

Benthic macroinvertebrate assemblages and water quality reflect the impacts of land use and land cover in Marikina Watershed, Philippines

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Watershed systems provide various ecological services such as good water quality, regulate water flow, maintain water balance and biodiversity conservation. However, human disturbances greatly affect the water quality and composition of biotic communities. Although anthropogenic changes in freshwater systems were truly evident, studies focusing on the human impacts on tropical watersheds are still limited in developing countries. Thus, this study aims to investigate the response of freshwater macroinvertebrates to varying land use patterns and land cover characteristics in Marikina Watershed, Philippines. For a total of 30 streams, which were categorized into 7 protected, 3 forested, 8 agricultural, and 12 residential streams based on land use and cover in their catchments, were collected benthic macroinvertebrates and measured environmental variables. PCA plots were not able to classify water quality according to land use and was supported with no significant difference in Kruskal –Wallis test. However, water quality of primarily vegetated and primarily non-vegetated sites as well as protected and protected streams had delineation, as accorded with the results of independent t - tests with significant differences ($p < 0.05$) on dissolved oxygen, conductivity, total dissolved solids and salinity. While the forested streams are clustered together in the NMDS plot but there is no clear pattern in the assemblage of benthic macroinvertebrates. The similarities in the composition of macroinvertebrates could be attributed to the similar magnitude and intensity of landscape alteration of each land use among the streams. Interestingly, the nMDS plot shows strong separation of macroinvertebrate assemblages across gradient of vegetation area (Global $R = 0.388$, $P = 0.001$) and were supported independent t - test where with macroinvertebrate diversity, density and abundance of pollution-sensitive taxa on primarily vegetated areas exhibited significant differences from non-vegetated areas ($p < 0.05$). Additionally, biotic indices such as SingScore, Average Score per Taxon THAI (ASPT^{THAI}), Biological Monitoring Working Party (BMWP^{THAI}), and Stream Invertebrate Grade Number Average Level version 2 (SIGNAL 2) reveal significant differences among protection status, land use types and land cover ($p < 0.05$). CCA plot also revealed pollution –sensitive taxa with primarily vegetated sites were associated with pollution-sensitive taxa and primarily non-vegetated sites are associated with pollution-tolerant organisms to on CCA plot. The findings of this study demonstrate the effects of land alteration to the macroinvertebrate community and water quality. Furthermore, it emphasizes the importance of vegetation cover and designation of protected areas to have better ecological quality in a watershed. This study thus suggests for an extensive and improved policy development and implementation. Furthermore, extensive biomonitoring and formulation of Marikina Watershed Biotic Index are recommended.

Keywords: Marikina Watershed, land use, land cover, water quality, benthic macroinvertebrates