Depth and Quality of the Groundwater in North Delta Soils

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Abstract

Water table levels had been recorded daily on 227 locations in North Delta under different soil, land use and drainage conditions. The measurements were made in observation wells (perforated plastic tubes 38 mm diameter and 2 m deep). The measurements were started in November 1999 and will continue through the next two growing seasons. Ground water samples were collected (twice until now) from the observation wells. Salt content, concentration of the essential cations and anions, and the concentration of some heavy metals and microelements were determined.

The preliminary results for the first six months are presented here and the final results will be published after the end of the investigations. The obtained data revealed that the lands of the North Nile Delta region are characterized by a high water table. The mean water table level ranged between 33-150 cm with overall mean of 78 cm. Water table levels reach a maximum after irrigation and gradually decrease reaching a minimum before the next irrigation. Such trend was observed in all studied locations. The quality of ground water was influenced by the land use and drainage conditions, and also by the levels of the water table. Negative correlation was obtained between groundwater depth and quality of such water. The correlation coefficients between mean water table level and mean values of EC, Na, Ca+Mg, HCO_3, Mn, Fe, and Pb of the groundwater were 0.319, 0.296, 0.323, 0.359, 0.378, 0.244, and 0.069 respectively. The data of depth and quality of the ground water will be used to justify identifying the ground water as a resource to cover a part of the water requirements of the different field crops.

Introduction

In arid and semi-arid regions usually shallow water table is the decisive factor of salinization and alkalization. The limiting depth of groundwater table that might be considered of practical importance would vary with the nature of the soil and quality of groundwater, land use, irrigation and drainage conditions (Kovda, 1961 and Elgabaly, 1972). Most lands of North Delta region are clay textured soils, mainly under flood irrigation system and increased cropping intensity. Groundwater table level of 60–90 cm for sandy soils and of 100–150 cm for clay soils were considered suitable for most field crops (Benetin, 1983). The sub-irrigation from groundwater may greatly contribute in the water requirements of the plants. Ground water may be considered as a water supply source for crops and may reduce irrigation demand (Ragab and Amer, 1989; Ibrahim, 1999).

Specially in North Delta region, where water supplies become scarce, evaluation of the depth and quality of groundwater is necessary for effective water use and management. Therefore the objectives of this investigation are to: (1) evaluate the fluctuation of water table levels for 227 locations in North Delta, representing wide variations in land use, drainage conditions, and hence groundwater depth; (2) determine the quantitative relations between depth and quality of ground water.

Material and Methods

Water table levels had been recorded daily on 227 sites in Kafr El-Sheikh governorate, north Nile Delta, Egypt. The study sites were chosen to represent a wide variation in locations, land use, irrigation and drainage conditions. The measurements were made in observation wells (perforated plastic tubes 38 mm diameter and 2 m deep), which were installed at the half distance between two tiles (or open field drains). The measurements were started first November 1999 and will continue for at least one year. The data presented here cover the first six months. (November 1999 – April 2000). Ground water samples were collected from the observation wells at the beginning of December 1999 and at the end of April 2000. Salt content (EC value) and the concentrations of essential cations and anions were determined as the methods described by Richards (1954). Fe, Mn, Zn, Cu, Pb, Ni, Co, and Cd were determined by Atomic Absorption spectrophotometer. Statistical analyses were calculated for the relation between ground water depth and quality of such water. Correlation coefficients were calculated according to the method given by Snedecor and Cochran (1967).

Results and Discussion

Ground water depth varies from 5 cm to 191 cm according to the location, cultivated crop and drainage conditions. The average values of water table depths for the studied sites from beginning November 1999 until end April 2000 are presented in Fig. (1)[9]. These values ranged between 33 cm and 150 cm with overall mean value of 78 cm. The lands of studied locations were characterized by a high water table.

Table 1: Mean water table depth (M.W.T) and chemical analysis of such water in the main studied regions

Location	M.W.T (cm)	EC dS/m	Na^+ Meq/L	Ca^{++} + Mg^{++}	HCO_3 Meq/L	Mn (mg/L)	Fe (mg/L)	Pb (mg/L)
Dakalt	(89) 65-127	(2.6) 1.2-9.8	1.7-58	4.7-36	3.2-29	0.11-4.8	0.1-1.6	0.2-1.8
Kom Elwahal	(65) 33-83	(4.0) 1-8.8	6.9–57	2.5-27	2.6–30	0.1 – 4	0.17–2.5	0.1-2.2
El Ragama	(63) 42-123	(4.8) 1.6-13	10-72	5.1-47	7.5-30	0.1-2.9	0.26-1.3	0.1-2
Abo Moustafa	(67) 47-93	(7.0) 1.4-22	11-138	6.5-83	6-49	0.29-6.4	0.27-2	0.1-3.7
El Daba	(93) 44-144	(3.5) 1.3-8	8-48	5.9-31	4-28	0.1-3.9	0.1-1.3	0.1-3.1
GarbMansour	(96) 84-105	(6.7) 3-12	17-79	11.5-47	11-30	0.5-2.4	0.3-1.3	0.6-4.6
Aruamon	(79) 62-101	(2.6) 1-8.6	6.2-50	4.2-50	4.9-23	0.1-4.9	0.1-3.4	0.2-3.5
El Manifa	(82) 56-137	(1.7) 1.3-3.6	8-23	4.2-13	5.7-15	0.1-3.9	0.1-6.1	0.2-3.6
Ibto	(82) 40-150	(4.3) 1.3-16	8-93	5-38	5.6-30	0.21-3.5	0.25-2.2	0.1-2.7
El Taufa	(73) 45-144	(2.3) 1.3-3.7	7-22	4.8-13	5.3-13	0.1-2.8	0.13-2.9	0.2-3.4
Nosra	(86) 76-99	(1.9) 1.5-2.7	9-17	5.2-9	6.5-9	0.43-2.4	0.15-1.1	0.1-1.4
Sakha	(87) 80-96	(2.7) 1.9-4.2	11-24	6.8-14	6.7-16	0.5-0.9	0.2-1.1	3-3.8

[9] Figures 1-4 are only available in the print copy (Beihefte zu Der Tropenlandwirt Nr. 71)

The daily fluctuations of water table depth for some chosen sites are illustrated in figures (2) and (3). The depth of water table reached the deepest level of 90-150 cm before irrigation, it came close to soil surface upon irrigation and decreased gradually in between irrigations. Such trend was observed in all studied locations. The highest and lowest water table depth and drawdown rate of water table level varied according to cultivated crop, soil, irrigation and drainage conditions.

The 227 studied sites were regional divided into twelve main regions. Mean water table and chemical analysis of ground water in the main studied regions presented in Table (1) showed that water table depth and quality varied between these regions according to soil and drainage conditions as well as quality of irrigation water. High water levels of 63-67 cm with high salt content (mean EC value of 4-7 dS/m) were recorded in some regions such as Kom–Elwahal, El Ragama and Abo-Moustafa due to excessive use of bad irrigation water and not conserved drainage system. The studied locations in Garb-Mansour had newly reclaimed soil irrigated with mixed irrigation, but they had an adequate tile drainage system. The other studied regions had old alluvial soils irrigated with Nile water, and had mean water table level varied between 73-89cm with not bad quality (mean EC values of 1.7-4.3 dS/m). Groundwater analysis showed also that Na is the dominant cation. The Na exceeds the sum of Ca+Mg in all the studied locations. Groundwater is free of residual sodium carbonate (RSC) in some locations and contains different levels of RSC in other ones.

Negative significant relation between mean water table depth and EC values of such water was found (r = 0.320, and R-squared = 0.102) as illustrated in Fig. (4). Table (2) showed the data of regression analyses among mean water table level and chemical analysis of such water. The quality parameters of ground water were negatively correlated with the depth of such water. The correlation was found to be significant or high significant except for Pb. The correlation coefficients were 0.320, 0.296, 0.323, 0.359, 0.244, and 0.069 for EC, Na, Ca+Mg, HCO_3, Mn, Fe, and Pb respectively. The obtained low R-squared values mean that variations of groundwater quality can not be considered due to the depth of such water only. But it affected by many other factors such as soil, land use, irrigation and drainage conditions. In this concern, Oosterbaan (1988) concluded that if the water table becomes shallow the salt leaching can no longer occur and the salts accumulate in the soil and consequently in the ground water.

Table (2): Correlation of mean water table depth with quality parameters of such water.

Quality Parameter	Range	Average	Standard deviation	Correlation Coefficient	R-squared
EC	1.1-12.7	3.7	2.6	-0.320**	0.102
Na	6.7-77.8	23	15.6	-0.296**	0.088
Ca+Mg	3.9-47	13.2	9.2	-0.323**	0.104
HCO_3	3.2-33	12.2	6.7	-0.359**	0.129
Mn	0.01-4.7	1.3	0.96	-0.378**	0.143
Fe	0.01-2.5	0.79	0.46	-0.244*	0.059
Pb	0.01-4.6	1.07	0.89	-0.069 n.s.	0.005

** Significant at 1% level, * significant at 5%, n.s Non-significant.

Recent research has indicated that most crops have higher salt tolerance values than previously thought (Rhoades et al. 1989) which means that many drainage and ground waters are suitable for supplemental irrigation purposes. Water supply from groundwater can be evaluated as potential sources of irrigation water. Many researchers (Kruse et al. 1985; Ayars and Schoneman 1986; Ayars 1996) have shown that field crops will extract significant quantities of water from the shallow groundwater. Preliminary data of the present study revealed that groundwater quality in many of the studied regions is not bad. Results of this study strongly support the argument that groundwater may contribute on water requirements of field crops. This will be discussed in detail in a following study.

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