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# Phytosociological Attributes of Wadi Gaza Area, Gaza Strip, Palestine

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**Abstract:** Wadi Gaza area, Gaza Strip, Palestine was subjected to a phytosociological study through 24 trips in the period from March to September 2007. This area has a characteristic semi-arid climate and locates in a transitional zone between Mediterranean, Negev and Sinai regions. Nine quadrats (10×10 m) at buttom, bank and open field wadi in six locations; namely, Al-Brikat, Al-Nabaheen, Al-Saoud, Al-Bahr, Al-Rabowa and Abu-Malaa representing the entire area of Wadi Gaza, Gaza Strip were chosen to study the vegetation, including species cover-abundance, species frequency, relative frequency, community similarity, in addition to soil analysis. Some quadrats were pure stand of one species; e.g., *Tamarix nilotica* in Al-Rabowa and *Arundo donax* in Abu-Malaa. Some species like *Cynodon dactylon* were restricted only to one place (wadi bank) of the location (Al-Brikat) due to the lower degree of animal grazing and the moisture availability. *Alhagi graecorum* and *Silybum marianum* recorded the highest species frequency in the studied area. Unique occurrence of some salinity tolerant species were observed in Al-Bahr (a coastal location). The highest similarity was found between Al-Brikat wadi bank and Al-Nabaheen wadi open field. In contrast to the dissimilarity between both of Abu-Malaa and Al-Rabowa wadi buttom and other locations as they were pure stands and more or less unique locations. Physical and chemical structure of soil varied according to soil texture, pH values, salinity, moisture, sewage water, urban effect and bordering agricultural fields.

**Key words:** Community similarity, cover-abundance, frequency, Gaza Strip, palestine, phytosociology, relative frequency, soil, Wadi Gaza

## INTRODUCTION

Biodiversity of Palestine is of interest, it has a semi-arid Mediterranean climate. Vascular plants in Gaza Strip mainly belong to the Saharo-Arabian, Mediterranean and Irano-Turanian phytogeographic regions. Shrubs and grasses prevail in Wadi Gaza. The agricultural fields bordering both banks of Wadi Gaza are of great importance and have capital role in supporting different wildlife species (Rabou *et al*., 2008). Palestine climate has favoured the evolution of an extremely variable flora, since it is a meeting area of plant geographical regions and has high climatic, lithologic and edaphic diversity. These factors, together with the prolonged influence of human activity have led to the development of rich flora and diverse vegetation. The Mediterranean region retains its biological significance due to a high level of plant endemism and the occurrence of many relict species. Biodiversity plays a crucial role in ecosystem stability and productivity (Alhamad, 2006).

The plant communities which occur in particular place are influenced by their phytogeographical positions, climatic factors, lithology soil andhuman activities. The plant communities are not functional realities but just assemblages of species living together in homogeneous vegetation quadrats because there they find similar or complementary environmental resources. Species-rich plant communities are considered to be particularly valuble and a prime target for conservation efforts (Heywood, 1995; Gaston, 1996; Wilson and Peter, 1998; Primack, 2002).

The vegetation bears the result of interaction among many species andbetween the species and the environment. The vegetation has a patchy structure, with different patches containing different species (or sometimes one species) and even different growth forms (El-Hadidi, 1993). Ecoregions are relatively large units of land delineated to reflect the boundaries of natural communities of animal and plant species in their natural state (Kier *et al*., 2005).

Data of vegetation have become the prime source for habitat characterization e.g., in monitoring programmes (Spellerberg, 1991) and for assessing global biodiversity hot-spots (Myers *et al*., 2000). Occurrence and abundance

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of plant species enables ecologists to assess the prevailing environmental conditions (Englisch and Karrer, 2001).

Botanical composition of vegetation can be described by a number of methods that describe different aspects of plant productivity and growth (Karsten and Carlassare, 2002). Classification of vegetation of natural plant cover into various groups of ecological species is widely used for ecohydrological models (Van Ek *et al*., 2000) ecosystem mapping (Witte and Meijden, 2000; Goebel *et al*., 2001) and synecological studies (Witte, 2002).

Plant species are recorded generally in terms of abundance (and/or presence) and this is used to measure indirectly the ecological responses of the species in the environmental situation where the relevé has been taken (Whittaker, 1967). In this sense, the relevé (quadrat) is considered in this study as a sampled state of vegetation showing the responses of the assemblage of the species found in it. It follows that a relevé itself represents a response of a vegetation type to the environment.

State of knowledge on the biodiversity of Palestine is still fragmentary and requires in-depth studies to reveal all of its components. The Middle East in general and Palestine in particular, went through extensive man-made changes during the past two centuries.

No information is available about phytosociological studies in Palestine, therefore this is the first research related to plant communities in Palestine. In the present work, the area of Wadi Gaza, Gaza Strip, Palestine was subjected to a study aiming at determing the most important factors controlling the distribution and richness of plant communities, plant species abundance and presence at different quadrats and highest species frequency. Therefore, some phytosociological parameters; i.e., species cover-abundance scale, species frequency, species relative frequency, community similarity and soil analysis were examined. This might aid in planning programs of sustainable development of plant natural resources in the studied area and to shed light on the conservation value of its biological diversity.

## MATERIALS AND METHODS

**The studied area:** Floristic composition and vegetation along Wadi Gaza was studied during the spring season of 2007. The present study dealt with Wadi Gaza area (Fig. 1, 2) which belongs to Gaza Strip in the middle east coast of the Mediterranean sea at the south Governorates of Palestine (31° 25′ N and 34° 27′ E).

Some 1200 dunams of the wadi area is coastal with sand dunes and salt water. Area suitable for plant wild life, in general, is about 2000 dunams. The maximum elevation of the wadi is 30 m.a.s.l., droping to sea level where it reaches towards the Mediterranean sea (MedWetCoast, 2003). Wadi Gaza catchment area covers about 3500 $km^2$ of the Negev desert. Its length from origin to the coastal mouth is about 105 km, the last 9 km only are located in Gaza Strip.

The studied area has a typical semi-arid climate and is located in a transitional zone between a temperate Mediterranean climate to the west and north and the arid Negev and Sinai desert to the east and the south. The average daily mean temperature ranges from 26°C in summer to 12°C in winter. The average annual rainfall is 335 mm. The mean daily evaporation in December is about 2.1 mm $day^{-1}$, rising to a maximum of 6.3 mm $day^{-1}$ in July. The average maximum wind velocity is about 3.9 m $sec^{-1}$. In winter, the prevailing wind direction is south-west with an average speed of 4.2 m $sec^{-1}$ and in summer it is from the North-West sector (MedWetCoast, 2003).

**Sampling procedure:** Vegetation analysis started with selection of stands that effectively represent variation in


Fig. 1: Map of Wadi Gaza area showing different investigated locations

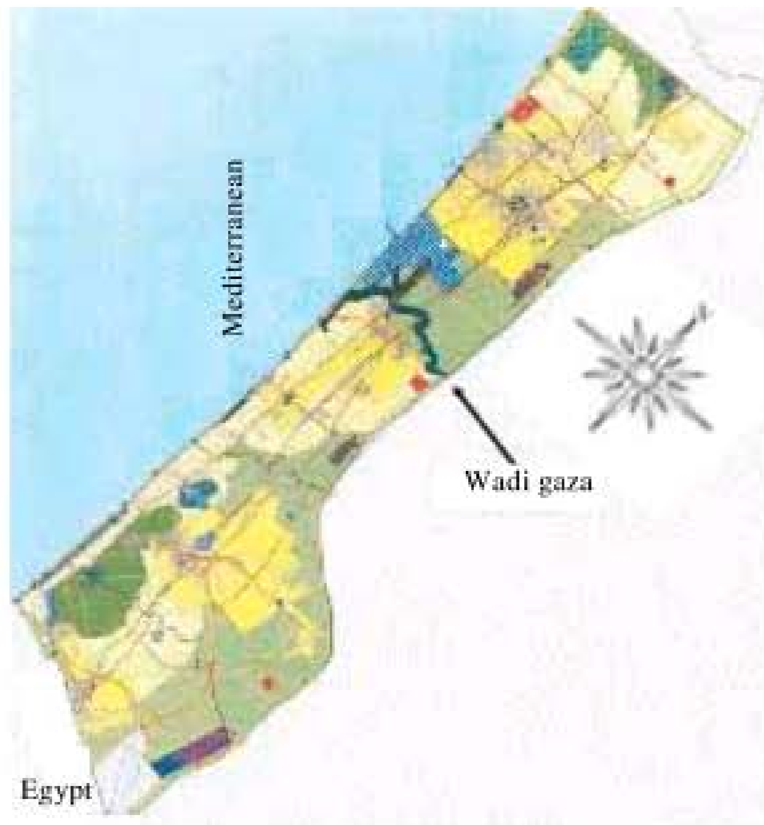


Fig. 2: Location of the study area of Wadi Gaza in the general map of Gaza Strip

Table 1: Details of the nine stands chosen for vegetation analysis

| No. | Location | Quadrat place |
|---|---|---|
| 1 | Al-Brikat | Wadi bank |
| 2 | Al-Brikat | Wadi buttom |
| 3 | Al-Brikat | Wadi open field |
| 4 | Al-Nabaheen | Wadi open field |
| 5 | Al-Nabaheen | Wadi buttom |
| 6 | Al-Saoud | Wadi buttom |
| 7 | Al-Bahr | Wadi bank |
| 8 | Al-Rabowa | Wadi buttom |
| 9 | Abu-Malaa | Wadi buttom |

the vegetation. Investigated locations (Fig. 1 , 2) extend along Wadi Gaza for a distance of about 9 km. Vegetation was sampled at buttom, bank and open field of the wadi. Six locations comprise nine quadrats (each quadrat 10×10 m) were found to be satisfactory to represent the vegetation of the area. Name of the locations and place of the quadrats are given in Table 1.

Representative samples of various plants grown wildly in the studied area were collected during the period from March to September 2007 through 24 trips. Herbarium specimens were prepared according to usual herbarium techniques and preserved at Biology Department, Faculty of Science, Al Aqsa University, Palestine. Identification was carried out according to Zohary (1966, 1972), Täckholm (1974), Dothan (1978a, b, 1986), Boulos (1999, 2000, 2002, 2005) and Danin (2000, 2004).

**Species cover-abundance:** The combined estimation of cover-abundance scale was used together with sociability values as shown in Table 2, Braun-Blanquet (1932, 1964). Presence percent was obtained from the number of quadrats in which the taxon occurs out of the nine studied quadrats. Cover was determined from estimates of vertical plant shoot-area projection as a percentage of quadrat area (Mueller-Dombois and Ellenberg, 1974).

Table 2: Braun-Blanquet cover-abundance scale

| Braun-Blanquet scale | Range of cover (%) |
|---|---|
| 5 | 75-100 |
| 4 | 50-75 |
| 3 | 25-50 |
| 2 | 5-25 |
| 1 | <5; numerous individuals |
| + | <5; few individuals |
| r | solitary, with small cover |

**Species frequency:** Frequency is most often used to compare plant communities and to detect changes in vegetation composition over time. It is used to describe the distribution of a species in a community and often used in combination with density or cover estimates to measure trend or condition. It is estimated as follows (Ambshat, 1982):

$$\text{Frequency percent} = \frac{\text{(Number of quadrats a species occurs)}}{\text{(Total number of quadrats analysed)}} \times 100$$

**Relative frequency:** Relative frequency of one species is a percentage of total plant frequency. It is estimated as follows (Barbour *et al*., 1987; Alhamad, 2006):

$$\text{Relative frequency} = \frac{\text{(Frequency of a species)}}{\text{(Total frequency of all species)}} \times 100$$

**Community similarity:** Community similarity expresses the ratio of the common species to all species found in two vegetation quadrats.

Sørensen similarity coefficient (ISs) is estimated as follows (Brower and Jerrold, 1977):

Sørensen similarity cofficient (ISs) = ( 2C/A+B )×100

Where:
A = Total No. of species in quadrat A
B = Total No. of species in quadrat B
C = No. of species common to two quadrats

**Soil sampling and analysis:** Five soil samples at depth of 0-30 cm from the soil surface were collected from each quadrat, four samples from the corners and the fifth from the centre. Samples were pooled to form one composite sample, spread over sheets of paper, air-dried, thoroughly mixed, passed through 2 mm sieve to remove gravel and debris before being preserved in suitable polyethylene bags ready for physical and chemical analysis. Soil texture was determined by hydrometery method as described by Allen *et al*. (1974). The percentage of fractions (sand, silt and clay) was calculated. Soil pH was measured in a soil extract (1 soil: 5 water) by means of a pH meter. Electrolytic conductivity (Ec) was measured using a portable conductivity meter. Nitrate was measured with a spectrophotometer. Bicarbonate was determined by titration with $H_2SO_4$. Potassium and sodium were determined by the flame photometry method. Soluble calcium and magnesium were determined by titration with EDTA solution method (Page, 1982).

## RESULTS AND DISCUSSION

Flora of Palestine shows an enlargement diversity (Abou Auda *et al*., 2009). This is depending on the location; where the Mediterranean, Irano-Turanian, Sudanian and Saharo-Arabian phytogeographic zones intermingle in area of varying climates and soil types (Euroconsult and IWACO, 1994; ARIJ, 2002; Ali-Shtayeh and Jamous, 2003).

**Species cover-abundance:** Cover-abundance scale, frequency and relative frequency of species grown in the studied area are shown in Table 3. Regarding Al-Brikat location, quadrats 1 (Wadi bank), 2 (Wadi buttom) and 3 (Wadi open field) were chosen. The highest values of cover-abundance scale (5) were recorded by *Cynodon dactylon* in quad.1 and *Crypsis schoenoides* in quad. 2. In quad. 3; however, both of *Anagallis foemina* and *Leontodon lanciniatus* were on top, being 4 on the scale.

Worthy to note that *Cynodon dactylon* was restricted to quad. 1 only. This might be due to the nature of the soil surface influencing moisture availability and the high grazing effect in buttom and open field wadi, beside the difficulty for animals to graze at the wadi bank. Moreover, the various slope degree among the three quadrats might influence moisture availability, where more gentle slopes have lower runoff rates and greater moisture availability. These findings are in agreement with Marks and Harcombe (1981).

With qualitative data, equal importance is given to all species present. Thus species richness becomes the major factor in comparison among various sites (Smartt *et al*., 1974). Energy flow through arid and semi-arid rangeland ecosystem is largely limited by soil moisture (Snyman, 1999). The high variability in biomass production reflects the small-scale spatial variability that characterizes the arid and semi-arid Mediterranean rangeland ecosystems (Osem *et al*., 2002).

Table 3: Cover-abundance, frequency (Freq.) and relative frequency (RF) of the studied area

| | Quadrat No. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Freq. | RF |
| *Alhagi graecorum* Boiss. | + | | | + | + | + | + | | | 55.55 | 3.52 |
| *Anagallis foemina* Mill. | | | 4 | | | | | | | 11.11 | 0.68 |
| *Anagallis arvensis* L. | | | | 1 | | | | | | 11.11 | 0.68 |
| *Anthemis pseudocotula* Boiss. | + | | | | | | | | | 11.11 | 0.68 |
| *Anthemis palestina* Boiss. | | | 3 | + | | | | | | 22.22 | 1.38 |
| *Arundo donax* L. | | | | | | | | | 5 | 11.11 | 0.68 |
| *Arisarum vulgare* Targ-Tozz. | | + | | | | | | | | 11.11 | 0.68 |
| *Astragalus pelecinus* (L.) Bameby | 1 | | | | | | | | | 11.11 | 0.68 |
| *Astragalus boeticus* L. | | | | | + | | | | | 22.22 | 1.38 |
| *Avena wiestii* Steud. | | | 1 | 1 | | | | | | 22.22 | 1.38 |
| *Brassica nigra* Koch. | | | | + | | | | | | 11.11 | 0.68 |
| *Capsella bursa –pastoris* (L.) Medek. | | 2 | | | 1 | | | | | 22.22 | 1.38 |
| *Cutandia dichotoma* (Forssk.) Trab. | | | | | 4 | | | | | 11.11 | 0.68 |
| *Crypsis schoenoides* (L.) Lam. | | 5 | 1 | | 1 | | | | | 33.33 | 2.08 |
| *Carduus getulus* Pomel | | 3 | r | | | 1 | | | | 33.33 | 2.08 |
| *Conyza bonariensis* (L.) Cronquest | | | | + | | + | 1 | | | 33.33 | 2.08 |
| *Cynodon dactylon* (L.) Pers. | 5 | | | 3 | | 5 | | | | 33.33 | 2.08 |
| *Crepis aspera* L. | | 2 | | | | | | | | 11.11 | 0.68 |
| *Chrysanthemum coronarium* L. | | | | 3 | | | | | | 11.11 | 0.68 |
| *Carthamus tenuis* (Boiss. and Blanche) Bornm | | | | + | | + | | | | 22.22 | 1.38 |
| *Centaurea pallescens* Delile | + | | | r | | | | | | 22.22 | 1.38 |

Table 3: Continued

| | Quadrat No. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Freq. | RF |
| *Cakile martima* Scop. | | | | | | | 1 | | | 11.11 | 0.68 |
| *Calendula arvensis* L. | | | | | | | + | | | 11.11 | 0.68 |
| *Centaurea procurrens* Sieberex Spreng. | + | | | | | | | | | 11.11 | 0.68 |
| *Carduus australis* L.f. | r | | | | | | | | | 11.11 | 0.68 |
| *Ciclospermum leptophyllum* Pers. | + | | | | | | | | | 11.11 | 0.68 |
| *Dittrichia graveolens* (L.) Greuter | | | | | 1 | | | | | 11.11 | 0.68 |
| *Diplotaxis erucoides* (L.) DC. | | + | | | | | | | | 11.11 | 0.68 |
| *Euphorbia peplus* L. | | 3 | | | | | | | | 11.11 | 0.68 |
| *Erodium cicutarium* (L.) L'Hér. | | r | | | | | | | | 11.11 | 0.68 |
| *Erodium telavivense* Erg. | 4 | | | + | r | | | | | 33.33 | 2.08 |
| *Echium angustifolium* Mill. | | + | | | | | | | | 11.11 | 0.68 |
| *Hordeum glaucum* Steud. | 3 | 3 | | 1 | | 3 | | | | 44.44 | 2.78 |
| *Hirschfeldia incana* (L.) Lagr. Foss. | | | | + | | + | r | | | 33.33 | 2.08 |
| *Hymenocarpos circinnatus* (L.) Savi | 3 | | + | | | | | | | 22.22 | 1.38 |
| *Hordeum geniculatum* All. | 4 | | | | | | 1 | | | 22.22 | 1.38 |
| *Ifloga spicata* (Forssk.) Sch. Bip. | | | | | + | | | | | 11.11 | 0.68 |
| *Imperata cylindrica* (L.) Raeusch. | | | | | | | 1 | | | 11.11 | 0.68 |
| *Lamarckia aurea* (L.) Moench | 4 | | | | | | | | | 11.11 | 0.68 |
| *Lathyrus gorgonei* Parl. | + | | | 1 | | | | | | 22.22 | 1.38 |
| *Lavatera cretica* L. | | | + | | | | | | | 11.11 | 0.68 |
| *Leontodon laciniatus* (Bertol.) Widder | | | 4 | | | | | | | 11.11 | 0.68 |
| *Lotus halophilus* Boiss. and Spruner | | | | 3 | | | | | | 11.11 | 0.68 |
| *Mesembryanthemum crystallinum* L. | | | | | | | 1 | | | 11.11 | 0.68 |
| *Malva parviflora* L. | | + | | | | | + | | | 22.22 | 1.38 |
| *Medicago truncatula* Gaertn | 1 | | | r | | | | | | 22.22 | 1.38 |
| *Medicago rotata* Boiss. | | | | + | | | | | | 11.11 | 0.68 |
| *Medicago polymorpha* L. | | 1 | 1 | | | 1 | | | | 33.33 | 2.08 |
| *Notobasis syriaca* (L.) Cass. | | | + | | | | | | | 11.11 | 0.68 |
| *Nicotiana glauca* Graham | | | | r | | | | | | 11.11 | 0.68 |
| *Olea europaea* L. | | | 3 | | | | | | | 11.11 | 0.68 |
| *Onobrychis crista-galli* (L.)Lam. | | + | | | | | | | | 11.11 | 0.68 |
| *Parapholis filiformis* (Roth) C.E. Hubb. | | | | | | | 1 | | | 11.11 | 0.68 |
| *Paronychia argenta* Lam. | | | | | | | + | | | 11.11 | 0.68 |
| *Plantago lanceolata* L. | 3 | 1 | | + | | | | | | 33.33 | 2.08 |
| *Plantago lagopus* L. | | | | 3 | 1 | 2 | | | | 33.33 | 2.08 |
| *Plantago coronopus* L. | 1 | 2 | | | 1 | + | | | | 44.44 | 2.78 |
| *Polygonum equisetiforme* Sm. | + | 2 | | + | | + | | | | 44.44 | 2.78 |
| *Papaver decaisnei* Elkan | | | | + | | | | | | 11.11 | 0.68 |
| *Poa trivialis* L. | | | | 1 | | | | | | 11.11 | 0.68 |
| *Polypogon monspeliensis* L. Desf. | | 1 | | 1 | 4 | | | | | 33.33 | 2.08 |
| *Pulicaria arabica* (L.) Cass. | | | | | 1 | r | | | | 22.22 | 1.38 |
| *Papaver humile* Fedde | | | r | | | | | | | 11.11 | 0.68 |
| *Rostraria pumila* (Desf.) Tzvelev | 2 | | | | | | | | | 11.11 | 0.68 |
| *Rumex dentatus* L. | | 2 | | + | + | | + | | | 44.44 | 2.78 |
| *Spergularia diandra* (Guss.) Boiss. | | | | | 1 | | 3 | | | 22.22 | 1.38 |
| *Spergularia bocconei*(Sheele) Graebn. | | | | | | | 1 | | | 11.11 | 0.68 |
| *Sarcocornia perennis* (Mill.) A.J.Scott. | | | | | | | 1 | | | 11.11 | 0.68 |
| *Salsola kali* L. | | | | | | | 2 | | | 11.11 | 0.68 |
| *Senecio glaucus* L. | | + | | 1 | | | | | | 22.22 | 1.38 |
| *Scorpiurus muricatus* L. | | | | + | | | | | | 11.11 | 0.68 |
| *Silybum marianum* (L.) Gaertn. | + | + | | 1 | 1 | 1 | | | | 55.55 | 3.52 |
| *Stipa capensis* Thunb. | | | | | | 3 | | | | 11.11 | 0.68 |
| *Scolymus hispanicus* L. | | | | | | + | | | | 11.11 | 0.68 |
| *Solanum elaeagnifolium* Cav. | | | 2 | | | | | | | 11.11 | 0.68 |
| *Sisymbrium irio* L. | | + | | | | | | | | 11.11 | 0.68 |
| *Sinapis alba* L. | 3 | | | | | | | | | 11.11 | 0.68 |
| *Tamarix nilotica* (Ehrenb.) Bunge | | | | | 1 | 1 | | 5 | | 33.33 | 2.08 |
| *Trifolium bullatum* Boiss. and Hausskn | | | + | | 1 | | | | | 22.22 | 1.38 |
| *Trigonella arabica* Delile | | | + | + | | | | | | 22.22 | 1.38 |
| *Trifolium campestre* Schreb. | 3 | | | 3 | | 3 | | | | 33.33 | 2.08 |
| *Trifolium purpureum* Loisel. | | | | | | 1 | | | | 11.11 | 0.68 |
| *Urospermum picroides* (L.) F.W.Schmidt | | | + | | | | | | | 11.11 | 0.68 |
| *Vicia sativa* L. | + | | + | + | | | | | | 33.33 | 2.08 |
| *Xanthium spinosum* L. | | | | | + | | | | | 11.11 | 0.68 |

The most common species recorded in Al-Brikat location are mostly belonging to Compositae, Gramineae and Papilionaceae families. Al Brikat location is under a high grazing pressure, *Cynodon dactylon, Hordeum glaucum, Malva parviflora, Medicago* sp., *Polygonum equistiforme, Rumex dentatus, Trifolium* sp., *Urospermum picroides* and *Vicia sativa* are the most palatable species in this location for animals.

In respect of Al-Nabaheen location, the wadi open field (quad. 4) included 31 species, 9 species of them were restricted to this quadrat only; namely, *Anagallis arvensis*, *Brassica nigra*, *Chrysanthemum coronarium*, *Lotus halophilus*, *Medicago rotata*, *Nicotiana glauca*, *Papaver decaisnei*, *Poa trivialis* and *Scorpiurus muricatus*. The wadi buttom (quad. 5), however, included 18 species; i.e., the wadi open field quadrat included 13 species more than the wadi buttom quadrat in the same location. This might due to variation of edaphic conditions, human activity and grazing influence (Kassas, 1966; El-Karemy and Zayed, 1999) also found that when the edaphic conditions are more favourable to plant growth, the vegetation becomes denser and numerous association are encountered.

Regarding Al-Saoud location, represented by a wadi buttom quadrat (quad. 6), a total of 18 species belonging to 16 genera and 7 families were recorded. *Cynodon dactylon* was the most abundant species recording 5 on the scale of cover-abundance.

Al-Bahr location, represented by wadi bank quadrat (quad.7), recorded a total of 16 species belonging to 15 genera and 9 families. The most abundant species was *Spergularia diandra* with 3 on the scale of cover-abundance, in contrast to *Hirschfeldia incana* where only one individual species was observed in this quadrat.

Al-Rabowa location was represented by a wadi buttom quadrat (quad. 8). Meanwhile, Abu-Malaa location was also represented by a wadi buttom quadrat (quad. 9). Noteworthy, to mention that both quad. 8 and 9 were pure stands of one plant species, being *Tamarix nilotica* in case of quad. 8 and *Arundo donax* for quad. 9.

**Species frequency:** Concerning the frequency percent of recorded species (Table 3) *Alhagi graecorum* and *Silybum marianum* came on top (55.55%) followed by *Hordeum glaucum, Plantago lagopus, Polygonum equisetiforme* and *Rumex dentatus* with frequency of 44.44% each. In contrast 50 species showed the least frequency (11.11%). This indicates variation of the plant distribution alongside Wadi Gaza which might be due to different specific microenvironments where *Alhagi graecorum* and *Silybum marianum* had high adaptation to livestock grazing and environmental heterogeneity in the reserve on the contrary to species of low frequency percent. These findings are in agreement with (Boucher *et al*., 1982; Couteron and Kokou, 1997; Alhamad, 2006), who mentioned that the positive interaction between individuals in the community might be caused by direct facultative mutualism, or attributed to physical environmental heterogeneity; e.g., topographic variations.

*Tamarix nilotica* was recorded alongside wadi buttom, weltland edge and other sites near the wadi channel of Al-Nabaheen, Al-Saoud and as pure stand in Al-Rabowa locations. As to the characteristic coastal region of Al-Bahr location, unique appearance of some salinity tolerant species were observed; namely, *Cakile maritima*, *Imperata cylindrica*, *Mesembryanthemum crystallinum*, *Parapholis filiformis*, *Paronychia argenta*, *Salsola kali*, *Sarcocornia perennis* and *Spergularia bocconei*. The unique appearance of these species at Al-Bahr coastal area reflected specific environmental stress conditions; mainly short distance to sea shore, soil salinity, sandy soil and sewage water at the wadi buttom.

Zohary (1973) distinguished three kinds of salinity in the Middle East: (1) Mediterranean coastal salines (including northern Sinai and the salines near Akko; (2) Turanian inland salines (including Central Anatolia and Central Iran) and (3) Hot desertsalines (including those of the Red Sea coastal salines and of the Dead Sea area).

Worthy to note that the highest recorded number of species occurred in quad. 4 (Al-Nabaheen wadi open field), being 31 species. On the contrary, wadi buttom of both Al-Rabowa and Abu-Malaa recorded one species. This might be a result of human activities effect and suffering of coastal conditions highly prevailing in Al-Rabowa and Abu-Malaa locations.

**Relative frequency:** The relative frequency of investigated species varied (Table 3). *Althagi graecorum* and *Silybum marianum* showed the highest relative frequency (3.52%) recorded for species occurred in Wadi Gaza. In contrast, the relative frequency of 50 species was comparatively low, being 0.68%. the remainder of species were in between.

**Community similarity:** Estimated Sørensen similarity cofficient between different investigated quadrats (Table 4) proved that Al-Brikat wadi bank (quad. 1) and Al-Nabheen wadi open field (quad. 4) showed the highest similarity value between different studied quadrats, being 43.64%; followed by Al-Nabaheen wadi open field (quad. 4) and Al-Saoud wadi buttom (quad. 6) with similarity coefficient 40.82%. However, the estimated similarity between Al-Brikat wadi bank (quad. 1) and

Table 4: Sørensen similarity coefficient values for various quadrats representing the studied area

| Quadrats | AL-Brikat, wadi bank (1) | Al- Brikat, wadi buttom (2) | Al-Brikat, wadi open field (3) | Al-Nabaheen, wadi open field (4) | Al-Nabaheen, wadi buttom (5) | Al-Saoud, wadi buttom (6) | Al-Bahr, wadi bank (7) | Al-Rabowa, wadi buttom (8) | Abu-Malaa, wadi buttom (9) |
|---|---|---|---|---|---|---|---|---|---|
| AL-Brikat, wadi bank (1) | - | 13.64 | 9.76 | 43.64 | 14.28 | 33.33 | 10 | 0 | 0 |
| Al-Brikat, wadi buttom (2) | 13.64 | - | 16.22 | 23.58 | 31.58 | 26.31 | 11.11 | 0 | 0 |
| Al-Brikat, wadi open field (3) | 9.76 | 16.22 | - | 16.67 | 11.43 | 5.71 | 0 | 0 | 0 |
| Al-Nabaheen, wadi open field (4) | 43.64 | 23.58 | 16.67 | - | 24.49 | 40.82 | 17.02 | 0 | 0 |
| Al-Nabaheen, wadi buttom (5) | 14.28 | 31.58 | 11.43 | 24.49 | - | 27.78 | 17.65 | 10.53 | 0 |
| Al-Saoud, wadi buttom (6) | 33.33 | 26.31 | 5.71 | 40.82 | 27.78 | - | 17.65 | 10.53 | 0 |
| Al-Bahr, wadi bank (7) | 10 | 11.11 | 0 | 17.02 | 17.65 | 17.65 | - | 0 | 0 |
| Al-Rabowa, wadi buttom (8) | 0 | 0 | 0 | 0 | 10.53 | 10.53 | 0 | - | 0 |
| Abu-Malaa, wadi buttom (9) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - |

Table 5: Mean and standard deviation values of the soil variables in various quadrats representing the studied area

| | Al-Brikat | | | Al-Nabaheen | | Al-Saoud | Al-Bahr | Al-Rabowa | Abu-Malaa |
|---|---|---|---|---|---|---|---|---|---|
| Soil variables | Wadi bank | Wadi buttom | Wadi open field | Wadi open field | Wadi buttom | Wadi buttom | Wadi bank | Wadi buttom | Wadi buttom |
| Sand (%) | 51.60±14.24 | 46.80±7.150 | 29.20±3.030 | 30.80±2.280 | 46.80±11.79 | 44.40±9.840 | 89.20±3.350 | 31.60±6.540 | 56.00±27.20 |
| Silt (%) | 34.40±11.95 | 39.60±6.980 | 44.80±0.890 | 43.20±2.280 | 32.00±9.490 | 40.00±9.270 | 4.40±2.190 | 34.80±8.550 | 23.20±11.19 |
| Clay (%) | 14.00±3.160 | 13.60±2.610 | 26.00±3.740 | 26.00±2.000 | 21.20±4.820 | 15.60±2.610 | 6.40±3.580 | 33.60±13.74 | 20.80±16.65 |
| pH | 7.05±0.140 | 7.04±0.130 | 7.97±0.072 | 8.25±0.052 | 8.30±0.095 | 8.23±0.041 | 8.80±0.078 | 7.93±0.108 | 7.80±0.090 |
| Ec dSm | 0.59±0.120 | 0.44±0.047 | 1.11±0480 | 0.69±0.120 | 0.96±0.095 | 0.86±0.106 | 0.81±0.084 | 1.37±0.920 | 8.64±2.830 |
| $NO^{-}_{3}$ (%) | 55.20±20.18 | 53.92±22.22 | 75.08±12.53 | 68.50±22.07 | 62.12±9.940 | 57.48±10.57 | 50.42±24.44 | 98.18±20.59 | 218.16±98.62 |
| $HCO^{-}_{3}$ (%) | 2.80±0.560 | 3.28±0.520 | 9.52±12.57 | 4.32±0.590 | 4.88±0.330 | 2.56±0.730 | 3.12±1.420 | 5.68±1.400 | 6.88±1.970 |
| Na+ (%) | 2.72±0.910 | 1.96±0.600 | 9.02±2.920 | 2.48±0.550 | 4.80±1.190 | 4.34±0.920 | 5.22±0.500 | 5.98±3.320 | 52.52±23.64 |
| $K^{+}$ (%) | 0.24±0.055 | 0.24±0.055 | 0.12±0.044 | 0.28±0.109 | 0.32±0.045 | 0.36±0.055 | 0.34±0.090 | 0.38±0.240 | 1.60±0.390 |
| $Ca^{++} + Mg^{+}$ (%) | 3.60±0.550 | 3.88±0.850 | 3.80±0.690 | 7.00±1.980 | 6.76±0.870 | 6.92±0.870 | 5.48±1.650 | 13.72±9.990 | 40.92±8.150 |

Al-Saoud wadi buttom (quad. 6), almost 2 km apart, was 33.33%. Abu-Malaa wadi buttom (quad. 9) recorded 0.0 similarity with all other quadrats as it was a pure stand of *Arundo donax* which was not observed in any other location of Wadi Gaza. Zero value of similarity was also found between Al-Rabowa wadi buttom (quad. 8) and 6 of the other quadrats. Moreover, the similarity between Al-Brikat wadi open field (quad. 3) and Al-Bahr wadi bank (quad. 7), almost 8 km apart, was zero.

**Soil analysis:** The soil analysis (Table 5) proved that Al-Bahr wadi bank was the richest in sand (89.2%) compared with other investigated locations, followed by Abu-Malaa wadi buttom (56%), whereas Al-Brikat wadi open field was the least (29.2%) in this respect. On the other hand, the latter quadrat recorded the highest silt content (44.8%). The maximum clay content (33.6%) was recorded by Al-Rabowa wadi buttom; in contrast to Al-Bahr wadi Bank (6.4%), being the least in this respect.

As to pH value Wadi Gaza soil tended to the alkaline side, Al-Bahr wadi bank recorded the highest value (pH 8.8). Ec value varied greatly, from 8.64 dS $m^{-1}$ for Abu-Malaa wadi buttom to 0.44 dS $m^{-1}$ for Al-Brikat wadi buttom. The same trend was observed by anions and cations content, where Abu-Malaa wadi buttom had 218.16% $NO^{-}_{3}$, 6.88% $HCO^{-}_{3}$, 52.52% $Na^{+}$ and 40.92% $Ca^{++} + Mg^{+}$. The unique ecological conditions of Abu-Malaa wadi buttom might be a result of over flow of sewage water from neighboring populated area. Such sewage water could modify the soil chemical composition. This justifies the restricted occurrence of *Arundo donax* in a pure stand form under such salinity stress.

In conclusion, Wadi Gaza, Palestine proved to be an area of rich diversity of flora, suffering in the meantime of stress conditions. The most important factors controlling the distribution and richness of plant communities are soil texture, soil moisture, soil salinity, urban effects, bordering agricultural fields, suffering coastal conditions, sewage water and solid waste which create a great variety of ecological conditions for plants. Hence, biodiversity conservation, management and sustainable development of its natural resources is a must. Therefore, a baseline might be established from which environmental impact can be assessed.

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