IRRIGATION SEDIMENTATION IN THE LOWER MESOPOTAMIAN PLAIN

SEDIMENTATIE DOOR BEVLOEIING IN DE BENEDEN MESOPOTAMISCHE VLAKTE

by/*door*

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1. INTRODUCTION

The Lower Mesopotamian Plain is the river plain of the Tigris and Euphrates rivers, extending from about 150 km north of Baghdad to the Gulf of Basra, covering an area of 600 × 200 km (fig. 1). It is the land of Sumer, Akkad and Babylonia, well known from the Bible. The climate is arid, with dry and hot summers and a somewhat cooler winter. The average rainfall is 100–140 mm, which often precipitates in some torrential showers. The plain is flat, with a difference in height of less than 40 m over its full length. Cultivation is only possible if land is flooded or irrigated. Irrigation agriculture is practiced since the fifth millenium B.C. Soils are built up from flood and irrigation sediment. The main soil forming process is salinization. Therefore most soils are saline, some even strongly saline. The salt content in the soils may rise up to 32%, in most soils it is 1 to 4%, which still is extremely high. Agriculture is possible, because the traditional farm management system is adapted to saline soil conditions (Buringh, 1960).

The whole Lower Mesopotamian Plain is covered by a thick layer of young fluviatile sediment, which has been deposited mainly during irrigation of cropland.

Land surfaces of ancient times, indicating cultivation in various periods during the past 6000 years, are found at various depths below the present surface. These burried layers are characterized by a different soil colour, structure and consistence, in addition they contain flints and remnants of pottery and bricks of various periods. The oldest cultivated surface layers are formed at a depth of approximately 11 m in the upper section of the plain north of Baghdad, about 7 m in the middle section near Hilla and Diwaniyah, and at 4 m near Basra in the south. The examination of the characteristics of these layers is important for irrigation and drainage planning in agricultural development projects.

The layer of flood and irrigation sediment is not uniform all over the plain. There are many differences in soil texture and thickness even over short distances, both in vertical and horizontal directions. The upper few meters of most soils consist of irrigation sediment, deposited in an intricated pattern which is related to the former or present lay-out of irrigation canals and ditches. This pattern has highly influenced salinization of the soil. Both sedimentation and salinization have influenced living conditions in present and ancient times (Buringh, 1957).

The main reason for the deposition of sediment in the plain is the erosion of soil material in the middle course of the Tigris and Euphrates rivers. It is always believed that the mountains of Iraq, Iran and Turkey are the areas

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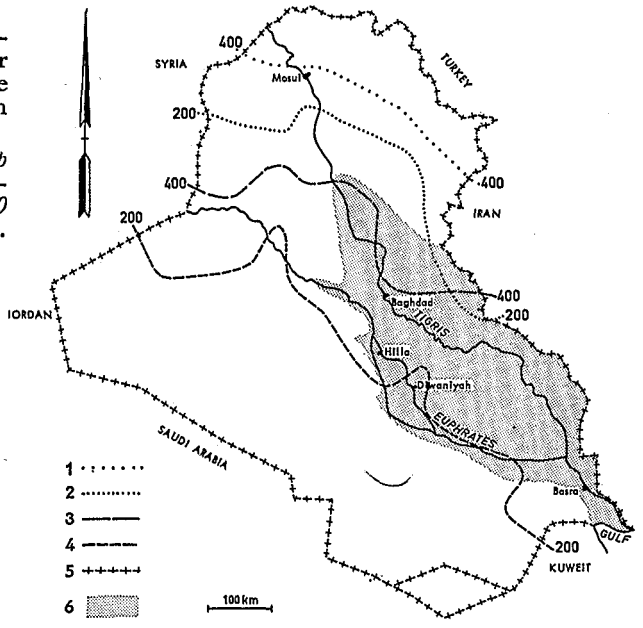
Fig. 1.
General map of Iraq, indicating the location of the Lower Mesopotamian Plain and the isohyets of 200 and 400 mm in wet and dry years.
Overzichtskaart van Irak waarop aangegeven de laagvlakte can Mesopotamië en de isohyeten van 200 en 400 mm in droge en natte jaren.



1. Isohyet of 400 mm – dry period
   Isohyeet van 400 mm – droge periode
2. Isohyet of 200 mm – dry period
   Isohyeet van 200 mm – droge periode
3. Isohyet of 400 mm – wet period
   Isohyeet van 400 mm – natte periode
4. Isohyet of 400 mm – wet period
   Isohyeet van 400 mm – natte periode
5. State boundary/*Landsgrens*
6. Lower Mesopotamian Plain
   Laagvlakte van Mesopotamië.

where soil is eroded and transported to the plains. Although some material is eroded from the mountain regions, recent investigations learn that most material originates from the semi-arid hills and plains, roughly located between the isohyets of 200 and 400 mm (fig. 1). The location of these isohyets varies annually over distances of some hundreds of kilometers. In this zone large areas are badly eroded (fig. 2). Precipitation often occurs in some torrential rains of 30 or 40 mm in a few hours. Baghdad for example has a maximum daily rainfall of 55.6 mm (March 16, 1938).

Water erosion is often accelerated by overgrazing and mechanized cultivation in the dry steppe land. As a consequence of erosion water in the Twin rivers is light-brown coloured. In 1953 the quantity of sediment in the Tigris river passing Baghdad was 11. 304.000 m^3 (Kholy, 1956). During the flood period in March 1953 more than hundred cubic meters of sediment passed Baghdad every second!

Almost all river load is deposited in the plain, mainly on irrigated land and partly in marshes in southern Mesopotamia. Therefore the land surface is gradually rising. River beds and irrigation canals are silted up. Various ancient cities, former centres of civilization and situated near ancient riverc ourses, have been abandoned. They now are ruins, surrounded by waste and idle land.

In central Iraq the Tigris and Euphrates are meandering rivers, consequently soils are built up in a levee-and-basin pattern. The river levees consist of relatively light-textured soils, occurring in strips along both sides of the river in a somewhat higher (2 to 3 m) topographical position as the basins, which consist of somewhat heavier textured sediments in a lower and more wet or moist position. During floods large areas are inundated and the basins are filled with water. As there is a gradual faint slope from north to south flood water moves to the southern section of the basin. Each basin (fig. 3) can be sub-divided into:

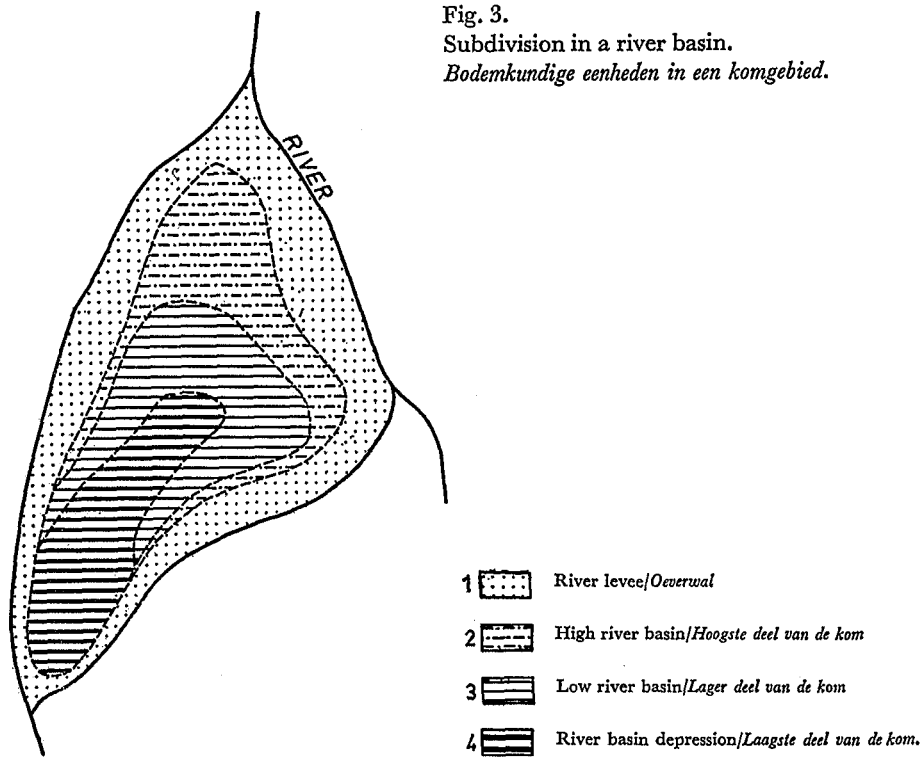


Fig. 3.
Subdivision in a river basin.
Bodemkundige eenheden in een komgebied.

a. the high basin, with relatively the best drainage conditions and lighter textured soils.

b. the low basin, with moderate drainage and somewhat heavier textured soils.

c. the basin depression, with poor drainage and heavy-textured soils. These depressions are flooded for at least some months of the year.

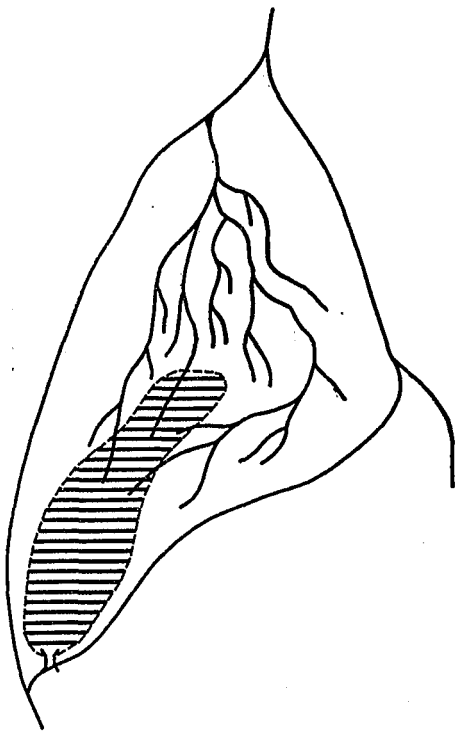
Even under natural conditions the basin depressions are saline to strongly saline, often of the genetic type of flooded solonchak soils, sometimes even with solonetzic characteristics.

Up to recently it was almost impossible to irrigate the river levees, because only simple techniques of lift irrigation were practized. The irrigated and cultivated land was situated in the river basins. The irrigation systems were based on techniques of gravity irrigation. Two main irrigation systems can be recognized:

2. THE SYSTEM OF UNCONTROLLED IRRIGATION

A kind of canal has been dug through the somewhat higher lying levee along the river. The water enters the basins at a relatively high point and there is a free or uncontrolled flow to the lower lying parts of the basins, forming a typical pattern of flood channels, similar to those mapped by Pons (1957) in

Fig. 4.
An un-controlled irrigation system in a river basin.
Wilde bevloeiing in een komgebied.



the Netherlands. Along the flood channels small levees are formed and in between lower lying parts of the basin occur, which all drain into the basin depressions (fig. 4).

3. THE SYSTEM OF CONTROLLED IRRIGATION

An irrigation canal has been dug through the levee far into the basin. The flow of water into the canal is controlled by a simple dam or sluice. The water level in the canal is higher than the land surface in the basin. Through an intricate pattern of branch canals and sluices irrigation water can be diverted to each plot, almost the whole year round. Here too levees have been formed along the canals. As these canals are gradually silting up they have to be cleaned and the material from the canal bottom form a kind of dyke on both sides of the canal. Due to irrigation, sheet and wind erosion of these dykes, broad strips along the canals are covered by silty irrigation sediment.

On a plot, which is irrigated by a small irrigation ditch more sediment is deposited near the ditch than at some distance. Each season the plot is divided into a number of small plots (15 × 15 m), each surrounded by a small dam (fig. 5). All plots are flooded a few times during the growing season. The small dam near the ditch in plot 1 is cut and the plot is flooded and most particles suspended in the irrigation water are deposited here. Then a cut is made in the small dam between plot 1 and 2 and the last plot is flooded etc. The sedimentation in plot 2 is less than on plot 1 and the sediment on plot 2

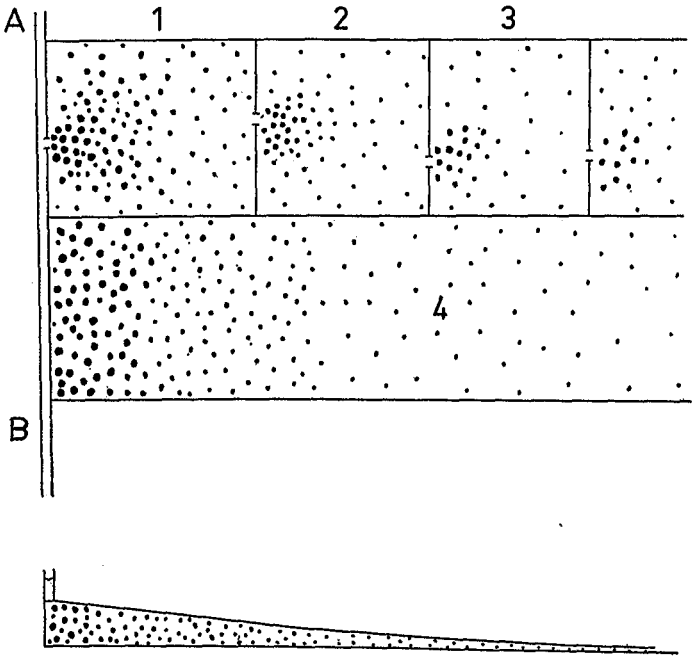


Fig. 5.
Sedimentation on irrigated plots and a cross-section after some years of irrigation (explanation in text).
Sedimentatie op bevloeide percelen met dwarsdoorsnede na enkele jaren bevloeiing (verklaring in de tekst).

is somewhat finer. The result of some years of irrigation is shown in plot 4 of fig. 5.

It can be easily understood that most irrigation levees are formed by a combination of both processes (deposition and erosion, in particular sheet erosion).

The result of such a system of controlled irrigation by canals is a subdivision of the extensive river basin in a large number of small depressions surrounded by irrigation levees (fig. 6). Such depressions are called "irrigation depressions". They have no outlet for excessive irrigation water, consequently drainage conditions are poor, soils are strongly saline and physical soil conditions are bad to very bad. Many depressions have solonetzic characteristics, in abandoned areas some consist of alkali soils. They also are characterized by gilgai-gullies or a typical gilgai relief. Details of these bad soils are published by Harris (1958).

The irrigation levee soils consist of rather uniform soil material in which silt particles dominate. Soil texture is mostly silt loam. The surface layer (about 2 or 3 mm) is very dense, non-porous and crusted, in particular after irrigation or rain (fig. 7). Almost all irrigation levee soils are saline to strongly saline often of the puffed-solonchak type. As deliquescent salts (Ca and Mg-chloride) are quite common in Mesopotamia saline soils of the so called "sabbakh" type also occur on irrigation levees, in particular on the lower types. Combinations of puff-solonchak and sabbakhsoils are common. More details on these soils are published by Buringh (1960).

Fig. 2. Badly eroded area in the northern section of the Lower Mesopotamian Plain.
Sterk geërodeerd gebied in het noordelijk deel van de laagvlakte van Mesopotamië.

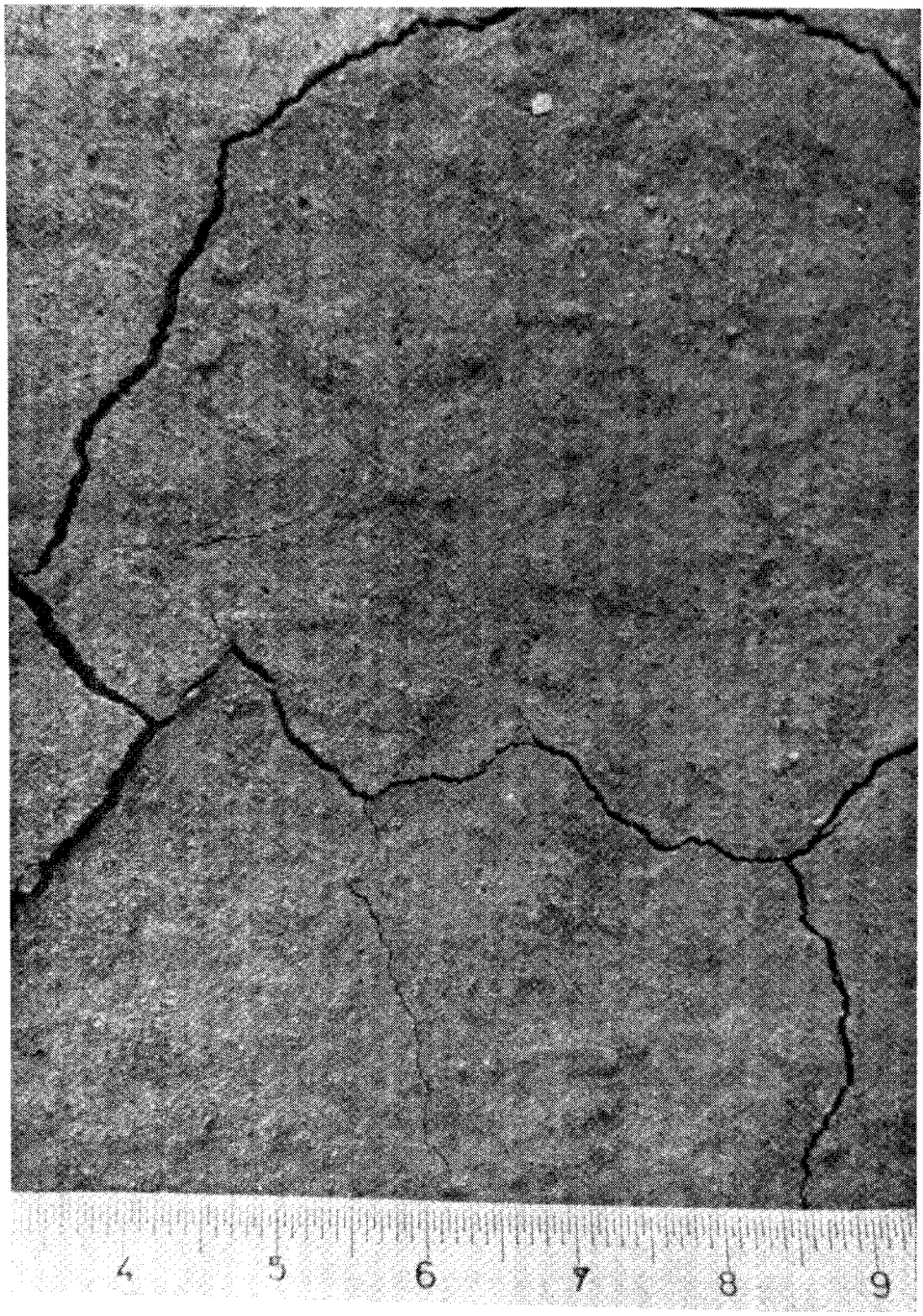
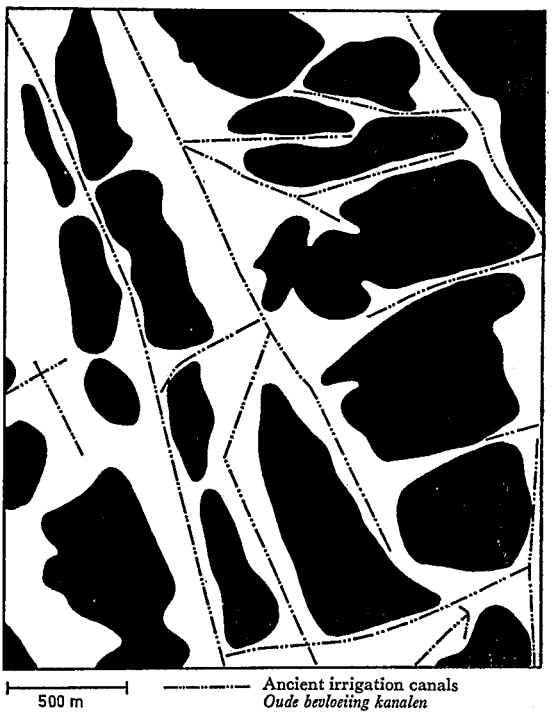


Fig. 7.

Close up of the crusted surface layer of an irrigation levee soil, demonstrating the dense soil structure.

Close up van de korstige bovengrond van een bevloeide irrigatierug-grond waaruit de dichte structuur blijkt.

Fig. 6.
Pattern of irrigation depressions and canals in an area of controlled irrigation (according to an unpublished soil map of the Naifa project by L. J. J. van der Kloes).



Patroon van bevloeide kommen en leidingen in een gebied met beheerste bevloeiing (volgens een niet-gepubliceerde bodemkaart van het Naifaproject door L. J. J. van der Kloes).

Besides the two main systems of irrigation, of which the controlled canal system is the most common, there are various combinations and transitions. The soil pattern becomes really complicated if a complete new irrigation system is made in an area which has already been irrigated for a long time.

It is quite typical that the irrigation sediment is rather uniform over large distances. Along the first kilometer of the canal the sediment is somewhat fine sandy, however all other irrigation levees have an uniform soil texture. This is caused by the lay-out of the canals and ditches which is made in such a way, that the velocity of the water in the canals and ditches is almost constant in order to avoid silting up of the canal itself. However it still is necessary to clean the canals regularly, heightening the argubs. The argubs along old irrigation canals are gradually lowered by sheet and wind erosion thus forming broad, large and high-lying strips of waste land.

The bad structures irrigation depression soils consist of clay. In abandoned areas they often are covered with blown silty irrigation sediment from irrigation levees or argubs, which results in a considerable soil improvement. As the groundwater in non-irrigated regions drops gradually, salinization decreases and finally leaching by rain and run-off water may result in solonization of irrigation depression soils.

The puff-solonchak soils on the irrigation levees are susceptible to wind erosion, in particular if the thin surface crust is broken, for example by steps of sheep and goats. In some areas dunes of the barkhan type up to 4 m in height are formed. They may consist of pseudo sand (Buringh and Edelman, 1955), being clay particles in crumbs of the size of sand particles, often cemented by salt or lime. Similar material, which however is of Pleistocene

age is called "parna" in Australia (Butler, 1956). Recently this has also been described in Russia and Algeria.

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4. SAMENVATTING

De Beneden Mesopotamische vlakte, de vlakte van de benedenloop van Euphraat en Tigris met een oppervlak van rond 120.000 km², strekt zich uit van ± 150 km ten noorden van Baghdad tot aan de Perzische Golf (fig. 1). Het is het land van de Sumeriërs, Akkadiërs en Babyloniërs, bekend uit de Bijbel. Het ariede klimaat en de geringe regenval (gemiddeld 100–140 mm per jaar, vaak in enkele regenbuien vallend) maakt landbouw slechts mogelijk indien bevloeiing toegepast kan worden. Bevloeiingslandbouw is reeds sinds het 5e millennium v. Chr. gebruikelijk.

De gronden zijn gevormd in fluviatiele sedimenten, afgezet door overstromings- en bevloeiingswater. Verzilting speelt bij de bodemvorming de voornaamste rol. Het zoutgehalte, meestal 1–4%, kan oplopen tot 32%. De beoefening van de landbouw is geheel aangepast aan deze zilte omstandigheden.

Vrijwel het gehele dikke, fluviatiele dek is ontstaan als gevolg van eeuwenlange bevloeiing.

De grote massa van de sedimenten is in hoofdzaak afkomstig van het enorm geërodeerde droge steppeland in de middenloop van de beide grote rivieren. Het vele slib veroorzaakt een voortdurende verhoging van het maaiveld en dichtslibbing van rivierbeddingen en irrigatieleidingen. Hierdoor moesten in de loop der eeuwen verschillende steden, centra van beschavingen, worden verlaten.

De meanderende Euphraat en Tigris hebben in Centraal Irak een geheel systeem van stroomruggen, oeverwallen en kommen doen ontstaan. Tot op heden was het bijna onmogelijk de lichtere oeverwalgronden te bevloeien. Slechts de kommen worden bevloeid en gedraineerd. Deze bevloeiing kan al dan niet beheerst zijn. Wild is het systeem, waarbij het kanaal enkel door de wat hoger gelegen stroomrug wordt gegraven, waardoor het water vanaf een relatief hoger punt de kom vrij kan binnenstromen. Een natuurlijk patroon met ruggen en kleinere kommen is hiervan het gevolg.

Bij het beheerste systeem wordt het kanaal tot diep in de kom gegraven. Het waterniveau in het kanaal en de zijkanalen ligt hierbij boven het maaiveld van het omringende land. Het water wordt verdeeld door middel van dammen en sluizen, die enige malen per groeiseizoen worden geopend. Langs de kanalen komen tengevolge van deze wijze van irrigatie, door het baggeren in de kanalen en door oppervlakte-erosie hoger gelegen gronden voor, waarin de fractie 2–50 mu overweegt. Vrijwel al deze irrigatierug-gronden zijn zoutgronden, doorgaans van het puff-solonchaktype. Ook komen, bij aanwezigheid van Ca en Mg-chloriden zoutgronden van het z.g. sabbakhtype voor.

De lager gelegen gronden in de depressies tussen de kanalen hebben geen afwatering. De gronden zijn sterk zouthoudend en de fysische eigenschappen ervan zijn slecht. In vele depressies komen zoutgronden voor van het solonetztype, soms in verlaten streken alkali-gronden. Voorts worden deze lager gelegen gronden gekenmerkt door gilgaiverschijnselen.

5. LITERATURE

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