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Article

Wastewater Reuse Planning in Agriculture: The Case of Aitoloakarnania, Western Greece

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Abstract: In the present paper, the possibility of the treated municipal wastewater (TMWW) reuse in agriculture, produced by the Wastewater Treatment Plants of Aitoloakarnania prefecture, one of the greatest agricultural regions of Greece, has been investigated. The boundaries of agricultural soils and the irrigated crops were defined, and the water requirements of crops were calculated. Also the chemical characteristics of the TMWW were determined for the safe reuse in crop production, and for the protection of soils from potential pollution. The research conducted in this area is expected to constitute the basis for an integrated TMWW reuse planning in soils and crops, in the context of sustainable agriculture, and environmental protection. It must be mentioned that the Messolongion-Aitolikon lagoon is in the area under investigation, one of the largest wetland ecosystem of Mediterranean region, which makes the area ecologically sensitive. The ultimate scope of this study is to describe the planning of the TMWW reuse on the basis of soil characteristics, climatic factors, and irrigation water requirements of the crops, grown in this ecologically sensitive area. The volume of the effluents produced by the wastewater treatment plants of Messolonghion, Agrinion, Nafpaktos, Aitoliko and Thermo could cover

19.3%, 25.14%, >100%, 17.18 and 87.84% of the irrigation water requirements, respectively.

Keywords: wastewater reuse; agriculture; irrigation water demand; environmental protection

1. Introduction

Agriculture is the greatest user of water all over the world. The water consumption for crop irrigation amounts to 70% and in some cases 90% of the world water requirements [1]. Given that the water shortage increases over time—due to: (i) the increase of world population food demand; (ii) urbanization; (iii) climatic changes; (iv) poor quality water used in some countries—the TMWW seems to be an attractive and sustainable solution, and therefore it is expected that reuse will further increase in the immediate future.

It is estimated that at least 10% of the world population will consume agricultural products produced under TMWW reuse [2]. The need for irrigation water is so urgent that about 7% of irrigated land worldwide, *i.e.*, 20 million ha in 50 countries, is irrigated using raw or partially treated water, indirectly or directly [3]. However, many other agriculturally advanced countries reuse TMWW. Water reuse applications in the United States, in order of descending water volume, are: (1) agricultural irrigation; (2) industrial recycling and reuse; (3) landscape irrigation; (4) groundwater recharge; (5) recreational and environmental uses; (6) non-potable urban uses; and finally, (7) potable reuse. In California USA about 65% of the water is recycled by being reused in agriculture [4-6]. Also in Israel about 64% of the available TMWW is recycled; the total volume of the annually produced effluents being 1.7 billion m^3 [7]. In Europe the TMWW reuse is less extensive volume and area wise [8]. More specifically, in Italy the reuse is applied in 4000 ha and is limited only in the islands of Sicily and Sardinia [9,10].

In Spain 346 hm^3 of water per year are reused in agriculture, but according to Royal Decree-Law 10/2001 of Hydrologic National Plan [11], this volume of wastewater is expected to become 1100 hm^3 by the year 2012. The main reclaimed wastewater projects in Spain are concentrated in the Mediterranean coast and in the islands. In Valencia and Murcia, where 57% of all the treated wastewater in Spain is reused, and in the islands of Canaries and Balearic, the reuse amounts to 23% of the total amount reused on national level. Other projects are in the middle and north of Spain, *i.e.*, in Madrid and Vitoria with 5 $hm^3\ yr^{-1}$ and 11.5 $hm^3\ yr^{-1}$ respectively [12].

The Segura basin (Murcia) is the only Spanish basin whose natural water resources cannot cover its water demands; for this reason, in Murcia the treated municipal wastewater reuse in agriculture is especially important. In 2008, 106 hm^3 of wastewater were treated in 80 wastewater treatment plants (WWTP). In this region, the irrigated land with treated wastewater is 1600 ha [13].

In Greece the annual demand for various uses of water is 8.2 million m^3 and 85% of this volume is used for agricultural purposes [14].

On the other hand, the regions of East Peloponnese, Thessaly, Aegean islands and Crete are confronted with the problem of saline irrigation water, which is unsuitable for crops. Therefore, the possibility of TMWW reuse was studied in the context of thirteen management plans for thirteen

regions [14,15]. More specifically, the possibility of wastewater reuse in cotton, maize and olive trees, including vegetables with encouraging results [14,16-22].

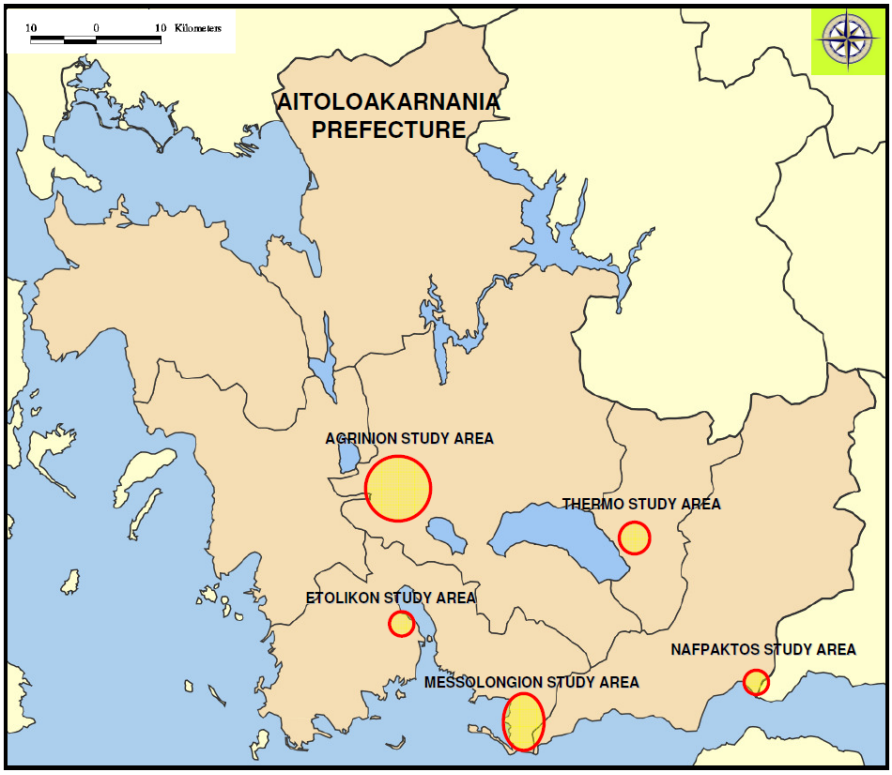
About 93% of the total effluents produced by the Wastewater Treatment Plants in Greece, is currently disposed into torrents, rivers, lakes and sea [23,24]. This method of wastewater disposal may have adverse effects on the ecosystem due to the high content of effluents in N, P and K, a fact that leads in eutrophication of surface water, especially of the sensitive wetland ecosystems [25]. Finally very important discussions and research into pharmaceuticals content in wastewaters have recently commenced [25].

2. Materials and Methods

2.1. Research Site

The research area is located in western Greece and specifically in the prefecture of Aitoloakarnania (Figure 1).

Figure 1. Study area of Aitoloakarnanias prefecture.



2.1.1. Demographic Data of Aitoloakarnania

The Aitoloakarnania is the most remote prefecture of western Sterea Hellas, and extends between 38°18' latitude to North and 20°43' and 22°02' longitude to East. It covers an area of 5,450 km^2, which corresponds to 4% of the total area in Greece. According to the 2009 census of the National Statistical Service it has a population of 228,069 or 2.3% of the total population of the country. The population of Messolonghion is 13,791 or 6% o and of Agrinion 60,000 or 26.3% of the total population of the Aitoloakarnanias Prefecture, respectively.

2.2. WWTP of Messolonghion and Agrinion

The installations of Messolonghion WWTP are located near the torrent of Koukos, North of Kleisova lagoon. The area covered by installations is about 1 ha. The altitude is 0.8 m and geographical coordinates are 38°22'08″ N and 21°27'31″ E in WGS84 (World Geodetic System 1984).

The treated wastewaters are drained into the torrent of Koukos, which terminates in the Kleisova lagoon, which is in connected to the Patras gulf.

The WWTP has been designed to serve 16,000 people with a future extension capacity by 50%, and with a mean daily production 4.630 m^3. The treatment method applied consists of active sludge subjected to continuous aeration, nitrification-denitrification and dephosphoration.

Agrinion WWTP is located near the river of Acheloos and it has been projected that the its full construction will be completed in three phases, *i.e.*, phase A, for a population—equivalent of 60,000 which has been completed by the end of the period 1995–2000; phase B (current) for a population—equivalent of 90,000 people, has been completed at the end of the 2000–2010; and phase C (final) for a population-equivalent of 120,000 people by the end of the 2010–2035 period.

Nafpaktos, Termo and Aitoliko WWTPs have started working last year (2010). The basic characteristics of the aforementioned WWTPs are given in Table 1.

Table 1. Wastewater treatment plants of Aitoloakarnanias Perfecture.

	Messolonghion	**Agrinion**	**Nafpaktos**	**Aitoliko**	**Thermo**
Population	16,000	60,000	25,000	7,000	5,400
Special Demand (m^3 cap^{-1} d^{-1})	0.29	0.24	0.22	0.15	0.19
Summer Demand (m^3 d^{-1})	4,630	14,400	5,500	1,050	1,050
Total Peak Demand (L s^{-1})	154	325	-	-	34.52
BOD_5 (kg d^{-1})	1,040	3,900	1,500	385	380
SS (kg d^{-1})	1,280	4,850	1,750	525	437
TKN (kg d^{-1})	200	720	250	87.5	50
P (kg d^{-1})	40	150	70	-	-

2.3. Chemical Analyses of Fresh Irrigation Water and Treated Wastewater

The treated municipal wastewater TMWWs which are planned to be applied in the context of the planed reuse have already been extensively studied and their effect has been investigated in relation to plant growth and their effect on soil. The TMWW, have been analyzed by methods internationally accepted and the results have been reported [23,24].Generally, the concentrations of the elements were within the limits set forth by WHO (2006), Consequently, quality wise, the treated municipal wastewater TMWWs of the aforementioned wastewater treatment plants WWTPs are of good quality, and therefore they could be reused successfully in the context of a future reuse planning.

2.4. The Investigated Area

2.4.1. Messolonghion Area

The cultivated area under investigation is extending around the WWTP of Messolonghion Municipality, which is located near the torrent "Koukos" and to the North of the Klisova estuary. The area presents a smooth relief, being found in between plain areas, adjacent to the Messolonghion estuary and to pro-mountains of Arakynthos Mountain. It is crossed by shallow torrents, one of which is "Koukos; Te area includes the alluvial plain of Mesolonghion-Evinohorion, as well as a polder. The main characteristics of the alluvial plain are the numerous irrigation canals, a great part of which have been installed in drained ex swamp sites, adjacent to the river Evinos. The borders of the investigated plain are given, the total area being 3,251.7 ha.

The WWTP of Mesolonghion is located southeast of the town, in a distance of about 3 km from its center, and adjacent to Koukos.

The area under investigation is an alluvial plain, and its formation is the result of the erosion to which the surrounding geologic formations have been subjected and the eroded soil material has been deposited in the plain. The soils of the wider area include the following categories:

(I) Deep soils of heavy to light texture with high ground water level. The main soil types found are clay and sandy loams (SL). The pH is alkaline and they are characterized by high infiltration rate.

(II) Deep soils with medium texture, characterized by medium to good drainage. The main soil textural classes found are loams (L), and Clays, The soil reaction is alkaline and their infiltration is low.

(III) Deep soils of medium to heavy texture, well drained, including the following soil textural classes: Clay loams. (CL) Sandy clay Loams (SCL) and silty clay loams (SiCL). These soils are characterized by alkaline pH and medium infiltration.

(IV) Soils of heavy texture, belonging to the types of Clays, and Clay loams (CL). Their reaction is alkaline and their infiltration is medium. It must be noted that there are also found saline and sodic soils in the lower flow of the river Evinos, mainly near the estuary areas, as a result of the intrusion of the sea water, into the higher ground water level on one hand and on the other of the drainage systems inefficiency.

2.4.2. Agrinion Area

The area under investigation is extending near the installations of the Agrinion Municipality WWTP, which was constructed in a state owned and abandoned bed of Achelloos River. The area is located Southwest of Kalyvia community at a mean distance of 2.5 km from the center of this community.

It is a level plain area, with a smooth topographic relief, and includes a great part of the wider Agrinion plain. It is characterized by the presence of an extensive irrigation system. The total area studied is 7,184 ha, which is covered by alluvial deposits, that are relatively new, the soils being classified as mainly Entisols, and Inceptisols. The alluvial deposits originate from a soil material which was formed in the hilly and mountainous region of Acheloos and Ermitsa river drainage basin. These

materials were weathered, and they were then transferred and deposited into the Agrinion plain and in other alluvial plains of these rivers via rain water floods. These materials have been distributed in the plain particle size wide, and according to the distance from the river's bed. As a result, a gradual decrease of the sand in favor of clay is observed as it moves from the river bed to the lake Lysimachia. Also, analogous are the changes in the distribution of soils hydromorphy. The soils with poor drainage are found between the airport and the lake Lysimachia, while those of good to very good drainage are located between the airport and the river Achelloos.

According to a soil study of the Greek Ministry of Agriculture (1996), which concerned the plain of Agrinion, the soils of the area under study were classified in 12 cultivated crop groups, 4 of which represent the alluvial terraces (Alfisols), and 8 cultivated groups, which represent the present alluvial field, and the transitional zone (Entisols, Inceptisols).

2.4.3. Nafpaktos

The Nafpaktos area is located near the installations of the Wastewater Treatment Plant (WWTP) of Nafpaktos Municipality, which is found in a coastal area near the delta of the river Mornos, and to the eastern side of the town of Nafpaktos.

The area is characterized by a smooth topographic relief, and includes the alluvial plain of Nafpaktos. The total area is 321.4 ha. The WWTP is located on the eastern side of the aforementioned town, at a distance of 5 km from the center of the town, and at about 500 m from the nearest houses, and extends in a coastal area near the delta of the Mornos river.

From the geological point of view, and more specifically in relation to the upper surface layers, which are of interest, the area under consideration is made of clays and deposits of fine particles, which are being crossed by numerous natural channels, and water trenches, the final receiver being the Corinth golf.

The alluvial deposits cover that part of the investigated area, which is a horizontal plain. The deposits are composed of sand, clays, and red earth, which have originated from the weathering of Miocene geologic formations. The depth (thickness) of the alluvium is <10 m. Due to the relatively small depth, these alluvial deposits do not play an important role in the hydrology of this region.

2.4.4. Etolikon Area

The Etolikon area, is extending southwest of the Etolikon town, and of the WWTP installations of the Municipality, the total area being 1,297.5 ha.

Generally, the soils of the investigated area are characterized as productive, with the exception of those extending along the coastal zones of the estuaries, which are saline and sodic. In the south and central part of the investigated area there are alluvial level plains with deep soils, which are highly productive. These soils cover the largest part of the studied areas.

In the north and northeastern section of the studied area, the soils originating from tertiary deposits deep to slightly deep with low to high slopes. These soils are cultivated mainly with olive groves.

2.4.5. Thermo Area

The investigated area is found near the installations of the WWTP of Thermos Municipality, located on the southwestern side of the town, at a distance of 1.5 km and 300 m from the provincial road of Nafpaktos to Thermo. The topographic relief of the area is smooth, and includes the alluvial plain of Thermos, which basically is a closed plain surrounded by small hills. The total area of this region is 270.3 ha.

The area under examination includes alluvial soils of acidic reaction, which extend over the region, with a small to relatively high depth, being originated from the weathering of rocks of the surrounding areas.

3. Results and Discussion

Among the requirements for the calculation of the water consumption by crops, needed for planning of the treated wastewater reuse for the protection of the sensitive ecosystems studied, was the determination of the crop irrigation water needs grown in the area of Messolonghion and the Acheloos estuary. Thus, the mean daily and monthly rate of reference evapotranspiration was calculated employing the Penman-Monteith equation according to FAO-56 [26].

$$ET_o = \frac{0{,}408\Delta(R_n - G) + \gamma \frac{900}{\mathrm{T} + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0{,}34u_2)}$$

Where:

ET_o = the reference evapotranspiration (mm d^{-1}),

R_n = net radiation at the crop surface (MJ m^{-2} d^{-1}),

G = soil heat flux density (MJ m^{-2} d^{-1}) which for daily intervals may be ignored, thus G = 0,

T = mean daily air temperature at 2 m height (°C), u_2 wind speed at 2 m height (m s^{-1}),

e_s = saturation vapor pressure (kPa),

e_a = actual vapor pressure (kPa),

$e_s - e_a$ = saturation vapor pressure deficit (kPa),

Δ = slope vapor pressure curve (kPa °C^{-1}), and

γ = psychrometric constant (kPa °C^{-1}).

The reference evapotranspiration was calculated on the basis of the data taken from the Messolonghion Meteorological Station, taking into account the mean daily and monthly values of the parameters involved in the above equation, for the period 1967–2010 (*i.e.*, 43 years), as given by the National Meteorological Service of Greece (NMS).

The estimation of crop evapotranspiration, ETc, incorporates the single or the dual crop coefficients in the following equations:

$$\mathrm{ET_c} = \mathrm{K_c} \cdot \mathrm{ET_o}$$

Where:

K_c is the single crop coefficient, which averages crop transpiration and soil evaporation.

Thus, the evapotranspiration (ET_c) for crops in Messolonghion, Agrinion, Nafpaktos, Aitoliko and Thermo for the irrigation period of year 2010 was calculated. The cropping areas of Messolonghion Agrinion, Nafpaktos, Aitoliko and Thermo are reported in Table 2.

Table 2. Total area (ha) in five study areas cropped during 2010.

Crop	Messolonghion	Agrinion	Nafpaktos	Aitoliko	Thermo
Zea mays	190.17	1736.76	9	79.1	20.06
Medicago sativa	688.6	1754.23	35.8	257.01	15.33
Gossyrium hirsutum	692.65	7.6	-	14.0	-
Citrus tree crops	213.62	774.1	1.8	8.5	-
Olea europaea	119.43	160.86	27.92	79.0	92.54
Nicotiana tabacum	-	10.2	-	-	-
Vegetables	6.16	38.7	0.2		-
Asparagus officinalis	-	217.3	-	4	-
Vitis vinifera	0.31	0.48	1.1	-	2.04
Actinidia chinensis	-	38.7	-	-	-
Various tree crops	1.75	32.12	0.32	-	-
Total	1912.69	4771.05	76.14	441.61	129.97

The mean plant coefficients according to the plant development stage (K_c), given for the climatic conditions prevailing in Greece, were used in the Penman-Monteith equation suggested by FAO for maize, citrus fruits, and olives. Since the plant coefficients under the climatic conditions of Greece have not been as yet determined for alfalfa, and vegetables, the analogous coefficients, by plant growth of stage, (K_c), were taken from Allen [26].

Net irrigation water needs for the crops were determined according to equation:

$$In = ET_c - (P_e + G_w + S_m)$$

Where:

P_e = refers to the fraction of rainfall, which may be used by the crops and is known as "effective rainfall"**,**

G_w = is the contribution of the groundwater, and

S_m = is the water stored in the topsoil layer at the beginning of the germination period which can be used for crops.

In the present study, G_w was considered equal to zero, since the underground water table in the Messolonghion area and Agrinion plain is very low as a result of excessive pumping. It was also considered that the soil moisture at sowing, and at harvest time, was the same, and the term S_m was, therefore, equated to zero. Beyond, however, the obvious needs in irrigation water, which must be met, additional quantities of irrigation water are necessary for leaching of salts, which accumulate in the root-supporting layer of the soil, as a result of irrigation. Consequently, the calculation of the net irrigation water requirements was based on the difference between the crop evapotranspiration minus "effective rainfall" (P_e), the latter being calculated by means of an equation suggested by USDA (Soil Conservation Service, 1970), as follows:

$$P_e = f(D)[1.25P_t^{0.82416} - 2.93]10^{0.000955ETc})$$

Where:

P_e = average monthly effective precipitation (mm)**,** P_t monthly mean precipitation,

ET_c = average monthly crop evapotranspiration (mm), and

f(D) = soil water storage factor.

The soil water storage factor was defined by the following:

$$f(D) = (0.531747 + 0.295164\ D - 0.057697\ D^2 + 0.003804\ D^3)$$

Where:

D = usable soil water storage (mm).

Finally, the total water demand of the crops ($I_n$tot), for the 2010 irrigation season, was calculated for the 2010 year crop statistics.

In Figures 2–6 which follow the water needs of crops for each area studied, as calculated by the aforementioned FAO-Penman Monteith equation, are presented.

Figure 2. Net Irrigation Requirements for crops in Messologhion area.

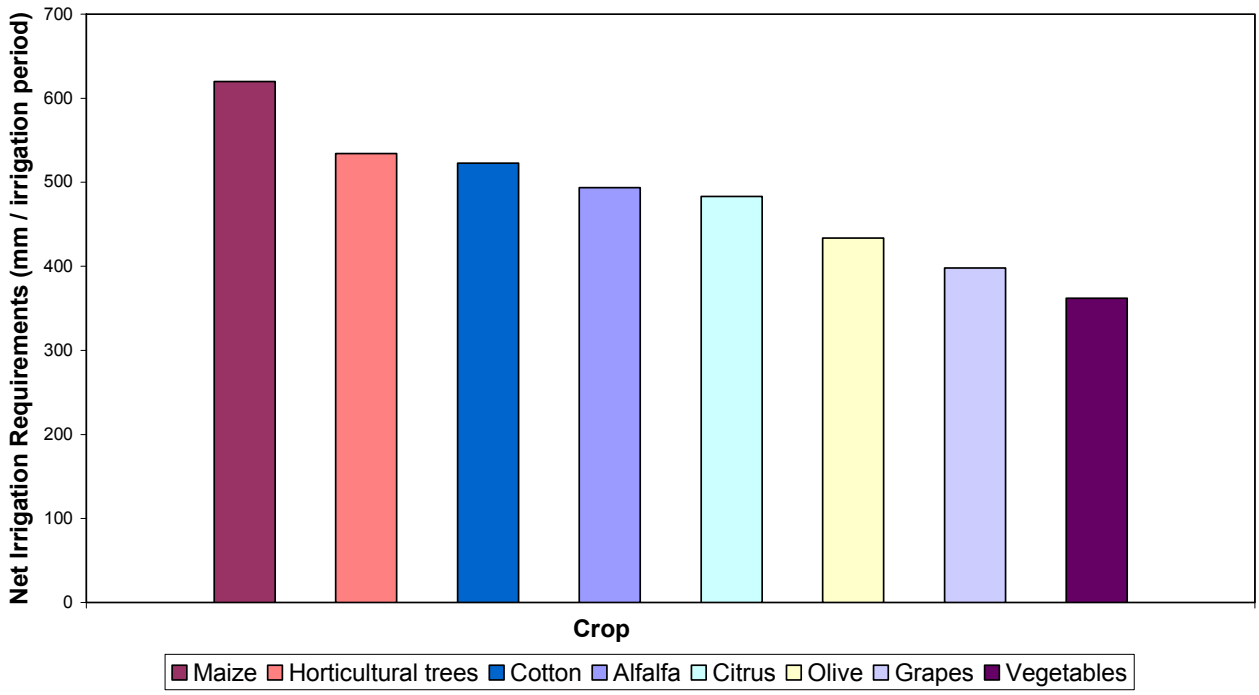


Figure 3. Net Irrigation Requirements for crops in Nafpaktos area.

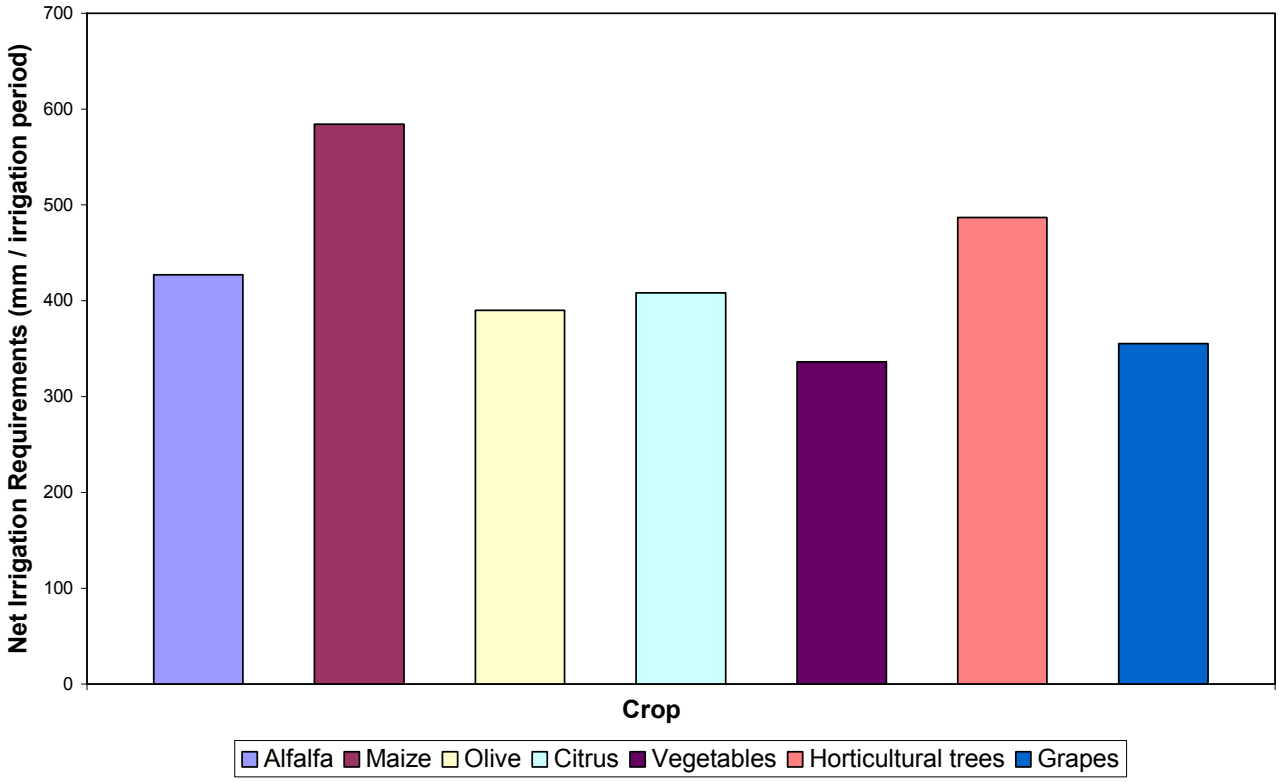


Figure 4. Net Irrigation Requirements for crops in Thermo area.

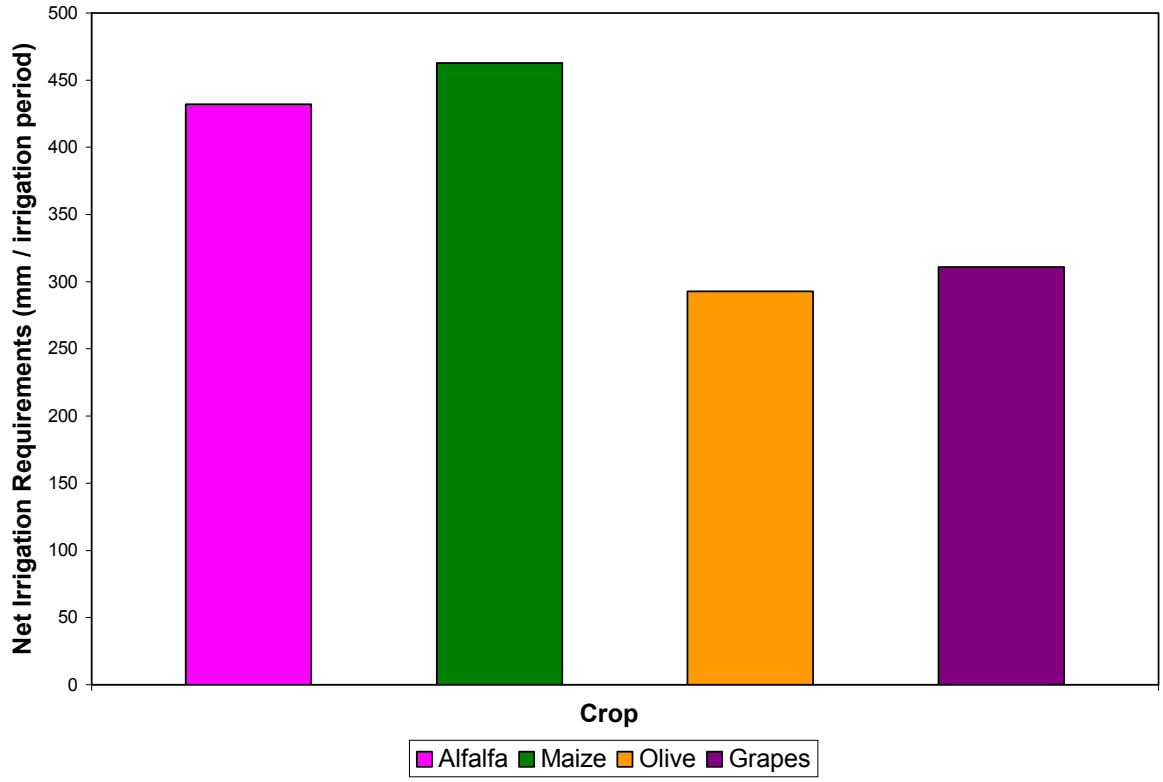


Figure 5. Net Irrigation Requirements for crops in Agrinion area.

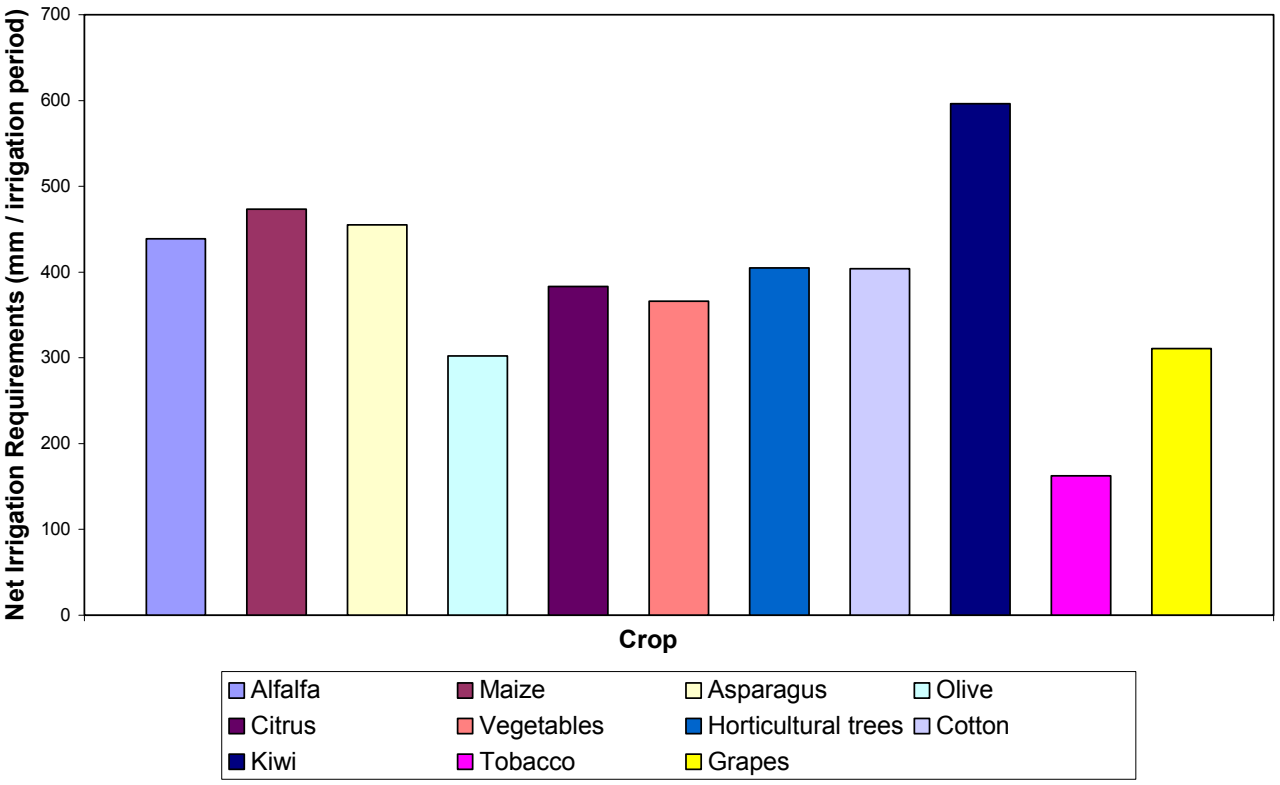
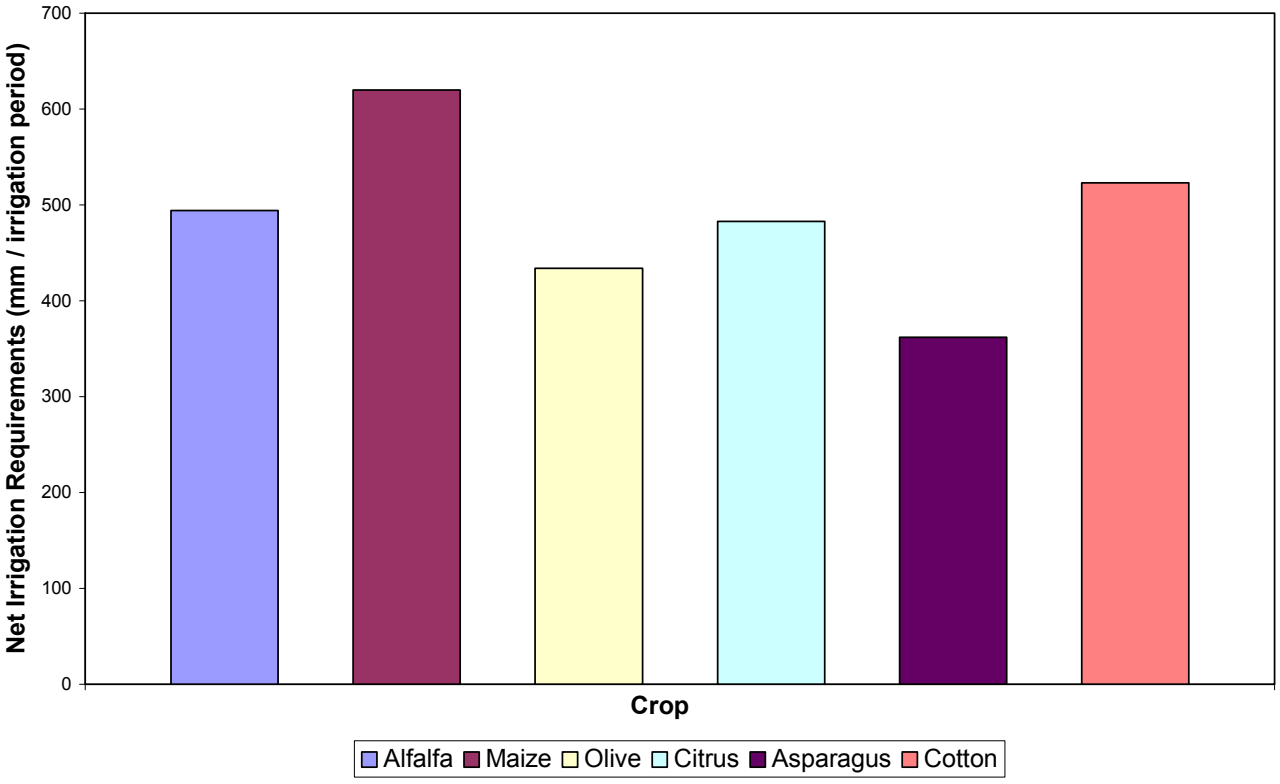


Figure 6. Net Irrigation Requirements for crops in Aitolikon area.



The calculation of the total irrigation water demand for each crop ($I_n$tot), was made by multiplying the net irrigation water needs of each crop by the corresponding area covered, and the relevant data are reported in Table 3.

Table 3. Total crop irrigation water demand in the study areas during 2010.

Crop	Net crop irrigation water demand in mm during the irrigation period 2010				
	Mesolonhgion	**Agrinion**	**Nafpaktos**	**Aitoliko**	**Thermo**
Zea mays	619.7	473.3	584.2	619.7	462.8
Medicago sativa	493.8	438.7	426.7	493.8	432.1
Gossyrium hirsutum	522.5	-	-	522.5	-
Citrus tree crops	483.3	383.4	407.6	483.3	-
Olea europaea	433.7	301.9	390.3	433.7	292.9
Nicotiana tabacum	-	162,6	-	-	-
Vegetables	361,9	366,2	336,1	-	-
Asparagus officinalis	-	455,1	-	361,9	-
Vitis vinifera	398,1	310,9	355,4	-	310,9
Actinidia chinensis	-	595,9	-	-	-
Various tree crops	534,5	404,5	486,6	-	-

Figures 7–11 show the water volume required per crop in each area , as calculated by the previously mentioned equation.

Figure 7. Water volume (m^3 yr^{-1}) that is required per crop in Messologhion area.

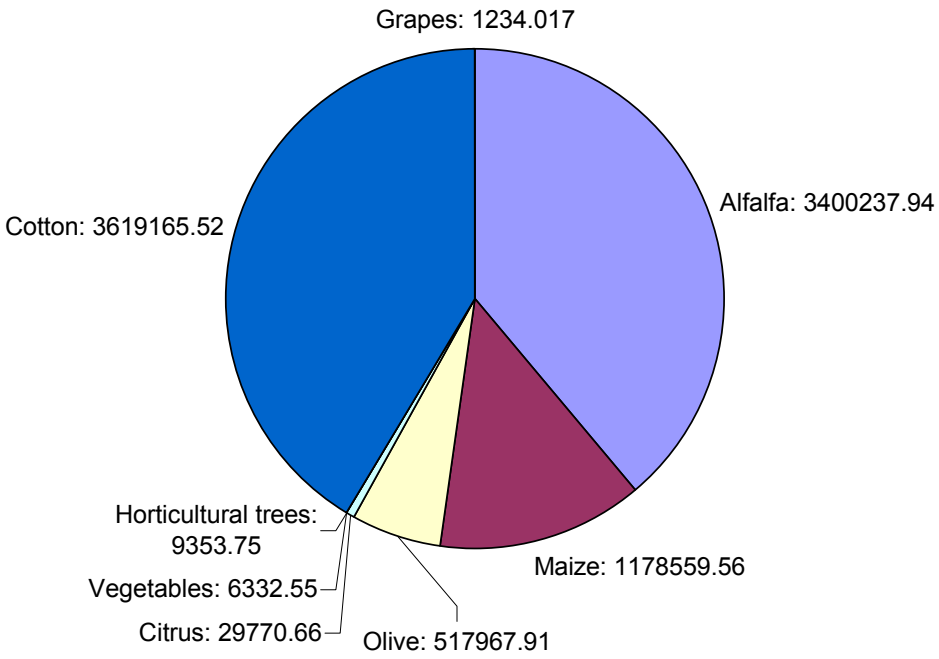


Figure 8. Water volume (m^3 yr^{-1}) that is required per crop in Nafpaktos area.

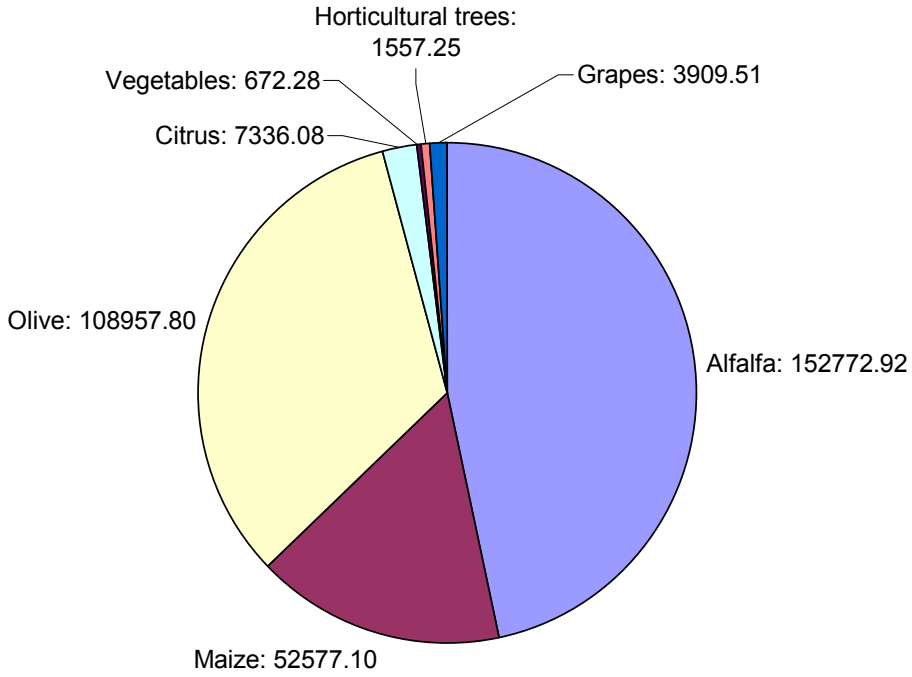


Figure 9. Water volume (m^3 yr^{-1}) that is required per crop in Thermo area.

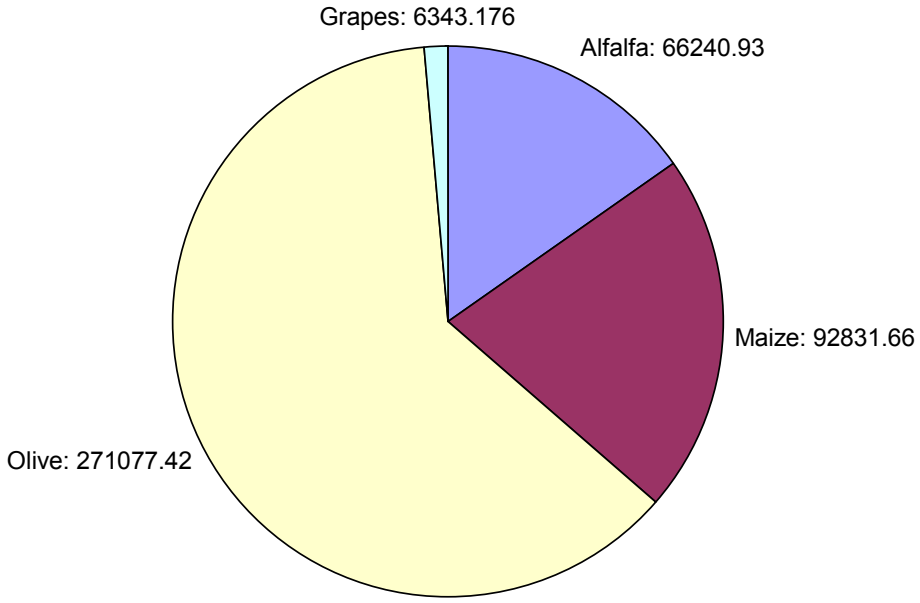


Figure 10. Water volume (m^3 yr^{-1}) that is required per crop in Agrinion area.

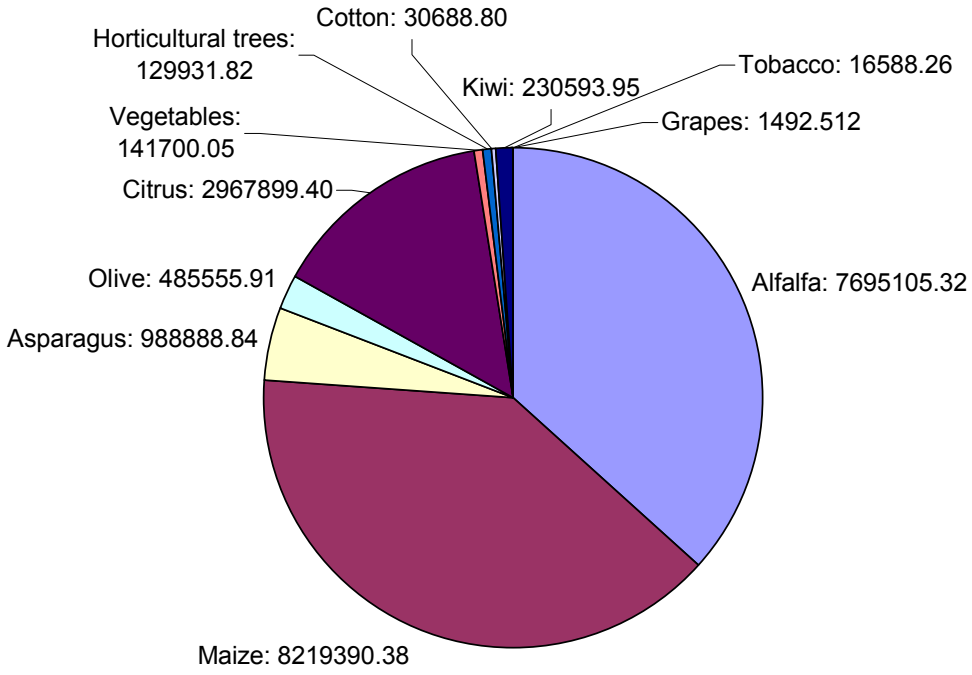
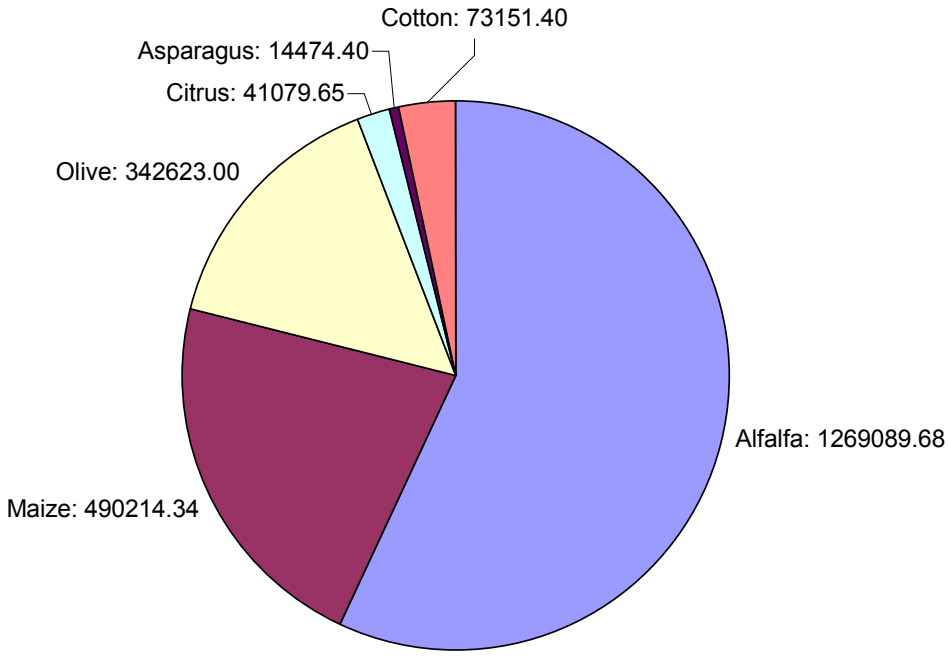


Figure 11. Water volume (m^3 yr^{-1}) that is required per crop in Aitolikon area.



3.1. Contribution of the Treated Wastewater to Irrigation Water

In wastewater reuse planning in agriculture, one important requirement is knowing the percent contribution of the TMWW to the total volume of irrigation water required for the crops of the area under study.

In Table 4, relevant information is given in relation to the above requirement. It can be seen that a significant percentage of the irrigation water is covered annually by the TMWW ranging from 17.18 to >100% for the cultivated areas under study; the lower percent corresponding to Aitolikon and the highest to Nafpaktos, respectively. The above results show that the contribution of the TMWW to the irrigation water could be significant in partly replacing the irrigation water, in addition to the nutrients that would be added to the soil.

Table 4. Contribution of the WWTPs effluents to the annual irrigation water required by each of the areas studied.

Region	Volume of water required for irrigation (m^3)	Annual outflow from WWTPs (m^3)	% Coverage of the irrigation water by TMWW
Mesolonghion	8762621.90	1689950.00	19.30
Agrinion	20907835.24	5256000.00	25.14
Nafpaktos	321665.346	2007500.00	>100
Aitolikon	2230632.47	383250.00	17.18
Thermo	436493.19	383250.00	87.8

4. Conclusions

The basic principles of treated wastewater reuse planning in agriculture in five areas of Aitoloakarnania prefecture were examined. They were based on the knowledge of: demographic data, soil characteristics, crops grown and their water requirements according to the evapotranspiration, calculated by means of Penman-Monteith equation, and the net water requirement of each crop cultivated in the area under study. Taking into account the annual outflows of the five WWTPs, it was found that the annual percent contribution of the treated wastewater in the total irrigation water volume needed for each area was: Messolonghion 19.3%, Agrinion 25.14%, Nafpaktos > 100, Aitolikon 17.18%, and Thermo 87.8%.

References

1. FAO. *Crops and Drops: Making the Best Use for Agriculture*; FAO: Rome, Italy, 2002.
2. Smit, J.; Nasr, J. Urban agriculture for sustainable cities: Using wastes and idle land and water bodies as resources. *Environ. Urban.* **1992**, *4*, 141-152.
3. WHO. *Guidelines for the Safe Use of Wastewater, Excreta and Greywater*; WHO: Geneva, Switzerland, 2006; Volume 2, p.178.
4. Asano, T.; Pettygrove, G.S. Using reclaimed municipal wastewater for irrigation. *Calif. Agric.* **1987**, *31*, 15-18.
5. Asano, T. Planning and implementation of water reuse projects. *Water Sci. Technol.* **1991**, *24*, 1-10.
6. Asano, T.; Burton, F.L.; Leverenz, H.; Tsuchihashi, R.; Tchobanoglous, G. *Water Reuse: Issues, Technologies, and Applications*; McGraw-Hill: New York, NY, USA, 2007.
7. Shelef, G.; Halpenin, R. The development of wastewater effluent quality requirements for reuse in agriculture irrigation in Israel. In *Proceedings of the IWA Regional Symposium on Water Recycling in Mediterranean Region*, Iraklio, Greece, 26–29 September 2002; pp. 443-449.

8. Angelakis, A.N.; Marecos do Monte, M.H.; Bontoux, L.; Asano, T. The status of wastewater reuse practice in the mediterranean basin. *Water Res.* **1999**, *33*, 2201-2217
9. Lazarova, V. Wastewater disinfection: Assessment of the available technologies for water reclamation. In *Water Management Publication and Conservation in Arid Climates*; Goosen, M.F.A., Shayya, W.H., Eds.; Technomic Publishing, Co. Inc.: Lancaster, PA, USA, 2000; Vol. 3, pp. 171-198.
10. Lofrano, G.; Brown, J. Wastewater management through the ages: A history of mankind. Sci. Total Environ. 2010, 408, 5254-5264.
11. Official Bulletin of State, BOE. The National Hydrological Plan. Royal Decree-Law 10/2001, 5 July 2001.
12. Iglesias, R.; Ortega, E. Present and future of wastewater reuse in Spain. *Desalination* **2008**, *218*, 105-119.
13. Pedrero, F.; Kalavrouziotis, I.K.; Alarcon, J.; Koukoulakis, P.; Asano, T. Use of treated municipal wastewater in irrigated agriculture—Review of the practices in Spain and Greece. *Agric. Water Manag.* **2010**, *97*, 1233-1241.
14. Kalavrouziotis, I.K.; Drakatos, P. The Future of irrigation by using processed wastewater in Greece. *J. Environ. Waste Manag.* **2001**, *4*, 107-110.
15. Gikas, P.; Tchobanoglous, G. Sustainable use of water in Aegean Islaands. *J. Environ. Manag.* **2009**, *90*, 2601-2611
16. Tamoutsidis, E.; Papadopoulos, I.; Tokatlidis, I.; Zotis, S.; Mavropoulos, T. Wet sewage sludge application effect on soil properties and element content of leaf and root vegetables. *Plant Nutr.* **2002**, *25*, 1941-1955
17. Papadopoulos, A.; Parissopoulos, G.; Papadopoulos, F.; Karteris, A. Sludge accumulation pattern in an anaerobic pond under Mediterranean climatic conditions. *Water Res.* **2003**, *37*, 634-644.
18. Kalavrouziotis, I.K.; Robolas, P.; Koukoulakis, P.H.; Papadopoulos, A.H. Effects of municipal reclaimed wastewater on the macro and microelements status of soil and of *Brassica oleracea var. Italica, and Brassica oleracea var. Gemmifera*. *Agric. Water Manag.* **2008**, *95*, 419-426.
19. Kalavrouziotis, I.K.; Koukoulakis, P.H.; Papadopoulos, A.H. Heavy metal interactions in a soil cultivated with *Brassica oleracea var. Gemmifera* as a factor for the treated wastewater reuse in vegetables. *Glob. Nest J.* **2009**, *11*, 497-509.
20. Kalavrouziotis, I.K.; Koukoulakis, P.H. Distribution of elemental interactions in Brussels sprouts, under the treated municipal wastewater. *Plant Interac. Taylor Fr. J.* **2009**, *4*, 219-231.
21. Kalavrouziotis, I.K.; Koukoulakis, P.H. Quantification of elemental interaction effects in Brussels sprouts plants irrigated with treated municipal wastewater. *Desalin. J.* **2010**, *254*, 6-11.
22. Kalavrouziotis, I.K.; Koukoulakis, P.H. Plant nutrition aspects under treated wastewater reuse management. *Water Air Soil Pollut.* **2011**, *218*, 445-456
23. Kalavrouziotis, I.K.; Kanatas, P.I.; Papadopoulos, A.H.; Bladenopoulou, S.; Koukoulakis, P.H.; Leotsinides, M.N. Effects of municipal reclaimed wastewater on the macro and microelement status of soil and plants. *Fresenius Environ. Bull.* **2005**, *14*, 1050-1057.
24. Kalavrouziotis, I.K.; Kostakioti, E.; Koukoulakis, P.H.; Papadopoulos, A.H.; Leotsinidis, M.; Sakazli, E. The impact of Cl × Cd interrelationship on planning wastewater reuse in cabbage. *Water Air Soil Pollut.* **2011**, *214*, 565-573.

25. Kalavrouziotis, I.K.; Kalfountzos, D. Reuse of urban wastewater in environmentally protected areas: The case studies of Messolonghion Lagoon, Greece. In *Climate Change and Its Effects on Water Resources*; Springer: Berlin, Heidelberg, Germany, 2011; Chapter 32, Volume 3, pp. 293-302.
26. Allen, R.G.; Pereira, L.S.; Raes, D.; Smith, M. *Crop Evapotranspiration. Guidelines for Computing Crop Water Requirements*, FAO Irrigation and Drainage Paper 56; FAO: Rome, Italy, 1998; p. 300.