Vegetation Cover and Soil Characteristics Correspondence Analysis in Wadi Yalamlam, Saudi Arabia

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Abstract. Wadi Yalamlam is known as one of the significant Wadis in Western Saudi Arabia. The wadi is considered as one of the most important water torrents for the western region of the country. It starts from the top of Hijaz Mountains and pours into the Red Sea. It has a high amount of annual rainfall, about more than 200 mm. This work was conducted to study the floristic composition of seven stands of the Wadi and its relation to specific soil characteristics. The study revealed that the seven stands were represented by 48 species belong to 26 families. Fabaceae and Poaceae were the richest. Stands 1 and 7 were the most diverse while stand 6 was the least. Plant diversity was discussed in relation to the soil chemical composition.

Keywords: Wadi Yalamlam, Saudi Arabia, Floristic composition, Plant diversity, species richness, soil characteristic.

1. Introduction

Saudi Arabia is considered as a large arid land with an area of *c*. 2,250,000 km2 nearly comprises 80% of the Arabian Peninsula. It is located between latitude 15˚45'; 34˚35'N and between longitudes 34˚40'; 55˚45'E. Mainly, it consists of four topographic areas: The Coastal Plains, The Mountains Chain in the South and West, The Plateaus and The Deserts. There are some valleys (Wadies) scattered into these topographic areas. One of the most important is Wadi Yalmlam which is located in the Western region about 125km southeast of Jeddah city. It is bounded by latitudes 20°26'; 21°8'N and longitudes 39°45';40°29'E. Wadi Yalmlam basin is initiated from high elevation of Hijaz escarpment with mean annual rainfall of about 140mm starting from Taif escarpments and pour into the red sea coast. It provides the holy places in Mecca with drinking water. Even though Saudi Arabia is considered as a large arid zone, it has a vast number of plant biodiversity. Vegetation structure presents differences in the distributional behavior and that's refer to changes in some factors such as: weather factors, edaphic variables, anthropogenic pressures and water. The fact that Wadies are water streams that make their environment rich of plant diversity. The appearance and the changes in plant cover in different areas of the wadi is questionable. This work has been done to conduct the relation between the vegetation cover and some soil characteristics like the presence of importanmt elements such as (Ca,Mg,Na,Cu and K) in different areas of Wadi Yalmlam to explain the variation in vegetation cover along the Wadi.

Costal zones are fragile ecosystems and more often subjected to desertification and land degradation (Small and Nicholls, 2003; McGranahan *et al*., 2007). Impacts of soil salinity are varying from mid drastic effects to high drastic effects represented mainly by the biodiversity losses and the degradation of soil quality (Leatherman and Nicholls, 1995). Human activities are with a great influence on the coastal zones especially in mega cities, the negative impacts of human activities are water abstraction, hydrological regime alteration and sediments trapping (Nicholls *et al.*, 2007; Elhag and Bahrawi, 2014). Developing countries are less adapting and responding to climate change due to its poor management system of mega coastal cities (Nicholls *et al*., 2007; UNHABITAT, 2008).

Desirability analysis was able to deliver resourceful resolution to the indecision in multi-input statistics difficulties. It is an operational technique to examine the interactive degree between disconnected systems (Derringer and Suich, 1980). The desirability analysis and its implementations are mentioned in (Bogartz, 1994; Ku *et al*., 2011). The methodology of Harington (1980), is widely applied to analyze the maximum, minimum and overall desirability parameters for solitary concert features based on the fact that the desirability function desirability transforms a projected response into a scale free value (Jeyapaul *et al.*, 2005; Radhakrishnan, *et al.*, 2011; Muthukrishnan *et al*., 2012).

The aim of the current research study is to envisage the effects of soil minerals on the species richness. Desirability analysis is the used methodology to realize the correlation between the species richness and equality and certain physical/chemical properties of the under investigation soils.

2. Material and Method

2.1. Study area:

The Wadi Yalmlam basin elevations significantly diverge from upstream and downstream parts ranging from 2850m to 25m, repectively (Figure 1). The main itinerary of the Wadi has cut through the vastly splintered granitoid, gabbroic and metamorphic rocks until the coastal plain of the red sea. The basin can be divided into three main parts: upper stream, middle stream and downstream. The upper and middle parts are covered by intense natural vegetation. The lower part is covered mainly by quaternary deposits and sand dunes with small scattered highly altered granitoid and metamorphosed basaltic hills. Several basic ditches are recorded in the lower part of Wadi Yalamlam basin. Also, the thickness of quaternary deposits in the Wadi basin is increased in the lower part.

2.2. Samples Collection:

The Wadi was divided into seven stands randomly in every area at different growing seasons. Locations and sample were chosen to explain a large range of physiographic and environmental variation in every branch (Figure 1).

Plant and soil samples were collected between March 2015 to February 2016. Sample plots were chosen randomly using the relevé process in every site (Subyani and Bayumi, 2001) . The sample plots were 10 meter × 10 meter and the sampling process was taken through the spring season when all species were expected to be growing. The vegetation sampling involved recorded all plant species at the sample plots.

2.3. Plant Identification: The collected plant specimens were set by correspondence author and according to (Chaudhary, 1999,2000,2001; Collenette,1999; Cope, 1985;Mighaid,1996). And then, the plant cover of each species was estimated according to the Zurich-Montpellier technique (Mueller-Domboisand Ellenberg, 1974).

2.4 Soil Analysis: Soil was air dried and kept in glass bottled for later use for measure the elements in soil.

Soil Chemistry: The determination of Ca, Mg, K, Cu and Na was carried out by using a flame photometer and an atomic absorption flame photometer (Berkin Elmer AA Atomic absorption Model: 3100) as described by Allen, *et al*. (1974).

2.5 Statistical Analysis:

Desirability Analysis

The purpose of using the desirability function is to concurrently improve the model predictions based on multiple equations firstly introduced by Harrington (1980). Desirability analysis is one of the most common approaches used to augment of several response progressions (Derringer and Suich, 1980). Basically, desirability analysis converts the input functions into (0,1) scale to represent the model predication in term of desirability. According to Derringer and Suich (1980), desirability analysis confound on three methodologies analysis:

Maximization analysis:

$$d_r^{max} = \begin{cases} 0 & \text{if } f_{r(X)} < A \\ \left(\dfrac{f_r(X) - A}{B - A}\right)^s & \text{if } A \le f_{r(X)} \le B \\ 1 & \text{if } f_{r(X)} > B \end{cases}$$

Minimization analysis:

$$d_r^{min} = \begin{cases} 0 & \text{if } f_{r(X)} > B \\ \left(\dfrac{f_r(X) - B}{A - B}\right)^s & \text{if } A \le f_{r(X)} \le B \\ 1 & \text{if } f_{r(X)} < A \end{cases}$$

Overall desirability:

$$d_r^{target} = \begin{cases} \left(\dfrac{f_r(X) - A}{t_0 - A}\right)^s & \text{if } A \le f_{r(X)} \le t_0 \\ \left(\dfrac{f_r(X) - B}{t_0 - B}\right)^s & \text{if } t_0 \le f_{r(X)} \le B \\ 0 & \text{Otherwise} \end{cases}$$

Where

A, B and s are predefined variables based on the scope of the analysis. High *f(X)* indicates higher desirability and low *f(X)* indicates low desirability. The three methodological desirability functions are on the same scale and are sporadic at the points *A*, *B*, and t_0.

3. Result

The study revealed that the seven stands were represented by 48 species belong to 26 families. Fabaceae and Poaceae were the richest. Stands 1 and 7 were the most diverse while stand 6 was the least. The relation between species richness and soil chemical components was studies. According to both Shannon and Simpson indexes species richness was in correlation to Ca content in soil (Figure 2). The number of plant species increased as the concentration level of Ca decreased (r=02, r=0.3 according to Shannon and Simpson respectively). The same result was observed when applied to the content of Mg for both Shannon and Simpson indexes (r= -0.1, r=0.2) (Figure 3). On the other hand, there was no correlation between Na concentration and species richness in Shannon-Wiener (r=-0.19), while there was a positive relation in Simpson index (r=0.16). On another words, the Na content was persistent and did not affect species evenness in all sample stands when applying Shannon-Wiener index; while in Simpson index it increased as the concentration of Na decreased (Figure 4).

There was an inverse relation between species diversity and Kconcentration in Simpson index (r=-0.03) (Figure 5). In contrast, applying Shannon-Wiener equation gave a direct relation; species evenness was increased when K content increased (r=-0.15) (Figure 8). The situation was inversable in case of Cu content. The direct relation was in the Simpson index while the inverse relation was in Shannon-Wiener index. Species richness was increased when Cu content increased according to Simpson index (r=-0.17), while it increased when Cu content decreased in Shannon-Wiener (r=-0.15) (Figures 6). In general it could be said that species richness is in correlation with Ca, Mg, K and Cu.

4. Discussion:

In this investigation our theory was that the soil nutrient mineral content may affect the species richness in different localities. Seven stands were chosen along the study area in Wadi Yalamlam West of Saudi Arabia, soil minerals were measured and species eveness was calculated using Shannon-Weiner. Previous studies showed some kind of relationships between species richness and nutrient availability (Huston, 1980, Grime, 1973; Tilman, 1982). Huston (1980, 1993) on studies of tropical forests found that there is a decrease in species richness when soil fertility index and concentration levels of K and Ca in soil increase. This supports our findings in case of Ca concentration, but it disagrees with our results in case of potassium K. Janssen *et al.,* (1998) agreed with our result of that high potassium contents are compatible with high values of diversity. Alatar *et al.,* (2011) on a study similar to ours but on Wadi AlJufair in Saudi Arabia it was found that species diversity decreased with increasing of Mg and Na. Our findings agrees with Alattar that there is a correlation between species evenness and Mg, while it disagree in case of Na. Similar correlations were reported by El-Demerdash *et al.* (1995), Abbadi and El-Sheikh (2002), El-Sheikh *et al.* (2006) and El-Sheikh *et al.* (2010).

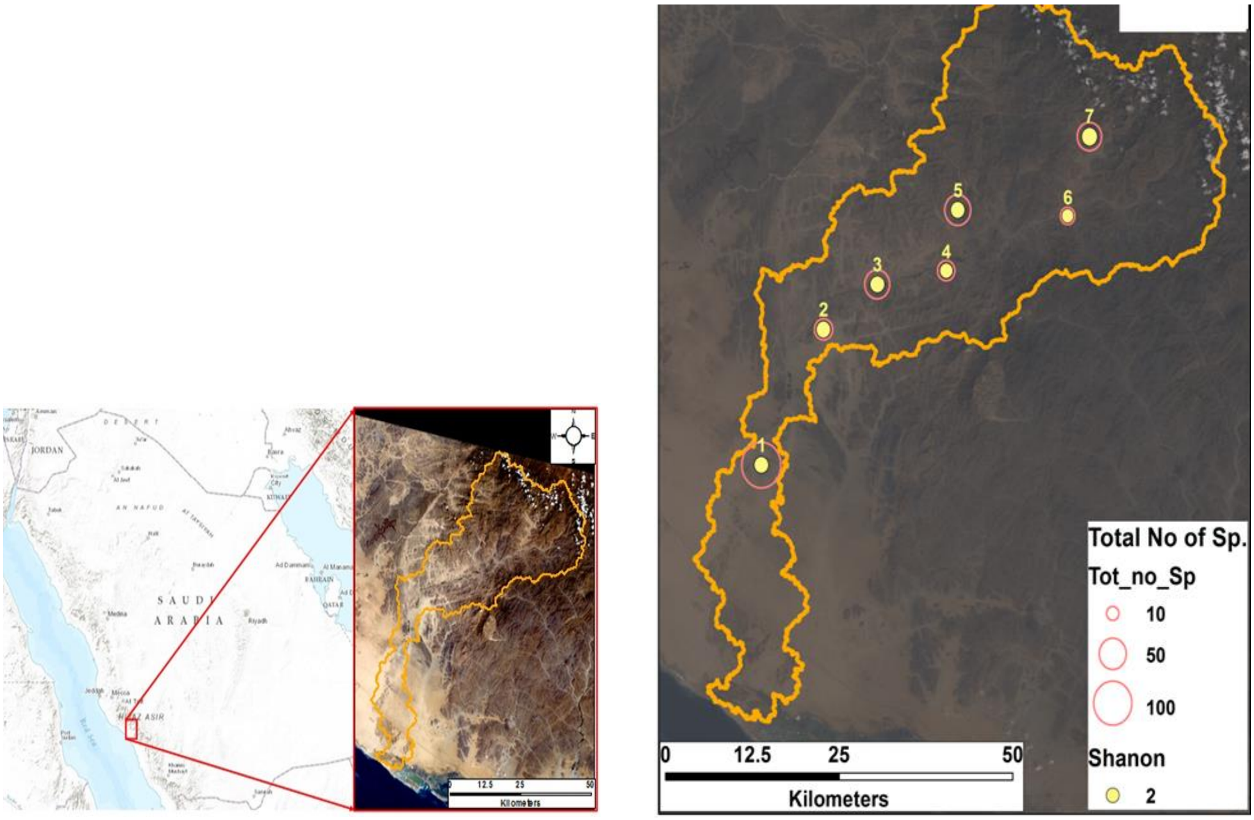

Figure 1: Study area “Wadi Yalmlam” and the selected stands

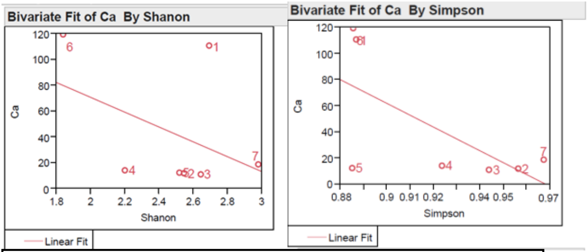

Figure 2: The relation between Ca concentration and vegetation richness in Shannon-Weiner and Simpson.

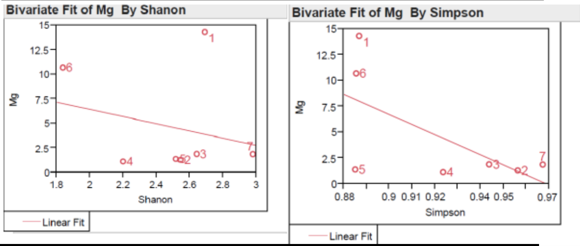

Figure 3: The relation between Mg concentration and vegetation richness in Shannon-Weiner and Simpson.

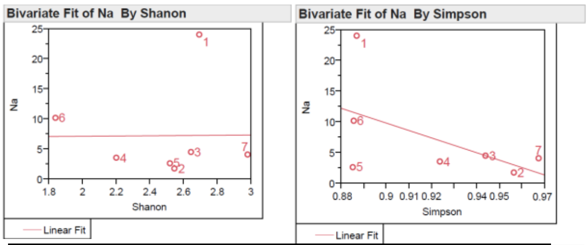

Figure 4: The relation between Na concentration and vegetation richness in Shannon-Weiner and Simpson.

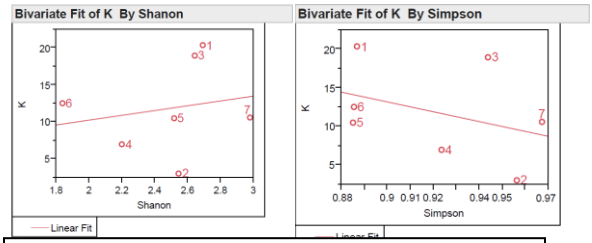

Figure 5: The relation between K concentration and vegetation richness in Shannon-Weiner and Simpson.

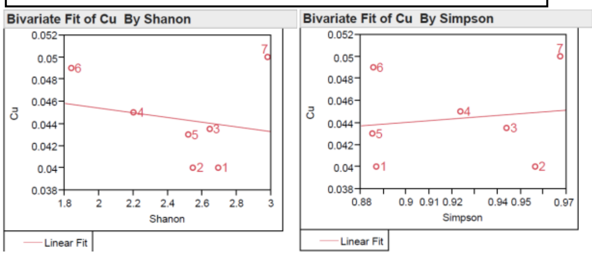

Figure 6: The relation between Cu concentration and vegetation richness in Shannon-Weiner and Simpson.

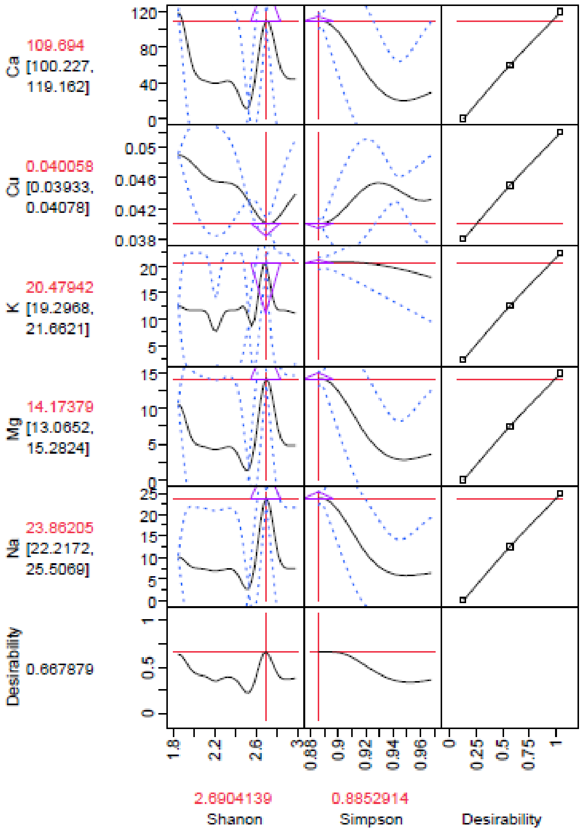

Figure 7: The overall desirability of Species diversity and soil minerals.

5.Conclusion:

In conclusion the overall desirability between some soil minerals and species diversity is not stable and different according to mineral type and location.

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