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Dorbid Ecosystem: A Natural Approach in Desertification Control

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Abstract

Having located on the dry belt of the earth, Iran encompasses wide surfaces of deserts. With an area of over 30 million hectares, the deserts form 20 percent of the country. There are a variety of traditional projects in combating desertification, yet biological phenomena in hot deserts related to microbial populations and the potential use of micro-organisms for restoring hot deserts environments has not been deliberately investigated. In this research, soil texture and pH of the oasis Dorbid surrounded by the central deserts of Iran recorded in years 1977, 2009 and 2010. These two factors were measured in 2009 for a boundary region as well as the nearest desert. The amounts of acid and alkaline phosphate as well as the number of microorganism (through Most Probable Number, MPN) have been studied in 2010 for all three sample areas. The results suggest that most microorganisms measured in the oasis should be bacteria indicating the rapid stage of the ecosystem evolution. Interestingly, the amount of alkaline phosphatase (representing microorganism activity) was more in soil samples outside the oasis indicating the influences of the oasis on the desert around. Finally, the results of the research has proved that Dorbid as an oasis attached to desert is in good condition and the finding also point out applying an appropriate management will lead the ecosystem to positively influence the desert reclamation systems.

Introduction

Following that 35 percent of the land has become desert in a short time, the United Nations Environment Programme (UNEP) in 1974 urged the countries to participate in the next international conference on desertification which was to be held in 1977. The countries were supposed to prepare all their available information on desertification controlling development, and to prepare their own national combating desertification projects. In Act No. 3511, the UNEP underlined more research to fundamentally clarify some issues of desertification (Agenda 21). Records and documents presented in 1977 in Nairobi, Kenya indicated that, 30 million square kilometers of the land as well as 78 million inhabitants of more that 100 countries were threatened with desertification (UNEP, 1977).

A desert is a landscape or region that receives an extremely low amount of precipitation, less than enough to support growth of most plants. Deserts are defined as areas with an average annual precipitation of less than 250 millimeters (10 in) per year. Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (Agenda 21, 1992). Based upon this definition, a large area of Iran (over 50 million hectares) included of deserts and much of the deserts in Iran has been severely damaged through human activities and livestock pressures together with unconscious measures (Javanshir, 1996).

Whatever that made the deserts unstable, it is felt that having a sustainable desert requires following a progressive close-to-nature approach. This study aims at monitoring the microorganisms' activities in the years 1997, 2009, 2010 in an oasis surrounded by the deserts.

Quantitative activities of the enzymes reflect the organisms producing them (Evenson, 1982; Kramer and Green, 2000; Scinner *et al*., 1996 and Taylor *et al*., 2002). Although apparently dynamic life is lacking in soil ecosystem, there are thousands of microorganisms living in this valuable habitat effecting the stability of the plant ecosystem (Evenson, 1982; Korori, S.A.A *et al*., 2011; Sachs, 1999 and Trasar-Cepeda *et al*., 2000).

Studying qualitative and quantitative activities of microorganism existing in different depths of soil bed and the rules they follow, we are capable of doing the ecosystem assessments (Dick, 2000). Tarlera *et al*., (2008) did a research on bacteria's' genome (rRNA) and proved that ecosystem development has been influenced by microorganism and bacteria, in particular through 77000 last years. Gram-positive bacteria and diversity of bacteria play an important role in conducting the ecosystem forward to the balance. Yang *et al*., (2008) showed Arbuscular mycorrhizal symbiosis with 11 out of 15 plant species. They also stated that changes in soil humidity, percent organic matter, and nitrogen, phosphorus, potassium as well as soil pH have been influenced by AM fungi. Bashan *et al*., (2010) proved that changes in ecosystem in dry lands are related to the microorganism population and their power turning dry desert ecosystem to a more moderate one.

Korori and Matinizadeh (1994) showed how *Aspergillus* genome, a large proportion of microorganisms in arid and semi-arid regions, is capable of changing amilase pattern of the trees. Comparing two ecosystems of healthy and unhealthy trees proved that the healthy elm trees were established in more intact areas. Finally, the experiments done by Carrillo-Garcia *et al.,* (1999) suggested the future role of the microorganism in establishing the plants on the floor, protecting them against severe environmental stresses together with transporting more food to them. They showed that how microorganisms could develop the root system of the plants of 46 species in Sonoran deserts in California by 10-70 percent.

Quantitative surveys of microorganisms in different soil depths together with studying acid and alkaline phosphatase enzymes activities in soil bed (as the ecosystem infrastructure), form the framework of the current research. Finally, the aims of the research are to consider conditions prevailing in the Dorbid ecosystem as an oasis surrounded by desert as well as to know if the current conditions continue, to what extent the ecosystem will combat desertification.

Materials and Methods

Study Area

Dorbid is an oasis surrounded by the central deserts of Iran with an altitude of 2050 m above sea level located in latitudes of 54º 32′ 42″ E and 32º 06′ 33″ N and has an area about 120000 square meters.

Data collection

In 1997, two profiles were dug between two long-lived cypresses and soil texture was studied. Thereafter, the study site was surveyed in 2006 untill 2010. The number of natural regenerations, general health status, climate statistics including precipitation, dry period, wind intensity, minimum and maximum temperature determined.

Soil samples of the central study area (the oasis), the border line, and the desert close to the oasis were analysed. To do the experiments, a layer of 4 cm above was cut and samples of layers 4-24 cm and 24-44 cm were taken in three replicates in every three study sites.

Soil Sample Analysis

Changes in soil texture, pH and the number of microorganisms (fungi and bacteria) as well as quantitative changes in Alkaline and acid phosphatase were studied. In order to culture fungi and bacteria, soil samples have been ready through MPN (Most Probable Number) method, and then grown on TSA (Oblinger and Koburger, 1975). The presence of at least one bacterium is needed to suitably growth in the medium. Serial dilutions were prepared in phosphate buffer saline from sampled soil. Then 1ml of each dilution was inoculated to three tubes containing 9 ml of Tryptocase Soy Broth (Merk) and incubated at 37 ºC for one week. After incubation, the number of tubes showing growth (turbidity) was recorded. The most probable number of bacteria (per g of soil) was estimated according to 3-tube MPN table (Fig. 1). Alkaline and acid phosphatase were measured using the method described by Ohlinger (1996).

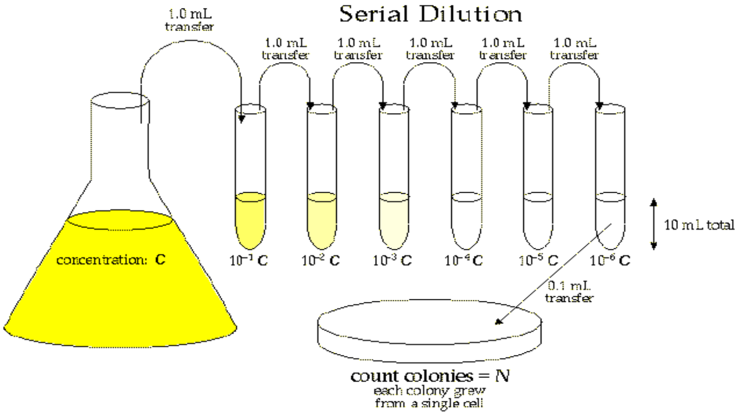

Figure 1: Method of successive dilution of the prototype

Results

The two long-lived cypresses of the oasis described in Table 1, showing the long life of the oasis even with a forested area years ago. The measurement reveal that the seedlings' diameter ranged from 5 to 64 cm and height varied from 1.2 to 4.5 m. the results reveal that the regeneration has occurred in different years and they are now in good conditions (Table 2).

Table 1: Phenotypic characterizations age and mean annual growth of two long-lived cypresses

Species	Diameter at BH (cm)	Height	Age	Mean annual growth (mm)	Healthy status
C. sempervirence	185	21	2500	0.39	Healthy
C. sempervirence	118	19	504	0.9	Healthy

Table 2: Phenotypic characterizations of 10 seedlings

Species	Diameter (cm)	Height	Healthy status	Distance from the nearest old tree
C. sempervirence	27	3	Good and healthy	6
C. sempervirence	7	1.2	Pitchfork and healthy	10
C. sempervirence	29	2.5	Pitchfork and healthy	6
C. sempervirence	73	4.5	healthy	56
C. sempervirence	24	2	healthy	58
C. sempervirence	35	2.7	Pitchfork and healthy	66
C. sempervirence	64	4	healthy	57
C. sempervirence	5	1.8	healthy	9
C. sempervirence	9	2	healthy	10
C. sempervirence	21	2.2	healthy	14

Climate Statistics

Graphs below show changes in climate parameters recorded from the nearest meteorological station to the oasis (Fig. 2, 3, 4, 5 and 6). Both the average annual minimum and maximum temperature in a period of 15 years (1991-2005) gradually increased. The average annual precipitation never exceeded 120 mm, this is while humidity of the area decreased and wind speed increased in the same period. All of the climatic components are consistent with climate change consequences, implying a severe desert area around the oasis Dorbid.

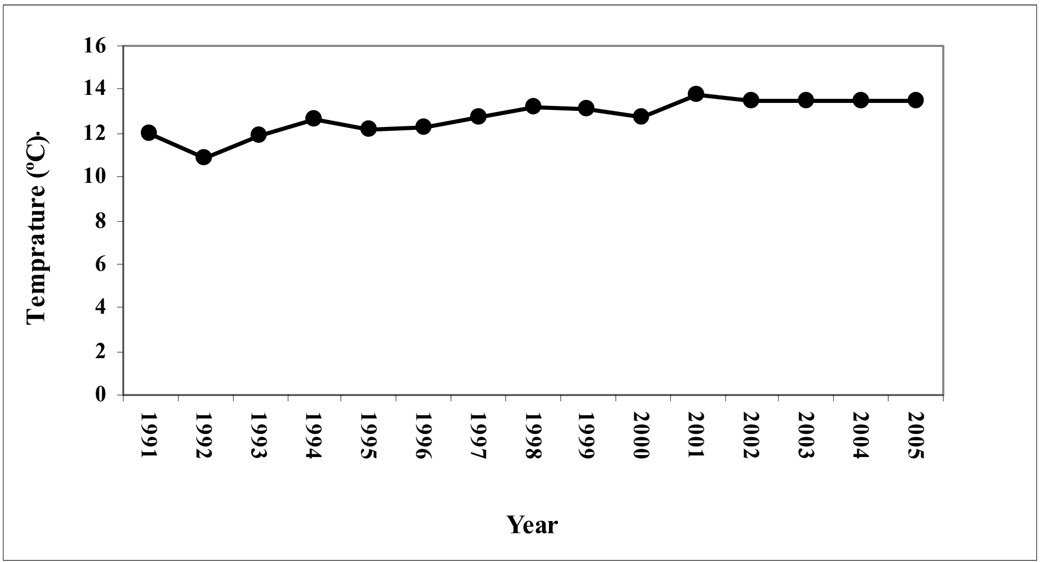

Figure 2: The average annual minimum temperature in the past 15 years

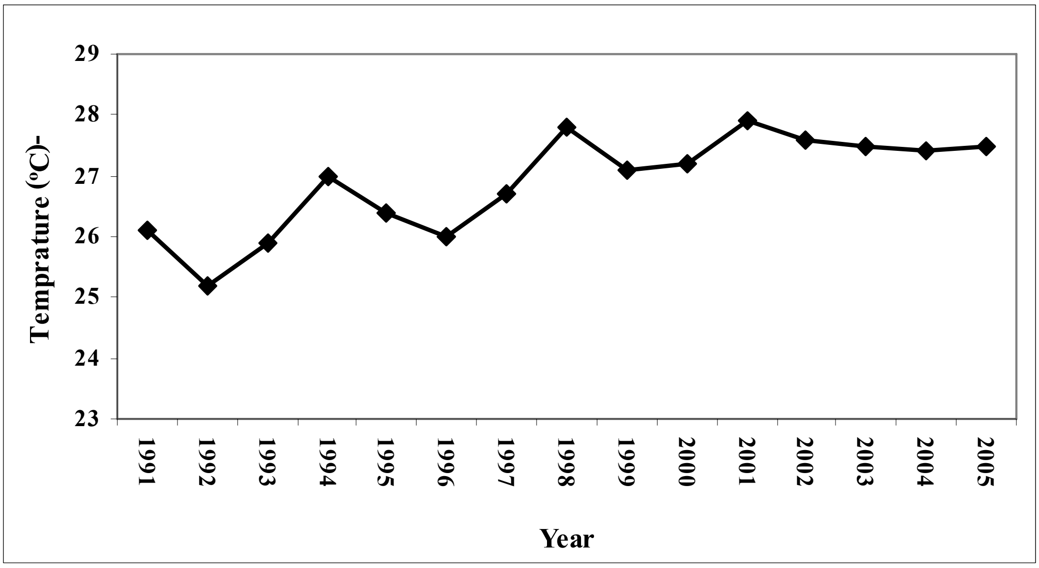

Figure 3: The average annual maximum temperature in the past 15 years

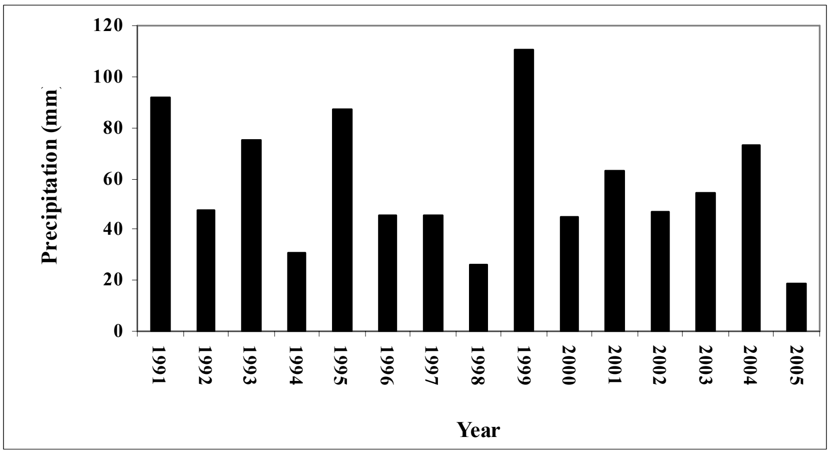

Figure 4: The average annual precipitation in the past 15 years

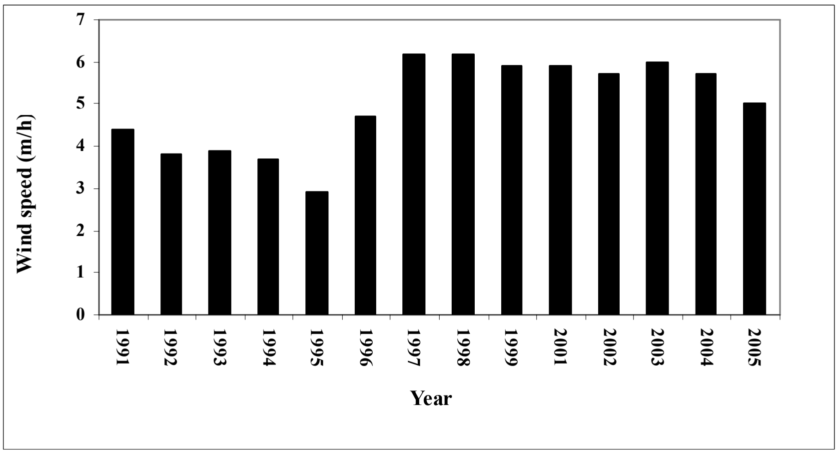

Figure 5: The average wind speed in the past 15 years

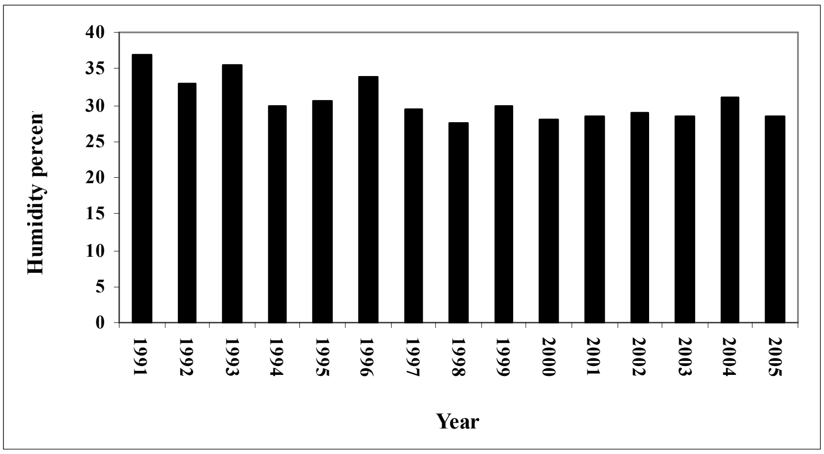

Figure 6: The average annual amount of moisture in the past 15 years

The comparison of Soil Texture and pH

Two factors including soil texture and pH directly influence the soil microorganism quantitatively and qualitatively. The results show that clay is just found in the oasis. Changes in pH are limited and they are in alkaline range (Table 3 and 4). The point is that soils of the oasis showed more acidic characteristics before in 1997 than in 2010.

Table 3: Soil texture and acidity in samples of central areas of the oasis

Study year	Depth (cm)	Soil texture	pH
1997	4-44	Sandy Clay	7.7
2009	4-24	Sandy Clay Loam	7.71
	24-44	Sandy Clay	8
2010	4-24	Sandy Loam	8.17
	24-44	Sandy Clay Loam	8.5

Table 4: Soil texture and acidity in samples of the border line as well as of the nearest Desert

Study year	Depth (cm)	Soil texture	pH
2009 Border	4-24	Sandy Loam	8.24
	24-44	Sandy Loam	8.63
2009 Nearest desert	4-24	Sandy Loam	8.65
	24-44	Sandy Loam	8.26

Changes of Microorganism in Soil Samples

In all three samples the results reveal a decreased amount of microorganisms in the second horizon compared to the first horizon. They are also more in samples of the oasis and the border line in comparison to the nearest desert (Table 5).

Table 5: The amount of microorganisms in samples

Soil sample	Depth (cm)		MPN
In the oasis	No. 1	4-24	$24*10^6$ /g soil
		24-44	$24*10^5$ /g soil
	No. 2	4-24	$2.4*10^6$ /g soil
		24-44	$0.95*10^5$ /g soil
	No. 3	4-24	$2.4*10^6$ /g soil
		24-44	$24*10^5$ /g soil
Border line	No. 1	4-24	$24*10^6$ /g soil
		24-44	$24*10^4$ /g soil

	No. 2	4-24	$0.23*10^6$ /g soil
		24-44	$0.95*10^4$ /g soil
	No. 3	4-24	$2.4*10^6$ /g soil
		24-44	$0.95*10^4$ /g soil
Nearest desert	No. 1	4-24	$24*10^5$ /g soil
		24-44	$24*10^3$ /g soil
	No. 2	4-24	$24*10^5$ /g soil
		24-44	$0.091*10^3$ /g soil
	No. 3	4-24	$24*10^5$ /g soil
		24-44	$0.091*10^3$ /g soil

The amounts of both enzymes in the second horizon are less than the first horizon and the amounts of alkaline phosphatase (with microbial origin) are more than acid phosphatase (with plant origin) (Table 6, Fig. 7 and 8).

Table 6: The amount of enzymes (acid and alkaline phosphatase) in samples

Soil sample	Depth (cm)		Acid phosphatase	Alkaline phosphatase
In the oasis	No. 1	4-24	38.99	202.206
		24-44	24.8	126.24
	No. 2	4-24	29.99	181.6
		24-44	22.95	89.82
	No. 3	4-24	35.5	190.90
		24-44	24.8	110.05
Border line	No. 1	4-24	70.76	249.9
		24-44	2.41	30.14
	No. 2	4-24	69.8	237.12
		24-44	1.5	25.52
	No. 3	4-24	71.3	240.5
		24-44	2	28.5
Nearest desert	No. 1	4-24	31.84	260.85
		24-44	16.28	14.34
	No. 2	4-24	28.36	263.75
		24-44	6.51	21.63
	No. 3	4-24	31.2	266.4
		24-44	12.2	18

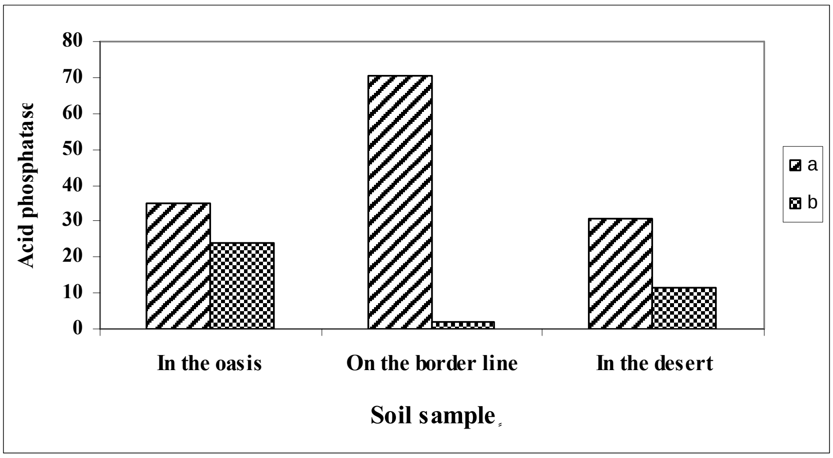

Figure 7: Acid phosphatase (µg ρ-nitrophenol g^{-1} soil h^{-1}) in soil samples in two horizon a (4-24 cm) and b (24-44 cm)

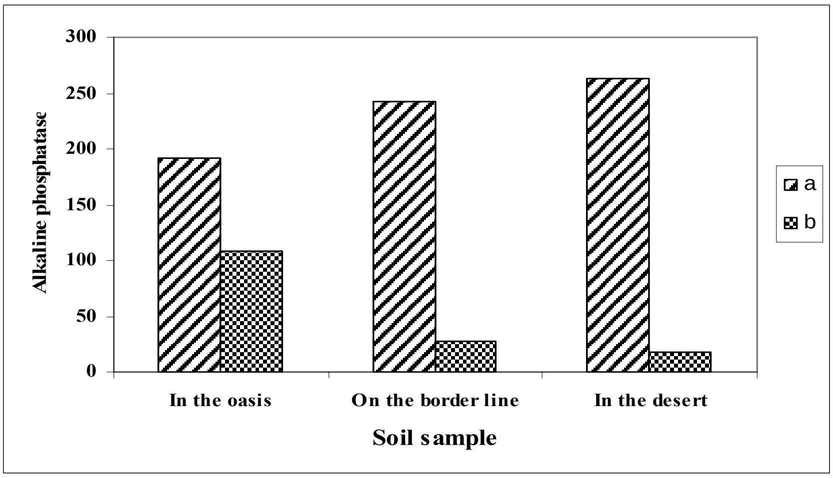

Figure 8: Alkaline phosphatase (µg ρ-nitrophenol g^{-1} soil h^{-1}) in soil samples in two horizon a (4-24 cm) and b (24-44 cm)

Discussion and Conclusion

The ecosystem is a complex set of relationship among the living resources, habitats, and residents of an area. Therefore, not only an ecosystem is influenced by the internal factors, but also through external conditions. Most of the microorganisms are aerobic then found at the upper layers of soils. The more the number and the diversity, the more capable the ecosystem is against the various stresses (Tarlera *et al.*, 2008).

The researches have proved that the arbuscular mycorrhizal plays an important role from the early stages of the ecosystem evolution (like fungi activity through pioneer plants in Japanese volcanic deserts). The ability of these mycorrhizae in stabilizing eroded, sandy land stabilization has also been proved (Kikvidze *et al.*, 2010).

Due to the intense radiation of the sun, wind intensity as well as flowing sands, microorganisms are not active at top soil layer in dry, warm regions then, the first 4 cm was neglected. The research has proved two major issues; the amount of clay decreased and soil went forward to alkaline side from 1997 to 2010. The results reveal that the higher concentration of the oxygen in the soil texture (resulting from reduced clay), made a better soil condition for the presence of microorganisms in the oasis. It is accepted that fungi exist more in Acid soil while bacteria in alkaline soil (Evenson, 1982; Scinner, 1996). According to the results and knowing that the early stages of developing an ecosystem are accompanied by fungi activity and rapid evolution of the ecosystem is followed by more presence of bacteria, it could be concluded that most microorganisms measured in the oasis are bacteria. With regard to the outcome, the study show that the oasis Dorbid has influenced desert lands around. Interestingly, the amount of alkaline phosphatase (representing microorganism activity) was more in soil samples outside the oasis, which are consistent with findings by Kikvidze *et al.*, (2010) and Hooper *et al.*, (2005).

The amount of acid phosphatase in desert areas indicate the existence of plant residues including the less evolved. Normally, the vegetation will increase soil acidity. Microorganisms in acidic soil are mostly of fungi while in alkaline soil are of bacteria Studies on microbial counts of the soil sample indicate a more activity of the microbes at the upper layer, and a lower activity in soil samples out of the oasis yet, a positive trend confirming the findings obtained by Akland *et al.*, (2008). More activity of acid phsphatase (of plant origin) compared to alkaline phosphatase (of animal origin) confirming the results of microbial counts. Lower levels of both mentioned enzymes at the second depth (24-44cm) show a regular movement of the ecosystem toward positive evolution.

Generally, the results of the research has proved that Dorbid as an oasis attached to desert is in good condition and applying an appropriate management will lead the ecosystem to positively influence the desert reclamation systems.

Acknowledgement

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