Final Project Report

1. Contestant profile

▪ Contestant name:	**Mostafa Ragab Abd El Wahab**
▪ Contestant occupation:	Lecturer and Researcher at The Faculty of Science
▪ University / Organisation	Beni Suef University, Egypt
▪ Number of people in your team:	**5 member**

2. Project overview

Title:	Environmental assessment of quarrying at Helwan quarry and its effect on biodiversity
Contest: (Research/Community)	Research
Quarry name:	HELWAN LIMESTONE QUARRY NO. 11623

Abstract

However previous studies were conducted to investigate the present fauna and flora in Helwan limestone quarry, no previous studies focused on the present micro-organisms and their effect in the quarry ecosystem and the present insects. Also, no clear studies were conducted to explain the relations between the biodiversity in the quarry and the interaction factors in the quarry. In this project, we covered this gap through the recording of 11 species of micro-organisms (10 micro-algae and 1Nematode). The present microalgae represented by 7 species diatoms, 2species blue-green algae and 1 species green algae. The enrichment in verities of diatoms related to saturation of bicarbonate that decomposed into CO_2 which fixed by Diatoms and resulted in realizing of O_2 and this phenomenon recorded extensively in the quarry. Which reflect its role in reducing the environmental loads in the quarry. The detected species of algae of freshwater and high salinity habitats which reflect the effect of mixing between groundwater and sewage water and their interaction with rocks in the quarry in providing a different condition for the living of different species. The open and sunny nature of the quarry in addition to the different elevations, seepage water, various types of grass and flowering plants provided new habitats for about 8 species of insects. The enrichment of seepage water in nutrients, as well as the variety in the present substrate (rocky, sandy, soil) and the different in the degree of salinity, represented suitable conditions for the growth of about 12 species of plants. The quarrying activities and the wide availability of insects and plants provided effective habitats for various vertebrates as about 12 species were detected in the area. The suggested plan to the suitable management of the quarry is to utilize the continuous flow of seepage water and its qualification for the living of fishes in addition to its saturation with ammonia and phosphate can provide best conditions for constructing aquaponics farm that will assist in converting the quarry into the eco-friendly quarry of economic value. Also, the wide distribution of Tamarix aphylla with its characteristic nectar which is reported as effective nectar for high-quality honey support the idea of producing beehives in the quarry.

Introduction

Biodiversity is a scientific term refers mainly to the present living species in the studied area including vertebrates, invertebrates, insects, reptiles, plants, fungi, and even micro-organisms. The conservation of the biodiversity in any studied area is of a critical importance as all the living species are interlinked to each other and preserve the living balance in nature. The human activities have a direct effect on the biodiversity of areas which associated with its communities and sectors of his activities. The human activities involved agricultural activities, mining activities, industrial activities, and other activities related to the human lifestyles.The quarrying activities increased extensively in the later periods under the continuous increase in the world demand for raw materials for several industrial and agricultural applications. The quarrying activities are of direct and/or indirect impacts on the surrounding ecosystems. However, the quarrying activities and the related excavation, blasting, drilling and the associated by-products normally associated with the destruction of some of the present animal habitats as well as the distributed flora. Even if the living habitats are not destructed directly by the excavation and blasting activities, they can be destructed indirectly under the associated environmental impacts as the changes in the groundwater levels that can be polluted by the toxic element according to the type of the quarried rocks and ore. Additionally, the saturation of wind by fine suspended particles from the quarried rocks plays a major role in blocking and destruction of the internal structure of the present flora as well as such articles can cause abrasion of the leaves of the plants. Dust polluted air also the main responsible of the crop yield loss and vegetation injury.

However, the mining activities and the associated byproducts from dust, solid wastes and interaction with raised groundwater affect widely the environment and the living system around the mining processes. But, also it can be resulted in the formation of new habitats and provide new environmental for other species and cause clear changing in the biodiversity of the area depending on the interaction between the present geological, climate and geographical factors. Moreover, the careful planning and management of the quarrying areas can be resulted in a possible minimize to the side effects of quarrying activities on the biodiversity in the area.

In this project, we focus on Helwan limestone quarry (No. 11623). The studied quarry is consists of two parts and covered an area about 1.8km2 adjacent to 15 of May city. The quarry was studied previously by other researchers to identify the present fauna and flora and they recorded about 12 vascular plant species and about 15 vertebrate species. The main target of the previous work is to make detection for the plants and vertebrates in the quarry. Thus, our work focus to complete the biodiversity image of the quarry and cover the present gaps through the recording of the present micro-organisms, insects, confirming the previous detected plants and vertebrates. Also, the study will cover the relationship between the geological features, seepage water in the quarry, quarrying activities and the biodiversity in the quarry. Finally, possible management model was suggested to enhance the biodiversity in the area and make it of economic and environmental value.

Methods

The bio-history of the quarry was evaluated utilizing about 15 thin sections of carbonate rocks in the quarry to define the preserved micro and macrofossils in the geological record of the quarry. The investigation of the studied thin sections was performed using a polarized transmitted microscope. Geochemical and quality evaluation of the seepage water in the quarry were done through the collecting of representative water samples from the main 3 water pools in the quarry and determination of the main components utilizing ICP and ion chromatography techniques. This was designed to test the suitability of such water resources for the present fauna and flora, its impact on the biodiversity in the quarry and to set the suitable management techniques.

Identification and recording of the present microorganisms were accomplished by collecting samples from the area in the quarry. After separation and isolation, the present species were studied using a transmitted microscope and scanning electron microscope. The identification and recording of the present fauna were accomplished based on two strategies involving direct and indirect survey methods after classification of the quarry into studied zones. The direct method involved realistic sighting and in site recording of the observed species into data sheets. The indirect method included the detection of significant traces or relicts related to living fauna in the studied zones. The recorded species and sub-species were investigated based on the criteria of the red list data set by set by International Union for Conservation of Nature for flora (IUCN, 2009). The diversity index was estimated based on Shannon Weaver's equation (Lameed and Ayodele, 2010).

1. Results

3.1. Life History of the area in the geological record

Deep investigation for about 15 thin sections for the limestone rocks in the area reflected the preservation of numerous living species in the geological record of the area. There are relicts for species of Echinoderm, Bivalvia, and Gastropod that lived in the area in the geological history from millions of years (Fig.1).

3.2. Geochemical quality of seepage water in the quarry

The average composition of the collected water samples from the three water pools (Fig.2) in the quarry is 2824mg/L, 124mg/L K^+, 456mg/L Ca^{2+}, 131mg/L Mg^{2+}, 450 mg/L HCO_3^-, 3470mg/L Cl^-, 2840mg/L SO_4^{2-}, 15mg/L NO_3^-, 0.032mg/L Zn^{2+}, 0.21mg/L Cu^{2+}, 12680 mg/L TDS. The total hardness within a range from 1240mg/L to about 1480mg/L and the phosphate content present within a range from 4mg/L to 28mg/L.

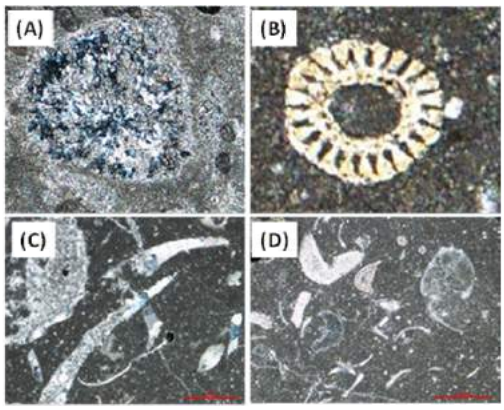

Fig.1. traces for echinoderm shells (A, B), relicts from bivalvia shells, and (D) relicts from brachipod shells

Fig.1. Seepage of water through the fracture systems in the limestone and formation of water pools associated with plants and algae communities

3.3. The present micro-organisms

Ten species of micro-algae in addition to Nematode were detected and recorded in the quarry. The detected micro-algae are belonging to three categories involving Diatoms, Blue green algae and Green algae. Seven species of diatoms were recorded in the three water pools in the quarry and identified as Pinnularia viridis (Fig.3.1), Achnanthes minutissima (Fig.3.2), Amphipleura pellucida (Fig.3.3), Nitzschia dissipata (Fig.3.4), Nitzschia vermicularis (Fig.3.5), Tabellaria flocculosa (Fig.3.6), and Actinocyclus normanii (Fig.3.7).

Two species of blue green algae (Cyanobacteria) were recorded extensively in the high water pools as well as in all the small disconnected pools in the quarry (Fig.4). The recorded species area is Gloeocapsa sp (Fig.4) and Oscillatoria agardhii (Fig.4). Only one species of green algae (Chlorophyta) was detected in the area and the recorded species is Microspora abbreviate (Fig.5).

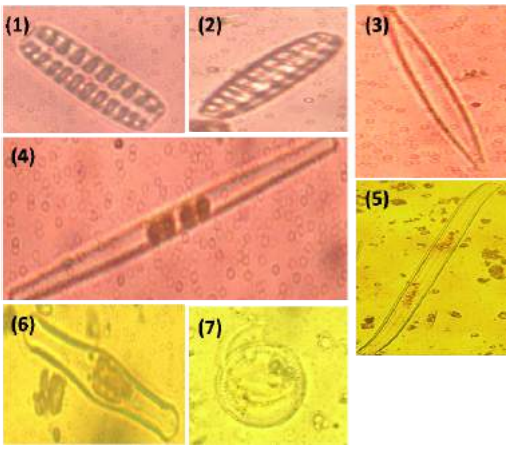

Fig.3. The edetcted diatoms species in the three water pools in the quarry under microscope

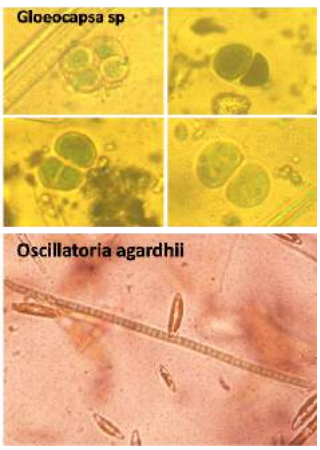

Fig.4. The edetcted blue green algae under microscope

Fig.5. The edetcted green algae under microscope

Fig.6. The edetcted Nematode under microscope

Nematode worms were detected extensively in the investigated water samples especially the more brackish samples (Fig.6). Other filamentous cyanobacteria were detected within the common sedimentary structure of the quarry especially as the sabkha deposits and commonly known in the geological studies as a result of microorganism's activity (Fig.7A, b, C). Filamentous cyanobacteria in these deposits were detected using SEM.

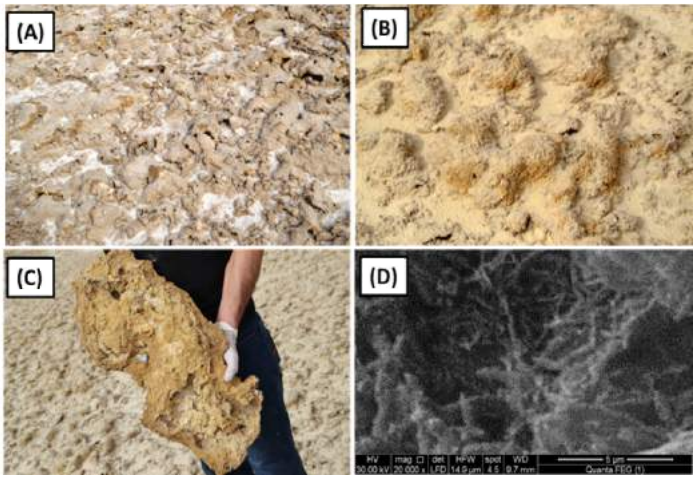

Fig.7. TP sedimentry structures of sabkha deposits (A, B, and C), and SEM image for the fibrous form of filamentous cyanobacteria in such deposits (D)

3.4. Insects

There are about 8 species of insects were detected in the quarry either by direct observation or by recording their habitats (Fig.8). The detected species of insects are Painted Lady (Vanessa cardui) (Fig.8A), Crocothemis erythraea (Dragonfly insect) (Fig.8B), Honeybee (Fig.8C), Bluebottle fly (fig.8D), Gray Beetle (Fig.8E), Pavement Ants (Fig.8F), Spider (Fig.8G and H), and rock boring bee (A. pueblo bee) (Fig.8I).

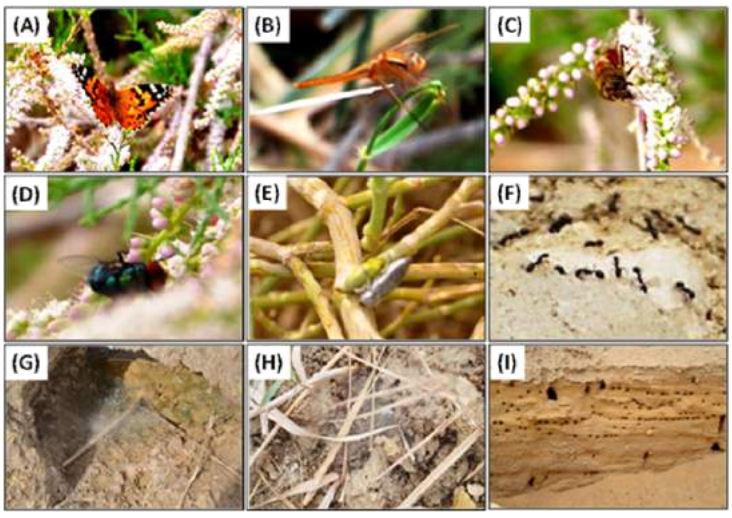

Fig.8. The detected insect species in the quarry from A to I

3.5. Plants

12 species of plans were recorded and identified in the quarry (Fig.9). The detected species are Tamarix aphylla (Fig.9A), Phragmites australlis (Fig.9B), Nitraria retus (Fig.9C), Haloxylon salicornicum (Fig.9D), Echinops spinosissimus (Fig.9E), Juncus rigidus (Fig.9F), Zilla spinosa (Fig.9G), Ochradenus baccatus (Fig.9H), Teucrium polium (Fig.9I), Zygophyllum coccinum (Fig.9J), Alhagi maurorum (Fig.9K), and Artemisia californica (Fig.9L).

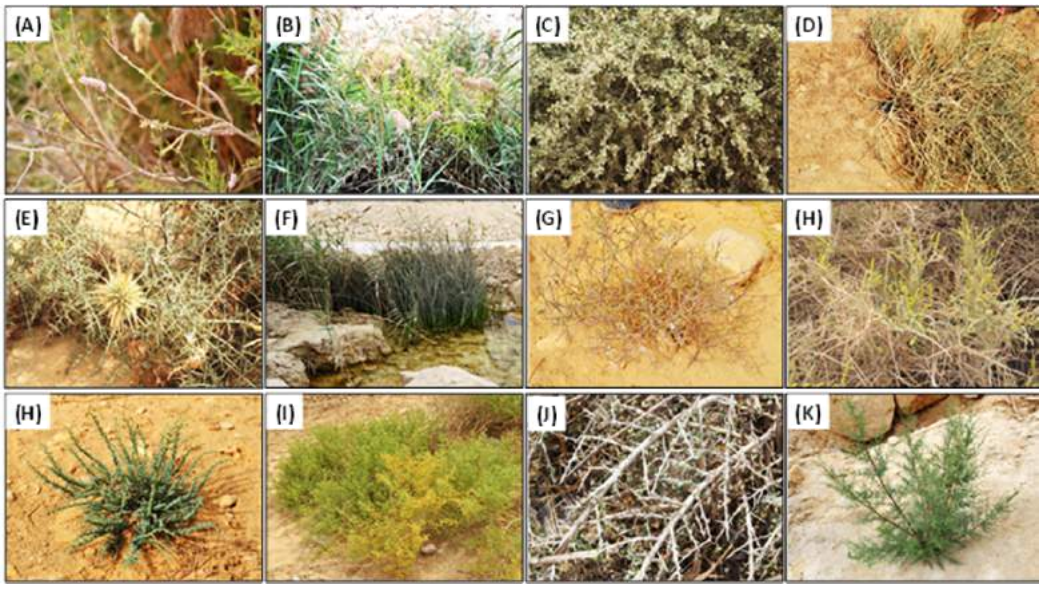

Fig.9. The detected plant species in the quarry from A to L

3.6. Vertebrates

The recorded vertebrates are of pet and wild types (Fig.10). The recorded species are Nile Tilapia fish (Fig.10A), Vanellus Spinosus (spur-winged plover) (Fig.10B), Passer domesticus (House sparrow) (Fig.10C), Streptopelia Senegalensis (palm dove) (Fig.10D), Passer domesticus (rock pigeon or rock dove) (Fig.10E), Corvus rhipidurus (crow) (Fig.10F), domestic goat (Capra aegagrus hircus) (Fig.10G), sheep (Ovis aries) (Fig.10G), the dromedary or the Arabian camel (Camelus dromedarius) (Fig.10H), Equus asinus, and domestic dog (Canis lupus familiaris or Canis familiaris) (Fig.10I). Other mammals were detected and their foot imprints (fig.10J) and their habitats (Fig.10K and L) and was recorded extensively in the quarry as Vulpesvulpes (red fox).

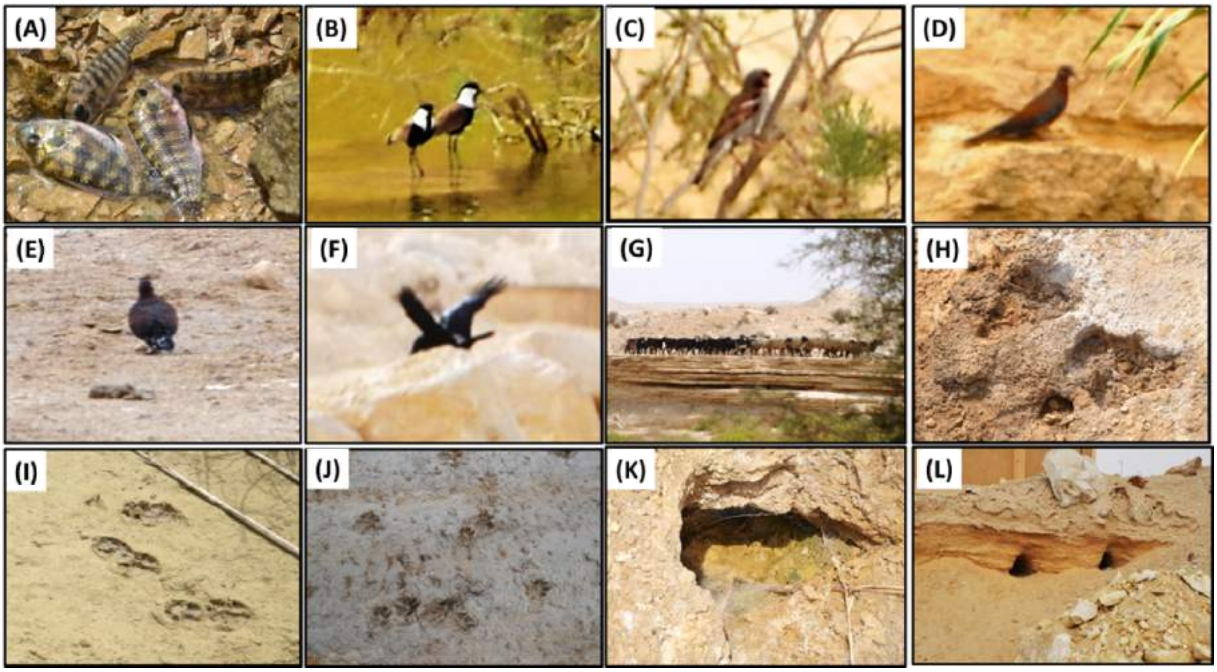

Fig.10. The detected veretebrates and thier indictors in the quarry

Discussion

The main parameters that control the biodiversity in Helwan quarry related mainly to five factors; (a) the quarrying activities, (b) the seepage water in the quarry, (c) the interaction between limestone rocks and the seepage water, (d) chemistry of the seepage water, and (e) the activities of population in the areas around the quarry (Fig.2). Based on the chemical analysis of the collected water samples, the present water pools cannot be classified as proper groundwater seepage or complete sewage water and was classified as mixing water between them. This was confirmed by the percentages of chloride, sulfate, nitrate and phosphate ions in the water. Such values related mainly to sewage water or agricultural drainage water in the nearby town (15th May town) which was concordant with other studies conducted by Abdalla and Scheytt, (2012). Additionally increasing the total hardness and bicarbonate ions reflected the interaction of seepage water with limestone and extensive dissolution of limestone by water which resulted in saturation of the water pools in the quarry by bicarbonate anions.

The mixing between different water resources and the interaction between rocks in the area provided suitable conditions for the growth of a different type of diatoms either those live under high salinity conditions (Nitzschia dissipata and Actinocyclus normanii) or those living in the freshwater environment. The semi-quantitative detection for the abundance of the diatoms species in the studied water pools in the quarry based on the SEM images (Fig.11A) reflected that the species can be ordered in abundance as Amphipleura pellucida > Pinnularia viridis > Tabellaria flocculosa > Achnanthes minutissima > Nitzschia dissipata > Nitzschia vermicularis > Actinocyclus normanii (Fig.11B). According to these values, the freshwater species represent the dominant species. This was confirmed by scan imaging for the isolated samples, as 95.73% pennate forms and 4.27% centric forms (Fig.11C). Members of both classes (Centric and Pennate) may be found in either fresh or salt water, However Centric forms tend to predominate in marine habitats, while Pennate diatoms are more typical of freshwater environments.

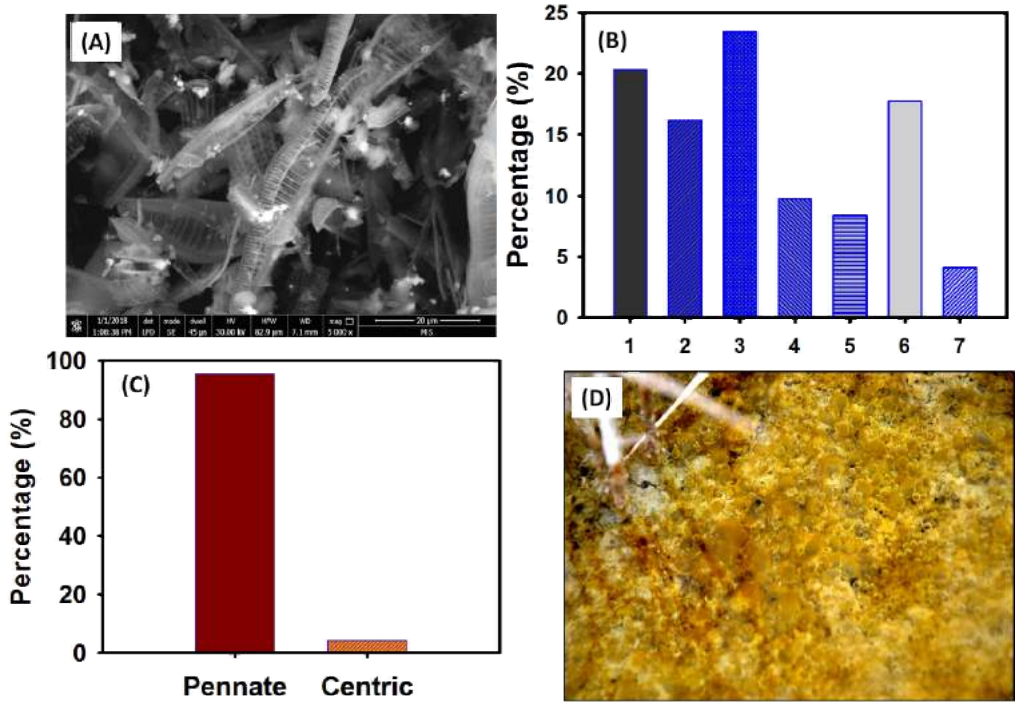

Fig.11. SEM image of separated diatoms from water pools in the quarry (B), the abundance percentages of different diatoms species (B), The baundance of centric diatoms in comparison with pennate forms (c), relaesing of oxygen in the shallow water pools in the quarry which is enriched in daitoms (D)

Diatoms produce 25-40% of the air we breathe through carbon fixation; diatoms remove carbon dioxide (CO_2) from the atmosphere. The CO_2 is converted to organic carbon in the form of sugar, and oxygen (O_2) is released. We breathe the oxygen that diatoms release. Thus, the seepage water in the quarry is an ideal environment for their activities and their flourish. Saturation of the water pools by bicarbonate anions from the dissolved limestone represents the main feeds for diatoms, as bicarbonate commonly decomposed into carbon dioxide. Also, diatoms in the quarry will play a major role in reducing the carbon dioxide environmental load from the quarrying activities and will contribute in releasing oxygen to the surrounding atmosphere which was recorded extensively in the water pools of the quarry (Fig.11D). Moreover, diatoms are an important food source for many aquatic organisms including Zooplankton which in turn will sustain larger organisms, like fish. Diatoms are a key source of food and energy for other organisms in many freshwater ecosystems as Snails, caddisfly larvae, small crustaceans and filter feeders like clams. Therefore, diatoms can represent start for complete aquatic ecosystem including fish.

The detected blue-green algae of Gloeocapsa species are common species that related to high salinity environment and detected mainly in the closed disconnected small pools of high salinity and close to salt deposits in the quarry (Sabkha deposits). Thus saturation of the seepage water by total dissolved salts through the interaction with halite and gypsum rocks in the quarry in addition to the high evaporation rate under the high temperature and sun exposure assist in providing habitats for such type of algae. However, Oscillatoria sp was detected in both high salinity pools and nearly freshwater pools. Oscillatoria sp used widely in the production of butylated hydroxytoluene (BHT) which is an antioxidant, food additive and industrial chemical. Also, the recorded green algae can be lived in a wide environment from freshwater to hypersaline water. SEM imaging of salt crust samples from sabkha deposits reflected the presences of filamentous cyanobacteria of hyper-saline nature.

Regarding the detected insects, Vanessa cardui was extensively recorded in the quarry in considerable numbers. The quarry represents ideal habitat for such species as it is sunny, warm and open region. The geomorphological nature and the quarrying process affected the topography which resulted in higher and lower elevations which is promising for its nutrient system as prefers nectar from composites 3-6 feet high. Additionally, the seepage groundwater and drainage water in the quarry resulted in large communities of flowering plants which provide the host plants and nectar resources in the area. Crocothemis erythraea also, distributed widely in Helwan limestone quarry which attributed mainly to the presence of shallow lagoons surrounded by different types of plants and grasses which represent the ideal environment for its habitat. The wide distribution of grass and flowering plants around the water swamps in the quarry provide the best environment for feeding and production of the honey bee. Also, the same conditions provided idea habitats for Bluebottle fly and Gray Beetle. Pavement Ants in Helwan limestone quarry were recorded extensively in the quarry as it represents an ideal environment for their habitat as the excavation of limestone rocks, cracks, and friable soils, providing the best area for their nests. Additionally, the richness of the quarry in flowering plants, insects, and remains of food remaining from the quarry workers provide the main feeding products. The presences of grasses, plants, rocks excavation, and other insects also reflected in the high abundance of spider nests as habitat for it. Finally, the presences of friable sandstone around the quarry represent an ideal place for the boring bee (A. pueblo bee) to build their nests that may be left later under the quarrying activities in the area.

The clear variation in the geomorphological features and growing environment between sandy, rocky, soil, swamps, high saline conditions, freshwater conditions resulted in considerable variations in the present flora. Which in turn act as the best attractive conditions for other dependent animals, insects as well as the pastoral activities by the local population. It is worth to be mentioned that the nectar from the blossoms of tamarix aphylla produces a high-quality honey with a unique taste which explains the wide distribution of the honey bee in the quarry. Also, the presences of Phmragites Australlis which is not native Egyptian plants reflected the role of winds and the Migratory birds in the transportation of plants pollens to the quarry which contains the suitable habits of its growth and flourishing.

Regarding the recorded vertebrates, the Nile tilapia is an omnivore that feeds on both plankton and aquatic plants. It generally feeds in shallow waters, as harmful gases (such as carbon dioxide, hydrogen sulfide, and ammonia) and temperature fluctuations found in deep waters create problems for the physiology of the fish. The Nile tilapia thrives on the warmer temperatures commonly found in shallow waters compared to the colder environment of the deep lake. In general, tilapias are macrophyte-feeders, feeding on a diverse range of filamentous algae and plankton. The shallow water polls in the quarry in addition to the extensive recording of different types of algae especially filamentous algae and aquatic plants provide good environment for growth and production of such types of fish. Vanellus Spinosus (spur-winged plover) has a preference for marshes and similar freshwater wetland habitats. It Feeds mainly on insects and their larvae, especially beetles; also grasshoppers, flies, midges, termites, ants, spider and myriapods which is present in high abundance in the quarry. Passer domesticus (House sparrow) is strongly associated with human habitation, and can live in urban or rural settings, and it is found in widely varied habitats and climates. It feeds mostly on the seeds of grains and weeds, but it is an opportunistic eater and commonly eats insects and many other foods. The camp of the engineers and workers; and the local habitation around the quarry provide the best conditions for its habitat in addition to the enrichment of the quarry by the main feeds for it.

Streptopelia Senegalensis (palm dove) is a common and widespread species in scrub, dry farmland, and habitation over a good deal of its range, often becoming very tame. The species is usually seen in pairs or small parties and only rarely in larger groups. Larger groups are formed especially when drinking at waterholes in arid regions. Small numbers assemble on trees near waterholes before flying to the water's edge where they are able to suck up water like other members of the pigeon family. Laughing doves eat the fallen seeds, mainly of grasses, other vegetable matter and small ground insects such as termites and beetles. They are fairly terrestrial, foraging on the ground in grasslands and cultivation. For Columba livia (rock pigeon or rock dove), it lives mainly in various open and semiopen environments. Cliffs and rock ledges are used for roosting and breeding in the wild. Thus, the quarry and the excavation processes provided ideal habitats for such two species. Additionally, Corvus rhipidurus (crow) lives in the desert or open dry country that includes crags for nesting. Its food is invariably taken on the ground and includes all manner of insects and other invertebrates, grain was taken from animal dung, carrion, and scraps of human food. It has also been seen taking skin parasites from camels and, where not persecuted, scavenges around rubbish dumps and camp sites. This species nests on rock ledges and in cavities in cliffs. Thus, the quarrying activities, open environment of the quarry, the residual foods in the worker camps, and the residual foods of local habitation in the area, the present insect and others provided ideal conditions for its habitat and its abundance in the quarry.

The wide distribution of plants and grasses in the quarry, as well as the water sources, made the quarry one of the best pastures for the local populations around the quarry. Thus several types of pets were observed in the quarry including domestic goat (Capra aegagrus hircus), sheep (Ovis aries), donkey or ass (Equus africanus asinus), domestic dog (Canis lupus familiaris or Canis familiaris) and the dromedary or the Arabian camel (Camelus dromedarius). Other mammals were detected and their habits and foot imprints were recorded extensively in the quarry as Vulpesvulpes (red fox).

Management plan

Recently aquaponic farming attracted the attention of several researchers as well as the investors and the government institutes. Aquaponics is the combination of aquaculture (raising fish) and hydroponics (the soil-less growing of plants) that grows fish and plants together in one integrated system. The fish waste provides an organic food source for the plants, and the plants naturally filter the water for the fish (Fig.11). Thus, it exhibits several advantages as it provides continuous feed within the system, save the amount of used water fixed for a long time, the growing crops are of healthy effect as they are free of pesticides or chemical and in addition to the high prices of aquaponic crops in the market.

In Helwan quarry, there is continuous seepage of water from teen of years, this water saturated already by plants nutrients and aquatic plants and organisms. The local habitats in the area were succeeding in growing fishes in the formed water pools in the quarry. Therefore, there are the suitable water resource and fish in the area which are the main parameters for aquaponic farming. Suitable basins can be designed around the main water pools in the quarry and through pumping of water from pools (that enriched in ammonia and phosphate from its source and from the activity of aquatic organisms and fishes) to the basins effective aquaponic farms can be built in the quarry. After a period, the growing crop will reduce the ammonia content from water and the water return purified water to the pools which will dilute the ammonia saturation in the pools which will enhance the fish flourishing (Fig.12). This will assist in converting the quarry into eco-friendly quarry of economic value. Also, the wide distribution of tamarix aphylla with its characteristic nectar for high-quality honey support the idea of producing beehives in the quarry

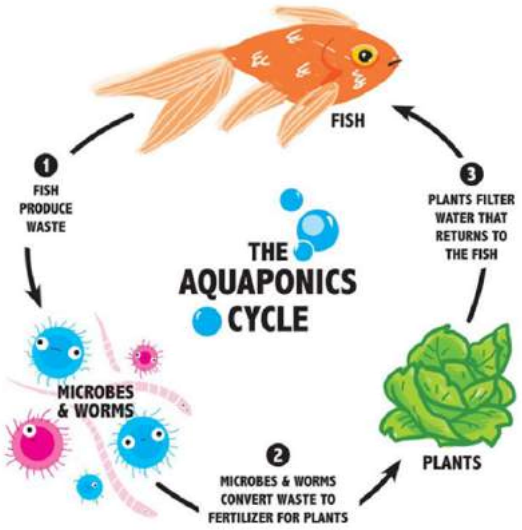

Fig.11. Schematic diagram for aquaponic system

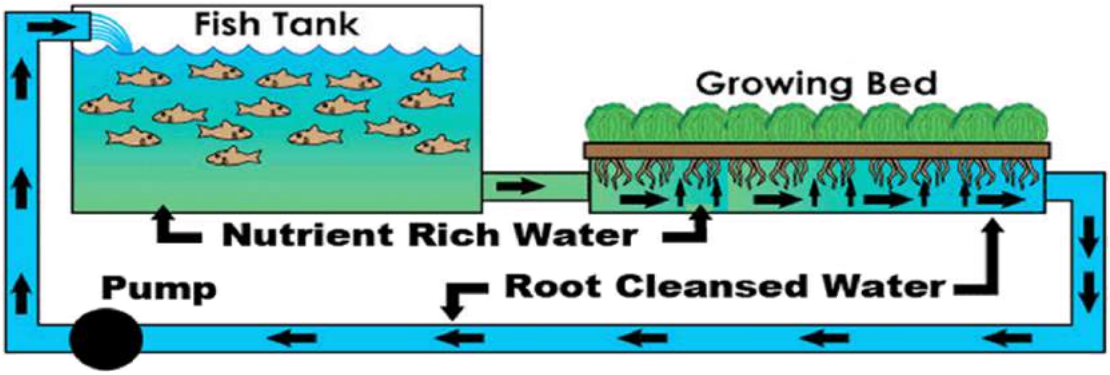

Fig.12. Possible design of aquaponic system (https://smallfarms.cornell.edu/2014/10/06/your-new-farming-partner-fish/)

Conclusion

This project covered the study gap about the micro-organisms and insects biodiversity in Helwan quarry. There are about 11 species of micro-organisms (10 micro-algae and 1Nematode). The present microalgae represented by 7 species diatoms, 2species blue-green algae and 1 species green algae. Diatoms play a major role in the quarry by reducing the CO_2 environmental load as they consume CO_2 from dissolved limestone and release O2. The detected species of algae and plants (12 species) belong to both freshwater and high salinity habitats which reflect the effect of mixing between groundwater and sewage water and their interaction with rocks in providing different conditions for the living of different species. The open and sunny nature of the quarry in addition to the different elevations, seepage water, various types of grass and flowering plants provided new habitats for about 8 species of insects. The quarrying activities and the wide availability of insects and plants provided effective habitats for various vertebrates as about 12 species were detected in the area. The suggested plan to the suitable management of the quarry is to utilize the continuous flow of seepage water and its qualification for the living of fishes in addition to its saturation with ammonia and phosphate can provide best conditions for constructing aquaponic farm that will assist in converting the quarry into the eco-friendly quarry of economic value. Also, the wide distribution of tamarix aphylla with its characteristic nectar for high-quality honey support the idea of producing beehives in the quarry

To be kept and filled in at the end of your report

Project tags (select all appropriate):

This will be use to classify your project in the project archive (that is also available online)

Project focus:

- ☐Beyond quarry borders
- ☒Biodiversity management
- ☐Cooperation programmes
- ☐Connecting with local communities
- ☐Education and Raising awareness
- ☐Invasive species
- ☐Landscape management
- ☐Pollination
- ☒Rehabilitation & habitat research
- ☒Scientific research
- ☐Soil management
- ☒Species research
- ☐Student class project
- ☐Urban ecology
- ☒Water management

Flora:

- ☒Trees & shrubs
- ☒Ferns
- ☒Flowering plants
- ☐Fungi
- ☒Mosses and liverworts

Fauna:

- ☐Amphibians
- ☒Birds
- ☒Insects
- ☒Fish
- ☒Mammals
- ☐Reptiles
- ☐Other invertebrates
- ☒Other insects
- ☐Other species

Habitat:

- ☐Artificial / cultivated land
- ☐Cave
- ☐Coastal
- ☐Grassland
- ☐Human settlement
- ☒Open areas of rocky grounds
- ☐Recreational areas
- ☒Sandy and rocky habitat
- ☐Screes
- ☐Shrub & groves
- ☐Soil
- ☐Wander biotopes
- ☒Water bodies (flowing, standing)
- ☐Wetland
- ☐Woodland

Stakeholders:

- ☒Authorities
- ☒Local community
- ☒NGOs
- ☐Schools
- ☒Universities