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Soil Salinity of Mesopotamia and the Main Drains

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Abstract

Since early civilization and the farmers in Mesopotamia are suffering from the soil salinity. This problem had caused the transfer of power from the Sumerians to the Babylonians in ancient history. Great efforts and research have been made since the beginning of the 20th century to overcome this salinity problem. Experts have concluded that the main reason for salinity is the salt content of irrigation water and the shallow saline groundwater derived from the irrigation activities. General schemes were planned, which involve building a new system of drains in parallel to the irrigation network. The backbone of the drainage system in Mesopotamia is the Main Outfall Drain (MOD). Large works such as Musayab Main Drain, Main Outfall Drain, Great Gharraf Drain, East Euphrates Drain were implemented, but there are still large needs for much more work to be done.

Keywords: Soil Salinity, Musayab Main Drain, Main Outfall Drain, MOD, Great Gharraf Drain, East Euphrates Drain.

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1. Introduction

Civilization in Mesopotamia is inherently related with agricultural activities. This applies not only to the early Mesopotamia empires but to all subsequent eras until recent history. The nature of the Mesopotamia plain, climate, soil properties, and very mild slope had triggered the chronic problem of salinity in top soils. Salinity has not affected productivity of lands and farmers only, but it was one of the major reasons of declination of empires; for instance, the control and power transfer from Sumerians to Babylonians was attributed to the decrease in land productivity of Lower Babylon, which is now Thi-Qar area. This decrease was caused mainly by soil salinization (Al-Hayali, 1964). Evidence of the land deterioration in Lower Babylon is witnessed in the decrease in land productivity of barley as shown in Table 1 below.

Table 1: Selected annual land productivity of barley in Lower Babylon (Al-Hayali, 1964).

Date	Productivity (kg/donum)
2400 BC	380
2100 BC	220
1700 BC	135

A main drain was proposed between Tigris and Euphrates for the first time in Willcocks report (Willcocks, 1911). Efforts were made to study the leaching of lands in Mesopotamia, and an early attempt was one experiment in Hilla in 1921, second experiment was conducted near Hindiya Barrage in the season of 1926/1927. Third experiment was conducted in Saqlawiya area in the seasons of 1927 and 1929, unfortunately, this experiment failed (Buringh, 1960.) A conclusion was drawn that the major factor which is causing salt accumulation is the groundwater rising in the irrigated lands. The concentration of ground water in lower and the middle of Mesopotamia varied between 10,000 to 60,000ppm and up to 80,000 (Buringh, 1960). The capillary action and high temperature on soil surface were causing the salt accumulation at the top soil profiles. Further, it had been estimated that the Euphrates as an example is depositing salts of about 150gm/m^2/year. The accumulation of this last amount for 13 years will result in tangible effects on land productivity, while the accumulation for 78 years makes the land unproductive. Experts have concluded that the best diagnose to reduce groundwater impact is by lowering groundwater depths by constructing a sophisticated drainage system paralleling the irrigation system. The first drains were excavated in 1952 (Al-Hayali, 1964).

The first study of the master plans for the main drains was presented by the American consultants Messrs Knappen-Tippetts-Abbett-McCarthy (TAMS) in 1952, where the company had proposed the route of the Main Outfall Drain (MOD) to flow into Hammar Marsh (Al-Jabbari and Nawfal, 2001, Mohammed, 1986). Since then, many of the main drains were implemented, and the others are either ongoing or proposed drains such as East Tigris Drain and Western Euphrates Drain, in addition to some of the evaporation lakes (Al-Simawi, 2011).

2. Overview of Salinity in Mesopotamia

Salinization covers around 60-70% of Mesopotamia. In the irrigated lands, 4% are severely saline, 50% moderately saline and 20% slightly saline (Al-Falahi and Qureshi, 2015). It can be easily concluded that the salinity increases significantly in parts where there are no drainage networks or field drains. It is noticed also within the reclaimed projects that, were covered by field drains, the soils at the end of the system have comparatively more salinity. Figure 1 shows salinity mapping in Mesopotamia according to 2010.

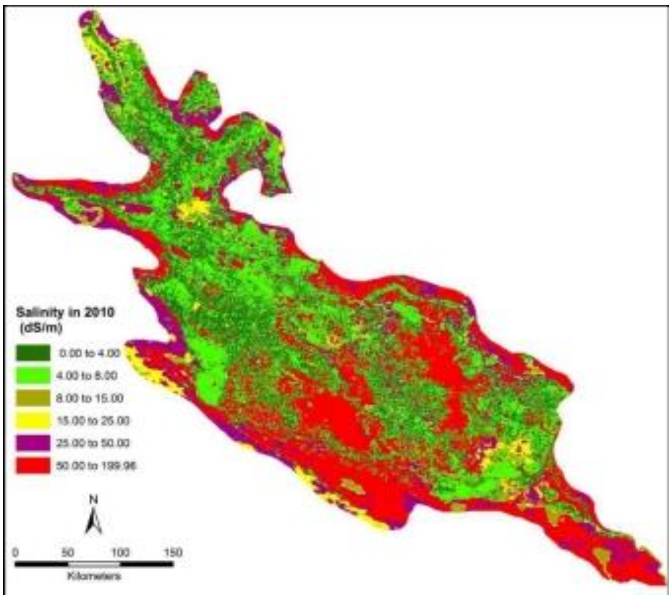

Figure 1: Salinity mapping in Mesopotamia according to 2010 (Al-Falahi and Qureshi, 2015).

An example of salinity distribution in reclaimed project is Great Musayab project, as shown in Figure 2, where the variation of salinity over the time is manifesting the fact that mismanagement of water and soil resources is an important factor of deterioration.

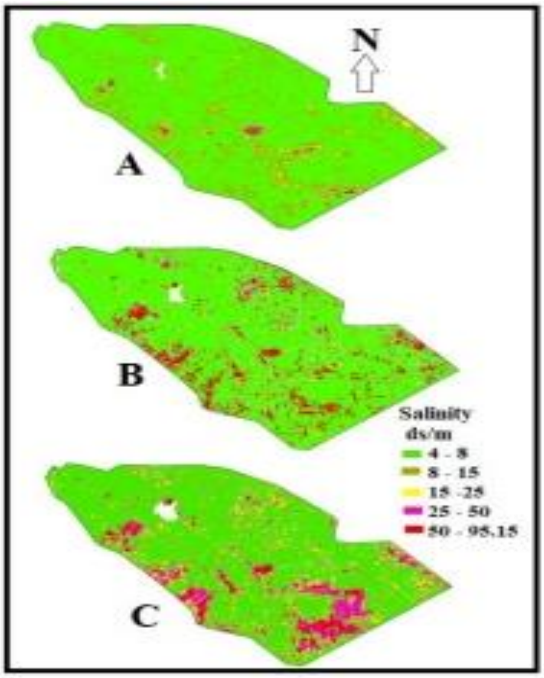

Figure 2: Multi temporal Salinity mapping in Great Musayab project (A-1990, B-2000,C- 2010). (Modified from Wu et al , 2015).

3. Main Outfall Drain (MOD)

MOD is the backbone of drainage system in the Mesopotamian plain. It starts form Ishaqi project and continuing to Shatt Al-Basra which is connected to the Arab Gulf. MOD's total length is 565km and it is draining estimated areas of 6 million donum completed up to 1992. After TAMS study another study by Sir M. McDonald was presented in 1963 treating also the drainage in Mesopotamia. By the early 1970s, Soviet companies were entrusted to carry out excavations of MOD. The first phase was excavated from 1973 until 1977; this is the middle sector whose length is 156 km. Following this Joint Venture of Phillip Hollzmann and Polensky were contracted to implement the southern sector, after adopting an alternative proposal to link MOD to Arab Gulf instead of Hammar Marsh. This phase was completed in 1986, Shatt Al- Basra was developed also for a distance of 44km. In 1984, Mendes Junior Contracting from Brazil began the construction of the siphon structure and pumping station for the Euphrates River crossing, but the company left the site in 1990 due the war on Kuwait and the following economic sanctions on Iraq, without completing the work in its final form. Meanwhile, during the period 1981-1983, Messrs Nedeco had already prepared a study on the Northern sector which was on joining the Ishaqi main drains to MOD. Finally, Iraqi contracting companies began implementing of the northern sector and enlarging the middle sector and completed their work in 1992.(Al-Simawi, 2011, Mohammed, 1986). Figure 3 shows the route of MOD.

Figure 3: Route of MOD (Lecollinet and Cattarossi, 2015).

The MOD is comprised of the following parts.

3.1 Northern Sector

It starts from the end Ishaqi project to Dalmaj Lake. This sector is 206km long and the discharge capacity is $98m^3/s$ at Dalmaj Lake site. Part of this sector is the remodeled Northern Musayab Drain. This sector serves important projects, which are: Ishaqi, Great Abu Ghraib, Great Musayab, Middle-Tigris, and HillaHashmiyah projects.

3.2 Middle Sector

This sector starts from north of Dalmaj Lake to the intersection with Euphrates River. The route within this section is 187km long and discharge is $200m^3/s$, it is functioning as a navigation route for river vessels. Lake Dalmaj, an ancient marsh is used as an evaporation basin for the collected drained water of Musayab project since 1956. The lake was surrounded by asphalt lined dykes to turn it to a reservoir having capacity of 200 million cubic meters and a surface area of $200km^2$. The role of Dalmaj Lake is to act as a balancing reservoir for navigation purpose within the course of MOD, and for fish culture. The following facilities are also located within this sector:

a. Cross regulator on MOD at km 330. It has four openings of dimensions (4×4)m each and a maximum discharge is of 100m^3/s. It is now in the final stages of implementation. This regulator controls the discharges entering Dalmaj Lake.
b. Outlet regulator, which is located at the beginning of the drainage canal that links Dalmaj Lake to MOD. This regulator has four openings of dimensions (3×3.5)m, it was completed in 1988.
c. Cross regulator on MOD in km 249. It has three openings with dimensions (3×3.5)m, and it is located upstream of the link canal that links MOD with Dalmaj Lake and its function is to control the discharge. It was completed it in 1990.
d. Emergency Escape, located at the km 172km, 11km upstream of the pumping station. This escape does the function of passing excess water to nearby marshes in case the pumping station stops. The escape consist of canal located on the left side of the MOD and it is provided with a head regulator having ten openings with dimensions of (2.5×4)m each and the discharge capacity is 200m^3/s.

This escape was completed in 2012. This sector drains the projects of Dalmaj, Gharraf, Hurriya-Daghara and the projects drained by East Euphrates Drain.

3.3 Southern Sector

This sector starts from the intersection of MOD with Euphrates River to Shatt Al-Basra. The length of this part is 172km and the discharge capacity 300m^3/s. As well, it is functioning as a navigation canal, which is connected to the middle sector by navigation locks that are not implemented yet, these planned navigation locks are located at the intersection of MOD with Euphrates River. This sector includes the following infrastructure:

a. MOD Pumping Station: the station is located upstream of the siphon structure, at km 161 km. It is one of the largest pumping stations in Middle East and North Africa (MENA) region and the largest pumping station in Iraq. The station lifts the MOD water to the inlet of the siphon. The implementation of the station was started in the 1990s, stopped due to the UN economic sanctions on Iraq after the occupation of Kuwait, restarted again in 2002 and it was inaugurated in 2008. The station has twelve pumping units, each is of 20m^3/s discharge capacity. Figure 4 shows a general view of MOD pumping station from the inside.
b. The siphon Structure at the intersection with the Euphrates River: This siphon has three conduits, two in service and one standby. The dimensions of each conduit are (4×5)m and the length of the siphon below the Euphrates River is 320m, and the discharge capacity is 200m^3/s. Figure 5 shows and aerial view of the intersection of Euphrates River and the MOD.

Figure 4: General view of MOD pumping station from the inside. (Ministry of Water Resources, 2020).

Figure 5: Aerial view of the intersection of Euphrates River and MOD. (Modified by Authors from Esri, 2020).

c. Shatt Al-Basra Regulator: This is the last structure in this system is which is located at km (0) of the MOD. The regulator has two sets of gates. The first group is five gates with dimensions of (4×4)m each, and the second group which is two flood gates with dimensions of (4×6)m each. The gates pass discharge of 500m^3/s. The regulator includes a fish ladder and a navigation lock with dimensions of (16.5×191)m. The structure was completed in 1973. (Al-Jabbari and Nawfal, 2001; Al-Simawi, 2010; Al-Simawi, 2011; AlSimawi, 2011; Al-Simawi, 2014; Mohammed, 1986).

4. Eastern Euphrates Drain

It is one of the main drains of the Euphrates lower basin , and it is partially implemented so far. After full development, the drain shall be 261km long with discharge capacity is 85m^3/s. It is connected with MOD at km 189. The project was started in 2001 and it is an ongoing project. Two main drains are connected with this drain, the Eastern Shamiya, which became part of Eastern Euphrates Drain and the Western Shamiya Drain. The Eastern Euphrates Drain is carried out until the border of Kifl-Shinafiyah project, but the connection with the drainage project has not been completed, where a siphon structure is required under Shamiya Branch to pass the waters of the Western Shamiya Drain. This Drain serves the projects of Hilla-Kifl, Hilla-Diwaniyah, Shatt Al-Diwaniyah, Rumaitha, Muthana, and Kifl-Shinafiyah. The importance of East Euphrates Drain is coming from the improvement of water quality of the Euphrates River after Shinafiyah. Figure 6 below is reveals how water quality downstream Shinafiyah had improved from April 2007 to October 2009 due to the connection of Najaf and Babylon governorates drains.(Al-Simawi, 2011).

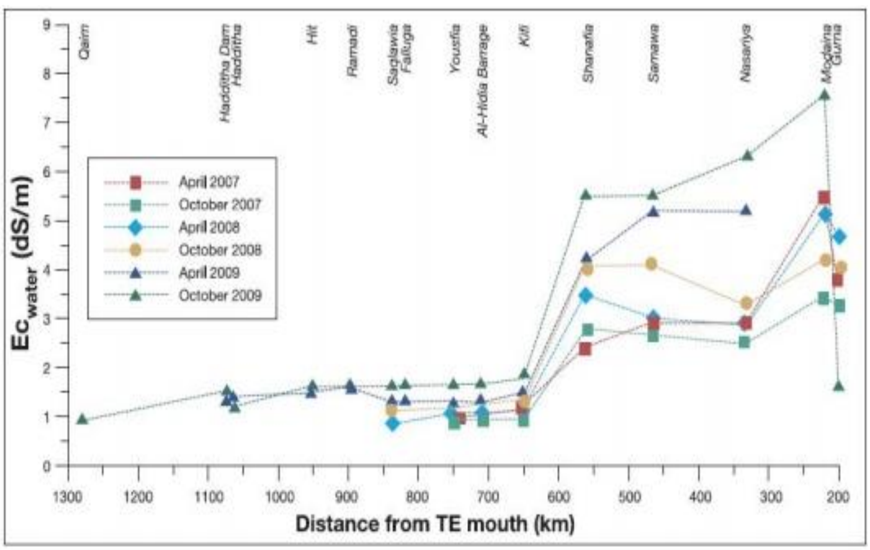

Figure 6: Water quality measurements along Euphrates River inside Iraq. (ICARDA, 2015).

5. Great Gharraf Drain

This is also called the Shatra Drain. It is 157km long and the discharge is $46m^3/s$. Great Gharraf Dain is draining projects of Middle-Tigris project in addition to Dalmaj and West Gharraf projects. Great Gharraf Drain is connected with MOD at the km 217. Moreover, the West Gharraf drain flows also in this drain (Al-Simawi, 2011).

6. Conclusion

Salinity in Mesopotamia is a chronic issue from old times until now. Several factors have contributed to this problem, namely; physiography, climatic conditions, mismanagement of water and soil resources, and the type of heavy clay common in this land. Most important factor, however, has been the impact of saline groundwater affecting the irrigated lands through capillary action and inducing the negative impacts of salinization on the soil. Farmers of Mesopotamia, since ancient history, have suffered of this and tried to avoid it by different ways. One method was to leave the land uncultivated every other year, allowing ground water table to drop, while a more drastic action was to switch to growing more salt tolerant plants, which was observed in Mesopotamia at the end of the Sumerian era, as they changed from growing wheat to barley. The only solution in Iraq nowadays, if intensive agriculture with cropping intensity of 120% or more is to be used as hoped, this does not depend on the construction of main and branch drains only but, goes further to a complete reclamation process. Such comprehensive action would include land levelling and installation of intensive networks of field drains, then leaching the salts from the land and modifying the soil structure and its fertility by using additives. Finally, and most importantly to have good and continuous management of this system. The large network of drains done so far, notably the Main Outfall Drain and the other drains already described in this paper may be considered as very large job, but this remains as only one small step in a long and costly process that can take many generation to complete. This must continue in the hope of maintaining reasonable level of food security for the fast-growing population of Iraq.

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