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# A Comparative Survey Of Freshwater Macroinvertebrates In Natural Forest Streams And Human-Modified Marshland, Rwanda.

Edmond Twagirayezu[1]
Leonce Ngirinshuti[2]
[1]Center of Excellence in Biodiversity and Natural resources Management, College of Science and Technology, University of Rwanda.
[2]College of Agriculture, Animal Science and Veterinary Medicine, University of Rwanda.

***Abstract***
*Rwanda is one of the most populated countries in Africa, its economic activity depends on agriculture, where 66.5% of its population depends on agricultural activities. This high population and non-smart agricultural dependence put noticeable pressure on biodiversity and ecosystems including aquatic environments. To reduce the effect of agriculture on aquatic bodies, Rwanda has adopted Integrated Water Resources Management (IWRM) as a pivot to ensure the provision of clean water as well as contribute to the well-being of aquatic living. This study assesses and compares the taxonomic diversity of freshwater macroinvertebrate fauna in natural forest streams and human-modified marshland. Sampling was conducted in Nyungwe National Park (NNP) a protected area, and Rwasave Marshland which is a disturbed area by using a 500µm mesh-size kick-net. Specimens identified through morphometric analyses show that NNP exhibits a higher family richness of freshwater macroinvertebrates than in the Rwasave marshland. Families within the orders Trichoptera, Ephemeroptera, and Plecoptera were found exclusively in NNP, reflecting their sensitivity to pollution and disturbances. The study highlights that freshwater macroinvertebrate fauna of Rwanda, particularly species within Plecoptera, Trichoptera, and various mayflies, are abundant in protected areas, making them valuable bio-indicators of aquatic ecosystem health due to their sensitivity to pollution. This knowledge is crucial for monitoring habitat restoration efforts, ecosystem health status, and advancing sustainable water resource management in tropical regions using indicators.*

***Keywords:*** *Rwanda, biodiversity, pollution, freshwater macroinvertebrates, streams, marshland*

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## I. Introduction

The high population densityof Rwanda and 66.5% of the population dependingon agriculture,particularly on the steep hillsides, increased pressure on the landscape to meet growing food demands (Kropff et al., 2020; Mizero et al., 2021; Uwimana et al., 2018; Wiliam, A. 2018). In non-protected areas, this demand has led to the destruction of forests and wetlands, which previously served as water catchments and reservoirs (Rukundo et al., 2018). Research shows that intensive agricultural practices result in severe environmental issues, including runoff, soil erosion, and water pollution from fertilizers and pesticides (Majoro et al., 2023; Shareef& Mushtaq, 2023.). Farming on steep slopes in highland areas also leads to sedimentation and nutrient enrichment in nearby streams, along with the decline of riparian vegetation (Uwimana et al., 2018; Ndayisaba & Mihale, 2015).

The protected areas such as national parks and forest reserves are generally affected less by human disturbances. In Rwanda, there are four (Nyungwe, Akagera, Volcanoes, and Gishwati-Mukura) (Gatwaza & Wang., 2021). These parks are vital habitats for wildlife, and crucial biodiversity protection, and serve as key hydrological sources of Rwanda (Nyandwi, 2003). Forests and marshlands are widely recognized for their importance to water resources, as they harbor numerous springs and act like sponges, absorbing high rainfall and gradually releasing water during dry seasons (Ellison et al., 2018). For example, Gishwati-Mukura and Nyungwe National Parks are a part of the Congo-Nile divide catchments and significant tributaries to the Congo and Nile Rivers (Candula, A. 2021; Kisioh, H. 2015). Additionally, Nyungwe National Park is considered the hydrological center of Rwanda and supplies 70% of Rwanda's water (Nyandwi, 2023).

Freshwater macroinvertebrates in Rwanda are distributed in rivers, ponds, lakes, swamps, and marshland, providing diverse habitats for a range of animal species like fish, mammals, invertebrates microscopic plankton (Moges, A. 2016). However, research in Rwanda has mostly primarily focused on fish and mammals in different water bodies, likely due to their direct relevance to people's lives and social and economic development (Olapade, 2010). This emphasis has left an important portion of aquatic fauna, such as freshwater macroinvertebrates less studied. However, they are indicators of stream health status due to their sensitivity(Barbosa et al., 2001).

Freshwater macroinvertebrates are aquatic invertebrates visible to our naked eyes including snails, worms, crabs, beetles, insects, and many others (Cimpean et al., 2022). Their success relies heavily on habitat health and integrity, influencing factors like water quality, marginal vegetation, bottom substrate composition, channel structure, land use, and alterations (Shilla, D.,2012; Jun et al., 2011, Cortes et al.,2011). Changes to these elements can disrupt their communities and taxonomic richness, especially for pollution-sensitive individuals leading them to death which made them excellent water quality indicators (Mehrjo et al., 2020).

## II. Methods

### Study area description

Our study was conducted within two distinct ecosystems: Nyungwe National Park and Rwasave marshland. Nyungwe National Park is a sprawling tropical montane rainforest located in the southwest of Rwanda, specifically at coordinates 2°17′–2°50′S and 29°07′–29°26′E. This park is integral to a mountain chain that contributes water to both the Congo River basin in the west and the Nile River basin in the northeast. Covering approximately 1019 km², Nyungwe National Park includes the Cyamudongo, a 4 km² natural forest located 10 km southwest of the main forest (Barakabuye et al., 2007). In contrast, Rwasave Marshland is situated in Southern Rwanda within the Huye District, approximately 2 km from Huye town. Adjacent to the Ruhande Arboretum forest and separated from Gisagara District by the Rwasave stream, Rwasave Marshland experiences various human activities such as aquaculture ponds, irrigated rice cultivation, tree nurseries, vegetable and crop cultivation, irrigated horticulture, and animal grazing (Munayneza et al., 2012).

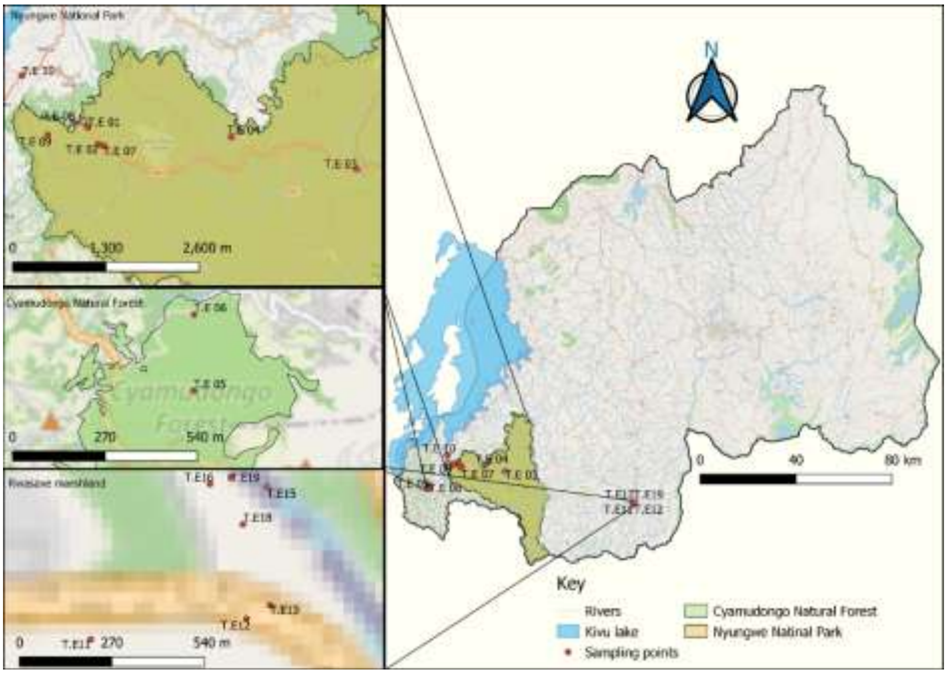


**Fig.1. The Sampling Points Across NNP, Include Cyamudongo And Rwasave Sites.**

### Data collection

By using a 500μm mesh-size kick-net, freshwater macroinvertebrates were collected from a diverse range of habitats including marginal vegetation, bottom substrates, channels, and area under bank cuts, to ensure a comprehensive assessment of species diversity and relative abundance. Sampling was strategically conducted upstream, middle stream, and downstream with an interval of 60 meters between sampling points. For streams, the kick-net is positioned down to capture organisms by disturbing substrates and turning over stones up of the kick-net to dislodge organisms into the kick-net. Upon collection, the specimens were contained in the viol with 96% ethanol to maintain the integrity of the specimens for subsequent identification under a stereo-microscope. In addition, Rwasave marshland was a part of the streams sampled, and two ponds were randomly selected to be a part of the sample. The physical-chemical parameters of water were taken by using the HANNA HI9829 Multiparameters device, to provide a detailed understanding of environmental conditions influencing the macroinvertebrate communities and other physical characteristics noted.

## III. Results

### Biodiversity distribution by taxonomic group

During our survey, we found 17 families of freshwater macroinvertebrates in Nyungwe National Parks across 10 sampling points at different streams (Fig.3). Conversely, in Rwasave marshland, 16 families of freshwater macroinvertebrates were found across 2 streams and 2 ponds selected randomly (Fig.3).

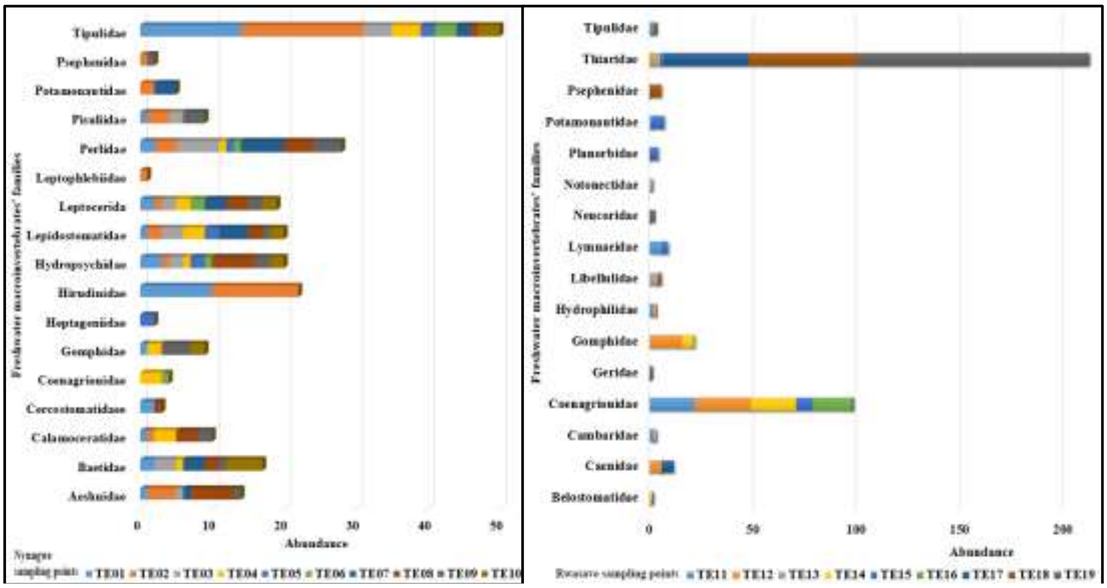


**Fig.2. The distributions of freshwater macroinvertebrates' families across various points from Nyungwe National Park**

**Fig.2. The distributions of freshwater macroinvertebrates' families across various points from Rwasave marshland**

### Taxonomic comparison

This study revealed that some freshwater macroinvertebrate families are present in both Nyungwe National Park (NNP) and Rwasave marshland, while others were specific to one part. The commonality families were Tipulidae, Psephenidae, Odonate-Zygoptera (Coenagrionidae), Odonata-Anisoptera (Gomphidae), and Potamonotidae. The exclusive presence of families from the order Trichopteras (Caddisflies) including Hydropshychidae, Pisuliidae, Leptoceridae, and Lepidostomatidae; Plecopteras (Stoneflies) with family Perlidae (one genus Neoperla), and various Ephemeropteras (mayflies)of familyHeptageniidae, Baetidae and Leptophebidae; and crab from family Potamonautidae found only in Nyungwe National Park. However, the Rwasave marshland exhibited a distinct set of families also unique to its environment, where the Odonata–Anisoptera (Dragonfly) of family Libellulidea, Crayfish (Cambaridae), Ephemeroptera (Caenidae), Belostomatidae, Notonectidae, Naucoridae, Sanils of Thiaridae, Lymnaeidae and Planorbidae.

### Water parameters

Numerous aquatic organisms exhibit a limited ability to thrive within specific water parameters. The temperature, dissolved oxygen (DO), turbidity, and other physical-chemical parameters contribute a lot to macroinvertebrates health (Nyambura&Abuyela, 202; Kannel&Lee, 2007). The parameters are also important for shaping the ecological niches and overall health of aquatic life. For example, temperature is a key determinant of metabolic rate and reproductive cycles for aquatic organisms (Bonacina et al., 2023). For organisms that are often adapted to narrow temperature ranges, the deviation can lead to stress and reduction in reproductive success even mortality. Also, Dissolved oxygen (DO) levels are vital factors influencing the survival of freshwater macroinvertebrates. High DO levels are typically associated with healthy, well-water bodies and are essential for the respiration of most freshwater macroinvertebrates (Divrik et al., 2021). Conversely, low DO levels, often resulting from pollution or eutrophication, can create hypoxic conditions detrimental to freshwater macroinvertebrates, especially for higher pollution-sensitive. Again, turbidity is impacted by suspended particles like algae, silt, and organic materials. Elevated turbidity can diminish light penetration in the waterbodies impact photosynthesis in aquatic flora and algae, and can also obstruct the gills of freshwater macroinvertebrates and other aquatic living organisms like fish by hindering their respirations (Van de Meuter et al., 2005). Other parameters such as pH and nutrient level can also contribute to the damage of water bodies. That is to say, the presence of certain levels of pH can also influence the toxicity of certain pollutants, however, higher nutrient levels lead to algal brooms and subsequent oxygen depletion(Mishra, 2023).

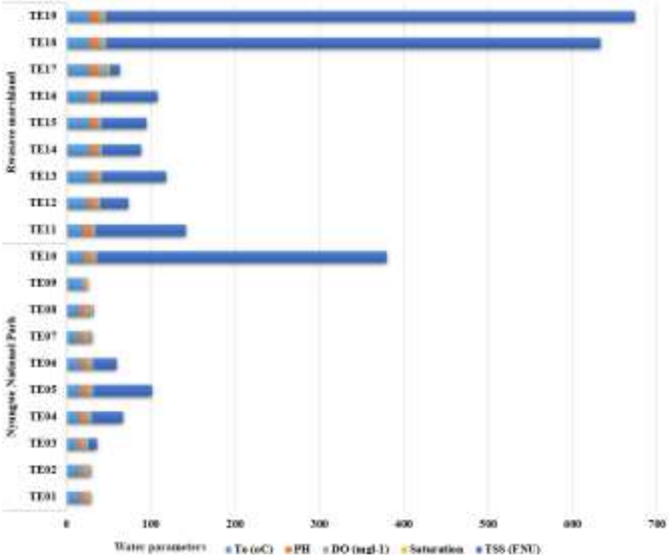

**Fig.4. The variation of water parameters across different sampling points**

The study shows noticeable differences in water parameters between Nyungwe National Park and Rwasave marshland. Specifically, NNP streams mean dissolved oxygen is 7.09 and a saturation of 90.0%, contrasting to Rwasave marshland, which has dissolved oxygen of 6.98 and a saturation of 91.2%. Temperature shows a significant divergence between the two sites, where NNP has a mean temperature of 16.6$^{o}$c, while Rwasave marshland exhibits a notably higher temperature mean of 26.28 $^{o}$c. Additionally, turbidity levels vary markedly in NNP of 49.13 FNU turbidity mean, however Rwasave has 178.74 FNU, suggesting a higher elevated suspended particle in Rwasave marshland. The detailed highlights further b-variation in pH, dissolved oxygen, saturation, conductivity, and turbidity across the NNP and Rwasave marshland.

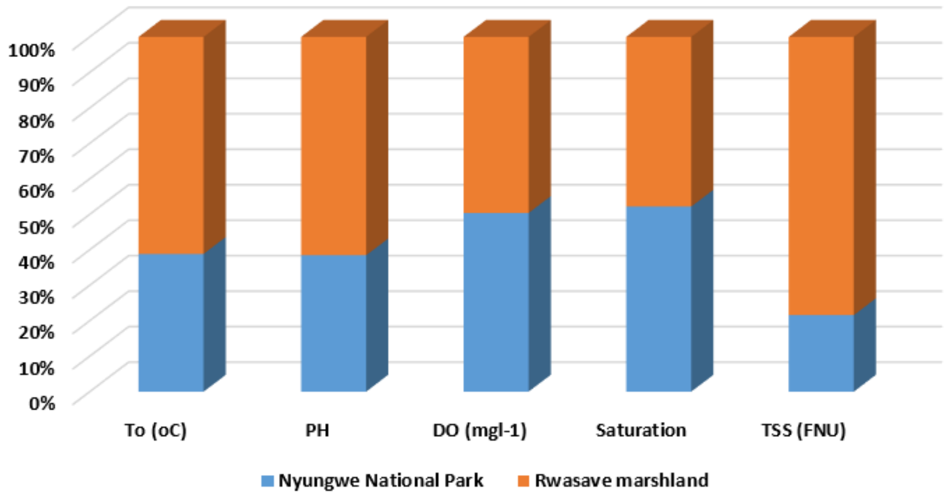


**Fig.5. Average in parameter between NNP and Rwasave marshland**

**The similarities of macroinvertebrates between NNP and Rwasave marshland**

The Sorensen Similarity Index (CCs) is a measure that considers the number of species shared between two sites, providing insight into the degree of commonality between them. In this study, the findings show that the CCs are 0.43 between NNP and Rwasave marshland. That is to say, the commonality of freshwater macroinvertebrates is 43%.

## IV. Discussion

Human activities can significantly alter the physical and chemical characteristics of habitats, especially aquatic bodies. This leads to a detrimental effect on aquatic life due to the disturbances (Yin et al., 2022). The diversity and distributions of macroinvertebrates are closely linked to the water quality of the stream, as macroinvertebrates' survival is highly vulnerable to disturbances caused by land use and habitat destruction and alteration (Leroy&Marks, 2006). The distributions of freshwater macroinvertebrates live accordingly, where some are highly sensitive to pollution while others are tolerant (Aura et al., 2010).

In NNP where human activities are less or none, 17 families recorded at high abundant including those pollution sensitive including stonefly (Perlidae), caddisfly (Cercostomatidae, Leptoceridae, and Hydropsychidae), and mayfly (Heptageniidae). Based on the parameters of high oxygen level, moderate temperature, pH, and low turbidity, conducive to the health and proliferation of macroinvertebrate species. In contrast, Rwasave marshland, subject to various human activities such as agricultural activities and aquaculture shows 16 families of freshwater macroinvertebrates and many of them are pollution-tolerant like snails (Thiariidae, Lymnaeidae) and somewhat tolerant pollution (Coenagrionidae, Libellulidae, and Caenidae).

## V. Conclusion

This study demonstrates that the Natural Forest Streams of Nyungwe National Park, exhibit significantly higher family richness of freshwater macroinvertebrates compared to that of Rwasave marshland. Among the species, NNP contains many that are pollution-sensitive due to its well-managed, avoiding minimal human impact and the preserved natural environment. The reduction of human activities the important in protecting natural habitats to maintain ecological health and water quality. In contrast, the Rwasave marshland, which is subjected to extensive human activities such as agricultural activities and aquaculture involving fish feeding and the addition of chemicals to enhance algae and phytoplankton growth, introduces pollutants to water, thereby significantly reducing water quality and ecosystem health. These pollutants contribute to the reduction of pollution-sensitive freshwater macroinvertebrates and increase pollution tolerance. However, pollution-sensitive species are unable to survive in degraded conditions. This study highlights the detrimental impact of human activities on the aquatic ecosystem, emphasizing the urgent need to implement the sustainable reduction caused by human activities on freshwater ecosystems including Rwasave marshland. Adopting some methods of making agriculture sustainable and aquaculture practices, will contribute to the reduction of pollutants, and safeguarding ofnatural water resources. It is possible to improve water quality to support more diverse and resilient freshwater macroinvertebrate communities. This study also serves as a compelling reminder of the interconnectedness of ecosystem health and human activities, and they underscore the importance of concerted conservation efforts to preserve the biodiversity and ecological integrity of both natural and human-modified environments.

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