

## Diversity of freshwater invertebrates in Wazo Hill quarry ponds

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### ABSTRACT

*This study assessed the diversity of aquatic invertebrates in Wazo Hill quarry ponds that are formed during extraction of raw materials for cement production. The study used invertebrates as important indicator species so as to reveal the importance of the ponds to biodiversity and ecosystem. Temperatures (°C), pH, conductivity (µS.cm-1) and dissolved oxygen (mg.L-1) were taken at each sampling site during biological sampling. Generally the abundance and diversity of invertebrates at Wazo Hill ponds was found to be good. This indicates that the ponds are very important for biodiversity and ecosystem conservation, but also can provide business and education opportunities.*

**Key Words:** Ponds, Wazo Hill, Freshwater, Invertebrates, Diversity

### INTRODUCTION

Dar es Salaam is a growing city which is accompanied with destruction of biological resources. Many wildlife species are purged out and some are threatened to extinction if no alternative means for conserving them is implemented. The Wazo Hill quarry site provides such remedy through different landscape including ponds made during the extraction of some raw materials for cement production [1]. No study has been done to determine the importance of Wazo Hill ponds in biodiversity conservation and provision of ecosystem services, hence this study aimed at filling this knowledge gap by assessing the diversity of freshwater invertebrates and using them as indicator species to determine the importance of Wazo Hill ponds to biodiversity and ecosystem services. Invertebrates are small animals without a backbone and live in diverse habitats and perform various important functions in the ecosystems such as nutrient recycling, completion of food chain and energy flow [2]. Aquatic invertebrates live around living or dead vegetation, on the surface or in the sediments of water bodies [3]. They feed on living and dead plant matter, and on each other, and are an important food for various vertebrates, example fishes, amphibians, reptiles, mammals and birds [3]. Aquatic invertebrates include many larvae of insects such as mosquitoes, dragonflies and caddis flies that begin their lives in the water before becoming land dwelling insects when they mature [4]. Other examples of common aquatic invertebrates include crustaceans (such as crayfish), snails, worms and leeches [5]. Freshwater invertebrates live in none saline water and are important part of the food chain and can tell us a lot about the conditions within a water body. Many invertebrates are sensitive to changes in pH, dissolved oxygen, temperature, salinity, turbidity and other changes in their habitat so they are used as indicators of aquatic ecosystem health because of their sensitivity to environmental change for instance pollution [6]. They play a key role in the nutrient cycling and energy flow of aquatic environments, acting in organic matter breakdown process and taking effectively part in ecosystems biogeochemical cycles [5, 7]. Community characteristics such as

abundance, richness, diversity, evenness, and composition of species can be monitored to determine whether the community is changing over time due to natural or human caused impacts. Freshwater invertebrates are also increasingly used by resource managers for biological assessment of freshwater habitat integrity, and some, such as *Daphnia* (Daphniidae) and *Chironomus tentans* (Chironomidae), are model organisms for toxicological studies [7]. Along with their applied significance, freshwater invertebrates' populations and communities can make excellent models for basic ecological studies because they are present in virtually every freshwater habitat on the planet with the exception of very highly polluted or deep ground waters bodies. Apart from having a very significant important in an ecosystem, they are ignored and thus rarely being studied.

## MATERIALS AND METHODS

### Study Area

This study took place at Wazo Hill quarry. Wazo Hill quarry is located at Tegeta area, Bagamoyo road approximately 25Km from Dar es Salaam city centre, Tanzania (Fig. 1). It is located between latitude 6° 34' South and longitudes 39° 24' East, and an altitude between 100 and 200meters above mean sea level. The climate of the area and Dar es Salaam in general is influenced by its closeness to the equator and being adjacent to Indian Ocean. It is tropical climate with hot and humid weather almost throughout the year. The rainfall pattern is bimodal with a period of short rains occurring between October and December and a long rain is between March and May. It receives around 1,000mm to 1,900mm of rainfall per annum; with the average temperature of 25°Celsius and the highest temperature goes up to 31°Celsius [8]. The quarry area contains various flora and fauna species which are supported by the ongoing quarry rehabilitation and restoration projects in which a large tree nursery has been established in the quarry for restoration purposes. The excavation of materials for cement production has changed the land scape where among distinctive features are ponds that were our study sites.

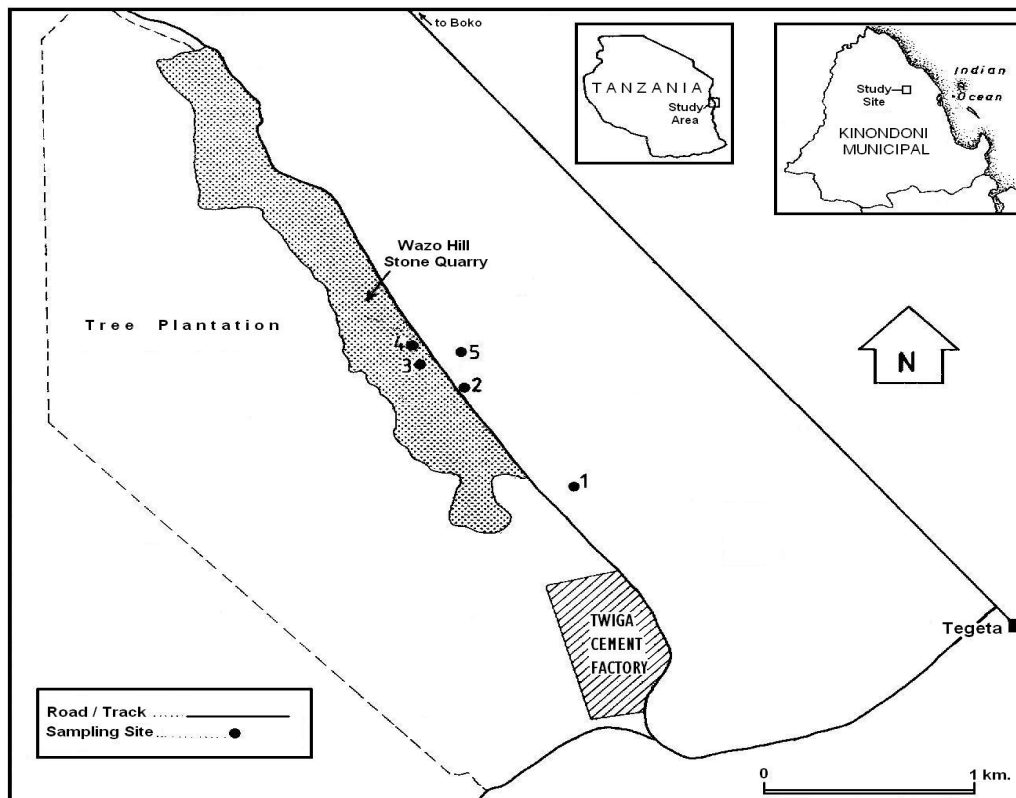


Figure 1: A map of Wazo Hill quarry area showing the location of sampled ponds. (Source: made from GPS points of the study sites).

**METHODS**

Five ponds in the quarried area were randomly selected, surveyed and studied. The GPS co-ordinate was recorded for mapping. The age of each sampled pond was estimated and supplemented by information from experienced factory staffs that had knowledge on when they were formed. Temperature readings ( $^{\circ}\text{C}$ ), were taken at each sampling site during biological sampling using a thermometer, along with other measurements of pH, conductivity ( $\mu\text{S}\cdot\text{cm}^{-1}$ ) and dissolved oxygen ( $\text{mg}\cdot\text{L}^{-1}$ ), which are very useful, particularly the latter which is an indicator of biological oxygen demand (BOD).

Sampling of invertebrates was done by using scoop net. Sampling was done to invertebrates found on water surfaces, within the vegetation, as well as in the benthic (soil or sand). Rocks were rubbed and substrates disturbed in order to dislodge invertebrates into the net. The sampling points in a particular pond were selected randomly. In each pond, about thirty (30) samples were collected. Number of samples were counted on the basis of the number of scoop net drawn from the water. One scoop net drawn from the water was equivalent to one sample. After sampling and sorting, samples were stored in 75% alcohol solution. The identification of invertebrates was done at the University of Dar es Salaam. Invertebrates were identified to the lowest possible taxonomic level, typically the family.

**Data Analysis**

Shannon Weiner index of Diversity ( $H'$ ) was used to determine the diversity of invertebrates in different ponds. Values of Shannon-Weiner indices were computed using the 'Species diversity and Richness, Version 2.65 Software' [9]. Kruskal-Wallis test (computed using a Statistical Analysis Software 'GraphPad InStat, v. 2.04, 1993, San Diego, CA, USA) was used to evaluate the significance of variation in abundance of invertebrates among ponds and Dunn's Multiple Comparison Test (computed using a Statistical Analysis Software 'GraphPad InStat, v. 2.04, 1993, San Diego, CA, USA) was used as the posterior test. The special t-test for comparing diversity indices [10] was used to measure levels of differences in diversity indices of the ponds.

**RESULTS****Water variables of sampled ponds at Wazo Hill**

Water variables (pH, dissolved oxygen and temperature) show some differences between the ponds, however the difference was statistically insignificant ( $P>0.05$ ). Conductivity was found to be significantly higher in pond 1 than in other ponds ( $P<0.05$ ). Moreover, dissolved oxygen was higher in pond 1 than in others, pond 3 was found to have the least dissolved oxygen. In case of age, pond 1 was found to be older than the others (Table 1).

**Table 1** Water variables of sampled ponds

Variables	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
Temp ( $^{\circ}\text{C}$ )	26	28	27	28	28
pH	8.92	8.93	8.51	8.76	8.94
Conductivity ( $\mu\text{S}\cdot\text{cm}$ )	210	193	191	172	185
Dissolved Oxygen ( $\text{mg}\cdot\text{L}^{-1}$ )	8.5	8.2	7.5	7.8	8.0
Age of the Pond	>5 years	3years	1 year	6months	2 months

Source: Field data, Wazo Hill quarry ponds, 2014.

**Table 2:** Values of Dunn's Multiple Comparison Test showing differences in Abundance of invertebrates in Wazo Hill ponds.

Comparison	Mean difference	P Value	Difference
P1 Vs P2	35.00	$P<0.01$	s
P1 Vs P3	46.500	$P<0.001$	s
P1 Vs P4	48.500	$P<0.001$	s
P1 Vs P5	42.500	$P<0.001$	s
P2 Vs P3	11.500	$P>0.05$	ns
P2 Vs P4	13.500	$P>0.05$	ns
P2 Vs P5	7.500	$P>0.05$	ns
P3 Vs P4	2.000	$P>0.05$	ns
P3 Vs P5	-4.000	$P>0.05$	ns
P4 Vs P5	-6.000	$P>0.05$	ns

Where: P1=Pond 1, P2= Pond 2, P3= Pond 3, P4= Pond 4, P5= Pond 5, ns= No significant difference, s= Significant difference.

**Abundance of Invertebrates at Wazo Hill Ponds**

Three hundred and five (305) invertebrates were sampled in five ponds of Wazo Hill. Odonata was found to have

the highest abundance (92 individuals) compared to other groups. Diptera was the least abundant group (7 individuals). Eighteen (18) families were observed in Wazo Hill ponds. Among the ponds, pond 1 was found to have more families (18 families) than other ponds, pond 3 observed to be the least. Among the families, the family Libellulidae was found to contain more individuals (71 individuals) (Annex 3). Generally for both five sampled ponds, pond 1 found to be more abundant than others (Kruskal Wallis Test: KW= 48.14,  $P < 0.05$  Table 2).

#### Diversity of invertebrates at Wazo Hill ponds

The overall Shannon Weiner diversity ( $H'$ ) of invertebrates' at all sampled ponds of Wazo Hill was found to be 2.32. The diversity of pond 1 was higher than the other ponds ( $P < 0.005$ ); (Fig 2).

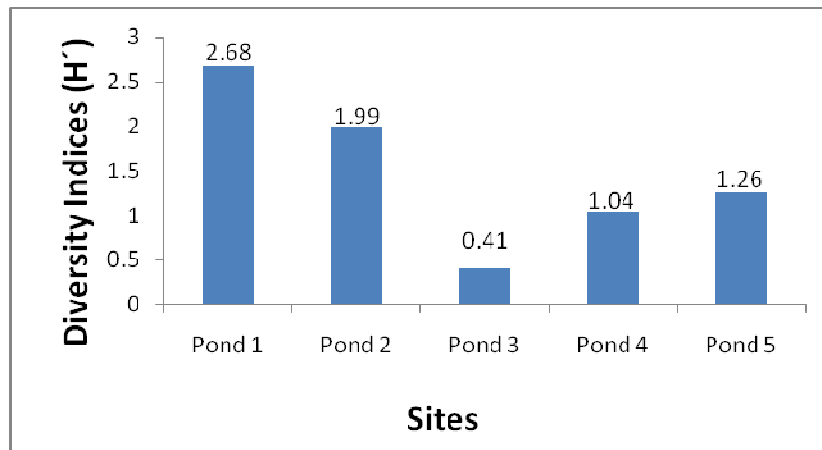


Figure 2: Diversity Indices ( $H'$ ) of Invertebrates at five ponds of Wazo Hill Quarry ( $H'$  = Shannon Weiner diversity Index)

### DISCUSSION

The study shows that, some water parameters such as conductivity and dissolved oxygen were found to be higher in pond 1. Conductivity is the measure of dissolved ions and dissolved oxygen is the tiny bubbles of oxygen gas which is mixed in water and accessible to aquatic living things for their respiration. Aquatic invertebrates survive and reproduce more effectively in water with higher conductivity [7]. This indicates that, more invertebrates survived in pond one (1) with high conductivity than in other ponds, and this was observed to be true in this study. Dissolved oxygen is one of the most important factors affecting invertebrate abundance and diversity [4]. This was revealed in this study as the pond 1 with higher dissolved oxygen possessed higher abundance and diversity of invertebrates than others. Temperature and pH also affects abundance and diversity of invertebrates [7]. Low pH has a strong impact in the growth and reproduction of invertebrates. For this study, pH was not observed to be the limiting factor as the pH was found to be high ranging from 8.51 to 8.94, this is due to the nature of the mineral found in the area where is predominated by limestone. Extremely high temperature also has effects on invertebrates. Increased water temperatures might affect the time of complete development of invertebrates example to Odonata [3, 8]. However, in this study this was not the case. It is possible that the average temperature readings were of a shorter observation that could not lead to clear observation of the not broad enough to observe the true relationship.

Generally the study revealed that Wazo Hill ponds support a good abundance and diversity of invertebrates; this is presumably due to high availability of resources and good conditions of the habitat since invertebrates are very sensitive to environmental quality [6, 8, 11]. They have a strong interaction with environmental conditions [5, 11, 12] thus; this faunal component has been frequently used in environmental quality assessment [6]. Invertebrates are functionally important in many terrestrial and aquatic ecosystems [4, 13-16]. Aquatic invertebrates play important roles within their ecosystems, while also providing valuable data for humans to use. They have very important functions in the ecosystem. These ecosystem functions include sediment mixing, nutrient cycling, and energy flow through food webs, acting in organic breakdown process and taking effectively part in ecosystems biogeochemical cycles [7].

Despite the fact that aquatic invertebrates are physically small, they are a major link in the energy exchange from

producer to consumer [14]. The biodiversity of aquatic invertebrates within watersheds is an important indicator of the ecosystem's function [8, 13]. Knowing the types of aquatic invertebrates present in a watershed allows for proper environmental assessments to be made. Dragonfly larvae are an example of aquatic invertebrates that can be used as biological indicators for changes in aquatic habitats [12]. For example, dragonfly abundance increases with a higher amount of aquatic plant density. Knowledge concerning these adaptations can provide important information about habitat conditions. With knowledge about how aquatic factors affect dragonfly abundance, habitats can be monitored for changes in conditions, such as pH, oxygen and temperature by observing changes in dragonfly populations. [13] found that increased invertebrate diversity accelerated the recovery rate of ecosystems following environmental shocks.

In the present study, the number of dragonfly was found to be higher than other groups; this indicates that there was a favorable condition for their survival. However, it has been observed that the abundance and diversity of invertebrates in older ponds was higher than in the young ones, this indicate that the older the pond the higher the diversity and abundance of invertebrates [11]. This could be due to the fact that in the older ponds invertebrates had time to reproduce, colonize and develop. Also in the older ponds there are enough resources for invertebrates to survive and invertebrates has already adapted to the condition of the particular pond [11]. Survival of invertebrates normally would attract aquatic vertebrates as well as terrestrial vertebrates such as birds, snakes, monkeys and others [7]. This enhances biodiversity conservation of the area and the ecosystem balance in general.

On the other hand, the study found that Wazo Hill quarry ponds are very important to the company, community nearby the company as well as throughout Dar es Salaam and in the World in general. Among the importance that the company could benefit from the ponds are fishing activities. The company could introduce the fish in various ponds which could help the company to earn money by supplying fish to people surrounding the company and throughout Dar es Salaam. The presence of invertebrates in the ponds indicates that even fish could survive in the ponds. In supplying fish the company benefits from it as the source of income to the company. Also the company could use water from the ponds with fish for irrigation in the tree nursery, as well as in flowers garden as the water will have good nutrients from the fish litter for the growth of vegetation. Apart from that, ponds may help the company by reducing the soil erosion from rain as water drain directly to the ponds. In another way, these ponds are useful in reducing dust on roads around the quarry site. On top of that, the company could use the ponds to keep frogs for supplying to schools and colleges for practical purposes, in this way the company would be benefiting the community, the country, as well as the world by supporting in the development of science and education in general. Furthermore Wazo Hill ponds could reduce unemployment level to the community around the quarry site by engaging them to fishing activities. However, the fishing activities within the quarry site should be taken under close supervision from the management in order to prevent environmental pollution.

## CONCLUSION

Wazo Hill ponds are very important to the biodiversity conservation, the ecosystem and the nation in general. It has been found that these ponds harbor varieties of invertebrates which are very potential in the ecosystem functioning. Invertebrates found to be very important to the ecosystem. Therefore, it is important to protect invertebrates' communities to lower the risk of unexpected and unwanted consequences. It is important that the Wazo Hill ponds be managed and monitored for the survival of biodiversity and balance of the ecosystem. Furthermore conservation education, awareness and sensitization on the importance of biodiversity found in the quarry site should be provided to the communities living nearby the quarry site so that they participate positively in reducing the risk to biodiversity loss.

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