WASTEWATER REUSE STANDARDS FOR AGRICULTURE IRRIGATION IN, EGYPT

Mohamed ELSayed Gabr

Assistant Professor, Civil Engineering Department, High Institute for Engineering and Technology, New Damietta, Ministry of High Education, Egypt., E-mail: m_egabr@yahoo.com

ABSTRACT

Water quality is a vast and very complex topic.A complete definition of the wastewater reuse standards for agriculture irrigation (cooked vegetables and cooked crops for human) in Egypt is not exist and the monitoring components that determine if the effluent is suitable for irrigation usesare insufficient. This paper considers: (a) the current wastewater reuse in Egypt, (b) future national water plan for wastewater reuse in Egypt, (c) examining the standards of the wastewater reuse in Egypt, organizations, and countries that have modified wastewater reuse standards. A draft proposed standards for direct and indirect wastewater reuse in Egypt were presented. The proposed draft is in terms of salinity, nutrients, turbidity, total suspended solids (TSS), pathogens, trace elements, biochemical oxygen demand (BOD), and chemical oxygen demand (COD).This study is expected to encourage wastewater reuse in Egypt and provide new suitable standards for future sustainable wastewater reuse in agriculture practices.

Keywords: WastewaterReuse, Irrigation Water Standards, agriculture practices.

1 INTRODUCTION

Water quality is defined by several parameters known as physical, chemical and biological. The deterioration of the quality of the surface water, groundwater systems is mainly controlled by the geological structure and the lithology of the watersheds/aquifers, the chemical reactions that take place within the watershed/aquifers as well as type of the land use and the anthropogenic activates (Loukas 2010, Melidis et al. 2007, Tsakiris et al. 2009). Furthermore, the quality of the water resources is vulnerable to a wide range of chemical components including organic pollutants (materials), salts, nutrients, heavy metals, sediments, etc. (Korfali and Jurdi 2011,Qadir 2010).Wastewater reuse as an agriculture water is increasing international interest (Meda et al. 2010).

The indirect wastewater reuse as agricultural water is frequently being perceived as an appreciated resource where, the demand for fresh water intensifies to compensate between supplies and demands. Direct wastewater reuse as agriculture water means the irrigation from the direct supplying coming from wastewater treatment plant, while indirect wastewater reuse is pumping treated wastewater into a watercourse, which is conveying irrigation water (Jeong et al. 2016).

The quality of wastewater treatment plant (WWTP) effluent controls the direct wastewater reuses, while the indirect wastewater reuses quality control is difficult because it is dependent on both the hydrological characteristics of the watercourse that is disposed off and the treated wastewater effluent quality. (Hanseok et al. 2016). The wastewater quality for indirect irrigation must be strictly controlled to prevent soil contamination. The accumulation of substances in the soil voids are harmful for crop growing and causing the microbe infection and soil deterioration (Rhee et al. 2009).

The periodic monitoring and analyzing processes of irrigation water quality are important issues to maximize crop productivity. The originations and many countries have laid the wastewater standards for agriculture irrigation, the United States Environmental Protection Agency (US EPA) and the World Health Organization (WHO) have suggested and modified water quality guidelines or standards for safe wastewater reuse (Westcot and Ayers 1985, USEPA 2012, and WHO 2006).

Countries such as France, Cyprus, (Hanseok et al. 2016 and Paranychianakis et al. 2015), Greece (Agrafioti 2012), Italy (Italian Decree 2003 and Angelakis et al. 2008), and Spain (Spanish Royal Decree 2007 and Ortega et al. 2009), have all recently modified wastewater quality standards for safe ruse. Egypt laid out water quality criteria and specifications for freshwater watercourses (Nile River and its branches) where treated industrial and sewage wastewater is disposed off. In addition, wastewater quality standards for discharging treated industrial wastewater into the Nile River and its branches in 1982 by the low 48/1982 and its Executive Regulations, and then it amended in 2013 by the Decree of Minister of Water Resources and Irrigation no. 92. Egypt also classified treated wastewater (TWW) into three groups: primary, secondary, and advanced TWW for direct agricultural reuse in Decree No. 44 of 2000.In Egypt, reuse of treated wastewater (domestic and industrial) is considered an effective saving measure in areas where this water would otherwise flow to sinks. Primary use of treated wastewater in Egypt is for irrigation of green areas (landscape development) and irrigation of non-food agriculture (MWRI 2005). The feasibility of treated wastewater for irrigation well largely depend on: the type of treatment and type of industrial pollutants, availability of suitable area for irrigation, cropping pattern, irrigation method and soil type, matching of supply and demand, environmental impact, and cost.

Degradation of fresh water quality is becoming increasingly important, especially with regard to salinity, trace elements and toxic organic compounds, which needs a big cost for treatment. Pumping treated wastewater into fresh watercourses or lakes for processes of treated wastewater dilution is an important issue causing water deterioration. Therefore, the need for strictly standards control the indirect wastewater reuses as agriculture water is necessary.

This paper considers the current wastewater reuse and the future national water plan for wastewater reuse in Egypt, examining the standards of wastewater reuse for agriculture irrigation in Egypt, organizations, and countries that applied modified wastewater reuse standards in agriculture practices. A proposed draft for wastewater reuses standards for agriculture irrigation (cooked vegetables and cooked crops for human consumption) in Egypt, were presented considering, salinity, nutrients, turbidity, total suspended solids (TSS), pathogens, trace elements, (BOD), and (COD).

2 WATER RESOURCESAND USES IN EGYPT

Egypt share of Nile water 55.5 BCM/Y does not satisfy Egypt’s water demands. The current available water resources in Egypt are limited and there is a big gap between the total water supply and the total current water demands due to urbanization and population growth. The water resources in Egypt are surface water from Nile 55.5 BCM/Y. Effective rains 1.6 BCM/Y on the northern region lies on the Mediterranean Sea. About 2.4 BCM/Y from non-renewable deep ground water in the western desert to Sinai and from shallow groundwater 6.5 BCM/Y in western desert. The total water supply is 66 BCM/Y and the total water demands in several activities is 79.5 BCM/Y in 2017 (Mohie and Ahmed 2016).

The current population in Egypt is 94 million capita (CAPMAS 2017). To satisfy the Egyptian water demands, the shortage of 13.5 BCM/Y of water should be accomplished through non-confidential water resources such as indirect wastewater reuse and agriculture wastewater reuse of good quality. The agriculture sector is the biggest consumer of freshwater 80 % of the total demands, the agriculture wastewater reuse is increasing from 5.4 BCM in 2005–2006 to 11.7 BCM in 2014–2015. Total production of refined water (fresh-piped water) by Egyptian producers in 2014–2015 was 8.9 BCM/Y (Tamer et al. 2017). The expected total water shortage in 2025 would be 26 BCM/Y comprises 18.3 BCM/Y in the agricultural land, 5.0 BCM/Y in the agricultural land consuming deep groundwater and 2.7 BCM/Y in the new reclamation lands projects 750,000 feddan, respectively. (Mohie and Ahmed 2016).

Egypt facing many challenges to satisfy its water demands, where the available water resources limitation and the deterioration of water quality by the demand side. Non-confidential water resources such as indirect wastewater reuse and agriculture wastewater reuse of good quality are the future key solutions to fulfil the shortage in water supplies.

Two laws and three decrees address the Egyptian water quality separately.Law 48 regulates treated wastewater discharges to the Nile and its branches, canals, drains, and ground waters by the Ministry of Water Resources and Irrigation (MWRI). Licenses are issued to factories, sanitary sewage treatment plants, and river boats, upon application, as long as the effluents meet certain standards and other conditions. Fine, jail sentence, or both prohibit unofficial Discharging or discharging in amounts or concentrations that exceed license limits. Other provisions of the law state that licenses may be withdrawn under several conditions, including failure to immediately reduce a discharge presenting an immediate danger of pollution or failure to install treatment yielding appropriate effluent quality within three months (Tamer et al. 2017). The law gives MWRI administrative and police authority over implementation; the Ministry of Interior's Water Police also have police powers, and the Ministry of Health has a standard-setting and discharge-monitoring role.

Water quality standards are specified in the implementing decree for Law 48 (Decree 8/1983). During 2013, the Executive Regulation of this Law was amended by the Minister of Water Resources and Irrigation via Decree No. 92 of 2013 for the following classifications:
- Criteria and specifications for waterways where sewage is disposed off.
- Criteria and specifications for effluents (treated industrial discharges to the Nile and canals.
- Criteria and specifications for waterways before going into the fresh water waterways (treated industrial and sanitary waste discharges to drains, lakes, and ponds).
- Criteria and specifications for non-fresh water bodies.

Law 93/1962 concerns the construction of sewers and sewage treatment facilities and the allowed discharges of residential, commercial, and manufacturing facilities to sewers. Ministerial Decree 9/1989 revised the standards laid out in this law. Although originally intended to control discharges to surface waters, Law 48/1982 removed this function from Law 93/1962. The revised standards cover discharges of industrial waste to sewers and the land application of treated sewage on clay and sandy soils. The Ministry of Housing, Utilities and Urban Communities (MHUUC) implement the Law 93/1962. The significance of this decree is that it specifies less stringent standards for industrial facilities that discharge to sewers due to the additional treatment that would occur before discharge. In, 2000 the MHUUC amended the Executive Regulation of this law through Decree No. 44 of 2000.

2.1 Present wastewater in Egypt

2.1.1 Domestic Wastewater

Urbanization in Egypt population places, increased stresses on the domestic central wastewater treatment systems. The total collected wastewater in 2014–2015 is 5.048 BCM and the total TWW represented 74.4% of the collected wastewater, the current reuse of the recycled TWW (1.3 BCM). In Egypt, TWW can contribute up to 5 BCM to water resources. Current TWW use of 1.3 BCM can be expanded to include around 3 BCM that is secondarily treated by Egyptian wastewater plants. Also an opportunity to improve the infrastructure of the treatment plants that are now treating less than 75% of the collected wastewater (Tamer et al. 2017; CAPMAS 2016).Now, the primary use of treated wastewater is for irrigation of green areas (landscape development) and irrigation of non-food agriculture (MWRI 2005).

2.1. 2 Agricultural Drainage Water

In Egypt, agricultural drains are collecting huge amounts of mixed pollutants. These drains discharge their effluent to the River Nile, branches, costal lakes and Mediterranean Sea. The pollutants may incorporate domestic and/or industrial wastewater (raw, treated or partially treated effluent) (MWRI 2005). Reuse practices of agriculture wastewater in Egypt are, official reuse planned and managed by MWRI by collecting agriculture wastewater in the main drains and mixing them with fresh water in main canal through mixing pump stations (Lubna and El Gammal 2014). Agriculture wastewater in branch drains before it discharged to a more polluted main drain can be utilized for direct irrigation when the water have an appropriate quality and under a pre-permission from (MWRI). Unofficial reuse is defined as farmer's direct reuse the agriculture drainage water without pre-permission from (MWRI 2005). It exists wherever canal water unavailable, mainly at canals ends (Ayman and Abdelazim 2013). Bahr E-Bagar drain, Edko drain, Mouheet drain, and El-Gharbia drain are agriculture drains collect treated and untreated wastewater located in the Eastern, western, and middle of Egyptian Delta respectively, with Greater Cairo and Alexandria. Many studies were carried out to investigate, the suitability of the water carried by this drains in irrigation and its environmental assessment on lake EL-Manzala and lake Edko, the conclusion, was that a prior water treatment is needed (Tamer A., et al. 2017; Alaa F., 2015; Ahmed et al. 2013; Abd El-Motaleb et al. 2013, Saad et al. 2013; Mohamed et al. 2017). A future horizontal expansion of 230000 faddan that is based on treated wastewater from that drains (MWRI 2005) .

Bahr E-Bagar Drain

Bahr El-Bagar drain has two main branches: Qalubia drain and Belbaise drain (Fig. 1). The total catchment area of Bahr El Bagar Drain system is 760 x 10^3 feddan (307.6 x 10^6 hectare) with total discharge to Lake Manzala is 1.4 BCM/Y. The state of the Qalubia main drain is more severe compared with the Belbaise Drain. Qalubia's main 14 branches (intermediates) collect treated and untreated wastewater legally and illegally from the heavily populated area of Shobra El-Khemma and its large industrial area, together with the urban communities of Qalubia and Sharkia Governorates (MWRI 2005).

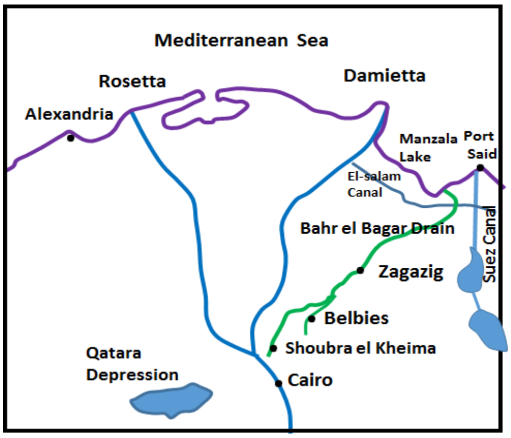

Figure 1. Bahr El-Bagar Drain

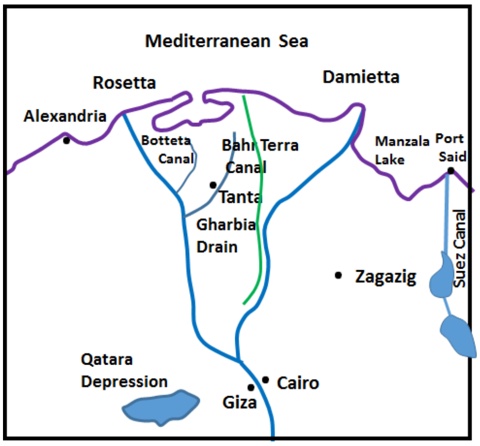

Figure 2. El-Gharbia Drain

El-Gharbia Drain

Gharbia Drain has a catchment area estimated at 283.3 x 10^3 hectare and covering a heavily populated area in Gharbia and Kafr El-Sheikh Governorates (Fig. 2). Gharbia drain has two mixing pump stations downstream from El-Segaeia. The first is El-Hamoul, which has a discharge of 0.55 BCM/Y., reaching 0.66 BCM/Y.in summer to supply Bahr Terra Canal. The second is Botteta mixing pump station. El Gharbia drain in high priority for immediate protection against pollution (MWRI 2005).

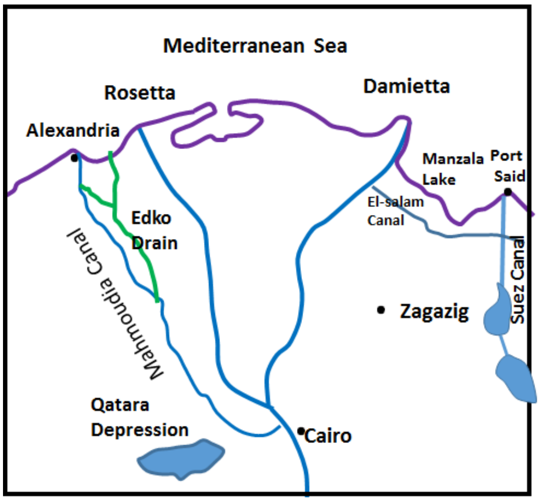

Figure 3. Edko Drain

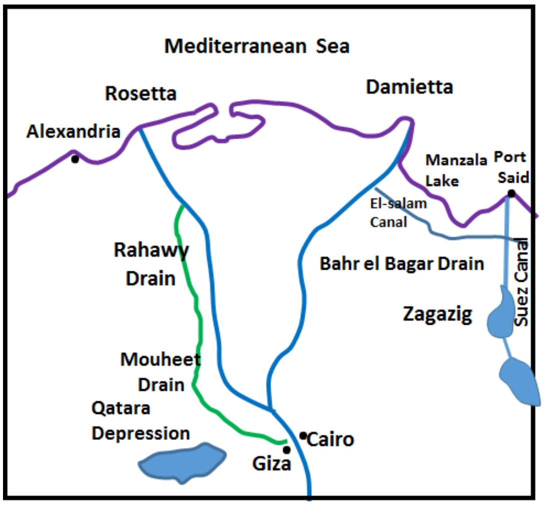

Figure 4. Mouheet Drain

Edko Drain

Edko Drain in Behera Governorate as shown in Fig. 3 supplies El-Mahmoudia Canal with Agricultural Drain water in order to cover the need for irrigation along the canal and for drinking water for Alexandria Metropolitan area. Edko drain catchment area covers a highly populated governorate in which the quality of water in the drain system is deteriorating due to legal and illegal discharging of wastewater (MWRI 2005)

Mouheet Drain

El Mouheet Drain in Giza (Fig. 4) is considered one of the most polluted main drains in Egypt; it discharges its water into the River Nile (Rossetta Branch) via Rahawy Drain. Two main treatment plants are located within the catchment area of El Mouheet drain: Abu Rawash and Zenein plants and both are discharging their treated wastewater effluent and raw wastewater overloads to this drain.

2.2 Future wastewater reuse in Egypt

The Egyptian Laws No. 12/1984 and No. 213/1994 are regulating irrigation and drainage systems including main canals, feeders and drains usage and management by public and private sector. The laws also provide legal directions for the operation and maintenance of public and private waterways and specify arrangements for cost recovery in irrigation and drainage networks. This will stay viable, until the year (2017), when the current wastewater-recycling program will be completed. According to Water for Future-National Water Plan for Egypt-2017 a total volume of treated wastewater of 1.4 billion m3/year could irrigate about 300000 feddan. Even when high irrigation efficiencies are assumed, the overall water use efficiency of the available wastewater flow will not higher than about 65 to 70 %. By that time (2017), Egypt must start implementing new strategies, to meet the "post 2025" irrigation and domestic water requirements (MWRI 2005).

Actions (carrying out feasibility studies, including environmental impact for reuse of treated wastewater in the new industrial cities) should be taken to implement policies for reusing the treated wastewater. These policies must aim to convincing the publics that such practice, when properly carried out; impose no risk to the public health. The Egyptian rules and regulations, right now, does not allow for treated "domestic" wastewater effluent for use in irrigating edible crops. This may continue for the next decade, as the current feasibility for irrigating "forests" for wood production and environmental protection are still prospective. Publics-on individual basis, must be convinced, through policies, to, use treated domestic effluents in their own private applications: landscaping, firefighting… etc.

Rural housing complexes, touristic 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 treated wastewater effluent by providing attractive incentives including tax deductions and free grants. Strict monitoring of the environmental protection law, in this regard is essential. Development of various technologies and management arrangements for domestic wastewater, which may be appropriate for implementation in urban areas, must be encouraged .

New communities (water borders and water user associations) must be designed for water and wastewater connections: The first, for drinking purpose, originally sourced from River Nile, branches, or similar fresh water supply. The second, for wastewater collection and treatment, individual or central. The third, for treated wastewater reuse. Realistic and acceptable standards for wastewater treatment and reuse in irrigation for cooked vegetables and cooked crops for human consumption must be promoted.

3 IRRIGATION WATER CRITERIA

Watercourses conveying irrigation water must be have a planned program for water quality monitoring and analyzing especially if the treated wastewater is dumped into this watercourses. The water quality parameters, hydrogen ion concentration, salinity, organic matters, and trace elements must be determined.

3.1 Salinity

Salinity is an assets factor for agriculture water quality because high levels of salinity in soil can create an aggressive environment for the crop to absorb nutrients and intensify specific ion toxicity (Pereira et al. 2010 and Bauder et al. 2011). Salinity Standards for safe use of wastewater reuse in agricultural have been established by the FAO, Westcot and Ayers 1985 were modified these guidelines, they put a restriction on uses divided into three degrees of severity: none, slight to moderate, and severe.

3.2 Nutrients

Nitrogen (N) phosphorus (P) are essential elements for plant growth and development and can give a side effect on crop growth. Excessive nutrients in irrigation water are a source of groundwater contamination as well as eutrophication in coastal areas or lakes (Ju et al. 2006).

3.3 Organic Matters

The organic matter index is presented by the biological oxygen demand (BOD). At high levels of BOD, the dissolved oxygen is consumed by aerobic pictorial to complete the decomposing of organic matters to create an anaerobic state, and, during decomposition process, oxides in the soil such as Fe3+, Mn5+, and SO-4 consume oxygen to lower the oxidation-reduction potential. In the end, the generated manganese, iron, and sulfide along with organic acids can disturb the paddy rice to absorb nutrients (Asano et al. 2007)

3.4 Hydrogen Ion Level

PH is an index for acidity upon its value, a quick assessment for water quality can be done. Normally, the pH for agriculture water ranges from (6.5 - 8.4). The pH values for irrigation water outside of the normal range might be suitable for agriculture, but it can be cause an imbalance of nutrients or contain toxic ions, (Westcot and Ayers 1985). The abnormal pH concentrations in water represents a hazards on the trickle irrigation facilities (Asano et al. 2007, Brian and Blake 2002).

3.5 Trace Elements

Crops need trace elements in water for growth processes, but high rates of trace elements concentrations in water can cause plants harm. Copper (Cu) can cause loss of root growth and leaf chlorosis (Asano et al. 2007). Zinc (Zn) and arsenic (As) have significance harm on stem chlorosis and root growth suppression (Asano 2007). Aluminum (Al), in acidic soil, can decrease crop productivity. Lead (Pb) and cyanide (CN) are normally strictly restricted since, when dissolved in water or soil, they accumulated by time in the crop and causing harmful to the human (WHO 2006). Molybdenum,nontoxic to plants; can be toxic to livestock if forage is grown in soils with high molybdenum(WHO 2006). The FAO's guidelines for agriculture water quality has set limitations for the levels of trace elements in irrigation water, (Westcot and Ayers 1985 and WHO 2006).

4 PROPOSED DRAFTINDIRECT WASTEWATER REUSE STANDARDS IN EGYPT

Non-food crops (seed crops, processed food crops, orchard crops, fodder crops, industrial crops etc.) irrigated with treated wastewater have some acceptance by the agricultural community. Many countries use the WHO guidelines, which are risk-based and designed to provide a reasonable level of safety, assuming conservative levels of exposure by the public, the consumer, and farm workers. In the United States, various states have adopted regulations for use of reclaimed water for non-food crop irrigation (US EPA 2012).Organizations and countries (e.g., WHO, US EPA, Cyprus, France, Italy, Spain, and Egypt) have recommended standards for safe reuse of wastewater as agricultural water. In Egypt, MWRI has laid out water quality standards for treated wastewater to safeguard freshwater watercourses. In this paper, the standards of the indirect wastewater reuse for, WHO 2006, US EPA 2012, Cyprus (Paranychianakis et al. 2015), Italy (ItalianDecree 2003) and Spain (Spanish Royal Decree 2007), and Egypt (Decree 92/2013, Executive Regulation of Law 48/1982), were examined in Table 1 and Table 2.

The current feasibility for wastewater reuse is in irrigating forest for wood production and environmental protection. From the above examination, The EgyptDecree 92/2013, Executive Regulation of Law 48/1982 protects fresh water watercourses from pollution by the discharged effluents. The Decree 92/2013 not detected concentration of some heavy metal , Aluminum (Al), Beryllium (Be), Cobalt (Co), Lithium (Li), and Vanadium (V), the proposed concentration for this heavy metals in mg/L are 0.5, 0.1, 0.05, 0.01, and 0.1 respectively as shown in Table 3. In addition, the Decree put high levels for Molybdenum (Mb) concentration (0.07 mg/L) we propose a concentration (0.01 mg/L). A proposed draft for indirect wastewater quality reuse in Egypt is presented in Table 3.

Table 1. Irrigation Water Quality Guidelines and Standards for Wastewater Reuse in Agriculture.

Parameters	**US EPA (2012) Reclaimed water quality for irrigation**		**WHO[1] (2006) Wastewater quality for agriculture**		**Cyprus [2] (Paranychianakis 2015) Water reuse for irrigation**		**Italian Decree (2003) wastewater quality for reuse**	**Spanish Royal Decree (2007) Water quality for irrigation**		**EgyptDecree 92/2013 Indirect wastewater reuse**
Coliform (/100 mL)	Food crops	ND FC (Median)	Unrestricted	E. coli (cfu) ≤1000	Cooked vegetables	FC (MPN) ≤100	E. coli (cfu) ≤ 100 (max) ≤ 10 (80%)	cooked Vegetables	E. coli (cfu) ≤100	-
	Processed food crops	FC (cfu) ≤200(Median)	Restricted	E. coli (cfu) ≤ 10000	Crops for human consumption	FC (MPN) ≤1000		Cooked Crops for human consumption	E. coli (cfu) ≤1000	
Turbidity (NTU)	Food crops	≤2 (average)	- (a)		-		-	cooked Vegetables	≤10	-
	Processed food crops	-					-	Cooked Crops for human consumption	–	
Suspended solids (mg/L)	Food crops	-	-		Cooked vegetables	≤15	TSS≤ 10	cooked Vegetables	TSS≤20	-
	Processed food crops	TSS ≤ 30	-		Crops for human consumption	≤45		Cooked Crops for human consumption	TSS≤35	
BOD (mg/L)	Food crops	≤10	-		Cooked vegetables	≤15	≤ 20	-	-	≤ 6
	Processed food crops	≤ 30	-		Crops for human consumption	≤30		-	-	
COD (mg/L)	-		-	-	-	-	≤ 100	-	-	≤10
Odor	-		-	-	-	-	-	-	-	-
T-N (mg/L)	-		-	-	-	-	≤ 15	-	-	≤ 3.5
T-P (mg/L)	-		-	-	-		≤ 2	-	-	≤ 2.0
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(1/10L)		-
EC (μs/cm)	Food crops	≤ 700	-	-	-	-	≤ 3000	-		≤ 700
	Processed food crops	≤ 2000	-	-	-	-				

ND = not detected; TC = total coliform; FC = fecal coliform; TSS = total suspended solids. 1 The most stringent verification monitoring level, which refers to what has previously been referred to as effluent guideline levels, for each irrigation type and arithmetic mean value. 2 For vegetables eaten raw is not allowed and maximum value allowed. (a) No recommendation.

Table 2. Comparison of Recommended Maximum Concentrations of Trace Elements in Irrigation Water.

Parameters	WHO (2006)	US EPA (2012)	Cyprus (Loannis, 2013)	Spanish Royal Decree (2007)	Italian Decree (2003)	Egypt Decree 92 (2013)
Aluminum, Al	5.0	5.0	5.0	-	1.0	-
Arsenic, As	0.1	0.1	0.1	0.1	0.02	0.01
Beryllium, Be	0.1	0.1	0.1	0.1	0.1	-
Boron, B	0.7	0.75	0.75	-	1.0	0.5
Cadmium, Cd	0.01	0.01	0.01	0.01	0.005	0.001
Chromium, Cr	0.1	0.1	0.1	0.1	0.1	0.05
Cobalt, Co	0.05	0.05	0.05	0.05	0.05	-
Copper, Cu	0.2	0.2	0.2	0.2	1.0	0.01
Fluoride, F	1.0	1.0	-	-	1.5	0.5
Iron, Fe	5.0	5.0	5.0	-	2.0	0.5
Lead, Pb	5.0	5.0	5.0	-	0.1	0.01
Lithium, Li	2.5	2.5	2.5	-	-	-
Manganese, Mn	0.2	0.2	0.2	0.2	0.2	0.2
Molybdenum, Mb	0.01	0.01	0.01	0.01	-	0.07
Nickel, Ni	0.2	0.2	0.2	0.2	0.2	0.02
Selenium, Se	0.02	0.02	0.02	0.02	0.01	0.01
Vanadium, V	0.1	0.1	2.0	0.1	0.1	-
Zinc, Zn	2.0	2.0	0.005	-	0.5	0.01
Mercury, Hg	-	-	-	-	0.001	0.001
Cyanide, CN	-	-	-	-	0.05	0.005
Tin, Sn	-	-	-	-	3.0	-
Thallium, Ti	-	-	-	-	0.001	-
Phenolates,	-	-	-	-	-	0.02
Detergents,	-	-	-	-	-	0.5

Table 3. The Draft Proposed Wastewater Reuse Standards for Agriculture Irrigation in Egypt.

Parameters	Wastewater reuse for agriculture irrigation	
Coliform (/100 mL)	Cooked Vegetables	ND FC (Median)
	Cooked Crops for human consumption	FC (cfu) ≤200(Median)
Turbidity (NTU)	Cooked Vegetables	≤10
	Cooked Crops for human consumption	–
Suspended solids (mg/L)	Cooked Vegetables	TSS ≤ 15
	Cooked Crops for human consumption	TSS ≤ 35
BOD (mg/L)	Cooked vegetables	≤ 15
	Crops for human consumption	≤ 30
COD (mg/L)	≤ 30	
Odor	-	
T-N (mg/L)	≤ 15	
T-P (mg/L)	≤ 2	
PH	6.5 - 8.5	
EC (µs/cm)	Food crops	≤ 700
	Processed food crops	≤ 2000
Aluminum, Al	5.0	
Arsenic, As	0.1	
Beryllium, Be	0.1	
Boron, B	0.75	
Cadmium, Cd	0.01	
Chromium, Cr	0.1	
Cobalt, Co	0.05	
Copper, Cu	0.2	
Fluoride, F	1.0	
Iron, Fe	5.0	
Lead, Pb	5.0	
Lithium, Li	2.5	
Manganese, Mn	0.2	
Molybdenum, Mb	0.01	
Nickel, Ni	0.2	
Selenium, Se	0.02	
Vanadium, V	0.1	
Zinc, Zn	2.0	
Mercury, Hg	0.01	
Cyanide, CN	0.001	
Tin, Sn	0.005	
Thallium, Ti	-	
Phenolates,	0.02	
Detergents,	0.02	

TC = total coliform; FC = fecal coliform; TSS = total suspended solids;EC= electrical conductivity

6 CONCLUSION

About 5 BCM/Y of waste agriculture water and domestic water needs treatment, to be directly reused in the future in irrigation. For the sustainability and safe application of wastewater reuse, there needs to be a firmly water quality standards for direct and indirect wastewater reuse.Based on the result of the examined wastewater reuse standards for irrigation in Egypt, local Decree 92/2013, WHO 2006, US EPA 2012, Spanish Royal Decree 2007, Italian Decree 2003, and Cyprus (Paranychianakis et al. 2015), draft for proposed direct and indirect wastewater reuse standards in Egypt were considered the parameters of irrigation water quality: salinity, nutrients, turbidity, suspended solids (SS), pathogens, trace elements, (BOD), and (COD), Table 3.The proposed standards put concentration for some heavy metals in mg/L, Aluminum (Al), Beryllium (Be), Cobalt (Co), Lithium (Li), and Vanadium (V), which not detected in the Egyptian local Decree 92/2013, this concentration values are 0.5, 0.05, 0.02, 0.5, and 0.05 respectively,in addition, the Decree put high levels for Molybdenum (Mb) concentration (0.07 mg/L); the proposed concentration is 0.01 mg/L.US EPA 2012 standards for pathogens is proposed.The suggested standards are expected to encourage wastewater reuse in Egypt and to provide new suitable standards for future sustainable wastewater reuse in agriculture practices.

ACKNOWLEDGMENTS

I am grateful for the outstanding logistical and technical support provided by the Ministry of Water Resources and Irrigation.

ABBREVIATIONS

BCM Billion cubic meter
BCM/Y Billion cubic meter per year
CAPMAS Central Agency for Public Mobilization and Statistics.
MHUUC Ministry of Housing, Utilities and Urban Communities.
MWRIMinistry of Water Resources and Irrigation.
USEPA United States Environmental Protection Agency.
WHO World Health Organization.
WWTP Wastewater treatment plant.

REFERENCES

Abd El-Motaleb M., Adel A., Ali M., Osama A. 2017. Evaluation of Wastewater Treatment Plants in El-Gharbia Governorate, Egypt. Organic Chem Curr Res 6: 184. doi: 10.4172/2161-0401.1000184.

Agrafioti, E., Diamadopoulos, E. A strategic plan for reuse of treated municipal wastewater for crop irrigation on the Island of Crete. Agric. Water Manage. 2012, 105, 57–64.

Ahmed M., Manal G., Maged S., Hermine R., (2013). "Major constituents in Lake Edku water, Egypt" Egyptian Journal of Aquatic Research (2013) 39, 13–20.

Alaa F., 2015 . Assessing the drain estuaries' water quality in response to pollution abatement. EgyptianWater Science Journal 29 (2015) 1–18.

Angelakis, A.N.; Durham, B.; Marecos Do Monte, M.H.F., Salgot, M., Witgens, T., Thoeye, C. Wastewater recycling and reuse in Eureau countries: Trends and challenges. Desalination 2008, 218, 3–12.

Asano, T., Burton, F., Leverenz, H., Tsuchihashi, R.E., Tchobanoglous, G., 2007. Water Reuse. McGraw Hill, New York, USA.

Ayman A. and Abdelazim N., 2013. Agricultural Drainage Water Quality Analysis and Its Suitability for Direct Reuse In Irrigation: Case Study: Kafr El-Sheikh Governorate. Egypt, Seventeenth International Water Technology Conference, IWTC17 Istanbul, 5-7 November 2013.

Bauder, T.A.; Waskom, R.M.; Sutherland, P.L.; Davis, J.G. Irrigation Water Quality Criteria. Colorado State University Extension: Fort Collins, CO, USA, 2011.

Brian B. and Blake R. 2002. Treatment and Maintenance Considerations for Micro Irrigation Systems. Virginia Cooperative, publication 442-757.

CAPMAS (Central Agency for Public Mobilization and Statistics), 2016. Statistical yearbook. Cairo. Ref. No. 71-01111-2016. http://www.capmas.gov.eg. Accessed 21 Mar 2017.

Egypt Decree, 92/2013. For The Protection of the Nile River and Its Waterways from Pollution. Decree of Minister of Water Resources and Irrigation no. 92 for year 2013 for the Executive Regulation of Law 48/1982, 92/2013.

Hanseok J., Hakkwan K., and Taeil J., 2016. Irrigation Water Quality Standards for Indirect Wastewater Reuse in Agriculture: A Contribution toward Sustainable Wastewater Reuse in South Korea. MDPI, Water 2016, 8(4), 169; doi: 10.3390/w8040169.

Italian Decree, 12 June 2003. Regulating Technical Standards for Wastewater Reuse.

Ju, X.T., Kou, C.L.; Zhang, F.S., Christie, P. Nitrogen balance and groundwater nitrate contamination: Comparison among three intensive cropping systems on the North China Plain. Environ. Pollut. 2006, 143, 117–125.

Korfali, S.I and Jurdi, M. (2011) Suitability of surface water for domestic water use : Awali river case study. European Water, 35:3-12.

Loukas, A.,(2010) Surface water quantity and quality assessment in Pinios River, Thessaly, Greece. Desalination 250:266-273.

Lubna A. and El Gammal H., 2014. Appraisal of Blending Water Quality for Agricultural Reuse: Laboratory Bench-top Experiments. Life Science Journal 2014, 11(12).

Meda, A., Cornel, P., 2010. Aerated bio-filter with seasonally varied operation modes for the production of irrigation water. Water Science and Technology 61 (5), 1173e1181.

Melidis, P., Akratos, C.S., Tsihrintzis, v.a, Trilidou E.(2007) Characterization of rain and roof drainage water quality in Xanthi, Greece. ENVIRON Monit Assess, 127: 15-27.

Mohamed M., Elansary A., Moussa M. (2017), " A Modelling Approach To Manage Water Quality At Gharbia Main Drain, Egypt" Twentieth International Water Technology Conference, IWTC20 Hurghada, 18-20 May 2017 133.

Mohie and Ahmed, 2016. Water management in Egypt for facing the future challenges.Cairo University Journal of Advanced Research, 2090-1232 _ 2016 Production and hosting by Elsevier B.V. on behalf of Cairo University.

MWRI (Ministry of Water Resources and Irrigation), 2005. Water for Future-National Water Plan for Egypt-2017. Planning Sector -Ministry of Water Resources and Irrigation, Arab Republic of Egypt.

Ortega, E., Iglesias, R. Reuse of treated municipal wastewater effluents in Spain: Regulations and most common technologies, including extensive treatments. Desalin. Water Treat. 2009, 4, 148–160.

Paranychianakis, N.V., Salgot, M.; Snyder, S.A., Angelakis, A.N. Water reuse in EU states: Necessity for uniform criteria to mitigate human and environmental risks. Crit. Rev. Environ. Sci. Technol. 2015, 45, 1409–1468.

Pereira, B.F.F., He, Z.L., Silva, M.S., Herpin, U., Nogueira, S.F., Montes, C.R., Melfi, A.J., 2011 b. Reclaimed wastewater: impact on soil-plant system under tropical conditions. Journal of Hazardous Materials 192 (1), 54e61.

Qadir, M., Bahri, A., et al., 2010.Wastewater production, treatment, and irrigation in Middle East and North Africa. Irrigation and Drainage Systems 24 (1e2), 37e51.

Rhee, H.P., Yoon, C.G., Jung, K.W.; Son, J.W. Microbial risk assessment using E. coli in UV disinfected wastewater irrigation on paddy. Environ. Eng. Res. 2009, 14, 120–125.

Saad A., Marwa G., Bayoumi A., Zoghdan M., El-Dissoky R., (2013)" Sustainable safe reuse of drainage water in agriculture at North delta soils, Egypt", Journal of Chemical and Pharmaceutical Research, 2015, 7(5):1033-1043.

Spanish Royal Decree 1620/2007, 7 December 2007. Spanish Regulations for Water Reuse. Real Decreto 1620/2007.

Tamer A., Noura B, and Maha E., 2017. Reuse of Treated Wastewater in Egypt: Challenges and Opportunities. Springer International Publishing AG 2017, The Handbook of Environmental Chemistry pp 1-25.

Tamer A., Noura B., Biju G., Maha E., 2017. Assessment of Marginal Quality Water for Sustainable Irrigation Management: Case Study of Bahr El-Baqar Area, Egypt. Water Air Soil Pollut (2017) 228: 214 DOI 10.1007/s11270-017-3397-2.

Tsakiris G., Spiliotis M., Pariytsis S., Alexakis D., (2009) Assessing the water potential of karstic saline springs by applying a fizzy approach: The case of Almyros (Heraklion, Crete). Desalination 237:54-46.

USEPA (United States Environmental Protection Agency), 2012. Guidelines for Water Reuse 600/R 12/618. Washington, DC, USA.

Westcot, D.W., Ayers, R.S., 1985. Irrigation Water Quality Criteria. In: Pettygrove, G.S., Asano, T. (Eds.), Irrigation with Reclaimed Municipal Wastewater e – Guidance Manual. Lewis Publishers, Inc., Chelsea, MI.

WHO (World Health Organization), 2006. Guidelines for the Safe Use of Wastewater, Excreta and Greywater. In: Wastewater Use in Agriculture. vol. 2. World Health Organization, Geneva.