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Research Article

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Coevolution of Climate Change, Surface Properties, Vegetation Cover, and Drainage Network in a Loess Covered Area.

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Abstract
Arid and semi-arid areas are often regarded as highly sensitive to climate change. Average annual rainfall is usually regarded as the most important factor controlling soil moisture regime, water availability, and therefore various environmental variables. The present study deals with the ecology of an area located in the semi-arid area of Israel, where average annual rainfall is ~280 mm. The area is located in a loess covered area. The loess cover was deposited during a wet climatic phase. However, pedological and ecological data point to a desertification effect. Data obtained show that non-climatic factors, such as local surface properties, can exert a strong influence on the environment. In addition, the global models disregard the characteristics of the local rainfall regime, such as the distribution of rain intensities, and the duration of individual rain-showers during a rainstorm. Under the present rainfall regime about 85% of the rains are below 5 mm/hr,1, rainfall is also highly intermittent, limiting runoff generation, and infiltration depth. Under such conditions, a high evaporation rate leads to a soil salinization process.

Keywords: Climate Change; Eolian Deposition; Rainfall Properties, Vegetation Cover, Desertification Processes.

Introduction

Climatologists use aridity indices to express the relationships between climatic and environmental variables. These indices, based on purely climatic variables, imply that the acuteness of aridity is inversely related to annual precipitation. This approach leads to the idea that average annual rainfall controls the water availability for plants, vegetation cover, productivity, species diversity, soil properties and soil erosion, up to 300 mm of annual rainfall (Langbein and Schumm, 1958; Fournier,1960; Wilson, 1969; Douglas, 1976; Dendy and Bolton,1976). Above 300 mm average annual rainfall, the vegetation cover increases (Shmida, et al., 1986). This approach may be valid for annual crops, where yields are greatly influenced by both, annual precipitation and the temporal distribution of rainfall during the growing season. The general approach that average annual rainfall is a good indicator of runoff, vegetation cover and soil erosion, does not appear to fit the link between climate and environment at the geological time scale. Climate change is not limited to annual rainfall. It is often accompanied by a change of surface properties, such as deposition of loess in a wet period, and of sand during a dry period. The aim of the present study is to draw attention to the complex relationships between average annual rainfall, water resources, and environmental characteristics (Tables 1 and 2+). The Northern Negev desert of Israel offers good conditions for the study of the relationship between average annual rainfall and environmental variables at a geological time scale, under changing climatic conditions.

Table 1: Botanical data, Northern Negev

Northern Negev-Botanical Variables

Variable	Rocky area	Loess covered area	Sandy area
Annual Rainfall (mm)	90	170	86
Vegetation cover %	30	5	27
Number of perennial plants	27	2	33
Mediterranean-IranoTuranian species	22	0	8
Saharo-Arabian perennial species	33	100	25

Table 2: Zoological activity at Sede Boker (rocky area, average annual rainfall: 90 mm), and Ramat Hovav, (loess covered area, 280 mm average annual rainfall).

Zoological activity: Sede Boqer and Ramat Hovav

Animal abundance (per 100m^2)

Species	Index	Sede Boqer	Ramat Hovav
1. H. reaumuri	families	25	1
2. Hystrix indica	diggings	30	0.2
3. T. seetzenii	individuals	260	6

Snail species richness

	Sede Boqer	Ramat Hovav
1. Euchondrus albulus	+	
2. E. desertorum	+	
3. Sphincterochila zonata	+	+
4. S. prophetarum	+	
5. Trochoidea seetzenii	+	+
6. Granopupa granum	+	

The study area extends from the semi-arid area, Beersheva depression, to the arid Ramon ridge in the south (Figure 1).

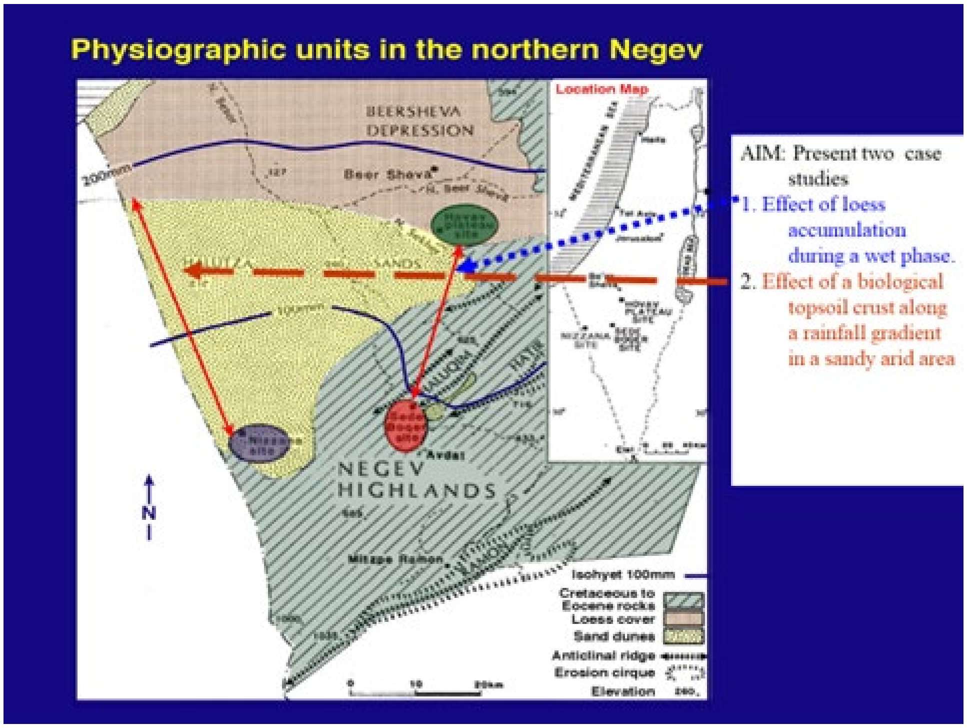
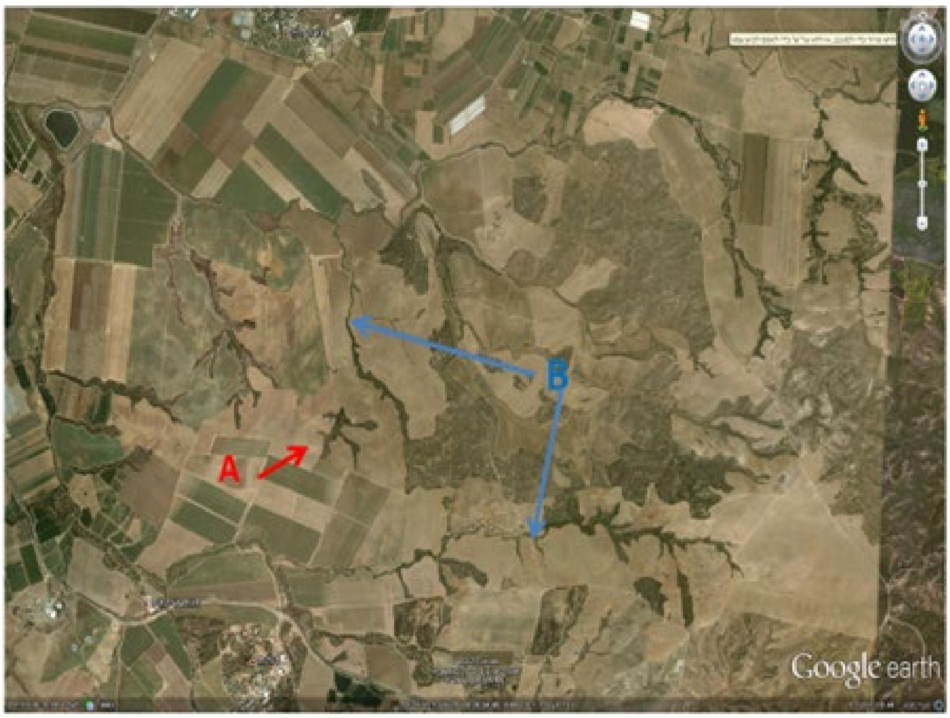


Figure 1: Location Map

At present, the mean average rainfall decreases from 250 mm in the Beersheva area, to 75 mm at the Negev Highlands. The southern part is characterized by extensive rocky areas, with small patchy soils. The northern part of the study area is characterized by extensive loess covered areas deposited during the wet period of the Upper Pleistocene [1, 2, 3]. Water level, at the Dead Sea, during the wet period was 180 m below sea level, as compared to ~400 m at present. An interesting question is: "How can we explain deposition processes, during a wet climatic period, when there is a general agreement that erosion increases with increasing average annual rainfall [4]. Available data, on present day eolian deposition rates, point to very low deposition rates: 0.04-1 mm a-1 [2]. In addition, how can we explain deposition processes over bare rocky surfaces (Figure 2) known for their very high overland flows, even at very low rain intensities [5]. In addition, how can we explain the lack of a vegetation cover over the loess covered hillslopes (Figure 3), and the disorganized drainage network (Figure 4). Many channels disappear.

Figure 2: Loess deposition over a rocky surface

Figure 3: Vegetation cover over the loess covered area.



Loess covered area: characteristics of the drainage network

Figure 4: view of the disorganized drainage network

Methodology

The study is based on three aspects: rainfall regime, hillslopes properties, and channel hydrological processes.

Rainfall regime

Figure 5 presents three rain events. In the three events ~ 85% of the rain are below 5 mm/hr^{-1}, and rain intensities are quite low. In addition, rain-showers are quite intermittent.

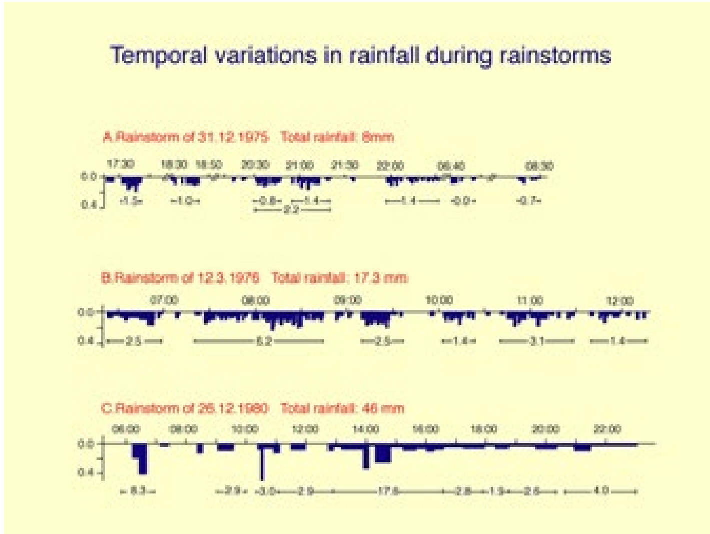


Figure 5: Rainfall regime

Hillslope processes

The study of the hillslopes characteristics is expected to provide the long-term processes of overland flows, and their possible contribution to channel flows. The study is based on a hillslope 400 meters long, in the "Haggedi basin that covers 11 km^2"

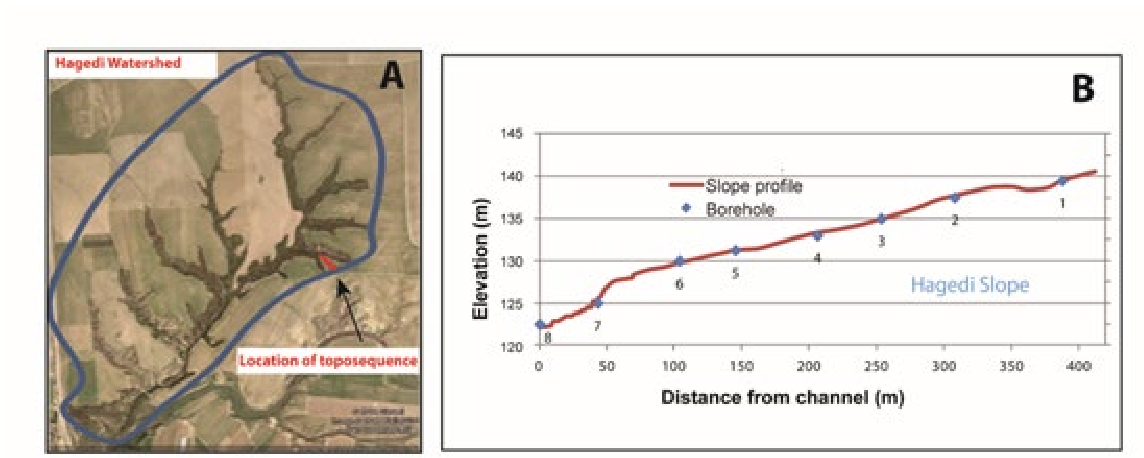


Figure 6: Location of boreholes along the Haggedi slope.

Table 1 presents the spatial variability in the clay content along the Haggedi slope. The variability in the clay content, and with depth, is limited. The highest values are at the upper part of the slope, and in the channel.

Table 1: Changes in Clay Content along the Haggedi Slope, and the Adjoining Channel.

Borehole No	1	2	3	4	5	6	7	Channel
Depth (cm)								
0-20	34	35	27	27	27	37	35	45
20-40	38	35	32	27	34	27	35	43
40-60	45	40	32	33	34	33	36	43
60-80	47	41	37	36	36	35	34	39

The chemical variability along the Haggedi slope is presented in Figure 7 Data obtained clearly point to a very low variability in the chemical composition along the slope. The highest value is at the top of the slope, due to local geological conditions.

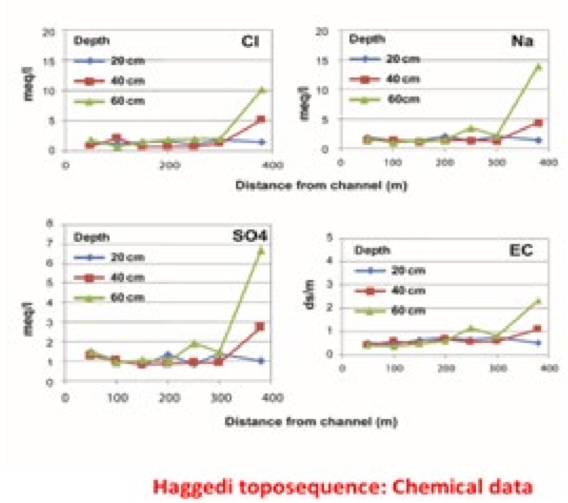


Figure 7: Chemical data, along the Haggedi slope

Figure 8: clearly shows that moisture content along the slope is quite uniform, and low. But the highest value, down to 20 cm is obtained in the channel itself.

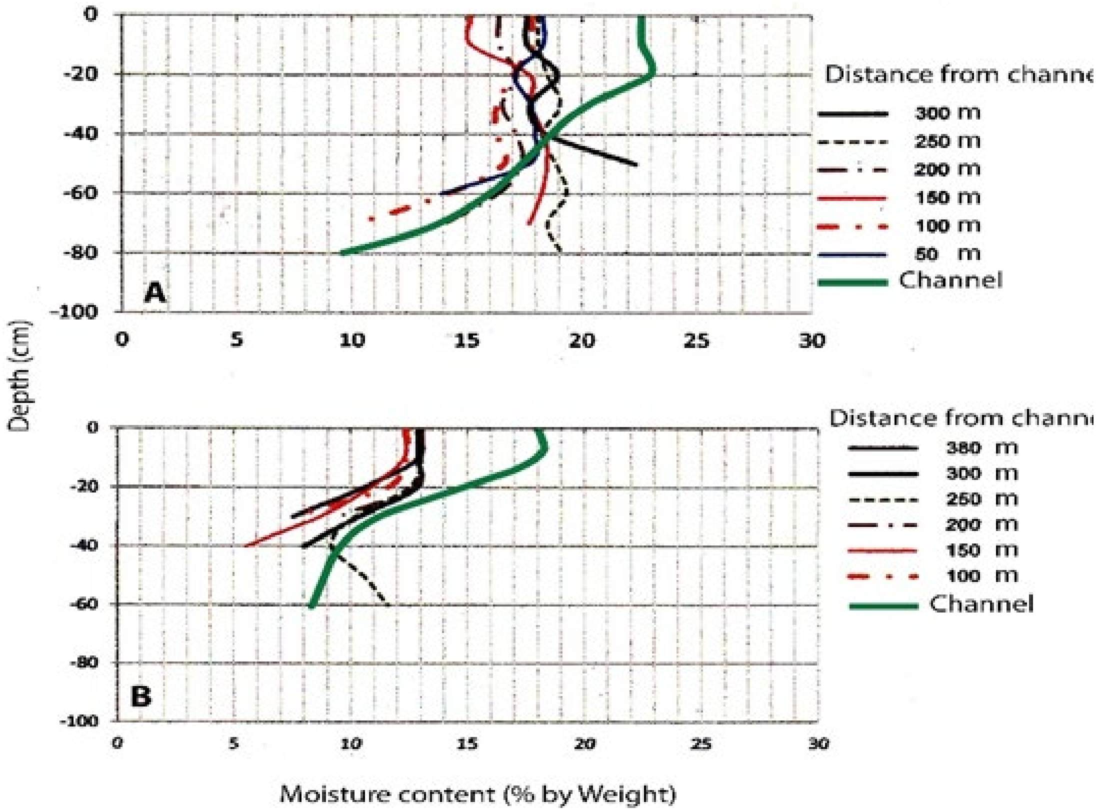


Figure 8: Moisture content, along the Haggedi slope, and the channel.

Table 2: zoological activity at Sede Boker rocky area, and Ramat Hovav loess covered area.

Zoological activity: Sede Boqer and Ramat Hovav

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Species	Index	Sede Boqer	Ramat Hovav
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In addition, despite the differences in the average annual rainfall, soils in the wet area are more saline. Sodium content at a depth of 40 cm is 80 meq/l, in the loess covered area, and only 10 meq at a depth of 90 cm in the rocky area (Yaalon and Dan 1974; Yair and Berkowicz, 1989). Clay content in the loess covered area is around 30-40% (Yair et al., 2016) and around 25% in the rocky area (Yair and Raz-Yassif, 2004). An additional factor is the mineralogical composition of the clay fraction in the loess soil. The mineralogical composition of the clay fraction plays an important role in the soil moisture regime. According to Singer 2007; Sandler, 2013, and Yair, 2021, the dominant clay in the loess covered area is the muscovite, known for its very high-water absorption capacity. An important factor is the rainfall properties in the loess covered area. 85% of the rain are below 5 mm/hr-1 and rainfall is highly intermittent (Yair, 2021). Such rain intensities are below the final infiltration rates reported for the loess covered area in the study area of 10-15 mm/hr`1 (Rawitz and Hillel, 1971; Morin et al.,1979; Kadmon et al., 1989) . The significance of such data is that the occurrence of overland flow is negligible.

Discussion

The discussion will focus on two observations. The first is the absence of a vegetation cover in the loess covered area (Figure 2) and the second is the effects of the loess over bare rocky areas (Figure 3), known for their high frequency and high magnitude of runoff generation, and soil erosion.

Figure 3: Loess deposition on a rocky surface

The explanation proposed is double. The first is related to the rainfall properties. As indicated earlier about 85% of the annual rainfall are below 5mm/ hr-1, and the duration of most individual rain-showers is too short to allow continuous runoff along long hillslopes (Yair and Yassif, 2004; Yair and Kossovsky, 2012; Yair, 2021). An additional factor that limits runoff is the mineral composition of the clay fraction. According to Sandler 2013, Singer 2022, Yair, 2021) the dominant clay in the study area is muscovite, known for its very high-water absorption. The combination of the factors mentioned above: low rain intensities with a short duration; negligible overland flows, high clay content, with muscovite as the domination clay, result in a limited depth of water penetration. Under the high annual evaporation rate of 2700 mm (Atlas of Israel, 1964) a soil salinization process occurs (Dan and Yaalon, 1982; Dan et al., 1981; Yair and Berkowits, 1989. The negative effect of rainfall increase, when the loess was deposited, was not limited to pedological and botanical aspects. The increase in the soil cover drastically reduced runoff generation, decreased erosion rates, leading to a general obliteration of the preexisting drainage network (Yair and Enzel*-, 1987) [6-10].

Sandy Areas

As indicated earlier sand was deposited during a dry climatic phase. Sand deposition may improve water availability due to deep rainwater infiltration, and good water preservation, resulting from limited evaporation losses. Despite the said above, the hypothesis advanced is that a variety of factors may interfere, leading to very complex relationships between average annual rainfall, water resources, and properties of the ecosystem. The aim of the present study is to focus on the complex relationships between average annual rainfall in sandy areas, along a rain gradient from 90-450 mm average annual rainfall, in the south eastern Mediterranean area [10-16].

References

1. Goldberg, P. (1981). Late Quaternary stratigraphy of Israel: an eclectic view. Préhistoire du Levant, 55-66.
2. Crouvi, O., Amit, R., Porat, N., Gillespie, A. R., McDonald, E. V., & Enzel, Y. (2009). Significance of primary hilltop loess in reconstructing dust chronology, accretion rates, and sources: An example from the Negev Desert, Israel. Journal of Geophysical Research: Earth Surface, 114(F2).
3. Torfstein, A., Goldstein, S. L., Stein, M., & Enzel, Y. (2013). Impacts of abrupt climate changes in the Levant from Last Glacial Dead Sea levels. Quaternary Science Reviews, 69, 1-7.
4. Yair, A. (1987). Environmental effects of loess penetration into the northern Negev desert. Journal of Arid Environments, 13(1), 9-24.
5. Yair, A., & Lavee, H. (1985). Runoff generation in arid and semi-arid zones. Hydrological forecasting/edited by MG Anderson and TP Burt.
6. Dan, J., & DH, Y. (1982). Automorphic saline soils in Israel.
7. Gerson, R., & Amit, R. (1987). Rates and modes of dust accretion and deposition in an arid region—the Negev, Israel. Geological Society, London, Special Publications, 35(1), 157-169.
8. Sandler, A. (2013). Clay distribution over the landscape of

Israel: From the hyper-arid to the Mediterranean climate regimes. Catena, 110, 119-132.
9. Singer A. 2022. The soils of Israel. Springer Verlag, berlin, 306 pp
10. Tsoar, H., & Pye, K. (1987). Dust transport and the question of desert loess formation. sedimentology, 34(1), 139-153.
11. Yaalon, DH; Dan J. 1974. Accumulation and distribution of loess derived deposits in the semi-desert and desert fringe area of Israel. Z. Geomorphology, 20: 91-105.
12. Yaalon, D. H., & Dan, J. (1974). Accumulation and distribution of loess-derived deposits in the semi-desert and desert fringe areas of Israel. Z. Geomorphol. Suppl, 20(91), e105.
13. Yair, A. (1983). Hillslope hydrology water harvesting and areal distribution of some ancient agricultural systems in the northern Negev desert. Journal of Arid Environments, 6(3), 283-301.
14. Yair, A., & Enzel, Y. (1987). relationship between annual rainfall and sediment yield in arid and semi-arid areas: the case of the northern Negev. Geomorphological models: theoretical and empirical aspects/Frank Ahnert (editor).
15. Yaalon D. 1982. Automorphic
16. Issar, A. S., & Bruins, H. J. (1983). Special climatological conditions in the deserts of Sinai and the Negev during the latest Pleistocene. Palaeogeography, Palaeoclimatology, Palaeoecology, 43(1-2), 63-72.