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Controlling Land Degradation Using Environmentally Friendly Materials

- The Case of Kuwait -

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Abstract: The harsh environmental conditions (including drought) as well as the degradation of natural resources due to human pressure are major impediments for the real development of the terrestrial environment of Kuwait. These two major elements represent a serious threat to Kuwait's national economy and quality of life. Challenges facing the real development of the terrestrial environment of Kuwait are diversified. Reversing the processes of land degradation through serious and sustainable control measures, as well as appropriate land use planning are the most significant challenges. The main objective of this study is to enhance the soil quality and stabilize the mobile sandy bodies using inexpensive and environmentally friendly materials. These materials include a wide range of plant cuttings (reaching about 10 elements). These include leaves, fruit bunches and fibers of date palms, dead tree branches and grasses. In addition, ecomat, which is an environmentally friendly material made up of 100% natural oil palm residues, was used for sand stabilization. Previous experience indicates that plant debris especially ecomat, leaves of date palms and tree branches, if properly applied, are very effective in the immediate stabilization of active sandy bodies.

Key Words: Drought, Ecomat, Human pressure, Land use planning, Mobile sands

1. Introduction

Kuwait covers 17,800 km^2. It consists of two main ecosystems to include terrestrial (about 85%) and the coastal and marine (15%). The rainfall in Kuwait is scanty and irregular; the rainy season extends between October and April. The average annual rainfall is about 110 mm. During the last forty years, Kuwait experienced a number of dry seasons during which rainfall was below average level. A record of dry seasons is as follows: 1963/1964 (28.1 mm total rainfall), 1972/1973 (39.7 mm total rainfall), 1988/1989 (31.6 mm total rainfall) and 1993/1994 (28.3 mm total rainfall). In addition to dry seasons, Kuwait experienced drought periods lasting more than three seasons, *e.g.* 1962-1967 (28.1-87.7 mm of rainfall) and 1987-1990 (31.6-84 mm of rainfall). As stated by Misak *et al*. (2013) during the last seven years, Kuwait experienced a period of drought (2007-2013).

Land degradation processes prevail in the majority of the terrestrial environment of Kuwait. Three classes of land degradation are identified in this terrestrial environment (Misak and Al Dousari, 2013). These are almost non-degraded (12-15%), moderately degraded (75%) and severely degraded (10-12%).

Land degradation processes include: soil salinization and water logging, loss of top soils (through both wind and water erosion), soil crusting, sealing and compaction, vegetation degradation and loss of biodiversity. In the open desert areas (close to 75% of Kuwait), where land is primarily used for livestock grazing, indicators of soil, vegetation and hydrological degradation as well as loss of biodiversity are prevailing. In the agricultural areas (about 2.7% of Kuwait), depletion of soil productivity, water logging and soil salinization are recorded.

Controlling land degradation using local environmentally friendly materials such as plant residues was first attempted by Kuwait Institute for Scientific Research (KISR) in 1995 at Burgan Oil Field (Al-Sudairawi *et al*., 1999). In 2003, a pilot experiment for mobile sand control, using dead plant materials was started at Al-Liyah protected area (Al Hajraf *et al*., 2007). In 2006/2008, field experiments on the stabilization of sandy soils, using a wide variety of local materials, were conducted by the Arabian Scientific Consultancy Center (ASCC) at the site of the spirit of the desert (Burgan Oil field) and Managish pilot site. Internationally eco-friendly materials are applied for controlling land degradation and stabilization of active sandy bodies in several areas. These materials are being used in Karakum Desert (Turkmenistan), Atlas sand dune belts (Morocco), Rajasthan Desert (India), Kubuqi Desert (China), Nile Delta and Siwa Oases (Western Desert of Egypt). **Figure 1** shows some applications of plant residues in mobile sand control in several parts of the world.

In 2006-2008, ecomat was used for stabilization of active sand bodies and enhancement of soil properties in the spirit of

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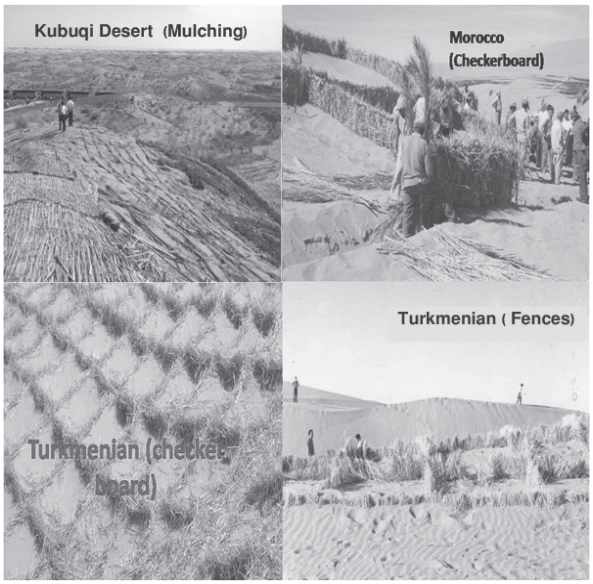

Fig. 1. Application of plant residues in controlling shifting sands in several arid regions.

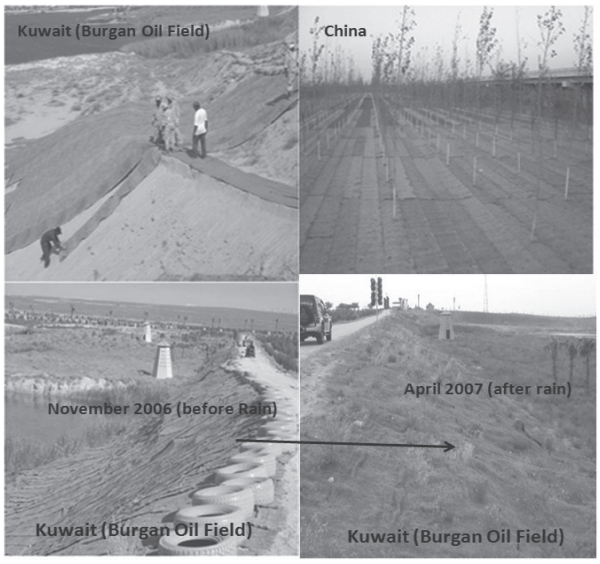

Fig. 2. Using Ecomat (100% natural oil palm residues) in China and Kuwait.

the desert (Burgan Oil Field). This material was applied in China as well (**Fig. 2**).

2. Materials and Methods

In 2006-2008, field experiments (three pilot sites) on controlling land degradation using environmentally friendly materials were carried out in three areas of different environmental conditions. These are Liyah area (north of Kuwait City), Spirit of the Desert (Burgan Oil Field, south of Kuwait City) and Managish Oil Field (southwest of Kuwait City). **Figure 3** shows the location of these areas. **Table 1** presents information on indicators of land degradation, land use and soil types at the pilot sites. The experimental plot

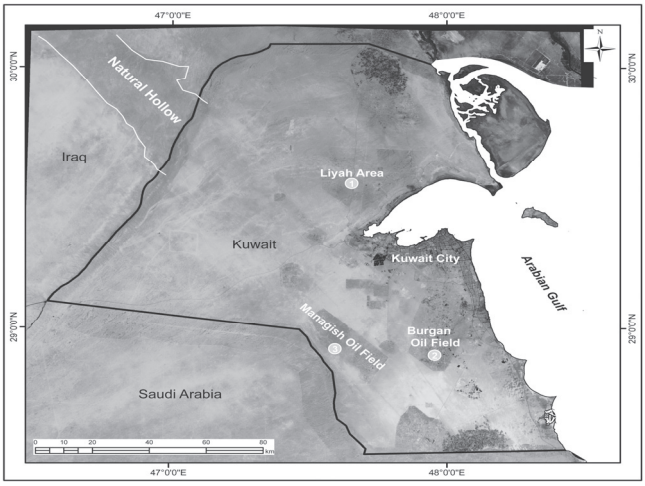

Fig. 3. Image of Kuwait (2010) showing the location of the field experiments.

Table 1. Information on the Indicators of land degradation, land use and soil types of the three pilot sites.

Pilot site	Area (m^2)	Indicators of l and degradation	Land use	Soil type	Remarks
Al Liyah	3000	Soil losses by wind. Soil crusting and sealing. Degradation of vegetation cover.	Abandoned gravel quarry (protected since 2002/2003)	Sandy soils (active sand sheets)	About 20 km to the north of Jahra City
Sprit of the Desert (Burgan Oil field)	60,000	Soil losses by wind and water. Oil pollution	Rehabilitated dumping site	Sandy and gravelly soils	Inside the oil field at the extreme northeastern portion of Burgan
Managish	78,177	Soil losses by wind. Soil crusting and sealing Loss of biodiversity Degradation of vegetation cover	Rangeland grazing	Deep sandy soil (fine to coarse)	Outside the Managish Oil Field

(250,000 m^2) was classified into 25 equal sections (each 10,000 m^2). Field experiments using different materials were conducted in 20 sections. The remaining 5 sections were designated as control. Ecomat sheets of different coverage were used as mulching materials in 8 sections. Checkerboard systems of different heights (100 cm, 75 cm, 50 cm and 25 cm) were tested in 4 sections and plant residues of different coverage were used in 8 sections.

The tested environmentally friendly materials are classified into processed and unprocessed (raw materials). Processed materials include Ecomat (Malaysian product), while unprocessed materials include plant residues such as palm leaves (fronds), tree cuttings, grasses, fruit bunches and fibers of date palms and others. These materials are biodegradable, environmentally/ecologically friendly, economically feasible, available in huge amounts, and highly flexible which makes them easily portable and efficient for workers to apply (user friendly). As stated by Arabian Scientific Consultancy Center (2008), Ecomat is environmental friendly mulching mat, fully biodegradable, made up from 100% natural oil palm residues. These residues supply nutrients to both the soil and the plants. The Ecomat contains elements *e.g.*, K (Potassium), Mg (Magnesium) and N (Nitrogen), which enhance soil quality

Table 2. Costs of stabilization of 1 m^2 of soil using different material (min. 1000 m^2) (Source Misak *et al*., 2007).

Material	Cost (KD) 1 KD = 3.6 USD	Remarks
Local plant residues	0.3-0.5 (source: Misak, 2006)	Available in agricultural farms and gardens
Chemicals (soil stabilizers)	3- 4 (source: local market, 2006)	Not recommended
Metal grid (Checkerboard system,1m spacing)	2.67 (source: A. Ramadan, 2008)	About 50 cm high
Metal grid (Checkerboard system ,2m spacing)	1.5 (source: A. Ramadan, 2008)	About 50 cm high
Ecomat (Malaysian)	0.5-0.6 (Source: ASCC, 2006)	Highly recommended

and plant growth (Arabian Scientific Consultancy Center, 2006).

3. Results and Discussion

Soil moisture retention: The tested materials help to retain moisture and reduce evaporation of water from subsoil, encourage plant growth and wildlife habitats. In Liyah area, mulching of fragile sandy soils with plant residues resulted in the immediate soil stabilization and enhancement of soil properties. Soil moisture content was about 2.5 times greater in the 0-60 cm soil profile of the mulched soils in comparison to control (untreated soil). This content was 16.2% for mulched soils, while it was 6.7% for untreated soil (un-mulched).

Reduction of sand drifting :Using raw plant residues (tree cuttings and grass clippings) as mulching materials on sandy soils reduced local sand drifting in Al-Liyah pilot site, by at least 50% after 8 months (August 2006-March 2007). This was based on field measurements using sand traps (Al Dousari, 2007, personal communication). In Managish pilot site, well designed low fences (about one meter high) of plant residues trapped not less than 90% of saltating sands within 6 months (May-October, 2008).

Rodent burrows: In Al-Liyah pilot site rodent burrows were about 6 times higher in treated soils (mulched) in comparison to control (un-treated soils) within 3-4 weeks (August-September, 2006).

Vegetation cover: In Burgan oil field, mulching Ecomat sheets on highly degraded crusted sandy soils resulted in the development of a dense vegetation cover after six months (November 2006-April 2007).

Cost effectiveness: The cost of stabilization of one square meter of fragile soils ranges between KD 2.67 for metal grid (one m spacing) and KD 0.3-0.5 for plant residues. For Ecomat cost is KD 0.5-0.6 (all costs include time and labour). This means that protective cover of plant residues is the simplest and most cost effective way to enhance soil moisture content, vegetation cover, and wild life habitats a **Table 2** presents information on costs of the mentioned materials.

4. Conclusion and Recommendation

Field experiments (three pilot sites) on controlling land degradation using a variety of environmentally friendly materials were carried out in three areas of different environmental conditions in the desert of Kuwait. The results of field experiments indicate that protective cover of plant residues is the simplest and most cost effective way to enhance soil moisture content, vegetation cover and wild life habitats. The cost of these residues is KD 0.3-0.5/m^2 compared with other materials, such as chemical soil stabilizers (KD 3-4/m^2). Raw plant residues (tree cuttings and grass clippings) reduced local sand drifting in Al Liyah area by at least 50% (compared to untreated areas). In this area, soil moisture content was about 2.5 times greater in the 0-60 cm soil profile of the mulched soils in comparison to control (untreated soil). As indicted in the field, the tested materials specially Ecomat, have the following common benefits :

- Environmental friendly and fully biodegradable, made up from 100% natural residues.
- Fast binders for active sandy soils.
- Providing excellent medium for quick vegetation and holding the seeds in place.
- Excellent for air and water permeability.

It is strongly recommended to use environmentally friendly materials on a large scale to rehabilitate degraded soils, specially the north-western parts of the terrestrial environment of Kuwait (about 600 km^2). First priority should be given to plant residues which are available in agricultural areas of Kuwait.

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References

Al-Hajraf S., Eneizi A. (2007): *Environmental rehabilitation study of the quarries in the State of Kuwait (phase 1, ongoing project, KISR).*

Al Sudairawi M., Misak R., Kwarteng A., Al-Dousari M., Zaghloul J., Abdulla I., Gharib M., Ahmed N. Boctor (1999): *Study of sand control at KOC operation areas of southeast, west and north Kuwait. Final Report, KISR.*

Arabian Scientific Consultancy Center (ASCC) (2006): *Rehabilitation of the Spirit of the Desert, Burgan Oil Field. Technical Report to KOC (Kuwait Oil Company).*

Arabian Scientific Consultancy Center (ASCC) (2008): *Protection of pipelines against shifting sands in west*

Kuwait (pilot site). Technical Report to KOC (Kuwait Oil Company).

Misak R., Al-Dousari A. (2013): *Prolonged Drought Issues and DLDD Desertification, Land Degradation and Drought in Kuwait.* Invited paper, Kubuqi International Desert Forum (KIDF), China (2-4 August 2013).

Misak R., Al-Dousari A., Al-Hagraf S. (2007): *Combating land degradation using eco-friendly materials.* Desertification Control in the Arid Region, 12-15 May, 2007, Kuwait Institute for Scientific Research.

Misak R., Khalaf F., Omar S. (2013): *Mahaging the hazards of drought and shifting sands in dry lands (the case of Kuwait). Development in soil classification, land use planning and policy implication*. pp 703-728.

Ramadan A. (2008): *Assessment of available sand stabilization techniques at As-Salmi Road: An experimental case study KISR, final report.*