ABSTRACT

STABILITY ANALYSIS OF PREY-PREDATOR MODELS WITH DIFFUSION OF AEROBIC BACTERIA AND PROTOZOA INTERACTIONS ON BIOLOGICAL OXYGEN DEMAND

by

Bagus Kohar Aji
24010122420006
Mathematics Magister Study Program
Faculty of Science and Mathematics
Diponegoro University

Wastewater treatment is essential to maintain water quality before it is discharged into receiving water bodies, primarily through biological processes that utilize the activity of microorganisms. Aerobic bacteria function as the primary decomposers of organic matter by utilizing dissolved oxygen for metabolic activities, while protozoa play a role in reducing Biological Oxygen Demand (BOD), controlling bacterial populations through predation mechanisms, and maintaining the balance of the microbial ecosystem. The interaction between aerobic bacteria and protozoa in a wastewater treatment plant (WWTP) can be modeled as a predator–prey system, with diffusion considered an important factor in the spatial distribution of microorganisms. This study develops a three-species predator–prey model with diffusion that represents the interaction among BOD as the prey, aerobic bacteria as the intermediate predator, and protozoa as the top predator within a WWTP pond. Local stability analysis indicates stable behavior around the equilibrium point under certain parameter conditions. Analysis of the traveling wave solution around the equilibrium point shows that the system is stable only if the wave velocity meets a minimum threshold value $(c \geq c_{\min})$*. Otherwise, the system becomes unstable and organic degradation does not proceed optimally. Numerical simulations show that BOD concentration decreases gradually from the inlet to the outlet in a traveling wave pattern, accompanied by the dynamics of aerobic bacteria as the primary decomposers and protozoa as population controllers of the bacteria at the outlet.*

Keyword: WWTP, stability, travelling wave solution, three species prey predator