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# ROLE OF MICROPOLLUTANTS IN EVALUATION OF DRAINAGE WATERS IN EGYPT

The aim of this work is to study the quality and the amount of drainage waters in different places in Egypt in order to evaluate these waters as a source for irrigation purpose. The effect of seasonal variation on the quality was also considered. In addition, the level of heavy metals in drainage waters was included. The evaluation of the water quality is carried out according to its physical and chemical characteristics. Results obtained showed that about 30–45% of the irrigation waters are discharged as drainage water. In terms of physical and chemical characteristics, it was found that these waters exhibited higher values than Nile water. Level of heavy metals in drainage waters was slightly higher than that of Nile water. This increase related the discharge of municipal and industrial wastewaters to the drainage pathway. The overall evaluation revealed that these drainage waters can be reused for irrigation purpose with most crops on light and medium textured soils without causing any hazardous effect to either soil or crops.

## 1. INTRODUCTION

There is observed a widespread public concern over the lack of food in the third world. Solutions to this problem include efficient water reuse, extension of irrigation and use of wastewater for crop production [1]–[3]. Recently Egypt is faced with serious threat, because crop production should be intensified to meet the ever growing population demands. Expansion of the cultivated land in Egypt is the only solution. In addition, agricultural land in Egypt represents only some 4% of the total land area, therefore up-to-date large-scale plans call for an increase of about 3–4 million of additional feddans*** by the year 2000. Any increase in cultivation can be achieved only by enough good quality of water sources. The Nile provides one principal, but insufficient, source of water of good quality for irrigation [4], [5].

At the same time, about 60 million $m^3$ of drainage waters are discharged every year. The quality of the waters varies greatly from one site to another. However, it is the nature of the water to be saline. For instance, the level of soluble salts in drainage water in Cairo

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***Feddan is an Egyptian unit of area equal to 1.038 acres.

reaches its maximum during spring time, namely in March, April and May [6], whereas in Aswan, this maximum is usually reached later, i.e. in May, June and July [7].

The aim of this work is to investigate the quality of the drainage waters and their amount in different places in Egypt. The effect of seasonal variations on their quality is also considered.

In addition, the level of heavy metals in the drainage waters is included. Furthermore, evaluation of these waters was carried out according to their physical and chemical characteristics.

## 2. MATERIALS AND METHODS

Approximately 50,000 of feddans were selected in El-Mansoura, El-Beheira and El-Menya provinces. The areas were defined in order to obtain a close system allowing observation of irrigation inputs and drainage outputs. Both El-Mansoura and El-Menya provinces represent the old fertile soil in Egypt. Tile drainage system was recently installed in El-Mansoura area. Drainage waters are finally collected in a main channel called Om Salama drain. El-Beheira area represents the reclaimed sandy soils served by open drainage system, namely Sid-Eisa drain. El-Menya province is served by an open drainage system called Kab-Kab drain.

An extensive sampling programme has been designed to collect 5 $dm^3$ of drainage water and Nile water every month for a period of one year. These samples were collected carefully to avoid any deterioration or contamination according to method used by RAINWATER and THATCHER [8]. The physical and chemical characteristics of these samples were investigated monthly. The levels of metals in acidified samples were also determined spectrophotometrically using atomic absorption PYE Unocam SP 9. Soluble boron was determined colorimetrically using curcumin [9].

## 3. RESULTS AND DISCUSSION

The drainage water balance throughout one year at three provinces is given in table 1. These waters represent about the third of the total input water used for irrigation purposes in Egypt. About 30–45% of this irrigation waters are discharged as drainage water, which rises the question as to the quality of this water: can it be reused or not, to what extent is it contaminated?

Therefore it seemed essential to investigate the physical and chemical characteristics of both drainage water and Nile water. The results obtained are given in table 2. From these results it can be seen that in all drainage waters studied, most of the parameters investigated had higher values than those characterizing the Nile water. However, in drainage waters there were slight variations in pH, hardness, silica and phosphate in comparison with Nile water. On the other hand, there was observed a remarkable increase in electric conductivity, alkalinity, chlorides, sulfates, total organic nitrogen, nitrates, sodium, potassium and boron in drainage water in comparison to Nile water.

The overall results (table 2) show that drainage waters of El-Mansoura area are char-

acterized by higher values of the studied parameters than the other two areas, namely El-Beheira and El-Menya. On the contrary, the level of boron in El-Beheira area is significantly higher than these of El-Mansoura and El-Menya. It is worth noting that the drainage waters are characterized by remarkably high alkalinity values in comparison to Nile water. This alkalinity is a result of washing out the calcium and sodium content of the soil. This statement is in a good agreement with these of AYERS and WESTCOT [10] as well as HAMDY, ABDEL-RASHID and SAID [5].

Table 1

Drainage water balance in one-year period (from May 1987 to May 1988) as million cubic meters in El-Mansoura, El-Beheira and El-Menya provinces

| Drainage water | Water input* ($10^6$ $m^3$) | Water output** ($10^6$ $m^3$) | Amounts of excess water *** (%) |
|---|---|---|---|
| El-Mansoura | | | |
| maximum | 24.35 | 12.43 | 51.04 |
| minimum | 9.65 | 3.95 | 40.93 |
| average | 15.07 | 5.96 | 39.55 |
| El-Beheira | | | |
| maximum | 9.50 | 2.80 | 29.47 |
| minimum | 3.10 | 1.10 | 35.48 |
| average | 6.41 | 2.10 | 32.76 |
| El-Menya | | | |
| maximum | 34.00 | 15.96 | 46.76 |
| minimum | 11.16 | 6.69 | 59.95 |
| average | 27.15 | 12.08 | 44.44 |

*Amount of water used for irrigation purposes.

**Amount of drainage waters.

***(output water: input water)·100.

Further examinations were carried out to investigate the level of metals in both drainage water and Nile water. The results obtained are given in table 3. They prove that the level of metals in the drainage waters studied is slightly higher than that in Nile water. This increase may be due to the discharge of municipal and industrial wastewaters to the drainage pathway. Soluble metals from the agricultural soil as well as particulates are additional sources of these metals in drainage waters [6], [11]. In addition, the levels of metals determined are also in good agreement with these reported by other investigators [6], [12], [13].

Table 2

Physical and chemical characteristics of both Nile and drainage waters

| Type of water | Temp. (°C) | pH | Turb. NTU | EC ($\mu\Omega^{-1}cm^{-1}$) | Alk. ph. ($CaCO_3$) | T. alk. ($CaCO_3$) | T. hard. ($CaCO_3$) | Ca hard. ($CaCO_3$) | Mg hard. ($CaCO_3$) | Chlorides | Sulphates |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ($mg/dm^3$) | | | | | | |
| Nile water | | | | | | | | | | | |
| maximum | 29 | 8.7 | 35 | 501 | 8 | 146 | 163 | 92 | 71 | 30 | 21 |
| minimum | 12 | 7.6 | 10 | 288 | nil | 112 | 75 | 47 | 28 | 14 | 14 |
| average | 19 | 8.2 | 20 | 348 | nil | 121 | 128 | 78 | 50 | 22 | 18 |
| El-Mansoura | | | | | | | | | | | |
| maximum | 30 | 9.1 | 49 | 1295 | 192 | 243 | 272 | 163 | 109 | 76 | 63 |
| minimum | 12 | 7.9 | 30 | 648 | 22 | 128 | 135 | 81 | 54 | 26 | 30 |
| average | 20 | 8.2 | 38 | 973 | 106 | 190 | 171 | 99 | 72 | 48 | 36 |
| El-Beheira | | | | | | | | | | | |
| maximum | 29 | 8.6 | 46 | 981 | 144 | 210 | 202 | 110 | 92 | 44 | 37 |
| minimum | 11 | 7.8 | 29 | 724 | 21 | 127 | 133 | 80 | 53 | 25 | 28 |
| average | 19 | 8.0 | 35 | 841 | 72 | 176 | 139 | 84 | 55 | 29 | 34 |
| El-Menya | | | | | | | | | | | |
| maximum | 35 | 8.5 | 48 | 563 | 133 | 200 | 182 | 96 | 86 | 32 | 35 |
| minimum | 10 | 7.4 | 31 | 424 | 16 | 124 | 130 | 79 | 51 | 23 | 19 |
| average | 22 | 7.7 | 38 | 521 | 58 | 165 | 137 | 82 | 55 | 28 | 32 |

Turb. – turbinity, T. – total.

| Type of water | Amm. | TON | Nitrite | Nitrate | D. silica | TP | Orth. P | DP | Na | K | B | SAR | Adj. SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/dm$^3$) | | | | | | | | | | | (meq./dm$^3$) | |
| Nile water | | | | | | | | | | | | | |
| maximum | nil | 2.544 | 0.031 | 0.178 | 10.3 | 295 | 167 | 95 | 127 | 4.6 | 0.9 | 1.7 | 4.2 |
| minimum | nil | 0.899 | nil | 0.029 | 4.8 | 63 | 22 | 25 | 53 | 2.1 | 0.3 | 1.4 | 3.4 |
| average | nil | 1.582 | 0.004 | 0.070 | 7.1 | 158 | 73 | 67 | 81 | 3.3 | 0.5 | 1.6 | 3.9 |
| El-Mansoura | | | | | | | | | | | | | |
| maximum | 0.062 | 4.10 | 0.160 | 2.00 | 20.7 | 526 | 436 | 310 | 319 | 17.1 | 1.6 | 4.7 | 10.5 |
| minimum | nil | 1.82 | 0.039 | 1.12 | 9.3 | 212 | 139 | 140 | 87 | 3.9 | 1.0 | 1.8 | 4.4 |
| average | 0.031 | 3.06 | 0.080 | 1.43 | 11.0 | 320 | 297 | 220 | 164 | 6.1 | 1.4 | 2.5 | 6.1 |
| El-Beheira | | | | | | | | | | | | | |
| maximum | 0.054 | 4.67 | 0.152 | 1.48 | 17.3 | 433 | 280 | 211 | 162 | 8.3 | 2.6 | 2.8 | 6.8 |
| minimum | nil | 0.93 | 0.028 | 0.83 | 7.5 | 190 | 119 | 112 | 87 | 3.6 | 1.7 | 1.8 | 4.4 |
| average | 0.028 | 2.44 | 0.076 | 0.91 | 10.8 | 284 | 209 | 196 | 96 | 5.0 | 2.1 | 2.0 | 4.9 |
| El-Menya | | | | | | | | | | | | | |
| maximum | 0.064 | 3.62 | 0.141 | 2.25 | 15.9 | 298 | 198 | 188 | 101 | 7.2 | 2.2 | 2.0 | 4.9 |
| minimum | nil | 0.94 | 0.020 | 0.73 | 6.8 | 106 | 97 | 69 | 83 | 3.3 | 1.4 | 1.8 | 4.4 |
| average | 0.032 | 2.59 | 0.053 | 1.48 | 9.6 | 265 | 116 | 150 | 96 | 4.7 | 1.7 | 1.9 | 4.6 |

Amm.– ammonia, TON – total organic nitrogen, TP – total phosphate (as P), D – dissolved.

It is worth evaluating these drainage waters as a source for irrigation purpose. For this reason, number of criteria have been established to classify the quality of water that is used for irrigation [10], [14]. These criteria vary from general to detailed classifications according to the particular crop of region for which the water is used. However, most water quality classifications have been developed for an arid climate. According to DARGAN [15], the most important parameters, that are used to evaluate the quality of irrigation water, are as follows: electrical conductivity (EC), sodium absorption ratio (SAR), residual sodium carbonate (RSC) and the level of some micronutrients and heavy metals, such as boron, zinc, copper, cadmium and lead. These parameters reflect the possible effect of water on the soil properties and plant growth. AYERS and WESTCOT [10] suggested that the quality of water can be assessed more precisely on the basis of "adjusted SAR" instead of SAR and RSC as the former accounts for the integrated effect of the latter. Taking into account this suggestion, GUPTA [14] classified irrigation waters under five heads on the basis of their alkalinity (A) or sodic hazard boron content (B) and conductivity (C) or salinity hazard. This ABC classification includes five categories for each water quality parameters (see table 3).

Table 3

ABC classification

| Adjusted SAR (A) | | Boron (B) | | EC (C) | |
|---|---|---|---|---|---|
| Class | Range ($meq./dm^3$) | Class | Range ($mg/dm^3$) | Class | Range ($\mu\Omega^{-1}\,cm^{-1}\cdot 10^3$) |
| $A_1$ | <10 | $B_1$ | <3 | $C_1$ | <1.5 |
| $A_2$ | 10–20 | $B_2$ | 3–4 | $C_2$ | 1.5–3 |
| $A_3$ | 20–30 | $B_3$ | 4–5 | $C_3$ | 3–5 |
| $A_4$ | 30–40 | $B_4$ | 5–10 | $C_4$ | 5–10 |
| $A_5$ | 40 | $B_5$ | 10 | $C_5$ | 10 |

According to this classification and the available data (table 2), the drainage waters studied belong to group $C_1$ if EC is taken into account. Such a kind of water can be used for irrigation of most soils with most of crops and there exists a slight possibility of problems [10], [14], [16], [17].

In terms of adjusted SAR, the drainage waters studied can be classified to group $A_1$ since their range is less than 10 $meq/dm^3$, whereas the maximum adjusted SAR value for El- Mansoura is higher than 10 $meq/dm^3$. According to the ABC classification [14], these waters are put into category $A_2$. The water of this category can be used for irrigation of light and medium textured soils without any problem and heavy textured soils if well drained [10], [14], [16]. However, irrigation using such a water may cause some problems in the case of deep black soils or alluvial soils with clay content higher than 30% [14].

Table 4

Levels of metals ($\mu g/dm^3$) in both Nile and drainage waters

| Type of water | Cd | Co | Cr | Cu | Ni | Pb | Hg | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|
| Nile water | | | | | | | | | | |
| maximum | 1.01 | 8.91 | 5.63 | 6.49 | 7.05 | 4.89 | 0.99 | 15.17 | 97.38 | 21.73 |
| minimum | 0.04 | 2.12 | 0.11 | 0.83 | 1.13 | 0.09 | 0.02 | 1.85 | 38.14 | 9.05 |
| average | 0.51 | 5.01 | 2.95 | 4.07 | 3.92 | 3.16 | 0.31 | 10.46 | 69.51 | 12.44 |
| El-Mansoura | | | | | | | | | | |
| maximum | 1.28 | 11.27 | 9.14 | 29.78 | 9.56 | 5.69 | 1.48 | 67.99 | 320.82 | 174.16 |
| minimum | 0.57 | 6.89 | 3.25 | 10.92 | 4.65 | 3.79 | 0.26 | 18.31 | 77.53 | 37.32 |
| average | 0.81 | 8.14 | 4.13 | 20.81 | 5.65 | 4.43 | 1.86 | 36.61 | 213.88 | 149.28 |
| El-Beheira | | | | | | | | | | |
| maximum | 0.85 | 8.17 | 6.79 | 28.74 | 7.11 | 5.06 | 1.74 | 49.69 | 232.59 | 130.62 |
| minimum | 0.60 | 6.26 | 3.28 | 9.72 | 4.42 | 3.16 | 0.39 | 18.31 | 88.22 | 49.81 |
| average | 0.64 | 6.89 | 4.01 | 19.36 | 5.39 | 3.76 | 1.55 | 31.38 | 184.47 | 124.43 |
| El-Menya | | | | | | | | | | |
| maximum | 0.68 | 6.99 | 4.98 | 10.47 | 5.15 | 4.66 | 1.06 | 20.92 | 85.57 | 48.91 |
| minimum | 0.52 | 5.64 | 2.54 | 5.07 | 4.17 | 3.48 | 0.31 | 13.08 | 69.51 | 12.44 |
| average | 0.61 | 6.26 | 3.85 | 6.14 | 4.83 | 3.68 | 0.52 | 15.69 | 77.53 | 43.52 |

The level of boron in all samples studied was below 1.4 mg/dm$^3$. According to GUPTA [14], these waters can be used for most of tolerant and semi-tolerant crops on all soils without any harmful effect on crop yields [10], [14].

Careful examination of the levels of metals in the drainage waters studied (table 4) reveals that they are lower than the maximum permissible limits recommended for irrigation water in 1972 [16]. Therefore, these drainage waters can be used for irrigation purposes on all soils without any hazardous effect.

From the overall evaluation of the drainage waters studied, it can be concluded that EC, SAR and adjusted SAR values of El-Mansoura drainage waters exhibit a slight increase in comparison to those of El-Beheira and El-Menya areas. However, El-Mansoura water still indicates the suitability of reusing. Therefore it is essential to stress here that all drainage waters studied can be reused for irrigating light and medium textured soils with most of the crops, without damaging either soil or crops.

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## ZNACZENIE MIKROZANIECZYSZCZEŃ W OCENIE JAKOŚCI WÓD DRENAŻOWYCH W EGIPCIE

Celem pracy jest ocena jakości i ilości wód drenażowych w różnych obszarach Egiptu ze względu na ich przydatność do nawadniania. W badaniach uwzględniono sezonowe zmiany jakości wód oraz poziom metali ciężkich. Jakość wód oceniano na podstawie ich fizycznej i chemicznej charakterystyki. Stwierdzono, że 30–40% wód nawadniających jest odprowadzanych jako wody drenażowe. Wykazano, że parametry fizyczne i chemiczne tych wód są gorsze niż parametry wody z Nilu. Poziom metali ciężkich w wodach drenażowych był nieznacznie wyższy niż w wodzie z Nilu, co było wynikiem odprowadzania ścieków miejskich i przemysłowych do ciągów drenażowych. Na podstawie ogólnej oceny jakości wód drenażowych można stwierdzić, że nie powodując szkodliwych skutków można nimi nawadniać większość upraw.

## ЗНАЧЕНИЕ МИКРОЗАГРЯЗНЕНИЙ В ОЦЕНКЕ КАЧЕСТВА ДРЕНАЖНЫХ ВОД В ЕГИПЕТЕ

Целью настоящей работы является оценка качества и количества дренажных вод в разных районах Египета из-за их пригодности для орошения. В исследованиях учтены сезонные изменения качества вод, а также уровень тяжелых металлов. Качество вод было оценено на основе их физической и химической характеристик. Было установлено, что 30–45% орошающих вод отводится как дренажные воды. Было обнаружено, что физические и химические параметры этих вод хуже параметров вод из Нила. Уровень тяжелых металлов в дренажных водах был незначительно выше, чем в воде из Нила, что было результатом отвода городских и промышленных сточных вод к дренажным тягам. На основе общей оценки качества дренажных вод можно принять, что не вызывая вредных последствий можно ими орошать большинство культур.