12

Egypt. J. Soil. Sci. Vol. **60**, No. 2, pp. 157-166 (2020)

Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Assessing The Quality of Untraditional Water Sources for Irrigation Purposes in Al-Qalubiya Governorate, Egypt

CrossMark

Hassan H. Abbas[1], Ahmed S. Abuzaid[1*], Hossam S. Jahin[2], Diaa S. Kasem[1]

[1]*Soils and Water Department, Faculty of Agriculture, Benha University, Egypt*

[2]*Central Laboratory for Environmental Quality Monitoring (CLEQM), National Water Research Center (NWRC), Egypt*

LIMITED freshwater coupled with the ever-growing population has forced the farmers in Egypt to reuse untraditional water sources for irrigation purposes. However, a precise evaluation of such water quality is necessarytoavoid potential risks. The current work aimed at verifying the potentiality of reusing agricultural drainage water (ADW) and mixed wastewater (MWW) for irrigation in Al-Qalubiya Governorate. The study based on the considerations set by FAO 29 and 47 guidelines besides the Egyptian code of practice (ECP 501/2015) for wastewater reuse for irrigation. Twenty water samples were collected along Sindwa drain (agricultural drainage water) and Shibin El-Qanater drain (mixed wastewater), ten samples from each. Another ten samples of the Nile freshwater (NFW) were collected nearby the previously water samples from El-Sharaqua canal. The three different locations of sample collection sites showed variable ranges of pH, dissolved and suspended solids, soluble ions, and trace elements. However, they were generally lower than the maximum allowable limits set by FAO guidelines and ECP 501/2015, except NO_3^- and Mn in the ADW. On the other hand, the fecal coliforms in the ADW and MWW were beyond the safe limits. Based on the ECP 501/2015 the NFW isrecommended for irrigating crops of Group B (*e.g.* dry cereal crops and cooked and processed vegetables, fruit crops and medicinal plants), while the ADW and MWW arerecommended for crops of Group D (e.g. bio-charcoal crops, bio-diesel fuel crops, cellulose production crops, and timber trees).

Keywords: Agricultural drainage water, Wastewater, Water quality, Al-Qalubiya Governorate.

Introduction

Egypt is facing a major challenge of freshwater scarcity coupled with increasing population growth (El-Rawy et al., 2020). The total annual renewable freshwater available in Egypt is estimated to be 57.5 billion cubic meters (BCM) year^{-1} (FAO, 2016). This quantity is coupled with a total water demand of 76.3 BCM year^{-1}as mentioned by CAPMAS (2019) and thus, a gap of 20 BCM year^{-1} exists between water supply and demand. In case of using current water policies, Mahmoud and El-Bably (2019) indicated that the water gap may reach 26 BCM by the year 2050. This current situation opposes the recycling of untraditional water resources in irrigation to compensate water shortage.

Untraditional water resources are the water sources that return back to water bodies, drains, and sewer systems from several activities, including irrigation, municipal, and industrial sectors (Aboulroos and Satoh, 2017). Recycling of treated wastewater provides several opportunities to diminish the gap between water supply and demand, achieve sustainable development, prevent pollution of water bodies, and provide a mitigation solution for water scarcity and climate change (Loutfy, 2011 and Elbana et al., 2019). On the other hand, due to the lack of effective sanitation systems (especially in the rural areas), nearly 43% of the total wastewater produced in Egypt are not treated (FAO, 2016). As a result, many farmers in urban and peri-urban areas are obligated to use raw (untreated) or partially treated

*Corresponding author: ahmed.abuzaid@fagr.bu.edu.eg

DOI: 10.21608/ejss.2020.24569.1343

Received : 24/02/2020 ; Accepted: 23/04/2020

©2020 National Information and Documentation Centre (NIDOC)

wastewater for irrigating crops (Abdel-Fattah & Helmy, 2015 and Farid et al., 2020). This practice is usually accompanied by several environmental and health risks (Abuzaid, 2016 & 2018a) due to pathogens and toxic chemical bioaccumulation (Elbana et al., 2019). Hence a precise assessment of water quality is of great concern to avoid potential risks (Farrag et al., 2017 and Abbas & Bassouny, 2018).

The term “quality”, applied to water, denotes its physical, chemical, and biological properties. The properties influence the fitness of a water body for a specific kind of use (drinking, irrigation and/or aquaculture). Water quality depends on both the sort and quantity of dissolved and suspended substances, which control water composition (Jahin et al., 2020). Prior to using water for irrigation, it is necessary to know not only its available quantity but also its quality, since even water of reasonable quality may induce negative effects over time (Ali, 2010). Irrigation water quality has significant effects on plant growth and development and finally crop yield. These effects occur directly through toxicity/deficiency or indirectly in terms of affecting nutrient availability. Thus, irrigation using high-quality water results in high crop yield and quality (Salem et al., 2019), while poor-quality irrigation water causes major damages to irrigated crops and human and animal health (Zaman et al., 2018). Hence, proper assessment and prediction of possible changes in water quality are of great concern.

Environmental problems associated with the quality of irrigation water vary widely in type and severity depending on soil type, growing plants, climatic conditions and methods of applying water (Kaletová and Jurík, 2019). According to the FAO 29 (Ayers and Westcot, 1994) and 47 (Pescod, 1992) guidelines, the most important problems aresalinity, infiltration, toxicity and miscellaneous problems (pH, NO_3-N and HCO_3^-). Dealing with wastewater requires identifying a further set of biological and microbiological parameters that varybased on national and local standards (Jeong et al., 2016). The Ministry of Housing, Utilities, and Urban Communities published the latest version of the Egyptian code of practice for the use of treated municipal wastewater for agricultural purposes in the year 2015 (ECP 501/2015) (ECP, 2015). The ECP defined the threshold levels of chemical elements in treated wastewater for short-term and long-term use. Based on the degree of treatment, wastewater is classified into four grades; A, B, C, and D. Each of these categories is devoted to irrigate specific crops. In this context, the current work aimed at evaluating and verifying the potentiality of reusing untraditional water sources; agricultural drainage water and mixed wastewater for irrigation in Qalubiya Governorate, Egypt. The evaluation based on the comparison between water characteristics with the standard quality parameters set by FAO 29 and 47 guidelines in addition to the ECP 501/2015 to recommend suitable crops in the studied area.

Materials and methods

Site description

The area of study is located in two districts of Al-Qalubiya Governorate; Shibin El-Qanatir and El-Khanka between latitudes 30° 14′′ 47″ and 30° 17′ 51″ N and longitudes 31° 17′ 38″ and 31° 20′ 12″ E (Fig. 1). The area is characterized by a hot arid summer and a mild rainy winter. The mean annual temperature is 21 °C and the highest (36.7 °C) occurs during July, while the lowest (6.4 °C) occurs during January. The total annual precipitation is 65 mm.

Sampling strategy

The area includes three water sources; the Nile freshwater (NFW), agricultural drainage water (ADW) and mixed wastewater (MWW). The source of the NFW is El-Sharaqua canal, while that of the ADW is Sindiwa drain, whereasthat of the MWW is Shibin El-Qanatir drain, which delivers mixes of treated and untreated effluents of domestic, industrial and agricultural activities to the main drain of Al-Qalyubia. Thirty representative sampling sites were selected on the three water sources in October 2019; ten sites (1 to 10) represented the NFW, ten sites (11 to 20) represented the ADW, and ten sites (21 to 30) represented the MWW. Water samples were collected at 1 km interval between every two subsequent points (Fig. 1). The pH and electrical conductivity (EC) were measured instantaneously *in-situ* using a HACH instrument (HQ 40d, multi, USA). Water samples were collected in acid-washed high-density polypropylene vials (1 L) at a depth of 0.5 m below the water surface(Jahin et al., 2020). Furthermore, samples to be analyzed for heavy elements were collected in another set of 0.5 L polypropylene vials previously washed with 50% HNO_3then double deionized water, and acidified with 5 mL HNO_3. The collected samples were transported in iceboxes to the laboratory within 24 hr of collection time and kept in the refrigerator at 4 °C until being analyzed.

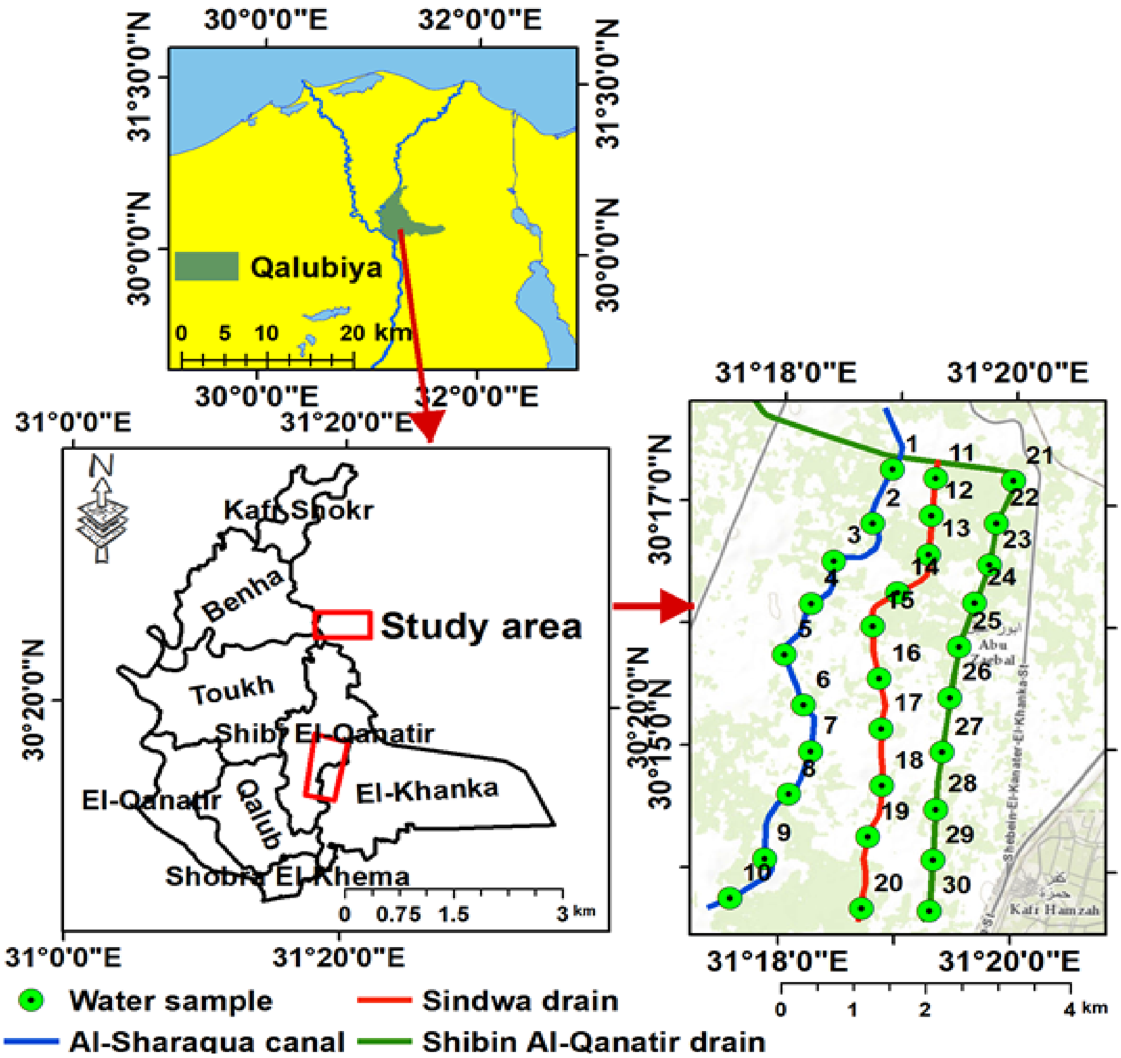

Fig. 1. Locations of the of the studied area and water samples

Laboratory analyses

Analyses were performed according to APHA (American Public Health Association) (2017). The total dissolved solids (TDS) and total suspended solids (TSS) were measured gravimetrically through evaporation of 50 ml-aliquot dried at 180 °C for the former 103 – 105 °C for the latter. Samples were filtered using Whatman42 filter paper (pore size-2.5 m) for the analysis of soluble ions. Na^+ and K^+ were measured using Sherwood model-410 (England) flame photometer. Ca^{2+} and Mg^{2+} were determined by titration against sodium EDTA. Cl^- was determined using Mohr's method by titration against $AgNO_3$ using K_2CrO_4 as an indicator. CO_3^{2-} and HCO_3^- were determined by titration against HCl. SO_4^{2-} was calculated as the difference between the summation of total determined cations and the above-mentioned determined anions. PO_4^{2-} was determined using phospho-molybdate-vanadate method and measured spectro-photometrically by UV–Vis spectroscopy (Cary 50 UV–Vis spectrophotometer, Varian, USA). NO_3^- was measured using ICs5000-Dionex (USA) ion chromatography system.The acidified samples were digested according to APHA (2017) using Method 3030 I. Nitric Acid-Perchloric Acid-Hydrofluoric Acid Digestion. Trace elements were measured in the filtrate using Inductively Coupled Plasma-Optical Emission Spectrophotometer (ICP-OES, Perkin Elmer Optima 5300, USA).The chemical oxygen demand (COD) was determined using Method 5210 B open reflux method. The biochemical oxygen demand at 5 days (BOD_5) was determined using Method 5210 B 5-Day BOD test. The counts of total and fecal coliforms were determined using Method 9221 B for the former and Method 9221 E for the latter.

Data analyses

The statistical analyses were performed using the SPSS statistical package for Windows version 19.0 (SPSS, Chicago, IL, USA). Analysis of variance (ANOVA) was conducted according to Snedecor and Cochran (1989). Tukey's test was used to evaluate the significant difference among treatments (P <0.05).

Results and discussion

Physicochemical parameters

As shown in Table 1, water samples collected from different sites had pH values higher than 7.0; however, they were within the normal range for irrigation (6.5 – 8.4) as set by FAO 29 guidelines (Ayers and Westcot, 1994).Salinity indicators, i.e. EC and TDS were lower than 3 dS m^{-1} and 2000 mg L^{-1}, respectively, hence were within the acceptable limits for irrigation (Ayers and Westcot, 1994).The TSS in the three different locations of sample collection sites did not exceed the maximum allowable levels for irrigation (300 mg L^{-1} according to ECP 501/2015 or 350 mg L^{-1} according to FAO 47 guidelines). The turbidity of the NFW did not exceed the recommended level of 5 Nephelometric Turbidity Unit (NTU) (ECP), while the corresponding turbidity levels of the ADW and MWW surpassed that limit. Turbidity is caused mainly by dissolved organic and/or inorganic materials, including mud, silt, fine sand, and other microorganisms (Alssgeer et al., 2017). The cationic proportion in the three different locations of sample collection sites followed a similar trend, where Na^+ was the predominant cation followed by Ca^{2+}, Mg^{2+}, and K^+; meanwhile, the soluble anions showed variable trends.The anionic sequences were as follow: HCO_3^-> SO_4^{2-}> Cl^-> NO_3^->F^->PO_4^{2-} in the NFW; HCO_3^-> Cl^-> SO_4^{2-}> NO_3^-> PO_4^{2-}> F^-in the ADW, and HCO_3^-> Cl^-> SO_4^{2-}> PO_4^{2-}> NO_3^-> F^-in the MWW.The concentrations of ions were within the permissible levels for irrigation, with an exception of NO_3^- in the ADW. The mean value of NO_3^- in the ADW was 1.7 folds the acceptable level of 10 mg L^{-1} (Ayers and Westcot, 1994). Excessive NO_3^- in irrigation water reduces quantity and quality of crop yield due to the over-stimulation of vegetation growth that delays crop maturity. Nitrate is also easily leached from the soil and may reach the groundwater, causing severehealth risks (Elgallal et al., 2016). The three different locations of sample collection sites contained sufficient concentrations of Ca^{2+} and Mg^{2+}, thereby maintained the SAR values within the permissible limits.The trace elements in thethree different locations of sample collection sites were within the permissible levels, except Mn in the ADW which occurred in concentrations exceeded the safe limit.

Biological properties

The most common biological parameters determining water quality are COD, BOD_5 and the total count of coliform group. Neither FAOnor ECP 501/2015 considered standard limits for COD. Attention has been paid to the BOD_5, and concentrations of 300 and 350 mg L^{-1} were considered as maximum allowable levels according to FAO guidelinesand ECP 501/2015, respectively. Accordingly, the three different locations of sample collection sites did not surpassthosemaximum allowable levels. However, Abou-Elela (2019) considered the BOD/COD as the best representation of biodegradability of organic matter in treated wastewater. The typical ratio falls within a range of 0.3–0.8, and a ratio of 0.5 or greater indicates that the organic matter is easily degradable, while the ratio below 0.3 indicates that the available organics are difficult to be degraded by microorganisms. In this context, all water sources fall within the typical range and contain easily degradable organic substances. Although the coliform group is the most common indicator for waterborne pathogenic bacteria, the fecal coliform test provides a better estimation of human fecal pollution rather than the total coliform test. This is because these microorganisms are excreted by several warm-blooded animals present in several environments (Abou-Elela, 2019). Accordingly, the FAO guidelines and ECP 501/2015 depended on the fecal coliform test to determine water suitability for irrigation. The NFW showed concentrations of fecal coliform within the permissible levels, which are 3 and 3.70 Log coliform forming unit (CFU) 100 mL^{-1} according to FAO guidelines and ECP 501/2015, respectively. On the other hand, the ADW and MWW surpassed both national and international recommended levels.

Comparison among the quality parameters of the studied water sources

As shown in Table 1, the ADW showed higher significant (P < 0.05) pH values with a slight difference between NFW and MWW. Such higher valuesmay be attributed mainly to the high influx of HCO_3^- from agricultural drainage water (El-Gamal, 2017), which causes Ca^{2+} and Mg^{2+} to form insoluble salts leaving Na^+ as the predominant

TABLE 1. Quality parameters of the studied sources of water

Parameter	Unit	Nile fresh water		Agricultural drainage water		Mixed wastewater		MAL	
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	FAO	ECP
pH	---	7.12 - 7.35	7.26 ± 0.07b	7.36 - 7.67	7.53 ± 0.09a	7.11 - 7.43	7.25 ± 0.09b	6.5 - 8.4[1]	NM
EC	dS m^{-1}	0.59 - 0.72	0.64 ± 0.04c	1.59 - 3.91	2.44 ± 0.69a	1.18 – 1.51	1.33 ± 0.09b	3[1]	NM
TDS	mg L^{-1}	287 - 323	315.7 ± 9.95c	946 - 1950	1374.23 ± 26.9a	714 - 839	746.4 ± 32.78b	2000	
TSS		2.11 - 4.95	3.28 ± 1.01c	26.25 - 46.65	33.01 ± 6.20b	32.16 - 65.62	50.75 ± 10.47a	350[2]	300
Turbidity	NTU	0.69 - 1.84	1.15 ± 0.4 c	12.63 - 24.53	16.50 ± 3.61b	15.97 - 36.38	27.14 ± 6.38a	NM	5
SAR	---	1.32 - 1.88	1.72 ± 0.15c	4.51 - 7.25	5.49 ± 0.84a	3.95 - 5.14	4.44 ± 0.37b	15[2]	9
Ca^{2+}	mg L^{-1}	35.01 - 48.21	40.61 ± 4.06b	83.01 - 204.41	128.20 ± 4.11a	39.81 - 95.01	62.21 ± 14.12b	400[1]	230
Mg^{2+}		15.61 - 27.01	19.68 ± 3.52b	31.08 - 76.32	47.71 ± 14.27a	20.04 - 31.44	23.78 ± 7.09b	60[1]	100
Na^{+}		51.75 - 66.47	57.04 ± 4.67c	189.98 - 480.01	288.74 ± 8.71a	154.10 - 169.97	160.38 ± 4.85b	900[2]	230
K^{+}		9.75 - 12.09	10.84 ± 0.67c	23.01 - 79.95	39.55 ± 16.27a	24.96 - 20.08	26.05 ± 0.92b	2[1]	NM
Cl^{-}		39.41 - 57.16	46.58 ± 5.76c	142.01 - 410.03	241.44 ± 7.77a	116.79 - 128.87	123.19 ± 4.06b	1100[2]	NM
F^{-}		0.34 - 0.36	0.35 ± 0.01a	0.23 - 0.42	0.33 ± 0.07a	0.22 - 0.38	0.29 ± 0.06a	NM	2
HCO_3^{-}		198.86 - 234.24	214.78 ± 9.8c	532.53 - 907.07	705.89 ± 10.31a	361.12 - 497.15	397.78 ± 7.32b	600[2]	400
SO_4^{2-}		57.61 - 129.59	80.78 ± 20.85b	4.32 - 571.20	269.95 ± 17.33a	66.72 - 193.92	128.45 ± 14.03b	1000[2]	500
NO_3^{-}		1.86 - 3.72	2.73 ± 0.79 c	6.82 - 79.98	17.24 ± 21.24a	1.86 - 17.36	4.96 ± 5.62b	10[1]	NM
PO_4^{2-}		< 0.20		5.23 - 12.83	8.88 ± 2.69a	5.71 - 9.50	7.93 ± 1.16a	20[2]	30
Al	µg L^{-1}	8 - 13	10.3 ± 1.62b	10 - 16	13.2 ± 1.99a	10 - 18	15.0 ± 2.39a	5000	
Cr		< 0.002		2 - 6	3.1 ± 1.22a	2 - 7	4.2 ± 1.41a	100	
Co		2 - 6	2.5 + 1.12b	2 - 3	3.5 ± 0.51ab	2 - 6	4.10 ± 1.45a	50	
Cu		10 - 18	13.9 ± 2.30b	32 - 68	44.9 ± 10.83a	30 - 58	49.20 ± 9.55a	200	
Fe		6 - 10	7.2 ± 1.33c	45 - 98	78.2 ± 17.09b	210 - 450	327.20 ± 7.02a	5000	
Pb		< 0.007		10 - 17	13.9 ± 2.07a	11 - 17	14.1 ± 1.64a	5000	
Mn		28 - 40	35.2 ± 3.68c	217- 461	320.7 ± 7.19a	109 - 167	136.8 ± 10.84b	200	
Ni		4 - 12	4.2 ± 2.73b	2 -- 8	6.6 ± 2.18b	13 - 19	16.0 ± 1.94a	200	
Zn		< 0.005		10 -- 19	13.1 ± 2.98a	12 - 19	15.0 ± 2.32a	5000	
COD	mg L^{-1}	2.16 - 5.62	3.59 ± 1.08 c	120.15 - 196.65	148.41 ± 2.49 b	305.15 - 379.52	337.56 ± 2.24a	NM	NM
BOD_5	mg L^{-1}	0 - 3.01	1.17 ± 0.97 c	84.93 - 116.89	96.73 ± 10.65 b	162.22 - 193.29	175.76 ± 9.42a	300[2]	350
Total coliform	Log CFU 100 mL^{-1}	2.95 - 3.08	3.02 ± 0.04 c	6.72 - 6.76	6.76 ± 0.01 b	6.82 - 6.85	6.83 ± 0.01a	NM	MN
Fecal coliform		2.88 - 3.01	2.96 ± 0.03 c	6.26 - 6.38	6.30 ± 0.04 b	6.55 - 6.66	6.60 ± 0.04a	3[2]	3.70

Means with different letters indicate significant difference ($P < 0.05$)

SD, standard deviation; TDS, total dissolved solids; TSS total suspended solids; SAR, sodium adsorption ratio; COD, chemical oxygen demand; BOD_5, biological oxygen demand ate 5 days; NTU, nephelometric turbidity unit, CFU, coliform forming unit; MAL, maximum acceptable limit; NM, not mentioned

[1] FAO 29 guideline (Ayers and Westcot, 1994); [2] FAO 47 guidelines (Pescod, 1992)

ECP Egyptian code of practice (501/2015) cation in solution (Mandal et al., 2019). In addition, higher significant contents ($P < 0.05$) of soluble cations and anions were detected in the drainage water. This made the EC of ADW 3.81 and 1.83 folds of the NFW and MWW, respectively. Salts can reach the agricultural drain with irrigation water percolated form soils, and are enriched due to evaporation and flushing of salts from soils and aquifers (Abuzaid, 2018b). The MWW showed the highest significant ($P < 0.05$) concentrations of TSS, while the lowest onescharacterized the NFW. Generally, a high load of suspended materials is a common property of wastewater (Abuzaid, 2016 and Elbana et al., 2017). Accordingly, the turbidity, a function of suspended materials, followed the same trend. The ADW showed significantly ($P < 0.05$) higher values of NO_3^- content represented 6.32 and 3.48 folds the corresponding values of the NFW and MWW, respectively, probably due to nitrate leaching from agricultural fields. Generally, higher concentrations of most heavy metals were found in the MWW, expect Mn that was found in significantly ($P < 0.05$) higher concentrations represented 9.11 and 2.34 folds the corresponding values of NFW and MWW, respectively. Contamination of waters with heavy metals can be attributed to the chemical fertilizers, which contain various amounts of these elements as impurities, and consequently find their way to waters through infiltrations (Abdelhafez et al., 2012). The MWW showed significantly ($P < 0.05$) higher concentrations representing 93.97 and 2.27 folds for COD and 150.48 and 1.82 folds for BOD_5 compared with the NFW and ADW, respectively. Such increases are due to the higher content of organic matter in the MWW compared with either the NFW orthe ADW. The COD and BOD are two important parameters determining the content of organic substances in water (Jeong et al., 2016). The COD is a measure of the susceptibility to oxidation of the organic and inorganic materials in water and in the effluents resulting from sewage and industrial effluents (Sharaky et al., 2017), while the BOD_5 measures the amount of biodegradable organic matter in water (Jeong et al., 2016). Moreover, the MWW showed significant ($P < 0.05$) increases in the coliform group (total and fecal) compared with the NFW and ADW. This also indicates that the MWW receives considerable amounts of human and animal wastes.

Recommended crops in the studied area

The NFW falls within Grade A (< 10 mg L^{-1}) based on TSS, while the ADW and MWW fall within Grades C (30 – 50 mg L^{-1}) and D (50 – 300 mg L^{-1}), respectively (Fig. 2). The TSS is one of the great concerns in treated wastewater irrigation since suspended sediments result in clogging problems with sprinkler and drip irrigation systems(FAO, 2003). In addition, several pathogens are incorporated within the suspended sediments or may be found as suspensions in the influent wastewater(Abou-Elela, 2019). The NFW falls within Grade A based on BOD_5 (< 10 mg L^{-1}), while both ADW and MWW fall within Grade D (60 – 350 mg L^{-1}). The NFW with a fecal coliform ranging from 2 to 3 log CFU 100 mL^{-1} falls within Grade B On the other hand, the ADW and MWW fall within Grade D since the concentrations of fecal coliform were higher than 3.7 log CFU 100 mL^{-1}. Using the maximum water quality limitation, the NFW could be recommended for irrigating crops of Group B, while the ADW and MWW could be suitable for irrigating crops of Group D (Table 2).

TABLE 2. Recommended plant species in the studied area

Treatment level	Group	Species
B	B-1. Dry cereal crops and cooked and processed vegetables	Rice, wheat, barely, maize, bean, lentil, sesame and all species of cooked and processed vegetables
	B-2. Fruit crops	Evergreen and deciduous fruit trees such as: Citrus, olive, palm, mango, pecan, pomegranate, fig for drying
	B-3. Medicinal plants	Anise, hibiscus, cummins, marjoram, trait, fenugreek, fennel, fennel, chamomile.. etc.
D	D-1. Bio-charcoal crops	Charcoal crop such as willow, poplar, moringa
	D-2. Bio-diesel fuel crops	Soybeans, rapeseed, jojoba, jatropha, castor
	D-3. Cellulose production crops	All species of non-food crops for the production of glucose and its derivatives such as ethanol, acetic acid and ethanol gel.
	D-4. Timber trees	All species of trees used for the production of wood such as eucalyptus, camphor, mahogany.

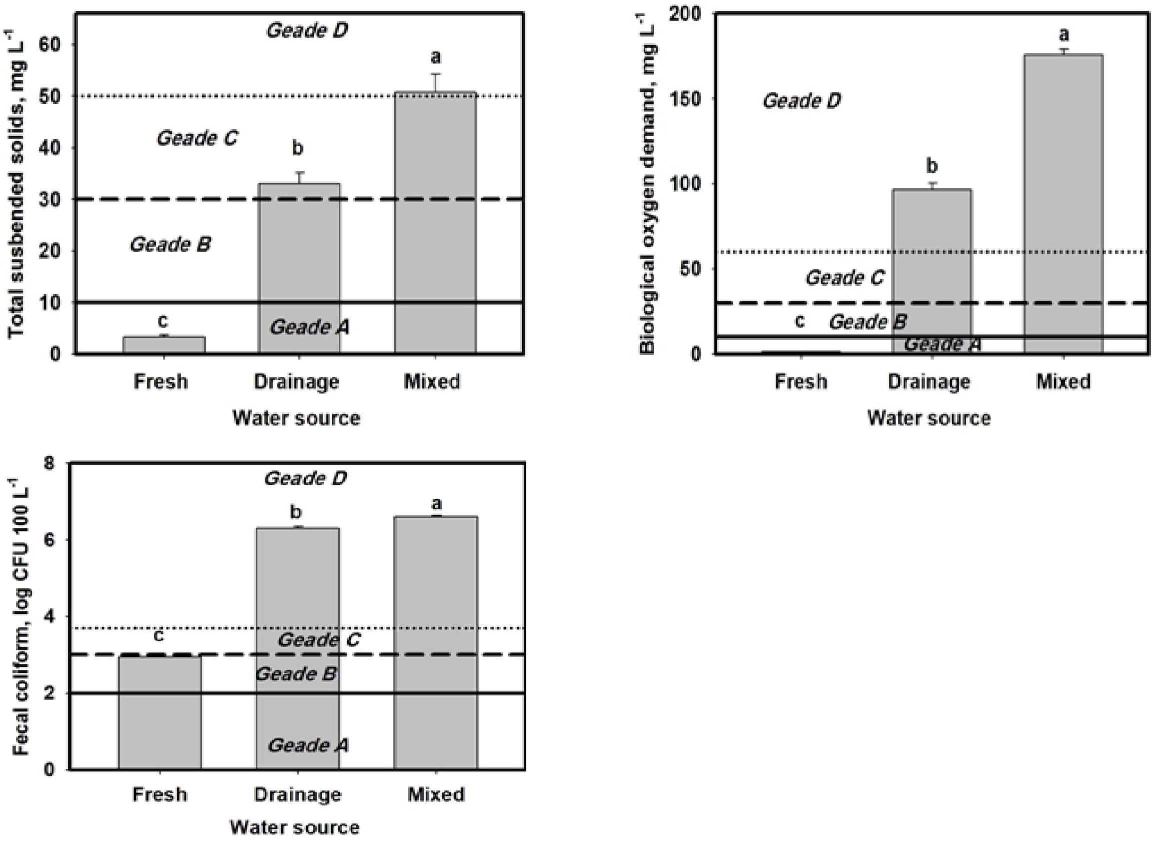

Fig. 2. Categories of water quality criteria according to ECP 501/2015

Conclusion

The three different locations of sample collection sites showed physicochemical parameters, including pH, EC, TDS, TSS, SAR, soluble ions (except NO_3^- in the ADW) and trace elements (except Mn in the ADW) within the permissible limits of FAO 29 and 47 guidelines and ECP 501/2015. On the other hand, the fecal coliformsin the ADW and MWW were beyond the safe limits.Lack of effective sanitation system has led to the discharge of domestic sewage effluents to the agricultural drain, causing considerable contamination with fecal coliform. The NFW is suitable for irrigating crops of Group B (dry cereal crops and cooked and processed vegetables, fruit crops and medicinal plants); meanwhile, the ADW and MWW are suitable for irrigating crops of Group D (bio-charcoal crops, bio-diesel fuel crops, cellulose production crops, and timber trees). Wastewater in the studied area would provide an alternative source for irrigating the recommended crops to mitigate the pressure on the freshwater.

References

Abbas, M., Bassouny, M.A. (2018) Implications of long-term irrigation with wastewater on the contents and retention kinetics of potentially toxic elements in Typic Torripsamment Soils. *Egypt. J. Soil Sci.* **58**, 337-357.

Abdel-Fattah, M.K., Helmy, A.M. (2015) Assessment of water quality of wastewaters of Bahr El-Baqar, Bilbies and El-Qalyubia drains in east Delta, Egypt for irrigation purposes. *Egypt. J. Soil Sci.* **55**, 287-302.

Abdelhafez, A.A., Abbas, H.H., Abd-El-Aal, R.S., Kandil, N.F., Li, J.H., Mahmoud, W. (2012) Environmental and health impacts of successive mineral fertilization in Egypt. *Clean-Soil Air Water* **40**, 356-363.

Abou-Elela, S.I. (2019) Constructed wetlands: The green technology for municipal wastewater treatment and reuse in agriculture. In: Negm, A.M. (Ed.), *Unconventional Water Resources and Agriculture in Egypt.* Springer International Publishing, Cham, pp. 189-239.

Aboulroos, S., Satoh, M. (2017) Challenges in exploiting resources-general conclusion. In: Satoh, M., Aboulroos, S. (Ed.), *Irrigated Agriculture in Egypt: Past, Present and Future.* Springer International Publishing, Cham, pp. 267-283.

Abuzaid, A. (2018a) Soil quality indicators in Al-Qalyubia Governorate as affected by long-term wastewater irrigation. *Egypt. J. Soil Sci.* **58**, 1-11.

Abuzaid, A.S. (2016) Sewage effluent as an alternative source for irrigation: Impact on soil properties and heavy metal status. *Ann. Agric. Sci. Moshtohor,* **54**, 387-396.

Abuzaid, A.S. (2018b) Evaluating surface water quality for irrigation in Dakahlia Governorate using water quality index and GIS. *J. Soil Sci. Agric. Eng. Mansoura Univ.* **9**, 481-490.

Ali, M.H. (2010) Water: An element of irrigation. In: Ali, M.H. (Ed.), *Fundamentals of Irrigation and On-farm Water Management:* Volume 1. Springer New York, New York, NY, pp. 271-329.

Alssgeer, H.M.A., Gasim, M.B., Azid, A., Alabyad, L.O.M. (2017) The evaluation of physicochemical and biological characteristics of water quality between wet and dry seasons of Nerus River, Kuala Terengganu, Malaysia. *J. Fundam. Appl. Sci.* **9**, 563-582.

APHA (American Public Health Association) (2017) *Standard Methods for The Examination of Water and Wastewater,* 23rd edition. APHA-AWWA-WEF, Washington, DC, USA.

Ayers, R.S., Westcot, D.W. (1994) *Water Quality for Agriculture.* FAO Irrigation and Drainage Paper 29. Revision, Rome, Italy

CAPMAS (Central Agency for Public Mobilization & Statistics) (2019) Egypt in figures CAPMAS, Cairo, Egypt. https://www.capmas.gov.eg/Pages/StaticPages.aspx?page_id=5035.

ECP (2015) Egyptian code of practice for the use of treated municipal wastewater for agricultural purposes. The Ministry of Housing Utilities and Urban Communities (in Arabic).

El-Gamal, A.A. (2017) Sediment and water quality of the Nile Delta Estuaries. In: Negm, A.M. (Ed.), *The Nile Delta.* Springer International Publishing, Cham, pp. 347-378.

El-Rawy, M., Abdalla, F., El Alfy, M. (2020) Water resources in Egypt. In: Hamimi, Z., El-Barkooky, A., Martínez Frías, J., Fritz, H., Abd El-Rahman, Y. (Ed.), *The Geology of Egypt.* Springer International Publishing, Cham, pp. 687-711.

Elbana, T.A., Bakr, N., Elbana, M. (2019) Reuse of treated wastewater in Egypt: Challenges and opportunities. In: Negm, A.M. (Ed.), *Unconventional Water Resources and Agriculture in Egypt.* Springer International Publishing AG, Chem, pp. 429-453.

Elbana, T.A., Bakr, N., George, B., Elbana, M. (2017)Assessment of marginal quality water for sustainable irrigation management: Case study of Bahr El-Baqar area, Egypt. *Water, Air, & Soil Pollut.* **228**, 214.

Elgallal, M., Fletcher, L., Evans, B. (2016) Assessment of potential risks associated with chemicals in wastewater used for irrigation in arid and semiarid zones: A review. *Agric. Water Manag.***177**, 419-431.

FAO (2003) Users manual for irrigation with treated wastewater. FAO Regional Office for the Near East, Cairo, Egypt.

FAO (2016) AQUASTAT Main Database. Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/nr/water/aquastat/data/query/results.html.

Farid, I.M., Abbas, M.H.H., Bassouny, M.A., Gameel, A., Abbas, H.H. (2020) Indirect impacts of irrigation with low quality water on the environmental safety. *Egypt. J. Soil Sci.***60**, 1-15.

Farrag, H.M., El-Desoky, M.A., Basha, A.A.A., Roshdi, N.M.K. (2017) Long-term impact of treated sewage water on some soil properties and nutrients status in Luxor Governorate, Egypt. *Egypt. J. Soil Sci.* **57**, 1-14.

Jahin, H.S., Abuzaid, A.S., Abdellatif, A.D. (2020) Using multivariate analysis to develop irrigation water quality index for surface water in Kafr El-Sheikh Governorate, Egypt. *Environ. Tech. Inno.* **17**, 100532.

Jeong, H., Kim, H., Jang, T. (2016) Irrigation water quality standards for indirect wastewater reuse in agriculture: A contribution toward sustainable wastewater reuse in South Korea. *Water,* **8**, 169.

Kaletová, T., Jurík, Ľ. (2019) Quality of water required for irrigation. In: Negm, A.M., Zeleňáková, M. (Ed.), *Water Resources in Slovakia: Part I: Assessment and Development.* Springer International Publishing, Cham, pp. 97-113.

Loutfy, N.M. (2011) Reuse of wastewater in mediterranean region, Egyptian experience. In:

Barceló, D., Petrovic, M. (Ed.), *Waste Water Treatment and Reuse in The Mediterranean Region.* Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 183-213.

Mahmoud, M.A., El-Bably, A.Z. (2019) Crop water requirements and irrigation efficiencies in Egypt. In: Negm, A.M. (Ed.), *Conventional water resources and agriculture in Egypt.* Springer International Publishing AG, Hdb Env Chem, pp. 471-487.

Mandal, S.K., Dutta, S.K., Pramanik, S., Kole, R.K. (2019) Assessment of river water quality for agricultural irrigation. *Int. J. Environ. Sci. Tech.* **16**, 451-462.

Pescod, M.B. (1992) Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47. Food and Agriculture Organization of the United Nations, Rome.

Salem, Z.E., Temamy, A.M.A., Salah, M.K., Kassab, M. (2019) Evaluation of water resources qualities for agriculture irrigation in Abu Madi area, northern middle Nile Delta. In: Negm, A.M. (Ed.), *Conventional Water Resources and Agriculture in Egypt.* Springer International Publishing, Cham, pp. 277-316.

Sharaky, A., Salem, T., Aal, A.A. (2017) Assessment of water quality and bed sediments of the Nile River from Aswan to Assiut, Egypt. In: Negm, A.M. (Ed.), The Nile River. Springer International Publishing, Cham, pp. 207-238.

Snedecor, G.W., Cochran, W.G. (1989) *Statistical Methods.* 8th eddition. Ames, Iowa : Iowa State University Press, USA.

Zaman, M., Shahid, S.A., Heng, L. (2018) Irrigation water quality. Guideline for salinity assessment, mitigation and adaptation using nuclear and related techniques. Springer International Publishing, Cham, pp. 113-131.

تقييم جودة مصادر مياه غير تقليدية لأغراض الري في محافظة القليوبية

حسن حمزة عباس[١]، أحمد سعيد أبوزيد[١]، حسام الدين سمير جاهين[٢]، ضياء سمير قاسم[١]
[١] قسم الأراضي والمياه - كلية الزراعة - جامعة بنها - مصر
[٢] المعامل المركزية للرصد البيئي - المركز القومي لبحوث المياه - مصر

يهدف هذا البحث إلى تقييم مدى إمكانية إستخدام مصادر مياه غير تقليدية في أغراض الري بمحافظة القليوبية – مصر بناءاً على مؤشرات تقييم نوعية المياه المقترحة من قبل منظمة الزراعة والأغذية بالإضافة إلى الكود المصريرقم 501لسنة 2015. تم تجميع ١٠ عينات مياه من ثلاث مصادر هي: مياه النيل (ترعة الشراقوة)، مياه الصرف الزراعي (مصرف سندوة)، ومياه الصرف الصحي والزراعي والصناعي المختلط (مصرف شبين القناطر). أظهرت الثلاث مصادر للمياه مستويات آمنة بالنسبة لرقم الحموضة، الأملاح الكلية الذائبة، المواد الكلية العالقة، الأيونات الذائبة (عدا النترات في مياه الصرف الزراعي)، و العناصر النادرة (عدا المنجنيز في مياه الصرف الزراعي). ظهرت البكتريا البرازية في مياه الصرف الزراعي والصرف المختلط بتركيزات أعلى من المسموح بها عالمياً ومحلياً. طبقاً للكود المصري، فيوصى بإستخداممياه الترعة في ري محاصيل الحبوب الجافة، الخضر والفاكهة والنباتات الطبية، بينما يمكن إستخدام مياه الصرف الزراعي ومياه الصرف المختلط في ري محاصيل الفحم الحيوي، وقود الديزل الحيوي، إنتاج السليولوز، وأشجار الأخشاب.