ENVIRONMENTAL IMPACT OF DRAINAGE PROJECTS (CASE STUDY MIT-KENANA PILOT AREA, EGYPT)

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ABSTRACT

The introduction of drainage system has conserved or improved millions of hectares of land for agriculture or other purposes. The benefits of drainage (i.e. the gain in land, better quality land, or the sustainability of irrigated land use) are associated with certain disadvantages. Sometimes, the gain in one location is associated with a loss in the same area. More commonly, however, improvement or gain in one place leads to a burden in another place. Examples are the environmental problems created by disposal of drainage effluent polluted with salts, nitrates, herbicides, pesticides, or harmful minor elements like selenium.

In the Nile Delta of Egypt at Mit Kenana Pilot Area an extensive study was carried out to determine the positive and negative impacts of the drainage projects. These effects could be physical, chemical, biological or hydrological. In this paper, focus will be mainly on the environmental side effects of agricultural land drainage mentioning the other aspects only occasionally. The positive and negative impacts of drainage are explained especially those related to soils, crops and health hazards. The results of this study indicated that, although the major benefits of drainage projects, it must be take into consideration its side effects especially which related to the hazards and the environment.

Keywords: Environmental Impacts, Side effect, Drainage burden, Bestside effects, Pollutions, Hazards.

1. INTRODUCTION AND GENERAL BACKGROUND

When we introduce a drainage system into an area, we are manipulating the environment. We can define the environment as the totality of ecosystems on different scales from local, to regional, to global. An ecosystem (or natural system) is a dynamic arrangement of plants and animals with their non-living surroundings of soil, air, water, nutrients, and energy. Successful development depends on the rational use of environmental resources and on minimising or eliminating any adverse environmental impacts by improving the planning, design, and implementation of projects. The Commission on Ecology and Development Co-operation (CEDC 1986) distinguishes three categories of environmental impacts: Disturbance and/or pollution of the environment; Depletion and/or over-exploitation of the natural resources and Destruction and/or impairment of the natural ecosystem. Disturbance: Drainage is, in principle, the regulation of the water-management system. Open drains are constructed, flows in natural streams are altered, and saline drainage effluent is discharged to rivers. All these activities have an effect on the environment. These effects are difficult to predict in full, but ecological studies may provide an insight into the main environmental consequences of the planned drainage systems. Depletion: It is often a gradual process, which in the beginning may not appear to be severe, but in the end can have major repercussions. Destruction: It is the most severe category of environmental impacts.

Side- Effects inside the Project Area

Loss of Wetland: Before drainage, the agricultural value of wetlands is generally very low. From an agricultural point of view, the loss of such poorly productive is easily compensated for by the greater land productivity resulting from drainage. On the other hand wetlands are usually of great value as wildlife habitats, flood-storage areas, groundwater-recharge areas, salutation basins, ecological filters, and ecological and recreational areas. The values of these functions are very difficult to estimate in monetary terms.

Change of the Habitat: Improving the drainage in land that is already used for crop production or grazing may appear environmentally less damaging than converting wetlands into crop land. But, in both humid and arid regions, improved drainage can still lead to a drastic change in habitat conditions. Consequently, plant and animal life can be considerably affected.

Lower Watertable: A direct effect of a drainage system is a lower average watertable. This systematic lowering of the watertable increases agricultural production, but can also has serious side-effects on the same agricultural production, and on nature conservation, forestry, and the landscape. One way to reduce these negative side-effects would be not to keep the drainage base at the same level throughout the year, but to accept higher levels in periods that are not critical for agriculture or periods with water shortages. Example, water levels in the open drainage systems in the Netherlands are generally allowed to be higher in summer than in winter.

Subsidence: The rate of oxidation is related to the depth of the watertable and the temperature: with a high watertable and a low temperature, the oxidation rate is low. Thus, to conserve a peat layer, a high watertable should be maintained. But a high watertable implies a low bearing capacity of the land. Peat soils are therefore unsuitable for arable crops, which require a relatively deep aerated layer and a good bearing capacity to allow the use of machinery, unless one accepts a high subsidence rate and can pay for the ever-increasing pumping costs to keep the watertable deep enough.

Salinization: To prevent Salinization, all these salts have to be removed by the drainage water. So drainage is the price one has to pay for sustainable agriculture in

irrigated lands. Sometimes, improved drainage can be an additional source of salts, as, for instance, when the lowered watertable induces saline seepage from outside area or when the drainage flow brings back into solution salts from the deeper soil layers. Both effects increase the salinity of the drainage effluent, which can have environmental effects both within the project area and downstream of it.
Acidification: Subsoil layers brought into contact with the air though drainage becomes oxidized, leading to the formation of sulphuric acid. By drainage, the acidification of the soil can be so pronounced, with PH values dropping to below 3, that plant and animal life are seriously affected. Acidification also has major negative impacts on the environment: Loss of habitat; Loss of amenity (landscape and recreational values); Changes in sedimentation and erosion; Change in water chemistry; and Diseases.

2. OBJECTIVES OF THIS RESEARCH

The objectives of this research work are studying the positive and negative impacts of the drainage projects in the area of the Nile Delta of Egypt. Also, the indirect effects to the environment were discussed take into considerations the physical, chemical, biological and /or hydrological effects to either positive or negative.

3. AREA OF STUDY

Mit Kenana Pilot area was established in 1992. It is situated 40 km, North West of Cairo with an area of 830 fed. It represents the problematic soils of the eastern fringes of the Nile Delta. It was divided into seven units with different types of the synthetic envelope materials. The soil of the area represents the transient stages between both soils of the desert and the Nile delta. The average hydraulic conductivity varied between 1.5 to 10.5 m/day. The drainage system consists of eight collectors and sixteen singular laterals. The lateral spacing calculated from the Hooghoudt formula. The lateral depth was taken as 1.0, 1.2 and 1.4 m.

Field investigations were carried out in the pilot area of the Delta area, Mit Kinana pilot area, as shown in Figure 1. The layout and the design of the pilot area are already made by the Drainage Research Institute of the National Water Research Center. This field is well controlled under the current farming conditions aiming to find out answers to questions dealing with the planning, design and implementation of the drainage projects in Egypt (Amer and Ridder, 1989). Measurements related to all parameters which affected to the drainage system over than ten years has been studied. The measured data was used in the analysis of the present thesis work. Disturbed and undisturbed soil samples were taken to determine the soil parameters such as salinity, physical, and chemical analysis.

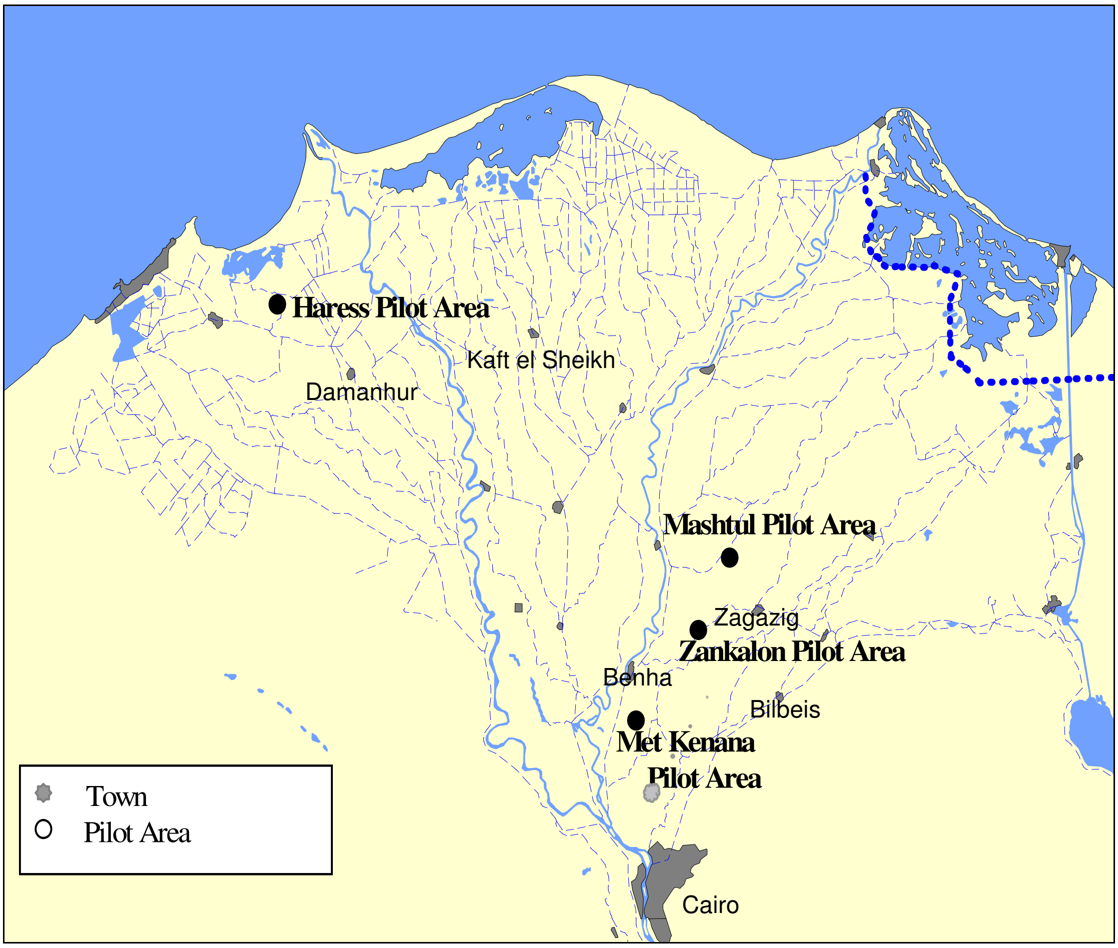

Figure 1. The location of the pilot areas under study

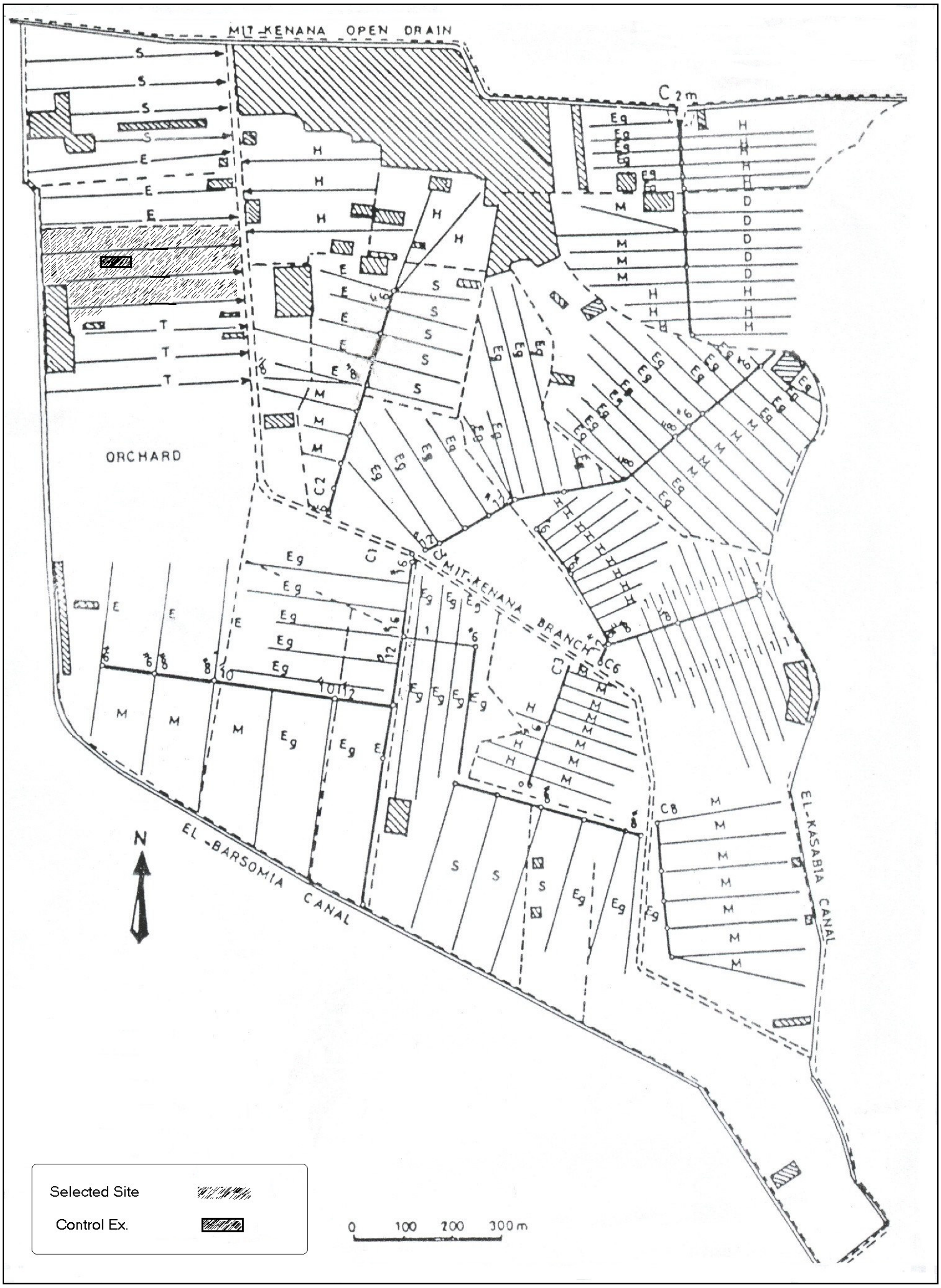

Figure 2 The layout of Mit Kenana Pilot Area

4. Environment impact of Mit Kenana pilot area

Nowadays, drainage project have a positive and negative effects, it is contributes to the degradation of the environment. These effects could be classified as follows: effects on hydrology of the area; effects on the quality of both surface and subsurface water; effects on the ecology of new land areas to be reclaimed; and effects on landscape. The overall impact is the result of all these effects. Therefore, it is very difficult to assess that in detail although several studies have been conducted in this direction.

The direct effects of installing a subsurface drainage system on hydrology of Mit Kenana Pilot area areas are:

- A reduction in the average amount of water stored in the soil. This will increase the moisture storage and prolong hydro-graphs of flow from the fields;
- Hydrological changes conditions, the hydraulic properties of the soil, and the physical characteristics of the drainage system;
- Land drainage result in a change in land use and capability. Reclamation of wet lands or highly affected saline lands result in change this land to crop land;
- Introduction of subsurface drainage will increase the agriculture area by not less than 15% as compared to surface drainage consequently mechanical agricultural operations are more facilitated;
- In terms of the ecology of the tile drained areas, weeds in the system are no longer a problem. However, the problem of weed control in the surface drainage system is still facing.

The direct effects trigger a serious of indirect effects. Climate, soil crop, agriculture practices, and the social, economic and environmental conditions determine these. Assessing the indirect effects is therefore much more difficult, but not less important than assessing the direct effects. The indirect effect, which can be physical, chemical, biological, and/or hydrological, can be either positive or negative one complex as:

- Positive effects owing to the discharge : removal of salts or other harmful substance from the soil, availability of drainage water for various purpose;
- Negative effects owing to the discharge: excessive leaching of valuable nutrients from the soil, associated with other salts or that result in polluted drainage water.

In the following, the environmental impacts associated with drainage discharge both positive and negative are briefly described.

4.1 Positive Impacts

4.1.1 Water Table Lowering

Subsurface drainage systems are designed primarily to control the watertable depth at a level which will allow optimum root development for crops, and prevent the capillary movement of salts into the root zone at levels which are harmful to the crops. The proper depth to be achieved by the drainage system is dependent on soil type, climate, crops, cropping intensity and water management (Dieleman et al., 1980). The interaction between depth and spacing is very significant and selection of a drain depth and spacing must satisfy the drainage requirements at the least possible cost (Abu-Zeid, 1992).

In Mit Kenana Pilot area at the long-term effects, one of the most frequent problems of irrigation schemes is the rise in the local watertable (waterlogging). With irrigation efficiencies commonly less than 50%, the groundwater level rise can be spectacularly fast where the water table has a law hydraulic gradient. The critical water-table depth is between 0.80 and 1.50 m depending on the types of crop, soil characteristics and the potential evapotranspiration rate. The watertable rising under capillary action will evaporate, leaving salts in the soil. The problems are of particular concern with major salinity problems. A high water table also makes the soil difficult for agricultural mechanisation and workability. Lowering the water table the provision of drainage to irrigation schemes with high water tables brings benefits to agriculture and improving soil conditions. An increase in the salinity of the groundwater is often associated with waterlogging. An appropriate and well-maintained drainage net work will mitigate against such effects. Before installation of subsurface drainage for the area, the average water table is equal to 0.3 m from the ground surface and in the lower parts, it is found at the surface. After drainage, the watertable depth is fluctuating between 0.80 to 1.40 m from the soil surface and also there is no surface water problems happen in the lower part area.

4.1.2 Salinization

In irrigated agricultural areas, likes Mit Kenana Pilot area, irrigation itself is the main source of salts. Even if the irrigation water is of good quality, it still brings in large amounts of salts to the soil. It can also cause secondary salinization through the capillary rise of groundwater. To prevent Salinization, all these salts have to be removed by the drainage systems. So drainage is the key for sustainable agriculture in irrigated lands. Agriculture in that area depends almost entirely on irrigation from the River Nile. Although the irrigation water is of good quality (0.35 ds/m), it brings salts into the soils at a rate of 8 ton/ha/year. To guarantee sustainable land use, this amount of salts has to be leached from soil each year by the means of subsurface drainage.

To assess the soil salinity of the Mit Kenana area, soil samples were taken at the different depths and different locations. It was analyzed in the DRI-laboratory (DRI, 1990, 1992). It was clear that, before drainage, the soil is moderate alkaline where the value of the pH from 7.1 to 8.4 and the salinity is 4.7 dS/m, and in some locations the salinity reached to 15 and 30 dS/m. After drainage by ten years ago, the salts was decreased from the surface layer and moved to the sub-layer as results of leaching by the irrigation process. The values of the pH not changed by big values but in the other way the values of the Sodium Adsorptions Ratio (SAR) reaches to 7.49 at 1.00m depth and the concentration of the sodium, calcium and Magnesium salt decreased by nearly 60% (Kenawey, 2003). This means that, the drainage system has positive effects for removal the salts away to the root-zone of the plants but in the other way it has a negative effect as a result of the movement of the salts at the sub-soil.

4.1.3 Productivity

Drainage projects contribute substantially to the country's balance of payments position through: Increasing the annual export of cotton and rice and annual savings in import of maize and wheat. In Mit Kenana Pilot area, the production levels of the major crops (berseem, wheat, rice and maize) were assessed on the basis of crop cutting made on the plots of the interviewed farmers. The crop cuttings were made according to the standard procedures laid down in the DRI manual for assessment of crop production. In the selection plots of the area, which represents all of the area, the production levels showed major variation after and before drainage.

The observation of productivity for Mit Kenana pilot area was started before drainage and continued to 10 years after drainage. Although the crop yield has generally increased after drainage, the amount of increase was not the same for each crop. This is due to the different tolerance levels of crops to salinity and excessive moisture. It can also be attributed to other agricultural inputs. Under the specific conditions of the area, wheat and rice had apparently the highest increase in yield; it is equal to 45% before and after drainage as presented in Table 1. The high increase in the yield monitored after drainage cannot be attributed all to drainage. A part of this increase should be related to other factors which affected the yield function although drainage remains responsible for a greet part of this increase. It is also clear that yield changes significantly from one year to another for the same reason. Berseem and maize had an increase in yield also; it is equal to 31, 34% before and after drainage for the same reasons.

Table 1 Productivity of crops before and after drainage

Crop	Before drainage 1990	After drainage 2001	Percentage (%)
Long Berseem	25.1	32.9	31
Wheat	2.15	3.12	45
Maize	2.30	3.09	34
Rice	2.20	3.23	45

4.2 Negative Impacts

The quality of the return flow, with or without irrigation, has become increasingly important in recent years. In the appraisal of drainage projects, questions have to be asked about the chemical composition of water that comes out of farm drains and flows into drainage channels, rivers and lakes. It is known today that the design and operation of drainage water management system can have an impact on the amounts of chemicals leaving an agricultural field. But the evaluation of the hazards associated with non-point pollutants is still very difficult due to the complexity of interdependent watershed factors which respond dynamically to many elements, especially since it is hardly foreseeable what will happen within the corresponding agricultural area in the field of water, soil and chemical management.

Sometimes, waste generated domestically or industrially in villages or towns finds its way to the open drains. Therefore, the drainage water in certain locations is highly polluted. Simple tests such as Biochemical Oxygen Demand, Chemical Oxygen Demand and some microbiological examinations have been done to ascertain the types of pollutants and their degree in water. Traditionally, the Coliform group of bacteria has been the principal indicator of the sanitary quality of water. It is convenient to express the results at the examinations in terms of the most probable number (MPN). If MPN exceeds 10x103/100ml in the water sample, this means that the water is polluted (Amer and Ridder, 1989).

5. ENVIRONMENTAL PROBLEMS OF OPEN DRAINS

Salinity

The drainage water salinity of Mit Kenana open drains and its branches is high and ranges between 1000 - 2000 ppm. This rise in drainage water salinity could be caused by one or more of the following sources: the salt originating from seepage of saline groundwater, particularly in those parts of low level; the salt originating from desalinization of soils through subsurface drainage and the salt accumulated in the soil cultivated with field crops, during periods of high demand for water. These salts leach into the drains during the period of low water demand. The composition of the soil solution and, consequently, drainage water varies to a great extent from place to place and from time to time as a result of changes in soil salinity, temperature and the preferential solubility of different salts at different temperatures.

During the winter months, the predominant anion in the drainage water in this part is bicarbonate, while the high temperature during summer season increases the solubility of SO_4 making this the dominant anion. In summer, the prevalent cation in the drainage water in this part in the Delta was sodium which is the dominant cation in the soil also. The salt content of the soil greatly modifies the composition of the drainage water. Since natural salts present in soil and irrigation water have different solubilises, some of them ($Ca\ Co_3$, Mg, Co_3 and $Ca\ So_4$) may precipitate in the soil as the concentration increases. The more soluble salts, such as Na Cl and $Na_2\ So_4$ will remain in soil solution and move towards the drains.

It is clear that when irrigation water enters the soil it becomes more concentrated without change in relative composition, i.e. the soluble sodium percentage does not change. The SAR value, however, increases proportionally to the square root of the total concentration. Thus, if the total concentration is doubled, the SAR value will be increased by a factor of 1.41; if the concentration is quadrupled, the SAR value will be doubled (Oster, 1979).

Nutrients

Recent figures of the application of nitrogen, phosphate and potassium fertilisers in Egyptian agriculture show an increase of nearly 4-fold during the 1960 - 1988 period. Phosphorus levels found in many drains range from 0.05 mg/l as Po2 and nitrogen levels of 0.8 to about 6.0 mg/l as NO_3. Concentrations appear to be significantly high reflecting increased use of fertilisers and more irrigated lands.

Pesticides and herbicides

One of the direct effects of drainage is that it introduces a discharge through the drainage system. Water can act a vehicle for all kinds of soluble elements that are stored in the soil. These elements are nutrients; herbicides, pesticide, organic matter, salts and toxic trace elements which could be leached from the soil and it are polluting the drainage effluent. Sometimes this is done intentionally, but it is often an unintended side-effect. The effect these elements have on the environment depends, among other things, on climatological conditions, on agricultural practices, and on the type of soil. Sometimes, the effect could be positive, the losses of nutrients reduced, sometimes negative, fertilizer applications was excessive.

6. HEALTH IMPACT OF THE DRAINAGE SYSTEM

The existence of the network of canals and drains has affected the social and health environment in Egypt in many ways, both positively and negatively. The state of health of the Egyptians has always changed from one area to another and from one part of the country to another. Water related diseases are classified as follows:

- Diseases prevented by washing and bathing (e.g. skin and eye diseases and diarrhoea diseases);
- Diseases prevented by clean water supply and sanitation (e.g. typhoid, cholera, and hookworm);
- Diseases acquired by water contact (e.g. schistosomiasis or bilharzia);
- Diseases acquired from bites by water related insects (e.g. malaria, yellow fever and river blindness).

Most Egyptian villages, especially Mit Kenana area, have either wastewater collection or treatment systems. On site disposal of the domestic wastewater through a leaching pit is the most common practice. The generated wastewater commonly exceeds the capacity of the onsite disposal facilities. As a result many villages are chronically flooded with sewage effluent, contaminating drainage water as well as ground water.

Results of recent programs indicate the widespread of the first two listed diseases. The last two diseases listed are often called vector-borne diseases. Agriculture development projects, and especially irrigation projects, can have a negative impact on human health if they increase the size and number of vector habitats.

Schistosomiasis, a water borne disease, has always threatened Egypt, due to the contact between people and polluted water since the paranoiac times. In 1900, before building the first Aswan Dam, the rate of infection from both the irrigation and drainage system of schistosomiasis, bilharzia, was reported to be 6% in Egypt. After three years from the project, the rate increased to 60%. After High Aswan Dam, this rate has not increased due to programs of environmental health control (Amer and Ridder, 1989). However, it has been observed that there is a shift in the dominant type of schistosomiasis from S. Haematobium to S. Mansoni. The change in water quality after the High Aswan Dam has inhabited the spread in the snail of the Haematobium (urinary) and favored the growth of the Mansoni (digestive system) snail. Drainage can help to control vector - borne diseases by eliminating or reducing open water bodies that vectors lived or breed in.

6. CONCLUSIONS

The impact of drainage system and drainage projects on the environment is presented. Focus is directed towards the effects of providing drainage to agricultural lands. The introduction of drainage systems (open and tile drainage) has direct and indirect effects. These indirect effects which can be physical, chemical, biological and hydrological can be positive or negative are complex such as:

- Positive owing to the removal of salts from soils and availability of drainage water to other uses, negative effects owing to the discharge: excessive leaching of valuable nutrients from the soil, pollution of drainage water, and other health hazards. These are explained in detail.
- Most of agriculture drains carry municipal, domestic wastes, industrial wastewater. There is a problem of disposing drainage water to the Nile. An action plan was made to minimise this disposal problem. Re-use of drainage water of 7 million m^3/year is planned up to year 2000. However, the program of using this water is under revision. Two main projects of the reuse of drainage water are under implementation. Those are El-Salam canals to irrigate an area of 600,000 fed. And El-Omum drains. Several ministries are connected to water quality problems in Egypt. The MPWWR is the main regulatory agency and has the responsibility of issuing discharge permits for municipalities, industries and other installations to the drainage and irrigation systems.
- Several legislation's pertinent to water pollution control have been passed in Egypt, pressuring water quality of all receiving water bodies and charges the MPWWR with responsibility of enforcing the law along with the MOI.
- The environmental impact assessment procedures are outlined to a new big project that is El-Salam canal project. Both positive and negative impacts are identified where recommended policy steps be given.

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