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Reuse of Municipal Wastewater in Irrigated Agriculture as a Strategy to Deal with the Water Scarcity Crisis

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Abstract:
Nowadays, the water crisis is one of the challenges that World is faced with. The lack of water resources has encouraged the researchers to use of non-ordinary waters including salinity waters, municipal and industrial wastewater. Farmers needs to treated municipal wastewater as a source of irrigation water than each other time, due to increased population and increased need for food, reduced water resources and the need to water transfer in long distances. Treated municipal wastewater is used for reducing water deficiency for irrigation, increase water use efficiency and reduce water resources pollution. In arid and semiarid climates due to the severe pressure on non-renewable. Non-conventional water sources, especially treated municipal wastewaters represent complementary supply sources that may be substantial in regions affected by extreme scarcity of renewable water resources. Therefore, use of treated municipal wastewaters is introduced to prevention of environmental pollution and as a source for irrigation in agriculture. Irrigation with treated municipal wastewater is considered an environmentally sound wastewater disposal practice compared to its direct disposal to the surface or ground water bodies. In addition, wastewater is a valuable source of plant nutrients and organic matter needed for maintaining fertility and productivity levels of the soil.

Keywords: Municipal wastewater, agriculture, irrigation, water crisis

1.0 Introduction:
Water deficiency is one of the main factors for limiting sustainable agricultural development in most arid and semi-arid regions. Nowadays farmers need to treated municipal wastewater as a source of irrigation water than each other time, due to increased population and increased need for food, reduced water resources and the need to water transfer in long distances. Treated municipal wastewater is used for reducing water deficiency for irrigation, increase water use efficiency and reduce water resources pollution (Mousavi et al., 2015). In arid and semiarid climates due to the severe pressure on non-renewable Nowadays farmers need to treated municipal drought and the increasing urbanization, optimum use of all available water resources including treated municipal wastewater is considered (Mousavi, and Shahsavari, 2014; Fonseca *et al*., 2007; Mohammad *et al*., 2007; Jimenez, 2005; Friedel *et al*., 2000).

Recently reuse of treated municipal wastewater as a non-conventional water resources are considered that can compensate the water deficiency partly. Considering that wastewater is contains elements that needed for plant nutrition, determine the correct method of using wastewater is very important to reduce the adverse effects associated with wastewater irrigation, and obtain optimum yield (Mousavi *et al*., 2013; Wang *et al*., 2007). Also need to be assessed other outcomes in irrigated with wastewater including elements changes in soil and plant, heavy metals accumulation and other pollutants (Zavadi, 2009; Al-Zoubi *et al*., 2008; Pollice *et al*., 2004). It is, possible to obtained high yields of crops without deterioration of their quality by using treated wastewater for the irrigation of crops.

In most of the crops that irrigated with treated municipal wastewater yield increased and need to use of chemical fertilizer reduced, and as a result, production costs decreased (Mousavi *et al*., 2013; Esmailiyan *et al*., 2008; Jimenez, 2005; Najafi *et al*., 2003). Alizadeh et al. (2001) reported that growth and yield of corn statistically affected with using reclaimed municipal wastewater, in this study, maximum grain and biomass were obtained of the treatment that was irrigated by wastewater. Marten et al. (1980) in a research on yield of corn and canary grass have perceived that irrigation with wastewater has significant increase on digestibility and dry matter of corn in comparison with canary grass, although amount of protein in canary grass is more than corn. Day and Tucker (1997) in the survey on sorghum found that leaf width, grain yield and postponed the sorghum maturity increased in irrigation with wastewater. Irrigation with wastewater increased yield of forage sorghum compared with irrigation with well water, wastewater irrigation also increased height, leaves green color and accelerate flowering (Jenkins *et al*., 1994). Cllap et al. (1987) studied the effects of treated municipal wastewater on maize yield and forage plants in the United States, and concluded that effect of wastewater irrigation in terms of plant needs to nutrients can be competitive with application of chemical fertilizer as ammonium nitrate. Wastewater is containing large amounts of nutrients can be used in agriculture and increase the yield of crops. Increasing amounts of organic matter and soil nutrients under the effects of wastewater application increased plant growth with positive influence on soil physical, chemical, and biological properties (Azarpira *et al*., 2014; Munir and Ayadi, 2005; Wong *et al*., 1998; Monte and Esousa, 1992). Al-Zoubi et al. (2008) in a field study, examined effect of sewage sludge on the yield of wheat, maize and peas, reported that wheat yield was not affected in sewage sludge application, but the peas and maize yields significantly increased compared with control by sewage sludge. The aim the present study was to investigate reuse of municipal wastewater in irrigated agriculture as a strategy to deal with the water scarcity crisis.

1.1 Necessitates the Use of Treated Wastewater in Irrigated Agriculture:

Nowadays, the water crisis is one of the challenges that World is faced with. The lack of water resources has encouraged the researchers to use of non-ordinary waters including salinity waters, municipal and industrial wastewater. By increasing population, water consumption increases wastewater production as well. Positive use of this new huge resource in agriculture may increase cultivate land, yield and also may decrease the environmental pollution. As FAO has reported, application of wastewater in agricultural context is its best applicability (FAO, 1985). The plant suitable nutrition and using of sufficient and suitable manure resources lead to increasing the forage quality. This rich resource from nutrient elemental especially nitrate, moreover economic advantage because of decrease chemical manure consume, can improve the forage quality (Galavi *et al*., 2009; Shanechi, 2004; Taei, 2005). Recently, many agricultural lands under cultivation of various plants such as wheat, barley, alfalfa and sorghum farms being irrigated by treated wastewater. But some deficiencies such as weak drainage, wastewater salinity (EC> 3ds/m), low annual rainfall (50 mm) and very high annual evaporation (more than 4500 mm), lead to worry in salinity, codification and destruction of region soils (Shabanian, 2004).

One of the solutions to this problem is to irrigate plant with wastewater and tap water alternately at developed stage of growth (Taei, 2005). This method could be an appropriate way to put a stop to salt accumulation and to increase the accumulated salt leaching in soil. Generally, in attention to poor pastures in arid and semi-arid region and high forage requirement for animal feeding, a proper choice to overcome this deficiency is to utilize these non-ordinary water resources. Irrigation with wastewater leads to increasing in forage qualitative yield, about 3 to 3.5 times more than irrigation with tap water. Also, it increased the stem length, chlorophyll and flowering rate (Jenkins et al, 1994). Irrigating Lettuce with municipal treated wastewater has increased the total fresh and dry weight of subterranean organ and upper organ in compare with the rest treatments (Erfani *et al*., 2002). Taei, (2005) has reported that irrigation with wastewater increased the wheat yield, as well. Day and Tucker, (1997) have reported that irrigation with wastewater increased the leaf width, grain yield and postponed the sorghum maturity. Although it had no efficacy on protein contain but it decreased some of amino acids and plant fiber (NDF and ADF[2]). Marten et al. (1980), in a research on yield of corn and canary grass have perceived that irrigation with wastewater has significant increase on digestibility and dry matter of corn in comparison with canary grass, although amount of protein in canary grass is more than corn. Crude protein increase in wheat grain has been reported in irrigation with wastewater (Taei, 2005).

In an investigation on millet, it has been reported that irrigation with wastewater has no effect on plant fat; although significant decrease in plant fiber and raise in protein (Rezvani and Baraki, 1999). The effect of municipal treated wastewater on growth and chemical compound of canola has no significant effects on protein and fat percentage; however, the protein percentage in the treats with low wastewater quantity, and fat percentage in the treats with high wastewater quantity were more than the rest (Zolfaghari, 2001; Galavi *et al*., 2010;). Wastewater because of high nitrate and other nutrient elements lead to increase the leaf to stem ratio. Eventually protein and stem fiber percentage will increase and decrease respectively, because of enhancement in water contains and WSC; Consequently, NDF decrease in forage and silage is resulted (Nakhoda, 1998). It has been shown that nitrogen fertilizer lead to increase in CP, crude fat and Ash and also decrease in celluloses, hemicelluloses, K, P, Ca, Mg, S in grasses; in addition, little decrease in Zn, B and increases of Cu, Co, NO3 attraction is reported (Vuckovic *et al*., 2005). Parhamfar (2006) in study of micro and macro elements effects on Millet forage quality has illustrated that the fertilizers such as N, Zn, Ca, and Fe increased CP, WSC.

Nakhoda (1998) reported that the increase of CP, WSC and decrease of plant fiber in Millet is a result of nitrogen fertilizer application. The present study is an investigation of Municipal Treated Wastewater effects on quality and quantity attributes in Forage Sorghum. Moreover, acquiring the most suitable application of wastewater and tap water jointly to achieve desired qualitative and quantitative yield and to put a stop to pollution accumulation in plant and soil is the another objective of this study. Water is a vital resource but a severely limited one in most countries. Municipal wastewater is a combination of the water and carried wastes removed from residential, institutional and commercial establishments together with infiltration of water, surface water and runoff water. Using large-scale wastewater irrigation on agricultural lands can be a synergistic management practice. The wastewater will have a different fate than being pumped into a river, agricultural crops can make use of the extra water and nutrients and groundwater recharge is yet another positive outcome of wastewater irrigation.

Recently, the amounts of wastewater are sharply increasing and the kinds of pollutants are also varied as the world wide industry is being developed incessantly. With respect to both the quantity and composition, the textile processing wastewater is recorded as the most polluted sources among all industrial sectors. Irrigation with treated municipal wastewater is considered an environmentally sound wastewater disposal practice compared to its direct disposal to the surface or ground water bodies. In addition, wastewater is a valuable source of plant nutrients and organic matter needed for maintaining fertility and productivity levels of the soil (Mousavi and Shahsavari, 2014; Azarpira *et al*., 2013; Mojiri *et al*., 2011).

1.2 Water Crisis and the Use of Treated Wastewater:

Currently, many countries, especially those located in the Mediterranean, are confronted with significant water shortage problems as a result of water supply insufficiency and unsuitability. Physical water scarcity and economic water scarcity by country are present in Figure 1. It is anticipated that these problems will be further exacerbated in the forthcoming decades due to the projected increase in the world population, and the anticipated increase in the water consumption per capita associated with such an increase. In conjunction with the extremely limited fresh water supplies on our planet, these phenomena make the development of monitoring and water use control systems imperative. Increasing water demand in the Mediterranean countries is driven by a number of variables, such as climatic conditions (mild winters, hot and dry summers), agricultural activities, tourism and industrial use. Also improvements in the standard of living, exploitation of underground water reservoirs and the tremendously fluctuating, unevenly distributed precipitation owing to climatic variations further aggravate the current situation. Often, the rather limited rainfall and water scarcity are a function of the contour profile of the land, and characteristic of arid climates.

The safe reuse of appropriately treated municipal wastewater could help to reduce the deficit between the water demand and the water supply currently available. Reuse of treated municipal wastewater is mainly helpful in the achievement of one basic objective; the wastewater effluents are utilized as a source of water with many significant benefits, such as eliminating their discharge into natural receptors (lakes, rivers, creeks, the sea) and, thus, avoiding the pollution of surface as well as underground water reservoirs. The basic premise of such a policy must be that municipal wastewaters may be used for whatever purpose according to demand as long as they have previously been subjected to the appropriate level of treatment and have met the quality standards requisite of such reuse purposes (Pedreroa *et al.*, 2010; Kalavrouziotis and Arslan-Alaton, 2008).

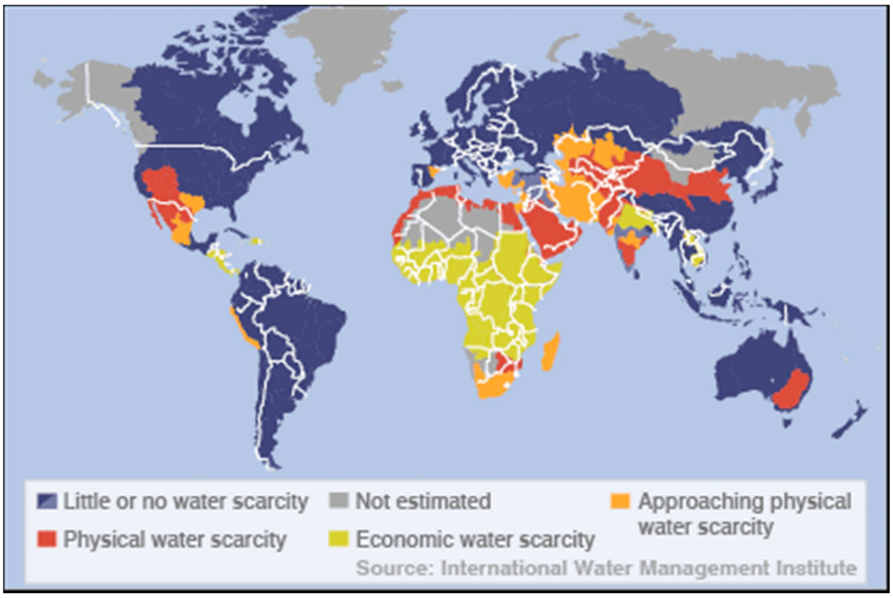

Figure 1- Physical water scarcity and economic water scarcity by country (United Nations Development Programme, 2006)

A significant number of countries are currently exploring the potential of municipal wastewater reuse, and their numbers have increased drastically during the past decade. The use of municipal wastewater for irrigation has become more widely practiced not only in countries with a water deficit, such as those of the Mediterranean, in the Middle East and in Latin America, but also even in countries with more temperate climates and water reserves, such as Japan, Australia, Canada, Northern China, Belgium, England and Germany.

The significance of wastewater quality and degree of treatment has already been recognized universally. The method and extent of their use, however, vary according to the infrastructure and the local socio-economic conditions prevalent from country to country (Kalavrouziotis and Arslan-Alaton, 2008).

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