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Evaluation of quality of some water sources and their suitability for irrigation

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Abstract

The investigation aims at evaluating the quality of some waste water and their suitability for irrigation. Samples of agricultural drainage water, domestic waste-water and mixed water were taken from Moshtohor agricultural drain, Moshtohor station of sewage water treatment Qalyobiya drain. Tap water of EC **0.65 dSm^{-1}** considered suitable for irrigation. Waste-waters and the agricultural drainage waters of EC 0.98 to 1.42 dS m^{-1} were unsuitable for irrigation. The SAR ranged from **0.36 to 0.96** and the RSC ranged from **-1.0 to -3.4,** and the waters can be classified as of low soluble. According to the classification of **Ayers and Westcot (1987**), water having EC of < o.75 dS m^{-1}hasnosalinity problems. Agricultural drainage water was of no problems regarding Cl content. Increasing problems would be expected due to the use of the wastewaters for irrigation if the overhead sprinkler irrigation system is used since their contents of HCO_3^- ions exceed **1.5 mmolcL^{-1}.**Both of domestic and the mixed waste-waters contained Fe, Zn, Mn, Co, Ni and Pb in a concentration exceeding the permissible limits except for Coin the mixed waste-water.

Keywords: Waste-water, agricultural drainage water, water quality for irrigation, heavy metals

Introduction

Irrigation water quality concerns the suitability of its use for irrigation purposes. Good quality water has the potential to maximize crop yield under efficient soil and water management. Poor quality water causes soil and crop problems unless special management are adopted to counteract these problems. Capability problems, resulting from using poor quality water, vary according to the kind and the degree of hazards caused by the use of such water **(Shamsad and Islam 2005).**

The major source of water comes mainly from the Nile. However, it is not sufficient for some old cultivated lands, which suffer from water shortage**(Rizk 2010).**Egypt in its efforts to increase the agricultural production is intensifying farming input in the old Valley and Delta lands and is also expanding the cultivated area outside them in the newly reclaimed desert lands.

The rapid population growth in Egypt continues to place increased demands on limited fresh water supply. Population increase has not only increased the fresh water demand but also increased the volume of wastewaters. Treating or recycling waste water is a water resource which increases with time. Utilizing wastewaters for irrigation adds appreciable amounts of heavy metals to soils. Sewage water and industrial wastewater may contain such elements in high levels. Some of these elements serve as nutrient. **Abdel-Hai, (2015)** reported that irrigation of coarse-textured soils with such waters may supply the soil with nutrient and improves their chemical and physical properties.

Due to the increasing population, huge volume of domestic wastewater is being produced in cities and disposal of such water would cause pollution of soil and groundwater. Cost of treatment of sewage water for recycling is high, although such wastewater could be used to irrigate plants not used for feeding.

The reuse of wastewater for agricultural irrigation purposes reduces the amount of water needed from water resources (**USEPA, 1992 and Gregory, 2000**). It is the potential solution to reduce the freshwater demand for zero water discharge avoiding the pollution load in the receiving sources.

The FAO (2000) estimated about 5000 million m^3 annually being treated at 121 wastewater treatment plants, and about 150 other treatment plants under construction , and a total capacity of 1800 million m^3 . According to **Al-Salem (2005)**the total treated wastewater in the year 2000was 5.3 million m^3 /day compared with only 1.78 m^3 / day in the year 1994 in East Mediterranean and that treated wastewater in Egypt is 10 % of available water resources in Egypt. Egypt produces From 5.5–6.5 billion m^3 of sewage water per year of which an amount of about3 billion m^3 is treated, but only 0.7 billion m^3 is utilized for agriculture (0.26 billion undergo secondary treatment and 0.44 billion undergo primary treatment), mainly by direct reuse in desert areas or through mixing with agricultural drainage water **(Abdel-Shafy and Abdel-Sabour,2006)**. Continuous use of wastewaters could contaminate soil with heavy metals such as Pb and Ni (**Achtinich, 1987)**.

The current investigation aims at evaluating the quality of some waste-waters sources in Moshtohor area, Qalyobiya Governorate and their suitability for irrigation purposes.

Materials and Methods

Samples of fresh waters, waste-waters (Domestic drainage water, agriculture drainage water and mixed waste-water were collected from Moshtohor, Qalyobiya Governorate, Egypt.

Locations of water sources:

(i) Tap water, collected from domestic water supply.

(ii) Agricultural drainage water collected from Moahtohor agricultural drain.

(iii) Sewage water collected from Moshtohor station of sewage water treatment

(iv) Mixed wastewater collected from El-Qalyobiya drain.

The water samples were analyzed for heavy metals and other related analysis according to methods cited by **Chapman and pratt (1961), USDA (1954)** and **FAO-UNESCO (1973)**.

Results and Discussion

Chemical properties

Table 1show chemical prosperities of waters. The pH of the fresh water was **7.3** while pH of the waste-waters ranged between **6.51** and **7.13** with mixed wastewater being of the highest pH value whereas that of the domestic wastewater was of the lowest one. The pH value of all waters are, therefore, within the normal range of **6.5-8.4** as outlined by **Ayers and Westcot (1987).**

The EC of the studied waters (**Table 2)** shows that the fresh tap water had the lowest salinity of **0.65 dSm^{-1}**while the drainage water shows**0.98 dSm^{-1}**, the domestic water shows, **1.42 dSm^{-1}**and the mixed wastewatershows**1.15 dSm^{-1}.**

Concerning the cationic composition of the investigated waters, the obtained results indicate that the Ca^{2+}cations were the dominant ones, followed by Mg^{2+}, Na and K^+. The tap water showed the lowest contents of cations. Contents in the other waters showed that the domestic wastewater was highest and the agricultural drainage water was lowest.

The anionic composition shows that HCO_3^- was the dominant ion followed by Cl^- then SO_4^{2-} . This pattern occurred in all waste-waters. The CO_3^{2-} ions were not detected in any of the studied waste-waters. The highest concentration of the anions occurred in the domestic wastewater whereas the lowest one occurred in the agricultural drainage water.

The concentration and composition of dissolved salts in a water determine its quality for irrigation. Quality of water is for its appraisal for irrigation. The parameters most important in determining its quality are: (1) Total concentration of soluble salts; (2) relative proportion of sodium to other cations; (3) concentration of boron or other elements that may be toxic, and (4) bicarbonates and carbonates as related to calcium and magnesium. Salinity occurs if the total quantity of salts is high so that it causes negative effect on crop growth and yield. If excessive quantities of soluble salts accumulate in the root zone, the crop has extra difficulty in extracting enough water from salty soil solution. This reduces water uptake by the plant and reduces growth.

Table 1. Chemical properties of the studied water sources under study.

Parameter	Tap water	Agriculture drainage water	Domestic waste water	Mixed waste water
EC (dSm^{-1})	0.65	0.98	1.42	1.15
pH	7.30	6.89	6.51	7.13
CO_3^{2-}(mmolc L^{-1})	0.00	0.00	0.00	0.00
HCO_3^- (mmolc L^{-1})	3.20	4.40	5.80	5.60
Cl^- (mmolc L^{-1})	1.00	2.98	4.62	3.41
SO_4^{2-}(mmolc L^{-1})	2.36	2.40	3.80	2.50
Na^+(mmolc L^{-1})	1.25	1.38	2.92	2.31
K^+ (mmolc L^{-1})	1.11	0.90	2.10	1.80
Ca^{2+}(mmolc L^{-1}	2.60	4.20	5.40	4.80
Mg^{2+}(mmolc L^{-1})	1.60	3.30	3.80	2.60

Indices controlling the quality of waters for irrigation:

Concerning the EC of the studied waters, results in **Table 2** show that the fresh tap water had the lowest salinity of **0.65 dSm^{-1}**followed by agricultural drainage water then the mixed wastewater and the domestic wastewater.

The sodium adsorption ratio (**SAR)** was highest lowest in the agricultural drainage water followed by the tap water, then the mixed wastewater and was highest in the domestic wastewater. All waters are of no sodicity hazards for irrigation (**USDA 1954).**

As for the **SSP** parameter**,** results in **Table 2** show that the **SSP** for all waters sources did not exceeds 21 % and this renders the waters no sodicity hazards since the values did not exceeds 60 % **(USDA, 1954).**High sodium ions in water affects soil permeability and induce infiltration problems. **(USDA, 1954, Abbas *et al*., 1991 and Rowe and Abdel-Magid, 1995).**

There was no residual sodium carbonate (RSC) an all waters **(Table 2)**. Thus all of the studied water are classified as class 1 (**USDA (1954).**

Mg-ratio in all waters did not exceed 50 %indicating no Mg hazards, mixed waste water was lowest (35.14 %). In the other waters it ranged between 38.10 and 44.00 %.According to **FAO-**

UNISCO (1973), all the studied water samples were within the safe limit (less than 50 %)

Table 2. Indices controlling the quality of the water sources under study

Indices of water quality	Tap water	Agriculture drainage water	Domestic waste water	Mixed waste water
EC	0.65	0.98	1.42	1.15
SAR	0.61	0.36	0.96	0.85
RSC	- 1.00	- 3.10	- 3.40	- 1.8
SSP (%)	19.05	14.11	20.53	20.07
Mg ratio	38.10	44.00	41.30	35.14

Classification of water quality for irrigation:

A- Classification according to the USDA (1954) system:

a- Salinity hazards.

According to the USDA classification system **(USDA, 1954),** the tap water is a class C_2i.e moderate salinity water while the other waters are class C_3i.e medium salinity waters (See appendix)**.**

b- Sodicity hazards.

According to the SAR parameter, all waters are of S_1 class, i.e. low sodicity**(USDA, 1954).** Low sodicity waters could be used for irrigation in all soils without danger of sodicityor problems of decreased permeability and the dispersion of aggregated clay particles with no effect on plant growth **(Gupta 2005).**

According to the RSC parameter **(USDA, 1954)** all waters have no residual sodium carbonate hazards since the RSC value is negative

B- Classification according to Ayers and Westcot (1987):

1- Salinity problems:

According to the classification of **Ayers and Westcot, 1987 (Appendix 2),** tap water is Class 1: i.e. no problems while the others are class 2: i.e. increasing problems. The use waters of agricultural drainage, domestic waste water and mixed waste waters for long periods could cause accumulation of salts in the root zone. Hence, using these waters for irrigation would not affect water permeability and infiltration.

2- Infiltration problems:

According to the guidelines proposed by **Ayers and Westcot (1987)** for assessing infiltration problems and taking into account both salinity and SAR of irrigation water together all waters are considered of class 1 (no problem waters) or restriction on using them for irrigation from the infiltration point of view.

3- Toxicity problems:

A- Sodium (Na^+) toxicity:

Concerning the toxicity hazards, results in **Table 2**reveal that all waters show no problems regarding Na toxicity where irrigation is by the surface methods. Also, there is no problems where sprinkler irrigation is used.

B- Chloride (Cl^-) toxicity:

Results presented in **Table 2** reveal that Cl^-ranged from **1 to 4.61 mmol$_c$ L^{-1}**lowest in the tap water and highest in the domestic waste-water. Contents in the mixed waste water and the agricultural drainage water did not exceed **3mmolc L^{-1}**. Therefore, only water of the domestic waste source can be of increasing problems ceeding**4** and within the range **4 to 10mmol$_c$ L^{-1},**hence this water are of increasing problem and of high degree of restriction on use for surface irrigation. From abovementioned results, if the mixed and the domestic wastewaters are used for sprinkler irrigation, they would have increasing and severe problems and high degree of restriction in usage since their Cl^- concentrations exceeded **3 mmol$_c$ L^{-1}.**

Specific ions from the irrigation water may accumulate in the plant and reduce yields. Concentration by evaporation of either water droplets on foliage or of soil water may help induce specific ion toxicities. Specific ion toxicities are commonly associated with woody perennials, such as citrus, stone and other fruits and result mainly from high concentrations of Na and chloride (Cl) ions or occasionally boron.

C-Bicarbonate (HCO_3^-):

Results in **Table 2** reveal that HCO_3^-can be of increasing problems if waters are used in sprinkler irrigation (**Ayers and Westcot,1987)**

Bicarbonates, carbonates and sodium in high contents cause hazards to plant and soil **(Akinbile, 2012).**Chlorides may be combined with high boron causing toxicity to plants.**(UCCC 1974; Tanji, 1990).**

4-Heavy metal hazards:

Data presented in **Table 4** show micronutrients and heavy metal contents in the investigated waters.

As for micronutrients, results reveal that fresh tap water showed lower concentrations of Fe, Zn, and Mn**(0.90, 0.05 and 0.01, respectively)**as compared with those of waste-waters

Contents of Fe, Mn, Zn, and Pb were lowest in the tap water and highest in the mixed waste water and contents of Co and Ni were lowest in the tap water and highest in the domestic waste water.

Table 3. Micronutrients and Heavy metals content of the different waste water sources under study used for irrigation purpose

Parameters	Tap water	Agriculture drainage water	Domestic Waste water	Mixed waste water
Fe (mg/L)	0.90	2.05	6.92	8.90
Zn (mg/L)	0.05	1.93	2.88	3.76
Mn(mg/L)	0.01	0.09	0.62	1.03
Co(mg/L)	0.01	0.03	0.07	0.02
Ni(mg/L)	0.01	0.18	0.90	0.62
Pb(mg/L)	0.72	3.09	5.99	7.10

According to the limits outlined by **Rowe and Abdel-Magid (1995)** for heavy metals in water for irrigation the content of heavy metals showed variable results; limits stated by those researchers are (mg L^{-1}) 5 Fe, 2 Mn, 0.2 Zn, 0.05 Co, 0.2 Ni and 5 Pb. The tap water did not exceed the limit for all such heavy metals. The agricultural drainage water exceeded the limit of Zn only. The domestic waste water exceeded the limit of Fe, Zn, Co, and Pb. The mixed waste water exceeded the limit of Fe,Zn, Ni and Pb.

The final result of quality evaluation depends on plant, soil and climatic variables all of which can be interdependent. A range of management strategies of varying complexity should be applied to mitigate the effects of poor quality water **(George, 1983).**

Conclusion

Irrigation water quality affects soils and crops. High quality crops can be produced by using high-quality irrigation water. Characteristics of irrigation water that define its quality vary with the source of the water. Water used for irrigation can vary greatly in quality depending upon the type and amount of dissolved salts. The tap water EC of**0.65 dS m^{-1}**falls in the "Class 2"of "Moderate salinity waters" suitable for irrigation while the domestic waste-water and the agricultural drainage water of EC 1.42 and 0.98dS m^{-1}, respectively are medium salinity water, unsuitable for irrigating sensitive and semi tolerant crops(**USDA, 1954).**These waters when used for irrigation require cautions to prevent the accumulation of salts. The SAR of all waters ranged from **0.36 to 0.96** thus, they are of no Na hazards and can be used for irrigation on most soils with little danger of sodicity. The RSC are negative, thus these waters can be used safely for irrigation. The SSP parameter falls in no hazardous class.

According to the classification of **Ayers and Westcot (1987) the EC of the studied w**aters some have increasing problems affect water availability to crops. No problems is expected to soil permeability and infiltration. The studied wastewaters are classified as waters of no problem or restriction on use for surface or sprinkler irrigation.

Agricultural drainage water is of no problems or restriction using for surface or sprinkler irrigation according to its content of Cl^- which is**2.98 $mmol_c$ L^{-1}**i.e less than **3$mmol_c$ L^{-1}**. The mixed waste-water is of no problem or restriction on using surface irrigation but it is of increasing problems using sprinkler irrigation according to its content of Cl^- which is **(3.41 $mmol_c$ L^{-1}**). The domestic waste-water is of increasing problems or restriction on using surfaces or sprinkle irrigation since its content of Cl^- exceeds 4 **$mmol_c$ L^{-1}.** Increase in g problems would be expected for the since their contents of HCO_3^- ions exceed **1.5 mmolc L^{-1}**.The domestic and the mixed waste-waters contained heavy metal ions of Fe,Zn, Mn, Co, Ni and Pbin contents exceeding the permissible limit except for Coin the mixed waste-water.

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تقييم نوعية بعض مصادر الماياه وملائمتها للرى

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يهدف هذا البحث إلى تقييم نوعية بعض مصادر مياه الري ومدى ملائمتها للري. لذلك، تم أخذ عينات من مياه الصرف الزراعي، مياه الصرف الصحي ومياه مختلطة (صرف صحى وصرف زراعى وصرف صناعى) من كل من محطة مشتهر لمعالجة مياه الصرف الصحي ومن مصرف مشتهر الزراعى ومن مصرف القليوبية العمومى ، على التوالي. وتمت مقارنة معايير نوعية المياه تحت الدراسة مع معايير جودة المياه المحددة للري وكذلك مع مياه الصنبور العذبة وقد أوضحت النتائج أن مياه الصنبور ذات درجة التوصيل الكهربى 0.65 ديسيسيمنز/ م تُعتبر صالحة للري في حين كانت مياه الصرف الزراعيمياه الصرف الصحى ومياه الصرف المختلطة غير مناسبة لأغراض الري حيث كانت قيمة الـECللمياه تحت الدراسة 0.98 و 1.42 و 1.15 ديسيسيمنز/ ملكل من مياه الصرف الزراعى والصرف الصحى والمياه المختلطة على الترتيب. أي أن كل المياه تحت الدراسة يمكن اعتبارهامياه متوسطة الملوحة C3طبقاً لوزارة الزراعة الأميركية (USDA, 1954) وهو ما يعني أن هذه المياه لا يمكن أن تُستخدم في التربة رديئة الصرف.كذلك أوضحت النتائج أن النسبة الإدمصاصية للصوديوم(SAR)لمياه الصنبور العذبة كانت 0.61 بينما كانت 0.36 , 0.96 and 0.85 بالنسبة لمياه الصرف الزراعى ، الصرف الصحى والمياه المختلطة على التوالى. قيمة الـRSCلمياه الصنبور العذبة كانت – 1.0 بينما كانت – 3.1 ، – 3.4 و – 1.8 بالنسبة لمياه الصرف الزراعى ، الصرف الصحى ومياه الصرف المختلطة على التوالى. كما أوضحت النتائج أيضاً أن النسبة المئوية الصوديوم الذائب (SSP %) فى جميع المياه تحت الدراسة كانت أقل من 60 % وبالتالي، فإن جميع المياه تحت الدراسة يمكن أن تصنف على أنها مياه منخفضة الصودية (S1)وفقا لوزارة الزراعة الأميركية (USDA, 1954) وهو ما يعني أن هذه المياه يمكن أن تستخدم لأغراض الري على معظم أنواع التربة دون خطر الصوديةكما أن قيم الـRSC السلبية تعني أن هذه المياه تحتوى على تركيز عالى من الكالسيوم والماغنسيوم ويمكن استخدامها بأمان للري دون خطر على تجمعات التربة ونفاذيتها للماء.

ومن ناحية أخرى وفقا لتصنيف (Ayers and Westcot, 1987) والذى يُصنف المياه على حسب الضرر الذى قد ينشأ عن إستخدامها على المدى البعيد أو ضحت النتائج أن مياه الصنبور العذبة لا ينتج عنها مشاكل ملوحةتؤثر على تيسر المياه للمحاصيل إذا ما إستُخدمت لريها ،بينما مياه الصرف الزراعي ومياه الصرف الصحي ومياه الصرف المختلطة ينتج عن إستعمالها للرى مشاكل ملوحة متزايدة تؤثر على تيسر المياه للمحاصيل. من ناحية أخرى، من المتوقع أنهلا ينتج عن إستعمال هذه المياه مشاكل تؤثر على نفاذية التربة ومعدل تسرب المياه إلى التربة ، أي أنها مياه بدون مشاكل تؤثر على نفاذية ومعدل تسرب الماء إلى داخل التربة. ومع ذلك، عند الأخذ بعين الاعتبار كلا من الملوحة والنسبة الإدمصاصية للصوديوم فى مياه الري معا، فإن أى من المياه تحت الدراسة تُستخدم للرى بدون أي مشكلة أو قيود من وجهة نظر تسرب أو رشح الماء إلى داخل التربة. وتصنف مياه الصرف تحت الدراسة كمياه بدون مشاكل أو قيود على الإستخدام للرى السطحى أو الري بالرش حيث قيم النسبة الإدمصاصية للصوديوم لا تتجاوز 3.

تُعتبر مياه الصرف الزراعي **ومياه الصرف المختلطة** صالحة للرى بدون أي مشاكل أو قيود على الإستخدام فى الرى السطحى أو الري بالرش وفقا لمحتواها من الكلوريد(2.98 mmolc L^{-1}) أي أقل من (3 mmolc L^{-1}). من ناحية أخرى، مياه الصرف المختلطة لا ينتج عن إستخدامها أي مشاكل وليس هناك قيود على استخدامها للري السطحي ولكن ينتج عن إستخدامها في الري بالرش مشاكل متزايدة وفقا لمحتواها من الكلوريد 3.41 (mmolc L^{-1}).ومع ذلك، فإن مياه الصرف المنزلي (الصرف الصحى)ذات مشاكل متزايدة وهناك قيود على استخدامهافى كل من الرى السطحى والري بالرش حيث أن محتواها من الكلوري يتجاوز قليلاً 4 (4.62 mmolc L^{-1}).ومن المتوقع تزايد المشاكل بسبب استخدام مياه الصرف تحت الدراسة للري بنظام الري بالرش بسب محتواهاالعالي من أيون البيكربوناتHCO_3^-حيث تجاوز 1.5 mmolc L^{-1}.

أظهرت النتائج أيضاً أن تركيز كلاً من أيونات الحديد، الزنك، المنجنيز، الكوبلت، النيكل، والرصاص في مياه الصرف الصحى ومياه الصرف المختلطة ، تحت الدراسة، تجاوز تركيز الحد المسموح به لهذه العناصر في مياه الصرف الصحي ومياه الصرف المختلطة فيما عدا الكوبلت فى مياه الصرف المختلطة حيث كان تركيزه بها أقل من ذلك أى أقل من الحد المسموح به لهذا العنصر فى مياه الرى.