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Soil Erosion and Other Factors as Indicators of Desertification Processes in an Agroecosystem in the Northern Negev Desert

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Abstract

Erratic and unreliable rains result in flash floods during winter that cause erosive activities in the basins and adjacent agricultural areas in the semi-arid parts of the Negev desert of Israel. This has led to the formation of gullies. The head-cuts of the gullies better known as knick-points, are activated during floods and migrate upstream, eventually making incisions into the cultivated areas, thus leading to the loss of soil nutrients over time. Soil erosion in conjunction with human activities has greatly contributed to desertification in the northern Negev. This research was carried out to examine the effects of soil erosion and agricultural practices on soil quality in seventeen eroded sites in the semi-arid part of the Negev desert. The hypothesis was that soil erosion and agricultural activities would reduce soil quality.

Field experiments were carried out within the semi-arid parts of the Negev desert of Israel between September, 1998 to August, 2001. This is the area to the northwest of Beer Sheva stretching up to Kiryat Gat and areas bordering Ashkelon. The area comprises of nature reserves and agricultural fields. Rainfall ranges between 200 mm to 350 mm per annum. The years 1998/99 and 1999/2000 received far below average rains. The soils are mainly loess but areas towards the north (Ruhama and Pura) of the study area have a large proportion of sand (60 cm depth). Seventeen gullies were randomly selected from within nature reserves and agricultural

areas during the period before winter rains (start of the cropping season). Soil samples were subsequently collected from areas above and below waterfalls, respectively. The soil samples were used to analyze both chemical and physical characteristics of the area in order to determine soil quality. Further soil samples were collected to perform bioassays. An area covering 135 km^2 was spatially and randomly sampled to establish the history of land use over time. The physical soil parameters analyzed included water-holding capacity and granulometry, whereas the chemical soil parameters ones were pH, organic carbon, electrical conductivity, nitrogen, phosphorus and soil respiration. A bioassay with radish (*Raphanussativus* L.) was carried out using 20 pots per site. Similarly, a bioassay with Wheat (*Aestivumsativus* L.) was carried out to determine the effects of land use history on soil quality. In order to assess plant species diversity, Whittaker plots sampling was conducted in all the seventeen sites. Aerial photographs were also used in order to establish the temporal pattern of soil erosion and to track land use changes during the years 1917, 1945, 1966, 1976 and 2000. All these data were graphically presented using a Geographic Information System (GIS).

In all the parameters investigated there were significant differences between sites. Areas above (uneroded) and below (eroded) gullies and distances (5m, 10m and 20m) from waterfalls showed significant differences at all sites under investigation. The pH showed that soils are calcareous; meaning that availability of some soil nutrients such as P were adversely affected. Organic carbon increased along a moisture gradient, being lowest in areas receiving 200 mm and highest where rainfall is over 300 mm per year. Nature reserves had higher organic carbon than agricultural areas. Salinity was highest in the nature reserve sites and irrigated areas because of accumulation of bases resulting from reduced leaching, continuous supplies of mineral salts in form of fertilizers and heavy metals from brackish water used in the irrigation system,

respectively. Nitrogen showed significant differences both between sites and eroded versus uneroded areas. Soil phosphorus had significant differences between sites. Soil respiration had significant differences in all sites. Water holding capacity was higher in nature reserve soils than in cultivated areas, whereas eroded sites contained larger soil particles than uneroded ones. Biomass of plants in a bioassay showed a positive correlation with amount of organic carbon, an indicator of soil quality. A detrended correspondence analysis (DECORANA) showed that plant community composition in nature reserves was distinctly different from the agricultural areas. There was a clear grouping of species based on moisture gradient and economic activities carried out in the area. Soil erosion resulted in increased plant species richness and significantly changed plant community structure in eroded areas of wadis. Increased plant species richness in eroded sites is consistent with the intermediate disturbance hypothesis of plant community structure. Biomass of plant species was significantly different between areas above versus those below gullies in agricultural areas, forested areas and non-forested areas. Land use historical records revealed a comprehensive picture in terms of distribution of yields in an east-west and a south-north gradient. Considering the presence/absence of settlement and close/far proximity to the wadi, no significant differences were recorded in either case. Wadis that were highly eroded more than fifty years ago and have been under afforestation by Keren KeyemetL'Israel (KKL) still show physical evidence of soil erosion. It is quite evident from mapping using GIS that eroded areas below waterfalls have lower soil quality than the uneroded ones above waterfalls. This information clearly points on the fact there is imminent desertification and remedial measures to combat it have to be instituted.

KEY WORDS. Soil, Erosion, Gullies, Negev, Israel