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Study of Reclaimed Water Reuse Standards and Prospects in Irrigation in Egypt

Gabr M.[1]

ABSTRACT:

The subjects of wastewater treatment and the reuse of reclaimed water are of excessive significance, especially in the regions where the lack of conventional resources is an essential problem as the situation in Egypt. This paper examines the present status for the reuse of reclaimed water in Egypt and future national water plan for reclaimed water reuse. In addition, to review the reclaimed water reuse standards for indirect irrigation in Egypt, organizations (World Health Organization (WHO) and United States Environmental Protection Agency (USEPA)) and countries (Spain, Italy and Cyprus) that have been modified reclaimed water reuse standards. In addition, the study proposing standards for reclaimed water reuse in irrigation purposes aimed to maximize environmental outcomes. The proposed standards were in terms of salinity, nutrients, turbidity, total suspended solids (TSS), pathogens, trace elements, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The proposed turbidity in (NTU) for cooking vegetables up to 10, (TSS) for cooking vegetables ≤10 mg/L and for cooking crops for human consumption ≤35 mg/L. (BOD) concentration for cooking crops for human consumption and for cooking vegetables were ≤35 and ≤15 mg/L respectively. (COD) concentration ≤ 35 mg/L. The proposed standards concentrations for Aluminium (Al), Cobalt (Co), Beryllium (Be), Lithium (Li) and Vanadium (V) that not detected in the Egyptian local Decree 92/2013 were added as 0.5, 0.05, 0.02, 0.5 and 0.05 mg/L respectively. Egyptian local Decree put high levels of Molybdenum (Mb) (0.07 mg/L) and the study proposes a concentration of 0.01 mg/L. Finally, (USEPA) standards for pathogens were proposed in this study. This study is expected to encourage reclaimed water reuse in Egypt in irrigation practices.

Keywords: Sustainable Reclaimed Water Reuse, Indirect Irrigation, Irrigation Water Standards, Egypt.

1. INTRODUCTION

Currently, in the water management global context, Mediterranean area including Egypt is particularly exposed to the consequences of different changes: population growth, global warming, climatic changes and decrease in biodiversity. This means a direct increase in water consumption rates for irrigation and drinking purposes. This is leading to the shortage of available surface and groundwater sources. Today, most countries in the Middle East and North Africa can be classified as facing entire water scarcity [1, 2], thus creating a very strong pressure on freshwater sources as well as a race for water between the various users. Egypt is among the most vulnerable countries exposed to the effect of climate change which inversely reflects on water resources degradation (overuse, soil salinization, low irrigation efficiency, etc.). In addition, the increasing water demand in agriculture as well as in the urban, industry and energy sectors [2].

1 Civil Engineering Department, High Institute for Engineering and Technology, New Damietta, Ministry of High Education, Egypt; m_egabr@yahoo.com.

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To reduce the pressure on freshwater resources and to preserve them for the providing of drinking water, it is important to consider how these resources are managed and advance water use efficiency by merging better management and policy developments. In this context, reclaimed water reuse has become a common practice in many Mediterranean countries since the mid-twentieth century. Here the term “reuse” means the use of wastewater, be it partially treated or raw, for beneficial purposes. It involves different sources of wastewater of variable quality and quantity that reused irrigation practices [3]. Many countries see water reuse as an important strategy of water resources management, mainly designed for irrigation purposes. In addition, the growth of irrigated agriculture in rural areas as well as around and within urban regions provides a new opportunity to consider reclaimed water to enhance water supply for agriculture. Thus, will enhance of food safety as well as poverty reduction in the rural communities [4, 5]. Reuse of reclaimed water in irrigation purposes has been modified and become of an international interest [6, 7]. Countries such USA have about 7% of reclaimed water is reused. Florida and California represent of 11% and 29 % of reclaimed water in respectively. Millions of hectares of cropland are irrigated with sewage effluent in China, India, Mexico and Mediterranean Rim without adequate treatment [5, 8]. In Tunisia, about of 25% of reclaimed water is reused and have become existent of the irrigation practice [5, 9]. Taking all above in mind, the choice of appropriate and cost-effective wastewater treatments is an important issue. And the adoption of suitable irrigation practices should be considered to protect public health from the adverse conditions and destruction of crops, soils and groundwater [7]. In fact, the use of wastewater for irrigation purposes can pose significant risks to farmers and more generally to the public health. There are many risk factors associated with the reuse of wastewater in irrigation such as the accumulation of the substances in soil voids which lead to a decrease in the crop growing, causing the microbe infection and soil deterioration [10]. The indirect reclaimed water reuse in irrigation occur when the cultivated land is far from the effluent source. It is commonly being supposed as a valued water source to compensate between supplies and demands. Direct reclaimed water reuse in irrigation means treated effluent pumped from the wastewater treatment plant (WWTP) directly to the cultivated land. While, indirect reclaimed water reuse means thrown the reclaimed water into a canal (mixed water treated effluent and canal flowing water) downstream effluent source to the cultivated far land. The quality of (WWTP) effluent controls the direct reclaimed water reuses while, the indirect reclaimed water reuses quality control is difficult because it is dependent on both the hydrological characteristics of the watercourse that is disposed off and the reclaimed water effluent quality [11]. The reclaimed water reuse for indirect irrigation must be strictly monitoring of the environmental protection law to prevent soil contamination. Organizations such as (WHO) [12] and (USEPA) [13] have suggested and modified water quality standards for safe reclaimed water reuse in irrigation. In addition, countries such as France [14], Cyprus [15], Greece [16], Italy (Italian decree 2003) [17], Californian standards Title 22 [18] and Spain (Spanish Royal decree 2007) [19] [20] have modified water quality standards for safe reclaimed water reuse in irrigation.

Egypt laid out in 1982 the law 48/1982 [21] and his executive regulations for water quality standards use from Nile River and its branches (Damietta and Rosetta branches) and to control the treated industrial water and secondary treated sewage water that disposed off in Nile River and its branches. In 2013 executive regulations for the Low 48 was amended by the decree no. 92/2013 of Ministry of Water Resources and Irrigation (MWRI) [22] and in 2018 amended again by the minister of water resources and irrigation by the decree no. 208/2018 [23]. The executive regulations (decree No. 44 /2000) by the minister of housing, utilities, and urban communities [24], for the Law no. 93 of 1962 that concerns the safe disposal of liquid effluents classified reclaimed water reuses into three groups: primary reclaimed water, secondary reclaimed water and advanced reclaimed water for direct irrigation. The primary use of reclaimed water in Egypt is for irrigation of green areas (landscape development) and irrigation of non-food agriculture. The sustainability of the reclaimed water reuse in irrigation depends mainly on the degree of treatment, availability of suitable area for irrigation, cropping pattern, soil type, irrigation method, matching of supply and demand and environmental impact. Therefore, the need for the study and updating the standards of reclaimed water reuses in indirect irrigation purposes in Egypt is necessary issue for reclaimed water reuse sustainability. In this study, Egypt reclaimed water reuse current status and future national water plan for reclaimed water reuse was discussed. In addition, the Egyptian current reclaimed water reuse standards for irrigation purposes were examined and compared to the organizations (WHO and USEPA) and some Mediterranean countries (Spain, Italy and Cyprus) that have modified reclaimed water reuse standards in irrigation practices. Consequently, a reclaimed water reuse standard for indirect irrigation in terms of salinity, nutrients, turbidity, (TSS), pathogens, trace elements, (BOD) and (COD) for cooking vegetables and cooking crops for human consumption were suggested.

2. EGYPT WATER RESOURCES AND REGULATIONS

Egypt suffering from water scarcity, its main water resources are surface water from Nile River (55.5 billion cubic meter per year). Egypt population in 2018 was 96.28 million capita (Fig. 1) [25].

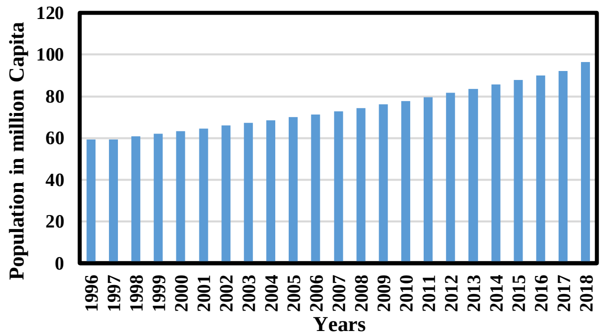

Fig. 1: Egypt population increase [25].

Therefore, Egypt total water uses during 2010 to 2017 are increased from 73.35 Billion m^3/year to 80 billion m^3/year (Table 1) [25]. Non-convention water sources such as agriculture drainage water of good quality and shallow groundwater in the Valley and Delta were reused in irrigation to satisfy the Egyptian water demands in the agriculture sector (Fig. 2). Egypt non-conventional water resources use is increased from 10.2 Billion m^3/year in 2010 to 13.5 Billion m^3/year in 2017 [25]. Fig. 3 shows the increase in the total water resources use and distribution in Egypt during the period from 2010 to 2017. The agriculture sector is the biggest user of freshwater source 76.7 % of the total demands, the drinking water production from the purification plants increased from 8.505 Billion m^3/year in 2010 to 10.75 Billion m^3/year in 2017 [25]. Water uses in industry increased from 1.2 Billion m^3/year in 2010 to 5.4 Billion m^3/year in 2017. In addition, the evaporation from open channel fresh water network increased from 2 Billion m^3/year in 2010 to 2.5 Billion m^3/year in 2017 due to the climatic change.

Egypt law 48 [21] regulates thrown the reclaimed water into watercourses and groundwater aquifer by MWRI. Sanitary sewage treatment plants, industrial workshops, and river boats are provided licenses to throw the reclaimed water into fresh watercourses if the effluents meet certain standards and other conditions. Fine, jail sentence or both prohibit unofficial discharging that exceeds license levels. Other requirements of the law state that licenses may be withdrawn in case of the failure to reduce the discharge that causes a pollution danger within three months. The law provides (MWRI) executive and police power on the application, the Ministry of Interior's (water police) also has a power in law applications, and the Ministry of Health is responsible for putting the water quality standard and discharge-monitoring roles.

Table 1: Egypt water resources balance [25]

Item		Water quantity in (Billion m^3/Year)							
		2010	2011	2012	2013	2014	2015	2016	2017
Conventional water resources	Share of Nile	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5
	Deep Groundwater	---	---	---	---	---	---	---	2.5
	Rainwater and Desalination	1.35	1.35	0.69	0.8	1	1	0.75	2
Total		56.85	56.85	56.19	56.3	56.5	56.5	56.25	60
Non-conventional water resources	Reuse of Agriculture Wastewater	10.2	10.6	10.47	11.4	12.8	13	13.1	13.5
	Shallow Groundwater in the Valley and Delta	6.3	6.3	7.5	7.7	6.7	6.9	6.9	6.5
Total		16.5	16.9	18	19.1	19.5	19.1	20	20
Total water uses		73.35	73.75	74.19	75.4	76	75.6	76.25	80

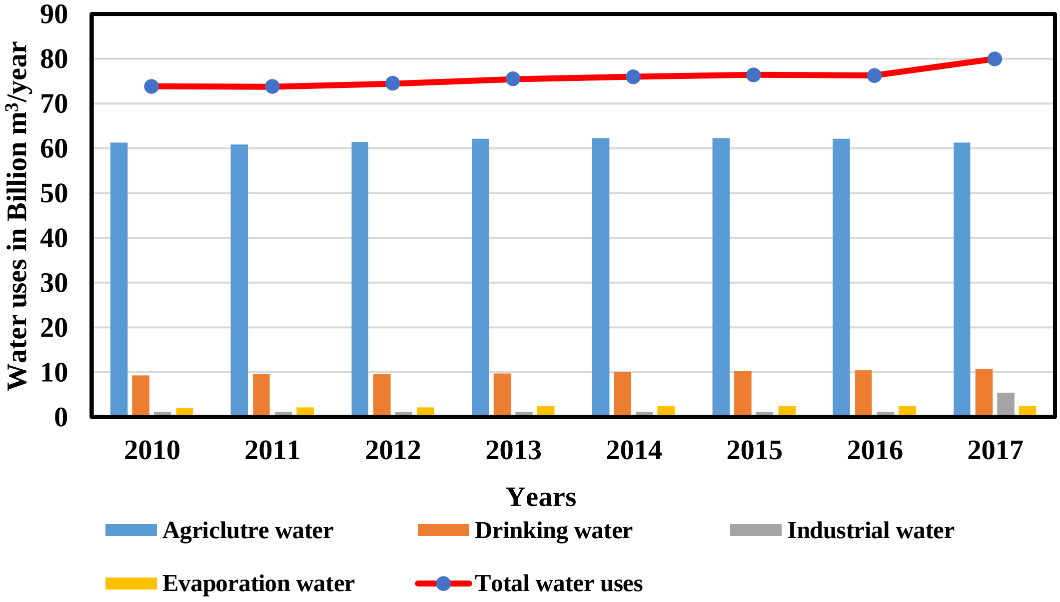

Fig. 2: Egypt non-conventional water resources uses [25]

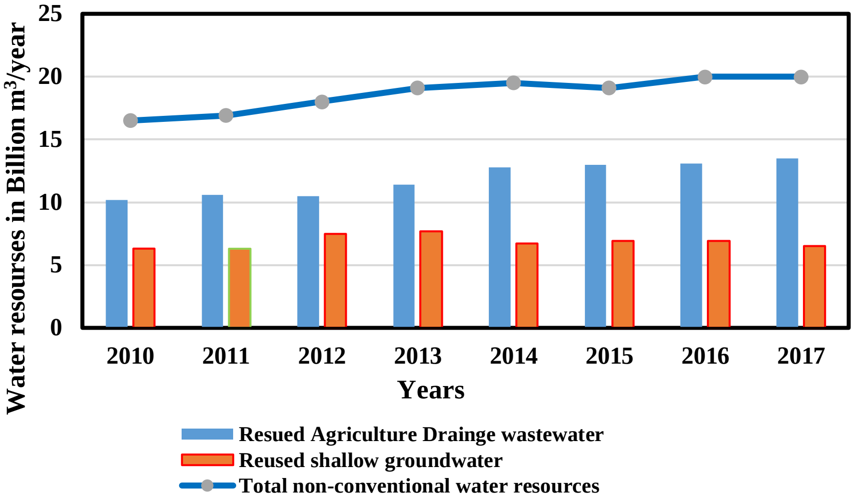

Fig. 3: Egypt total water resources uses [25]

During 2013, the Executive Regulation of law 48 was amended by MWRI via decree No. 92 of 2013 [22] for the following classifications:

- Standards and specifications for waterways where treated wastewater is disposed off.
- Standards of the treated industrial wastewater thrown into the Nile River, Nile branches, and canals.
- Standards of water quality for waterways after the treated industrial wastewater thrown.
- Standards and specifications of non-fresh water resources where treated wastewater is disposed of.

Law 93/1962 regulate the construction of urban sewer networks and sewage treatment plant services, permissible discharges of domestic, commercial and manufacturing services to sewer networks. The Minister of Housing, Utilities and Urban Communities (MHUUC) amended the executive regulation of this law through decree No. 44 of 2000. In 2015, the (MHUUC) published new version of the Egyptian code for reusing municipal reclaimed water [26], it classifies reclaimed water into four levels based on the level of wastewater treatment. The Egyptian code forbids the reuse of reclaimed water in irrigation of raw vegetables and allowable croups for each treated reclaimed water level.

2.1 Present Reclaimed Water Reuse in Egypt

In Egypt, rapid urbanization places increasing pressure on central wastewater treatment systems, and about 5 billion cubic meters of sewage water were collected every year, only 74.4 % is treated [25]. The annual current reuse of the recycled, reclaimed water is 1.3 billion cubic meters. The reclaimed water can add up to 5 billion cubic meters to Egypt water resources. The 1.3 BCM reclaimed water can be increased to 3 billion cubic meters through the secondarily treatment of Egyptian wastewater treatment plants.

2.2 Present Agricultural Drainage Wastewater Reuse

Agricultural drains collect huge amounts of mixed pollutants (raw, treated or partially treated effluent). These drains discharge their effluent into the main Nile, Nile branches, coastal lakes, and the Mediterranean Sea. Agriculture drainage water reuse in Egypt are official reuse planned and managed by (MWRI), where the agricultural drainage water is collected in the main drains channels and blending with fresh water in main canal through mixing pump stations. Agricultural drainage water in branch drains before it discharged into a polluted main drain can be utilized for direct irrigation when the water has an appropriate quality and under the prior permission of (MWRI) [27]. Illegal reuse occurs if the farmers directly reuse agriculture drainage water without prior permission from MWRI (Fig. 4). It exists wherever canal water unavailable and mainly at canal ends [27].

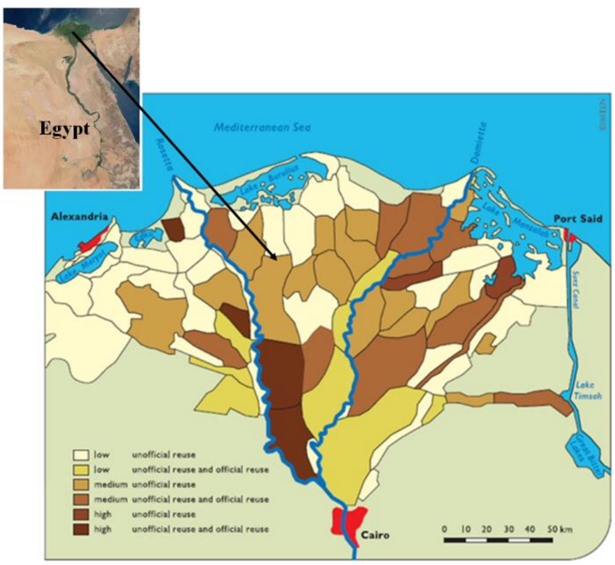

Fig. 4: Drainage catchment in Delta with official and non-official drainage water reuse [28]

Bahr Elbaqar, El-Gharbia, Tillia, and Edku drains are agricultural drains collect treat and untreated wastewater from eastern, western, and the middle of the Egyptian Delta respectively. Many studies were carried out to investigate the suitability of the wastewater carried by these drains in irrigation purposes and its environmental impact assessment on the natural lakes (EL-Manzala and Edko) (Fig. 4). The main conclusion was that prior water treatment is needed [27]. According to Water for Future-National Water Plan for Egypt 2017-2037 [28], future horizontal expansion of 96600 hectares will be developed based on that reclaimed water from these drains. Bahr Elbaqar Drain lies in the east of the Delta, it has a total served area of 320000 hectares and a discharge of 1.4 billion cubic meters per year into Lake Manzala (Fig. 5). The drain is highly polluted due to the accumulation of the treated and untreated water that discharged legally and illegally from the severely populated region in Shobra El-Khemma besides its great industrial area and the settlement populations of Qalubia and Sharkia Governorates [27]. El-Gharbia Drain lies in the middle of Delta, it has an area served of 283300 hectares to cover a severely inhabited populated area in Kafr El-Sheikh and Gharbia Governorates (Fig. 5). Edku Drain lies in Behera Governorate, it supplies El-Mahmoudia canal with agricultural wastewater in order to meets the shortage in irrigation demands for the area served by the iirigation canals (Fig. 5). The Edcu drainage area served a highly densely populated government in which the water quality of the drainage system was deteriorated due to the illegal and illegal discharge of wastewater. Tillia Drain (Fig. 5) is one of the most polluted major drains in Egypt. It is discharged its water into Nile Rosetta Branch through Al Rahawi Drain.

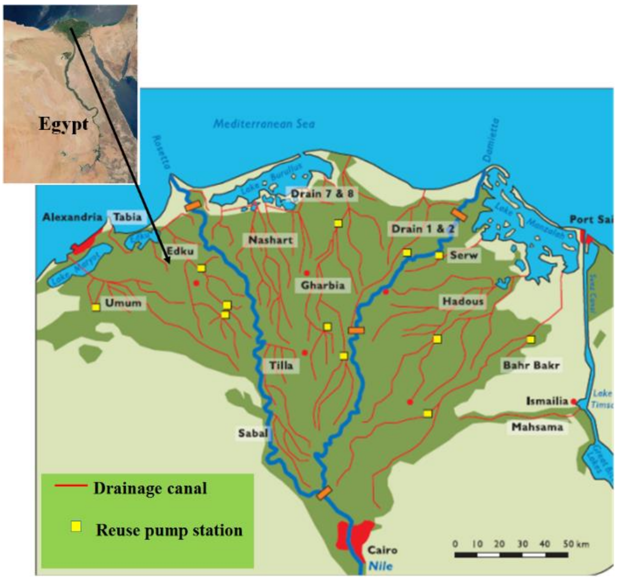

Fig. 5: Main drainage canals in Delta [28]

2.3 Future Reclaimed Water Reuse in Egypt

The Egyptian Laws No. 12/1984 and No. 213/1994 are regulating irrigation and drainage network systems containing main canals, feeders and drains usage and management by public and the private sector. These laws also provide legal guidance for the operation and maintenance of public and private watercourses and the determination of cost recovery arrangements from irrigation and drainage systems. Even when high irrigation efficiencies are assumed the overall water use efficiency of the available wastewater flow will not higher than 65 to 70 %. Currently, Egypt starts to implement new strategies to meet the "post - 2037" irrigation and domestic water requirements. Therefore, development of various technologies and management arrangements for domestic wastewater, which may be appropriate for implementation in urban areas must be encouraged. Water borders and water user associations must be designed for water and wastewater connections. In addition, the drinking purposes originally sourced from River Nile, branches or similar fresh water supply for wastewater collection and treatment individual or central and treated reclaimed water reuse must be encouraged. Finally, rrealistic and modified standards for wastewater treatment and reuse in irrigation for cooking vegetables and cooking crops for human consumption must be promoted.

3. PROPOSED RECLAIMED WATER REUSE STANDARD FOR IRRIGATION IN EGYPT

Non-food crops (seed crops, processed food crops, orchard crops, fodder crops, industrial crops, etc.) irrigated with reclaimed water have some acceptance by the agricultural community. Many countries use the (WHO) guidelines to provide a reasonable level of safety, assuming conservative levels of exposure of the public, the consumer, and farmworkers. In the United States, various states have laid out regulations for the use of reclaimed water in irrigation for the non-food crop [13] such as, Californian Standards Title 22 [18]. The current feasibility for reclaimed water reuse in Egypt is in the irrigation of forests for wood production and environmental protection. The current reclaimed water reuse standards for irrigation purposes in Egypt were examined and compared to the organizations and some Mediterranean countries that have modified reclaimed water reuse standards in irrigation. Consequently, a reclaimed water reuse standard for indirect irrigation in terms of salinity, nutrients, turbidity, TSS, pathogens, trace elements, (BOD), and (COD) for cooking vegetables and cooking crops for human consumption were suggested. Table 2 summarizes a comparison for the reclaimed water reuse standards for (WHO) 2006 [12], (USEPA) 2012 [13], Cyprus [15], Italy (Italian Decree 2003) [17], Spain (Spanish Royal Decree 2007) [19, 20] and Egypt Decrees [22, 23]. The investigated water quality parameters were in terms of Fecal Coliforms (FC) (/100 mL), Turbidity (NTU), Total Suspended Solids (TSS in mg/L), (BOD) (mg/L), (COD) (mg/L), Odour, Total Nitrogen (TN) in mg/L, Total Phosphors (TP) in mg/L, pH, Intestinal nematodes (No./L) and the Electric Conductivity (EC) in µs/cm. In addition, Table 3 summarizes trace elements concentration for the reclaimed water uses standard.

Table 2: Reclaimed water reuses standards for Egypt, organizations and some Mediterranean countries.

Parameters	US EPA (2012) [13]		WHO (2006) [12]		Cyprus (2015) [15]		Italian Decree (2003) [17]	Spanish Royal Decree (2007) [19, 20]		Egypt Decree (2013) [22, 23]
Coliform (cfu/100 mL)	Processed food crops	FC (cfu) ≤200 (Median)	Restricted	E. coli (cfu) ≤1000	Crops for human consumption	FC (MPN) ≤ 1000	E. coli (cfu) ≤ 100 (max) ≤ 10 (80%)	Cooking crops for human consumption	E. coli (cfu) ≤ 1000	-
	Food crops	ND FC (Median)	Unrestricted	E. coli (cfu) ≤ 10000	Cooking vegetables	FC (MPN) ≤100		Cooking vegetables	E. coli (cfu) ≤ 100	
Turbidity (NTU)	Processed food crops	≤ 2 (average)	(a)		-		-	Cooking crops for human consumption	-	-
	Food crops	-					-	Cooking vegetables	≤10	
Total Suspended solids (TSS) (mg/L)	Processed food crops	-	-		Crops for human consumption	≤45	≤ 10	Cooking crops for human consumption	≤35	-
	Food crops	≤ 30	-		Cooking vegetables	≤15		Cooking vegetables	≤20	
(BOD) (mg/L)	Processed food crops	≤30	-		Crops for human consumption	≤ 30	≤ 20	-	-	≤ 30
	Food crops	≤ 10	-		Cooking vegetables	≤ 15		-	-	
COD (mg/L)	-		-	-	-	-	≤ 100	-	-	≤50
Odour	-		-	-	-	-	-	-	-	-
(TN) (mg/L)	-		-	-	-	-	≤ 15	-	-	≤ 15
(TP) (mg/L)	-		-	-	-		≤ 2	-	-	≤ 3.0
(pH)	6.0 - 9.0		-	-	-	-	6.0 - 9.5	6.0 - 8.4	-	6.5-8.5
Intestinal nematodes (No./L)	-		≤ 1.0		ND		-	≤ 1(1/10 L)		-
(EC) (μs/cm)	Processed food crops	≤ 2000	-	-	-	-	≤ 3000	-		≤ 2000
	Food crops	≤ 700	-	-	-	-				

(a) No recommendations, ND = not detected, (FC) = Faecal coliform, Escherichia coli = E. coli, Colony-forming unit = (cfu), Electric conductivity = (EC), Biochemical oxygen demand = (BOD), Total Nitrogen (TN), Total Phosphors (TP) and Chemical oxygen demand = (COD).

Table 3: Trace elements concentration for the reclaimed water reuse standard for Egypt, organizations and some Mediterranean countries

Parameters	Unit	(WHO) (2006) [12]	(USEPA) (2012) [13]	Italian decree (2003) [17]	Cyprus [15]	Spanish decree (2007) [19, 20]	Egypt decree (2013) [22, 23]
Aluminium (Al)	(mg/L)	5.0	5.0	-	5.0	1.0	-
Beryllium (Be)	(mg/L)	0.1	0.1	0.1	0.1	0.1	-
Arsenic (As)	(mg/L)	0.1	0.1	0.1	0.1	0.02	0.01
Cadmium (Cd)	(mg/L)	0.01	0.01	0.01	0.01	0.005	0.001
Boron (B)	(mg/L)	0.75	0.7	-	0.75	1.0	0.5
Copper (Cu)	(mg/L)	0.05	0.05	0.05	0.05	0.05	-
Chromium (Cr)	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.05
Cobalt (Co)	(mg/L)	1.0	1.0	-	-	1.5	0.5
Iron (Fe)	(mg/L)	0.2	0.2	0.2	0.2	1.0	0.01
Fluoride (F)	(mg/L)	5.0	5.0	-	5.0	0.1	0.01
Manganese (Mn)	(mg/L)	5.0	5.0	-	5.0	2.0	0.5
Lead (Pb)	(mg/L)	0.2	0.2	0.2	0.2	0.2	0.2
Lithium (Li)	(mg/L)	2.5	2.5	-	2.5	-	-
Nickel (Ni)	(mg/L)	0.2	0.2	0.2	0.2	0.2	0.02
Molybdenum (Mb)	(mg/L)	0.01	0.01	0.01	0.01	-	0.07
Selenium (Se)	(mg/L)	0.02	0.02	0.02	0.02	0.01	0.01
Zinc (Zn)	(mg/L)	0.1	0.1	0.1	2.0	0.1	-
Vanadium (V)	(mg/L)	2.0	2.0	-	0.005	0.5	0.01
Cyanide (CN)	(mg/L)	-	-	-	-	0.001	0.001
Mercury (Hg)	(mg/L)	-	-	-	-	0.05	0.005
Tin (Sn)	(mg/L)	-	-	-	-	3.0	-
Thallium (Ti)	(mg/L)	-	-	-	-	0.001	-
Phenolates	(mg/L)	-	-	-	-	-	0.02
Detergents	(mg/L)	-	-	-	-	-	0.5

World Health Organization = (WHO) and United States Environmental Protection Agency = (USEPA)

Table 4: Proposed reclaimed water reuse standards for indirect irrigation purposes in Egypt

Parameter	Unit	Reclaimed water uses for indirect irrigation	
Coliform	CFU/100 mL	Cooking crops for human consumption	Faecal coliform (FC) ≤200 (CFU) (Median)
		Cooking vegetables	ND FC (Median)
Turbidity	(NTU)	Cooking crops for human consumption	-
		Cooking vegetables	≤10
Total suspended solids (TSS)	(mg/L)	Cooking crops for human consumption	≤ 35
		Cooking vegetables	≤ 15
(BOD)	(mg/L)	Cooking crops for human consumption	≤ 30
		Cooking vegetables	≤ 15
Electrical conductivity (EC)	(µs/cm)	Food crops	≤ 700
		Processed food crops	≤ 2000
Odour	-	-	
(COD)	(mg/L)	≤ 30	
(TP)	(mg/L)	≤ 2	
(TN)	(mg/L)	≤ 15	
(pH)	(mg/L)	6.5 - 8.5	
Aluminium (Al)	(mg/L)	5.0	
Beryllium (Be)	(mg/L)	0.1	
Arsenic (As)	(mg/L)	0.1	
Cadmium (Cd)	(mg/L)	0.01	
Boron (B)	(mg/L)	0.75	
Copper (Cu)	(mg/L)	0.2	
Chromium (Cr)	(mg/L)	0.1	
Cobalt (Co)	(mg/L)	0.05	
Iron (Fe)	(mg/L)	5.0	
Fluoride (F)	(mg/L)	1.0	
Manganese (Mn)	(mg/L)	0.2	
Lead (Pb)	(mg/L)	5.0	
Lithium (Li)	(mg/L)	2.5	
Nickel (Ni)	(mg/L)	0.2	
Molybdenum (Mb)	(mg/L)	0.01	
Selenium (Se)	(mg/L)	0.02	
Zinc (Zn)	(mg/L)	2.0	
Vanadium (V)	(mg/L)	0.1	
Cyanide (CN)	(mg/L)	0.001	
Mercury (Hg)	(mg/L)	0.01	
Tin (Sn)	(mg/L)	0.005	
Thallium (Ti)	(mg/L)	-	
Phenolates	(mg/L)	0.02	
Detergents	(mg/L)	0.02	

Biochemical oxygen demand = (BOD), Chemical oxygen demand = (COD), Total Nitrogen = (TN) and Total phosphorus = (TP).

From the above examination, proposed Egyptian executive regulation of Law 48/1982 [22, 23] that protects freshwater watercourses from pollution in terms of salinity, nutrients, turbidity, (TSS), pathogens, trace elements, (BOD) and (COD) were turbidity (NTU) for cooking vegetables is 10, (TSS) for cooking vegetables is 10 mg/L and for cooking crops for human

consumption is 35 mg/L. (BOD) concentration for cooking crops for human consumption is 35 mg/L, and for cooking vegetables is 15 mg/L. (COD) concentration is 35 mg/L. The previous proposed reclaimed water standards were used by Ahmed Rashed (2016) [29] within the Lake Manzala engineered wetland project to cultivate tomato, eggplant, and chilli pepper on rice bale media placed on an extremely saline sodic soil in the Lake Manzala area using treated drainage water. Irrigation water quality parameters were (EC) 5.45 dS/m^{-1}, (pH) 7.95, dissolved oxygen (DO) 5.3 mg/L, (BOD) 6.17 mg/L, (TN) 5.22 mg/L, (TP) 1.82 mg/L, and Facle coliform (FC) 230 FCU/100 mL the yields produced per hectare were 30.0 ton for Tomato, 23.3 ton for Eggplant and 6.67 ton for Chilli Pepper. In addition, Egypt Decree 92/2013[22] not detected concentration of the Aluminium (Al), Cobalt (Co), Beryllium (Be), Lithium (Li) and Vanadium (V). Based on the compassion of the trace elements concentrations for reclaimed water reuse presented in Table 3. The study proposes a concentration for Al, Co, Be, Li and V in mg/L of 0.5, 0.1, 0.05, 0.01 and 0.1 mg/L respectively. In addition, the Egypt Decree put high levels for Molybdenum (Mb) concentration (0.07 mg/L), the study proposes a concentration of 0.01 mg/L. Finally, the study proposes standard for the reclaimed water reuse in irrigation purposes in Egypt as shown in Table 4.

4. CONCLUSIONS AND FUTURE DIRECTIONS

Egypt's potentialities of reclaimed water reuse in irrigation purposes are available under the constraints of the start-up treatment process for five billion cubic meters per year of agriculture wastewater and domestic water. Many lows in Egypt control wastewater reuse such as Egypt decrees no. 92/2013, and no. 208/2018 for protection of Nile River and its waterways from pollution [22, 23]. Law No. 93/1962 concerning the disposal of liquid wastes and its executive regulation [24] and ECP 501 (2015) Egyptian code of practice for the use of treated municipal wastewater for agricultural purposes [26] in case of direct irrigations purposes. Therefore, the need to a one normative (standard) for wastewater reuse in Egypt is an important issue for the sustainable uses of reclaimed water in irrigation purposes.

Based on the reviewing of the reclaimed water reuse standard for indirect irrigation in Egypt, WHO, USEPA, Spain, Italy, and Cyprus. We propose a standard for the reclaimed water reuse in indirect irrigation purposes in Egypt. The proposed standards are in terms of salinity, nutrients, turbidity, total suspended solids (TSS), pathogens, trace elements, (BOD) and (COD) as following: turbidity in (NTU) for cooking vegetables 10. (TSS) for cooking vegetables 10 mg/L and for cooking crops for human consumption is 35 mg/L. (BOD) concentration for cooking crops for human consumption is 35 mg/L, and for cooking vegetables is 15 mg/L. (COD) concentration is 35 mg/L. The proposed standards put concentrations of some heavy metals in mg/L for the Aluminum (Al), Cobalt (Co), Beryllium (Be), Lithium (Li), and Vanadium (V) that not detected in the Egyptian Decree 92/2013 [22]. This concentration values are 0.5, 0.05, 0.02, 0.5 and 0.05 respectively. In addition, the Egyptian Decree put high levels of Molybdenum (Mb) (0.07 mg/L) and the study proposes concentration of 0.01 mg/L. Finally, the study proposes the application of (USEPA) 2012 standards [13] for pathogens concentration. The suggested standards are expected to encourage reclaimed water reuse in Egypt and to provide new suitable standards for future sustainable reclaimed water reuse practices in agriculture. For the sustainability and safe application of reclaimed water reuse in the new industrial cities and irrigation projects, the study recommends to carry out feasibility and environmental impact assessment studies to convince the public that such practice when properly applied will not impose risks to public health. The publics-on an individual basis must be convinced through policies to use treated domestic effluents in their own private applications: landscaping, firefight, etc. and rural housing complexes, tourist resorts, and remote industrial projects are required-by-law to implement on-site wastewater treatment and reuse systems. These users can be encouraged to reuse the reclaimed water effluent by providing attractive incentives including tax deductions and free grants. Strict monitoring of the environmental protection law is essential in this regard.

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دراسة معايير وأفاق اعادة استخدام المياه العادمة المعالجة في أغراض الري بمصر

تعد مواضيع معالجة المياه العادمة وإعادة استخدامها ذات أهمية كبيرة، خاصة في المناطق التي يمثل فيها نقص الموارد المائية التقليدية مشكلة أساسية ، كما هو الحال في مصر. تتناول هذه الورقة البحثية كل من: (أ) الوضع الحالي لمجالات إعادة استخدام المياه العادمة المعالجة في مصر ، (ب) الخطة الوطنية المستقبلية لإعادة استخدام المياه العادمة المعالجة في مصر ، (ج) فحص معايير إعادة استخدام المياه العادمة المعالجة في مصر ومقارنتها بمعايير بعض المنظمات الدولية وبعض الدول بحوض البحر المتوسط التي وضعت معايير حديثة لإعادة استخدام المياه العادمة المعالجة في اغراض الري. تتوفر إمكانات إعادة استخدام المياه المستصلحة في مصر لأغراض الري في ظل قيود عملية بدء التشغيل لخمسة مليارات متر مكعب من مياه الصرف الزراعي الملوثة والمخلفات السائلة المنزلية. في ضوء المقارنة المذكورة تم تقديم مسودة مقترحة لمعايير إعادة

استخدام المياه العادمة المعالجة في اغراض الري الغير مباشرة في مصر بدلالة الملوحة ، المواد العضوية ، نسبة العكارة ، إجمالي المواد الصلبة العالقة (TSS) ، البكتريا ، العناصر الثقيلة، الأوكسجين الحيوي المستهلك (BOD) ، الأكسجين الكيميائي المستهلك (COD). اقترحت الدراسة معايير إعادة استخدام المياه العادمة المعالجة في اغراض الري الغير مباشرة في مصركالتالي: درجة العكارة لخضروات الطبخ 10(NTU) ، إجمالي تركيز المواد الصلبة العالقة لطهي الخضروات 10 مجم / لتر ولمحاصيل الطهي للاستهلاك البشري 35 مجم / لتر، تركيز الأكسجين الحيوي المستهلك لري محاصيل الطهي للاستهلاك البشري هو 35 مجم / لتر، وخضروات الطهي 15 مجم / لتر. تركيز الأكسجين الكيميائي المستهلك (COD) 35 مجم / لتر. تقترح الدراسة تركيزات لبعض المعادن الثقيلة مثل الألومنيوم (Al) ، والكوبالت (Co) ، والبريليوم (Be) ، والليثيوم (Li) ، والفاناديوم (V) التي لم يتم ادراجها في المرسوم المصري المحلي 92 / 2013 لوزارة الموارد المائية والري كالتالي: 0.5 ، 0.05 ، 0.02 ، 0.5 ، 0.05 مجم / لتر على التوالي. بالإضافة إلى ذلك ، وضع المرسوم المصري تركيز عالي لعنصر الموليبدينوم (Mb) قيمة (0.07 مجم / لتر) ، وتقترح الدراسة تركيز 0.01 مجم / لتر. واخيرا تقترح الدراسة تطبيق معايير وكالة حماية البيئة الامريكية (USEPA 2012) اتركيزات للبكتريا ومسببات الأمراض. من المتوقع أن تشجع هذه الدراسة إعادة استخدام المياه العادمة المعالجة في مصر لري الزراعات في المستقبل تم مقارنة المعايير المقترحة مع الدراسة التي تم تنفيذها في مشروع معالجة مياه الصرف الملوثة باستخدام طريقة الارضي الرطبة للباحث احمد راشد [29] حيث قام بزراعة الباذنجان والفلفل والطماطم بنجاح. تقترح الدراسة من أجل الاستدامة والتطبيق الآمن لإعادة استخدام المياه العادمة المعالجة في أغراض الري عمل دراسات جدوى استخدام المياه العادمة المعالجة المقترحة وتقييم الأثر البيئي للمشاريع استصلاح الاراضي والمدن الصناعية الجديدة. 2. نشر ثقافة اعادة استخدام المياه العادمة المعالجة في مجال الزراعة، المناظر الطبيعية، ومكافحة الحرائق.