SALINE POOLING DIMENSIONS-DUNE MIGRATION EFFECTS ON ANTICIPATED DEVELOPING SITES, SIWA, WESTERN DESERT, EGYPT

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ABSTRACT

Siwa Oasis contains natural springs of different ages and salinities. The last decades witnesses uncontrolled mechanical over-pumping from the aquifer for irrigation purposes leading to environmental and developmental problems. Saline pools configuration increases due to over-pumping and climatologically implications resembled by the thermal effects of the saline content causes different pressures locally enhancing the dunes to change their direction and rate of migration.

Comparative interpretation using old and recent maps (topographic and TM image) confirms the deviation in direction of the dunes particularly close to the saline pools. The measured changes in direction(s) and rate(s) formulate a serious hazardous about the future development plans, meanwhile the constructed projects should estimate the anticipated hazardous compared with the newer directions and rates. The main anticipated threats are: city, cultivable areas and the industrial projects.

Continuous monitoring and proper planning (present and future) should consider the resulting effects of the uncontrolled behavior of man-made local thoughts otherwise hazardous will increase to a level that would affect both development plans and socio-economic trends.

INTRODUCTION AND SCOPE

Siwa Oasis is located in the Western Desert of Egypt about 300 Km south of the Mediterranean Sea. It is a known depression of east-west elliptical shape occupying the northwestern part of the Western Desert of Egypt (Fig. 1) having about 95 Km length and an average of 30 Km in width covering almost 2850 Km^2 (Embabi, 2004). The depression floor level is few meters above sea level with a general gentle slope from the west towards eastwards reflecting the structure control by folding followed by faulting and its intersectional points represent the prevailing lakes (El-Etr, 1977). It is bounded from the north by the famous escarpment of the Miocene age limestone and marls (Said, 1962 and 1990, Gindy and El-Askary, 1969 and Hermina, 1990).It is famous for its different types of springs and wells offering the fundamentals for its fertility for cultivation, hence the depression witnesses continual different monumental civilization since the Pharaonic eras till the Islamic ones.

The main geomorphological units can be categorized into: lakes (including marshes and sabkhas), sand dunes and hills. The hills are surrounding the oasis

particularly from the north as a cliff representing the Moghra Formation composed mainly of limestone, marls and shale sequences as represented by Gebel Abu Berig and Gebel Takrur (to the south). The hills elevation ranges between 100-200 m (above sea level), while a large part of the floor lies as a maximum at -18.5 below sea level (Embabi, 2004).

Lakes (Birket is the Arabic synonymous of lake or pond) of ephemeral type are always structurally controlled as explained through the lineament patterns of the aerial satellite images (El-Etr, 1977) occupies all areas below sea level. The main famous lakes (Fig. 1) are: Birket El Maraqi (to the west), Birket Siwa, Birket Aghrumi, Birket Samar Abu Lshaq and Birket Qureishit (to the east). In many instances, lakes are surrounded by marshes whereas shallower areas are represented by sabkhas. The great sand sea represents the southern margins of the Siwa Oasis, but its load of sand resembles the source for local sand forms in the area (Embabi, 2004).

SALINITY (CAUSES AND PERSPECTIVES)

The size of the lakes (Birket) witness drastic increase in size as compared between 1933 (help of the topographic sheet map) and 2002 (TM satellite images) as could be seen in Figure 2. The main cause is referred to the desire to expand the cultivable areas within the Oasis in order to increase the population there and turning them into permanent settlement and to increase its productivity. Moreover, cultivable crops will grow within a non-polluted area away from the civilization impact on air, water and air pollutant resources. The previous reasons encourage local Egyptians investors to dig many wells for irrigating the re-claimed and cultivable areas that expands desert-wards. Over pumping without controllable doses caused the excess waters to flush-out forming circular water bodies surrounding the Oasis and leaving only its northern entry as an access.

Continual discharge from the dug wells for irrigation time with rate(s) of evaporation constitutes the main reasons for turning lakes water into saline type. Whenever the input rate is less than the evaporation one, the saturation levels will be reached resulting into precipitation of salts according to the well water composition. The precipitated salts with its thermal conductive character will enhance the anaerobism to prevail, leading to rapid soil mineralogy alterations particularly kaolinite into smectite and/or illite. This result will affect the soil cohesive character that will decrease the soil porosity and improves its water retention one improving the

water/soil captivity and consequently water will longer be exposed for farther solar evaporation.

As a logistic implication(s) sabkha area will expand forming local high pressure and in between low pressure ones (Fig. 3) creating a local wind regime to blow around the wet salinas and the sabkha sites (continually expanding). This process was tested by Wali et al. (2000) in many coastal and desertic areas where sabkhatization and sabkhatized areas resembles an effective force in generating local winds and changes the dune direction and shape. At Siwa Oasis, particularly the southern side, dunes did change both rate of migration and directions as can be deduced from the TM satellite recent images (Fig. 4A). Figure 4B demonstrate in sketching manner the changes in dune trend based on re-reading of the recent TM images declaring the effect of the previously mentioned phenomenon and documenting its direction between wet and saline pooling areas.

DUNES AND DUNE MOVEMENTS

In the present study, the dune belt (linear type) occupying to the southeastern part of the Oasis showed that its floor is rising from 10-15 meters below sea level till few meters above sea level. The bases data are the topographic sheet of 1933 scale 1:25 000 with the recent TM satellite images of 2002 were thoroughly investigated with a choice of sample dunes (44 in number) as seen in Figure 4A.

Measurements of dune movements covering the period of 1990–2002 indicate a total of 221 meters averaging 18.7 m/y, while the threshold wind velocity of sand grains was found to be 11.6 knots (1 knot = 1.852 Km/h).

The direction of dunes is NNE-SSW (29.6º) except for two areas in the dune field, these are:

1- South of Aghurmi saline pool (25° 34′ 6″ E, 29° 9′ 13″ N and 25° 38′ 11″, 29° 5′ 96″ N) the orientation of dune range between 337° - 10°. The main direction in this area is N-E and NNW-SSE.
2- The second area is located south of Siwa saline poolings between 25° 23′ 50″ E, 29° 7′ 8″ N and 25° 29′ 12″ E, 29° 1′ 3″ N. The orientation of dunes range between 332° - 15° and their direction is almost north-south.

Although sand-moving winds occur from all directions, the prevailing directions are the W, WS, WSW, SW and S. This is in accordance with the general orientation of dune distribution south of Siwa Oasis. South of Aghurmi saline lake

(Fig. 2), where the main trend south Siwa Oasis is S-N and south of Aghurmi pool it is SSE-NNW due to the continual growth of saline pools surface area causing activation of the local wind regime generated by the difference in atmospheric pressure. The atmospheric pressure differences are believed to control also the shape of the dunes in addition to direction(s).

IMPLICATIONS AND HAZARDOUS

Dune migration constitute a drastic hazards particularly when approaches domestic, industrial, irrigational canals and roads. Always dunes are in motion as a result of the local and regional wind directions (Beadnell, 1910). In Egypt, the regional directions of winds are from NW-SE, N-S, NE-SW and SE-NW (personal communications with meteorological specialists). Speed of moving dunes are variable according to the speed of the wind itself and moreover if it is with slope or against it. In many records the speed did reach tens of meters particularly during seasonal dusty storms known as "Khamaseen".

At Siwa Oasis, many hazardous were recorded with increasing rate of its destructive and deteriorating effects on many vital fields. The followings are examples of the affected fields:

1- Road construction:

Figure 5A (white arrow) illustrates the constructed road across the saline pools. The road was constructed almost a decade ago as to connect the northeastern part with the agricultural farms at the southwestern part of the lake. Upon constructing the road, limestone bricks were used to for the base of the road. Continual increase in salinity pooling surface area had caused corrosion of the foundation base of the road made up of local limestone bricks. The corrosion in the limestone base was the result of increasing salinity formulating a non-suitable pH range for limestone bricks leading into corrosion and caving since the run-off was cut forming a hydroseal turning part of the lake into typified closed basin. Consequently, the northwestern side of the road was severely deteriorated rather than the larger saline area located to the southeast of the same lake. Figure 5B represents in a schematic manner the two main steps causing the deterioration having the titles (hydroseal and caving), while the third step (open circulation) indicate how can we avoid the money loss on a proper planning view. Photographs 1 and 2 show the actual situation as road hydroseal isolation (Photo 1), while the deteriorating effect on the side of the road. Crossing cars

with increasing population as a result of increasing activities (agricultural and industrial) did add a more negative effects seen as asphalted road to warp down.

2- Housing:

Moving dunes did gain a demonstrative turn concerning changeable recent rate(s) due to increasing saline pool surface area. In general, dune had caused destruction of houses (Photo 3) long time ago, but recently the migration rate is faster leading to serious threat on housing and particularly on the activation centers at the flanks of the Siwa Oasis.

3- Agriculture:

Dune advancements succeeded to reach the fringes of more than a farm as can be seen in Photos 4 and 5.

4- Archeological sites:

Siwa Oasis was known for its archeological sites of different ages and civilizations long time ago. It comprises many caves (among them the famous "Gebel of death") hosting many tombs from the Roman, Greek and Christian periods. Dunes did cover many archeological surface tombs as can be seen in Photo 6. The only left part is the ceiling of the rooms, while the height was almost disappears.

FUTURE PROPOSALS

The general spectrum of the present-day scenarios did prove the validity of non-planning either in the past or in the present urging scientists (covering multi-disciplinary fields) to decide together the implications for the increasing saline surface pooling areas (first) and describe the future scenarios (second) taking into consideration the different anticipated implications. Future planning should consider how to stop the causes that led to increase in saline pools surface area including the number of wells and over-pumping amounts of water.

Figure 6 represent a pessimistic future views, but still sustained one, concerning the possible drying-up and consequent desiccation of the saline pooling area as a result of enhancing dune migration rate and trend as to pass in in-between saline areas (today farming and housing sites) causing in consecutive steps: desiccation, advancement dry-up and desertification as a terminal stage. The term "terminal" was applied here as to describe clearly the non-availability of returning previous state(s) into norm. Sometimes, drastic views might cause the requested shocks for fighting against the negativities either in short and/or longer term plans.

CONCLUSIONS

Siwa Oasis is suffering from many non-proper planning systems that already caused much negativity. These negativities were originated by the dug non-controllable number of wells and the larger discharging amounts causing lake area to increase many folds since 1933 till 2002. The aridity and the non-equilibrium between inputs and outputs cause continual increase in lake water salinity creating differences in atmospheric pressures. This had created local wind regime enhancing rate(s) of migration and changing dunes trends that avoids wet land and attack the relatively drier ones causing deterioration of houses, farms and archeological sites.

The construction of roads within closed and/or semi-closed forms by hydroseal pattern caused caving and deteriorating the road itself. Such shift of the hopes will not serve the developing plans within desertic areas as government encourages investors and citizens to increase activity centers there and to get the advantages of such non-polluted areas.

REFERENCES

Beadnell, H. J. L, 1910, The sand dunes of the Libyan Desert, Geogr. Jour., Vol. xxxv, pp: 379-395.

El-Etr, H., 1977, Regional and economic geology of Siwa region, Paper No. 4-A, presented in Siwa Symposium (in Arabic), Ain Shamas University, Cairo, 4-6 April 1977, 342 p.

Embabi, N. S., 2004, The geomorphology of Egypt, land forms and evolution. Vol. 1 The Nile valley and the Western Desert. The Egyptian Geographical Society Special Publication. Nubar Printing House. 447 p.

Gindy, A. R. and El-Askary, M. A., 1969, Stratigraphy, structure and origin of Siwa Depression, Western Desert of Egypt, Bull. Amer. Assoc. Petrol. Geol., Vol. 53, pp: 603-625.

Hermina, M. E., 1990, The surroundings of Kharga, Dakhla and Farafra Oases, Chapter 14 in The Geology of Egypt (Editor R. Said), Balkema, Rotterdam. Pp: 259-292.

Said, R., 1962, The Geology of Egypt, Elsevier Publishing Co., Amsterdam, 377 p.

Said, R., (Editor), 1990, The Geology of Egypt, Balkema, Rotterdam, 734 p.

Wali, A.M.A., El-Asmar, H. and Assal, E.M., 2000, Interrelation between coastal sabkha belts and dune migration (rate and trend): bearing on developing N. Sinai, Egypt. 8th Worlds Salt Sym., R. E. Geertman (Editor). Elsevier, vol. 2: pp. 1237-1238.