QUARRY LIFE AWARD PROJECT

***MAPPING, ECOSYSTEM SERVICES AND DIVERSITY OF AQUATIC INVERTEBRATES IN WAZO HILL QUARRY PONDS***

# Project Report

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**29th September 2014**

Let your idea boost biodiversity

THE QUARRY LIFE AWARD

**ABSTRACT**

The presence of ponds at Wazo Hill quarry site which are formed during extraction of some raw materials for cement production prompted this study. The study has assessed the importance of the ponds to the biodiversity and ecosystem in general, to the company as well as the community around the quarry site and Dar es Salaam at large. The study used invertebrates as important indicator species so as to reveal the importance of Wazo Hill quarry ponds. Specifically the study assessed the abundance and diversity of invertebrates, mapping the location of studied ponds as well as collection of information on what could be the importance of Wazo Hill ponds. Sampling of invertebrates was done to five ponds by using scoop net. Semi-structured interview using Likert Scoring to people selected randomly in Dar es Salaam on what ecosystem services can be derived from such ponds was done. The GPS co-ordinate was recorded for mapping. The age of each sampled pond was also estimated. Temperature readings (°C) were taken at each sampling site during biological sampling along with other measurements of pH, conductivity ($\mu S.cm^{-1}$) and dissolved oxygen ($mg.L^{-1}$). Identification of sampled invertebrates was done to family level at University of Dar es Salaam, zoology laboratory. 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'. 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 was used as the posteriori test. The special t-test for comparing diversity indices was used to measure levels of differences in diversity indices of the ponds. Intensive interview was analyzed through descriptive analysis. Some water parameters such as conductivity and dissolved oxygen were founds to be higher in pond 1 than in other ponds. There was no statistical difference on other water parameters such as temperature and pH. 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 the biodiversity and ecosystem in general as these invertebrates play a great role in ecosystem functioning such as sediment mixing, nutrient cycling, and energy flow through food webs, acting in organic breakdown process and taking effectively part in ecosystems biogeochemical cycles. Ponds was also found to be important to the company as they could use them for fishing activities which would help the company to earn money by supplying fish to people nearby the company and throughout Dar es Salaam. The ponds also could reduce the rate of unemployment to people around the quarry by buying fish from the company and selling them as retailers. It is also found that, these ponds could be used as source of biological species example frogs for practical uses at schools and colleges. The study revealed that the old ponds harbour more invertebrates than the young ponds. Invertebrates found to be very important to the ecosystem, and different species comprise distinct functional groups that provide ecological integrity. In some cases, these functional groups may be represented by only a few species, so that any loss of species diversity could be detrimental to continued ecosystem functioning. 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.

## 1.0 INTRODUCTION

Invertebrates are small animals without a backbone. They live around living or dead vegetation, on the surface or in the sediments of water bodies. They feed on living and dead plant matter, and on each other, and are an important food for various vertebrates, example fish and some birds. They 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. Other examples of common invertebrates include crustaceans (such as crayfish), snails, worms and leeches. Freshwater invertebrates are an 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 stance pollution and sudden changes in their environment. 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. 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. 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. Thus, this project aimed at studying importance of Wazo Hill quarry ponds to biodiversity conservation and ecosystem services provision using invertebrates as indicator species.

## 2.0 OBJECTIVES

### 2.1 Major objective

To determine the importance of created ponds in quarry site for aquatic invertebrates, other biodiversity and human livelihood.

### 2.2 Specific Objectives

(i) To determine the diversity of aquatic invertebrate in the Wazo hill quarry ponds

(ii) To determine ecosystem services provided by the ponds

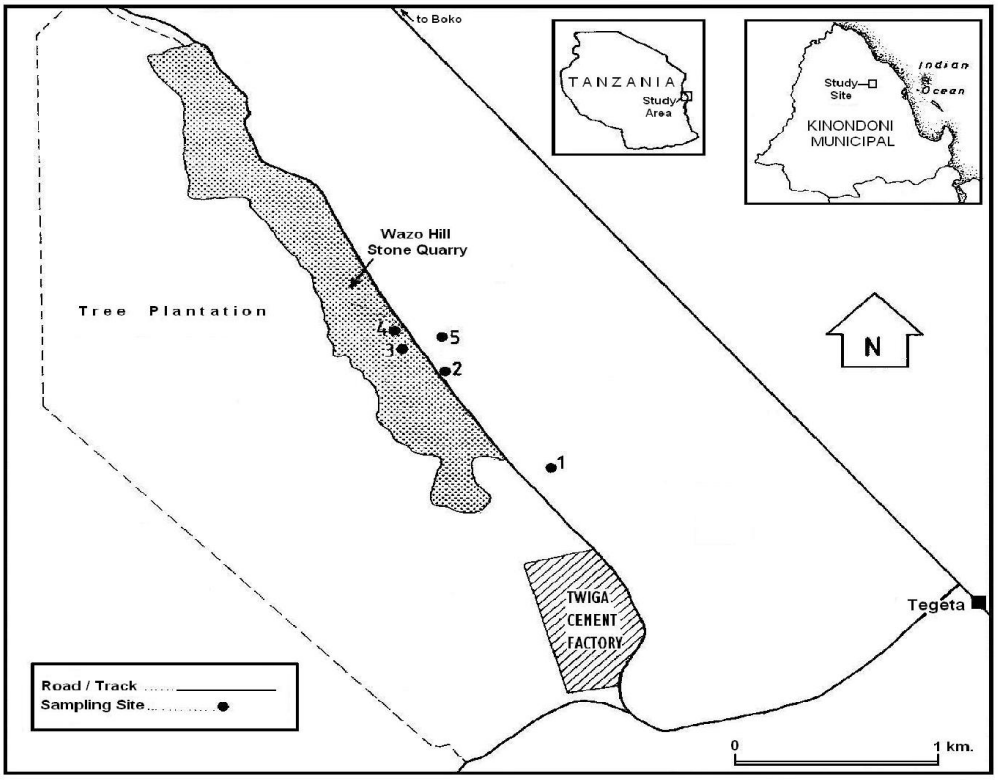
( iii) To map the ponds in Wazo Hill quarry.

## 3.0 BACKGROUND INFORMATION

### 3.1 Site description

This study took place at Wazo Hill quarry ponds (Fig. 1). Wazo Hill quarry is located at Tegeta area, Bagamoyo road approximately 25Km from Dar es Salaam city centre, Tanzania. It is located between latitude 6° 34' South and longitudes 39° 24' East, and an altitude between 100 and 200 above sea level. The climate of Dar es Salaam is influenced by its closeness to the equator and being adjacent to Indian Ocean. It has tropical climatic conditions 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 1,000 mm to 1,900 mm of rainfall per annum; with the average temperature of 25°Celsius and the highest temperature goes up to 31°Celsius (Start, 2011). The quarry area contains various biological 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. Among the manmade features found in Wao Hill quarry are ponds where by this study was done.

**Figure 1: A map of Wazo Hill quarry area showing the location of sampled ponds**




**Source: made from GPS points of the study sites.**

### 3.2 Summary of the project

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 such species 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. Ponds are known to occur at the Wazo Hill quarry, however no study have been done to determine their importance in biodiversity conservation and provision of ecosystem services. Through this study, ponds were determined and mapped. In addition to that the invertebrates and ecosystem services of invertebrates and those ponds are exposed. This will help the management of Wazo Hill to design the conservation strategies of the area considering the aquatic invertebrates available as essential component of the ecosystem. Additionally economic generating activities can be planned for the ecosystem services provided to the industry and the local communities around. Employment opportunities may be increased to local communities around the quarry sites which will enhance good relationship between the management and the local communities around.

## 4.0 METHODS

### 4.1 Experimental Design

Five ponds in the quarried area was selected, surveyed and recorded. The selection of the five ponds was done randomly. The GPS co-ordinate was recorded for mapping. The age of each sampled pond was also estimated and recorded by asking the management about the age of the pond. Temperature readings (°C), were taken at each sampling site during biological sampling, along with other measurements of pH, conductivity ($\mu S.cm^{-1}$) and dissolved oxygen, 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 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. The first pond was repeated to be sampled twice; in this pond fish was introduced by another person who was studying fish just after the sampling of invertebrates, so it was then our interest to see whether the introduced fish brought any changes to the invertebrates. Three months later after the introduction of fish in the pond, the second sampling was done to check the impact of the introduced fish on the abundance and diversity of invertebrates. The other four remaining ponds were sampled once. After sampling, sorting and storing sampled invertebrates in 75% alcohol was done. The identification of invertebrates was done at the University of Dar es Salaam. Invertebrates were identified to the lowest possible taxonomic level, typically family. Semi-structured interview using Likert Scoring (Anex 2) to thirty (30) people randomly selected from the house hold near the quarry site where ponds are, and in schools specifically to students and teachers in Dar es Salaam, on what ecosystem services can be derived from such ponds was done. Sampling was done to both females and males together with yong and old people. Intensive interviews to key informants such as workers of

Wazo Hill quarry like those working near the ponds example those dealing with tree nursery was done.

### 4.2 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'. 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 posteriori test. The special t-test for comparing diversity indices (Zar, 1996) was used to measure levels of differences in diversity indices of the ponds. Intensive interview was analyzed through descriptive analysis.

## 5.0 RESULTS

### 5.1 Water variables of sampled ponds at Wazo Hill

Water variables (pH, dissolved oxygen and temperature) shows 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 (Table 1). 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 (°C) | 26 | 28 | 27 | 28 | 28 |
| pH | 8. 92 | 8.93 | 8.51 | 8.76 | 8.94 |
| Conductivity (μS.cm) | 210 | 193 | 191 | 172 | 185 |
| Dissolved Oxygen ($mg.L^{-1}$) | 8.5 | 8.2 | 7. 5 | 7.8 | 8.0 |
| Age of the Pond | >5 years | 2years | 6 months | 4months | <1 year |

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

### 5.2 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). For pond one, the abundance of invertebrates before introduction of fish was higher (77 individuals) than after introduction of the fish (22 individuals), and most of these were mollusc.

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

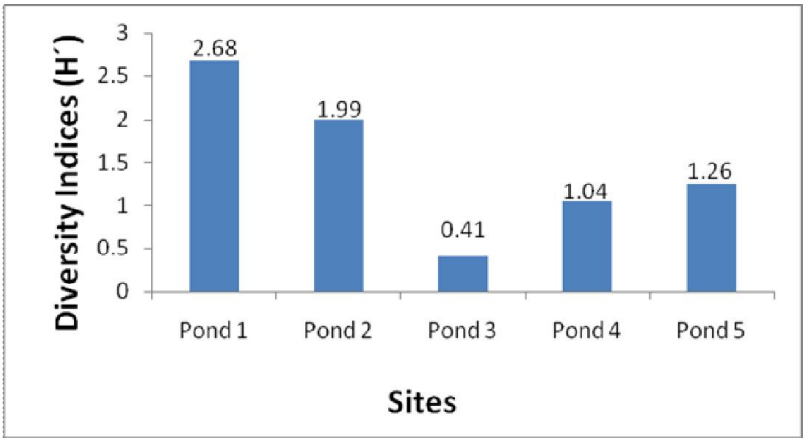
| Comparison | Mean difference | P Value | Difference |
|---|---|---|---|
| P1 Vs P2 | 35.00 | P<0.01 | s |
| P1 Vs P3 | 46.500 | P<0.001 | s |
| P1 Vs P4 | 48.500 | P<0.001 | s |
| P1 Vs P5 | 42.500 | P<0.001 | s |
| P2 Vs P3 | 11.500 | P>0.05 | ns |
| P2 Vs P4 | 13.500 | P>0.05 | ns |
| P2 Vs P5 |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

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

### 5.3 Diversity of invertebrates at Wazo Hill ponds

The overall Shann 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 3). The diversity (H') of pond one before introduction of fish was 2.68, and after introduction of fish the diversity (H') was 0.57. However, Special t test for comparing two diversity indices showed that there was a significant difference between the diversities of invertebrates before introduction of fish and after introduction of fish, (t= 1. 23, P < 0.05).

**Figure 3: Diversity Indices (H') of Invertebrates at five ponds of Wazo Hill Quarry**




**H'= Shannon Weiner diversity Index**

### 5.4 Results from interviews on importance of Wazo Hill Ponds

About fourty percent (40%) of respondents argue that the pond could be important for fishing activities, Seventeen percent (17%) of respondent argue that Wazo Hill ponds are very important as they can attract aquatic and terrestrial animals such as snakes, frogs, fishes, monkeys and others. About 11% of respondests argue that those ponds could be very potential source of employment. 10% of respondent thought that, Wazo Hill ponds could be very useful for domestic purposes to people around the quarry site. Among these, 87% were females. 9% of respondent suggested that ponds are important for keeping frogs for biology practicals in school and colleges, 7% of respondent responded that those ponds are important for swimming, and among these 96% were male respondents. 4% of respondent sugested that these ponds are useful for reducing soil erosion caused by rain and 2% of respondent argue that these ponds can be used for reducing dust on the roads as well as irrigation of flowers and vegetable gardens in the quarry.

## 6.0 DISCUSSIONS

The study shows that, some water parameters such as conductivity and dissolved oxygen were founds to be higher in pond 1. Conductivity is the measure of dissolved ions. Aquatic invertebrates survive and reproduce more effectively in water with higher conductivity (Brooks, 2002). 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 (Thorp and Covich, 1991). 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 (Brooks, 2002). 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. Extremely high temperature also has effects on invertebrates. Increased water temperatures might affect the time of complete development of invertebrates example to Odonata (Suhling et al. 2005; Lutz, 1974). However, in this study

this was not the case. It is possible that the average temperature readings were 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. They have a strong interaction with environmental conditions (Moretti and Callisto, 2005; Pamplin et al., 2006, Pech et al., 2007), thus; this faunal component has been frequently used in environmental quality assessment (Guimaraes et al., 2009). Invertebrates are functionally important in many terrestrial and aquatic ecosystems (Wilson 1992, Freckman et al. 1997, Postel and Carpenter, 1997). 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 (Covich et al., 1999).

Despite the fact that aquatic invertebrates are physically small, they are a major link in the energy exchange from producer to consumer. The biodiversity of aquatic invertebrates within watersheds is an important indicator of the ecosystem's function. 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. 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. Downing and Leibold (2010) 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 favourable 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. 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. Survival of invertebrates normally would attract aquatic vertebrates as well as terrestrial vertebrates such as birds, snakes, monkeys and others. 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 like 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. Again workers of the company could also benefit from fish during the lunch the company could provide fish to workers which enhances their working capabilities by gaining more protein. 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 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. People would employ themselves if fishing activities by buying fish from the company and selling them as retailers to people around the company and throughout Dar es Salaam. This will also reduce the level of poverty to people around the company and in another way will enhance good relationship between the company and the community around the company. However, the fishing activities within the quarry site should be taken under close supervision from the management so that not to pollute the environment.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

Generally Wazo Hill ponds are very important to the biodiversity conservation, to the ecosystem, the community around the company as well as the nation in general. It has been found that these ponds harbor varieties of invertebrates which are very potential as indicator species and in the ecosystem functioning. In the process of maintaining energy flow, these invertebrates species simultaneously provide essential ecosystem services, such as nutrient cycling and aeration of sediments. Different species comprise distinct functional groups that provide ecological integrity. In some cases, these functional groups may be represented by only a few species, so that any loss of species diversity could be detrimental to continued ecosystem functioning. Thus, it is important to protect the aquatic biodiversity communities to lower the risk of unexpected and unwanted consequences.

### 6.2 Recommendations

With respect to this study, it is therefore recommended that these ponds should continue be managed so as to benefit from them.

It is also recommended that further studies and monitoring be done to investigate on other species of biodiversity such as small mammals, amphibians and reptiles which are supported by these ponds.

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.

**ANNEXES**

**Annex 1: References.**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**Annex 2: Likert scale questionaire**

Please select and circle the number below with respect to how you think could be the importance of created ponds at Wazo Hill quarry site.

1= strongly disagree

2= Disagree

3= Neutral

4= Agree

5= strongly agree

1. Ponds can be useful for fishing activities. 1, 2, 3, 4, 5
2. Created ponds can be used for irrigation of flowers and vegetable garden in the company. 1, 2,3, 4, 5
3. Created ponds can attract aquatic invertebrates and vertebrates such as snakes, frogs, monkeys and other biodiversity. 1, 2, 3, 4, 5
4. Ponds can be used for swimming. 1, 2, 3, 4, 5
5. Ponds can be used to reduce soil erosion caused by rain. 1, 2, 3, 4, 5
6. Ponds can be used by the company to reduce dusts on the road within the company by watering the roads. 1, 2, 3, 4, 5
7. Ponds can create employment to people living near the company by engaging them in the fishing activities. 1, 2, 3, 4, 5
8. Water from ponds can be useful for domestic purposes to people nearby the Wazo Hill quarry. 1, 2, 3, 4, 5
9. Ponds can be used to keep frogs for practical in schools and colleges. 1, 2, 3, 4, 5
10. Ponds can be used by students to study some aquatic organisms. 1, 2, 3, 4, 5

**Annex 3: List of Orders and families of invertebrates sampled at Wazo Hill quarry ponds.**

| ORDER | FAMILIES | ABUNDANCE | | | | | Total |
|---|---|---|---|---|---|---|---|
| | | POND 1 | POND 2 | POND 3 | POND 4 | POND 5 | |
| Coleoptera | Dytiscidae | 18 | 11 | 3 | 0 | 0 | 32 |
| | Noteridae | 11 | 0 | 0 | 0 | 0 | 11 |
| | Hydrophilidae | 22 | 8 | 0 | 2 | 1 | 33 |
| Ephemeroptera | Beatidae | 8 | 2 | 0 | 0 | 4 | 14 |
| Odonata | Libellulidae | 32 | 7 | 18 | 4 | 10 | 71 |
| | Corduliidae | 8 | 0 | 0 | 0 | 0 | 8 |
| | Coenagrionidae | 13 | 0 | 0 | 0 | 0 | 13 |
| Hemiptera | Naucoridae | 21 | 11 | 0 | 0 | 3 | 35 |
| | Nepidae | 7 | 4 | 0 | 5 | 0 | 16 |
| | Hydrometridae | 1 | 0 | 0 | 0 | 1 | 2 |
| | Gerridae | 19 | 17 | 0 | 0 | 0 | 26 |
| | Notonectidae | 7 | 0 | 0 | 0 | 0 | 7 |
| Gastropoda | Thiaridae | 4 | 2 | 0 | 0 | 0 | 6 |
| | Physidae | 3 | 0 | 0 | 0 | 0 | 3 |
| Bilvalvia | Corbiculidae | 9 | 1 | 0 | 0 | 0 | 10 |
| | Sphaeriidae | 11 | 0 | 0 | 0 | 0 | 11 |
| Diptera | Chironomidae | 4 | 0 | 0 | 0 | 0 | 4 |
| | Tipulidae | 3 | 0 | 0 | 0 | 0 | 3 |

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

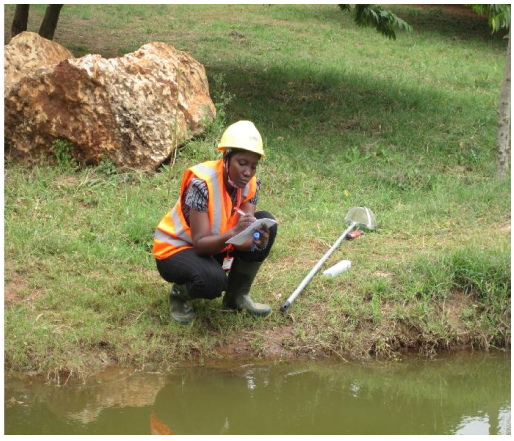
**Annex 4: Various plates showing activities done during the project.**

**4.1 Ponds where sampling was done**





### 4.2 Measurement of pH, temperature, Disolved oxygen and conductivity



### 4.3 Sampling of Invertebrates

**4.4 Interviewing people on what could be the importance of Wazo Hill pond**

**4.5 Some invertebrates sampled**