda dan responden yang pernah mengonsumsi ikan tersebut. Identifikasi mikroplastik dilakukan secara visual menggunakan mikroskop dan uji polimer dengan spektroskopi FTIR.

Hasil: Mikroplastik ditemukan pada semua bagian ikan dengan rata-rata kelimpahan 2 partikel/gr sampel, dan distribusi tertinggi berada di lambung (105 partikel), usus (84 partikel), dan daging (12 partikel). Mikroplastik bervariasi dalam bentuk (*line, fragment, film, pellet*), warna (dominasi hitam), dan ukuran (146.34 μm hingga 2626.45 μm) serta jenis polimer antara lain *PET, PP, PS*, dan *Polyamide*. Konsentrasi rata-rata mikroplastik dalam sampel ikan sebesar 0,004 mg/g, pada responden rata-rata frekuensi pajanan 181 hari/tahun dan rata-rata konsumsi 119 gram/hari. Nilai *intake* mikroplastik rata-rata sebesar $2,20 \times 10^{-4}$ mg/kgBB/hari dengan nilai *Risk Quotient* (RQ) rata-rata sebesar 0,551, menunjukkan risiko kesehatan bersifat potensial namun masih berada di bawah ambang batas risiko yang signifikan. Simulasi Monte Carlo menunjukkan risiko lebih tinggi pada kelompok lansia dan perempuan. Analisis sensitivitas menunjukkan variabel paling berpengaruh pada lansia adalah frekuensi pajanan sedangkan pada perempuan adalah konsentrasi mikroplastik.

Kesimpulan: Sistem pengelolaan sampah yang belum optimal berpotensi menyebabkan kontaminasi mikroplastik dalam rantai makanan. Diperlukan manajemen risiko dengan membatasi konsumsi ikan lele berbasis sampah pada kelompok rentan, mendiversifikasi sumber protein, serta mengedukasi tentang pangan sehat dan risiko mikroplastik. Secara umum, strategi mencakup pemilahan sampah dari rumah tangga dan diversifikasi pakan lele.

Kata Kunci : Mikroplastik, Prediksi Risiko, Simulasi Monte Carlo, Ikan Lele

HEALTH RISK PREDICTION OF MICROPLASTIC CONTAMINATION IN THE FOOD CHAIN AT TPST SINDU MANDIRI

ABSTRACT

Background: Microplastics have emerged as a significant environmental threat, with documented contamination across various ecosystem components, including the human food chain. One potential contamination pathway is through the consumption of fish cultivated using waste-based feed. TPST Sindu Mandiri, located in the Special Region of Yogyakarta, is an integrated waste management facility that utilizes organic waste to cultivate maggots as feed for catfish.

Objective: This study aimed to predict potential health risks associated with microplastic exposure in humans through the consumption of catfish produced at TPST Sindu Mandiri.

Methods: This quantitative study employed a cross-sectional design. The Environmental Health Risk Assessment (EHRA) approach was applied to identify hazards, assess dose-response relationships, exposure levels, and characterize risks. A Monte Carlo simulation using Oracle Crystal Ball software was utilized to model uncertainty and generate probabilistic risk distributions. The samples consisted of 30 catfish from three different ponds and community respondents who had consumed the fish. Microplastic identification was conducted visually and confirmed through Fourier-transform infrared spectroscopy (FTIR).

Results: Microplastics were detected in all parts of the fish, with an average abundance of 2 particles per gram of tissue. The highest distribution was found in the stomach (105 particles), intestines (84 particles), and flesh (12 particles). Microplastics varied in shape (line, fragment, film, pellet), color (dominant black), and size (146.34 μm to 2626.45 μm). The polymer types are PET, PP, PS and polyamide. The average microplastic concentration in fish samples was 0.004 mg/g. Among respondents, the average exposure frequency was 181 days/year, with a consumption rate of 119 grams/day. The estimated microplastic intake was 2.20×10^{-4} mg/kgBW/day, with a mean Risk Quotient (RQ) of 0.551, indicating a potential health risk, though still below a critical risk threshold. Monte Carlo simulation indicates a higher risk among the elderly and females. The sensitivity analysis of the elderly indicates the most influential factor is frequency of exposure and for females is concentration of microplastics.

Conclusion: An inadequate waste management system poses a significant risk of microplastic contamination within the food chain. Effective risk management strategies should include limiting the consumption of catfish reared with waste-based feed, particularly among vulnerable populations; promoting the diversification of dietary protein sources; and enhancing public education regarding safe food practices and the health risks associated with microplastic exposure. At the systemic level, recommended interventions include source-level waste segregation at the household scale and the development of alternative, safe feed formulations for aquaculture.

Keywords: Microplastics, Risk Prediction, Monte Carlo Simulation, Catfish