

PROJECT

**MONITORING OF CHEMICAL QUALITY OF IRRIGATION WATERS
(SURFACE AND GROUNDWATER) OF THE RIVER BASINS OF
MACEDONIA-THRACE AND THESSALY**

EXTENDED SUMMARY

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1. EXTENDED SUMMARY OF THE PROJECT

For the realization of the aim and of the targets of the project a network of 1172 Stationary Sampling Sites (SSS) was established in Macedonia-Thrace and Thessaly. Among the above SSS, 69 SSS were allocated for the monitoring of the chemical quality of the rivers Evros, Ardas, Erythrotamos, Nestos, Strymonas, Axios, Loudias, Aliakmonas, Pinios, Litheos, Pamisos, Portaikos, Sofaditis and Enipeas. From these SSS during a 30 month period 32 to 36 water and two sediment samplings were performed.

Thirty SSS were selected and established for the monitoring of the lakes Vistonida, Doirani, Kerkini, Volvi, Koronia, Vegoritida, Zazari, Petron, Chimaditida, Kastorias or Orestias, Big Prespa and Small Prespa. During a 24 month period 4 water and 3 sediment samplings were performed. At each sampling date water samples from the lakes Vistonida, Doirani, Kerkini, Volvi, Vegoritida, Kastorias and Small and Bid Prespa were taken from two depths; in the rest of the lakes sampling was taken only from the surface water.

For the monitoring of the chemical quality of groundwater 706 SSS, mostly irrigation wells, were selected which were distributed in the 21 river and/or lake basins of Macedonia-Thrace and Thessaly. From most of the SSS of wells two samplings were made; a small number of wells was sampled 3 to 4 times.

For the monitoring of soil drainage canals 367 SSS were established and sampling was performed 22 times during a 30 month period. Among the above 367 SSS a significant portion of SSS was allocated for the monitoring of other major surface aquatic systems (rivers, streams, ditches, irrigation dams etc.) of each basin not named above.

At each sampling date *in situ* measurements (pH, temperature, dissolved oxygen content and % oxygen saturation, Redox, conductivity, salinity and TDS-Total Dissolved Solids) were made by the use of well calibrated portable equipment; samples taken appropriately labelled and stored were transported to the laboratory for further analysis to determine the concentrations of anions (NO_3^- , NO_2^- , SO_4^{2-} , PO_4^{3-} , Cl^- , Br^- , F^-), ammonium salts, total phosphorus, soluble and total cations such as of Al, Sb, As, Ca, Cd, K, Mn, Mg, Pb, Na, Ni, Se, Si, Fe, Cu, Hg, Cr, Zn, Sn and B, water hardness, alkalinity, pollution indicators such as BOD_5 , COD and ecological quality, pesticide residues, caffeine, diphenylamine and other organic contaminants (a total of 329 organic compounds were monitored). During the *in situ* measurements of lakes, in addition to the above mentioned parameters, the

Secchi disk depth as well the depth of each SSS of the lakes were measured and an additional sample was taken for the chlorophyll content determination.

In addition to the experimentally derived data literature data concerning the hydrology, hydrogeology and geological formations, formations of groundwater aquifers, areas of groundwater replenishment and discharge of the study area were collected and reviewed. For each one of the 21 river basins in the study area, the following topics will be presented:

- a summary of the data concerning the status of the existing chemical quality of surface and groundwater aquatic systems,
- the identified point and/or disperse pollution sources,
- indications concerning the communication of surface water and groundwater aquifers.

1.1. BASIN OF THE ARDAS RIVER

1. During the monitoring period of 2010 - 2012 the water of the river Ardas at all SSS located along its course into the Greek territory was found to be low in TDS, conductivity and salinity with the respective mean values being <135mg/L, <280 μ S/cm and <0.1PSU. Nevertheless, it appears that there was a progressive deterioration of water quality along the course of the river into the Greek territory even though the respective mean values, as said above, were at low levels ranging from 148.91 to 169.95mg/L, 246.03 to 278.31 μ S/cm and 0.05 to 0.06PSU, respectively, at the SSS 5 located close to the Greek-Bulgarian border and the SSS 8 located upstream of its discharge area into the river Evros. There was also a progressive increase in the water temperature along the course of the river into the Greek territory with the mean temperature values at the SSS 5, and SSS 8 ranging from 14.2 to 15.1 $^{\circ}$ C giving a mean increase of temperature equal to 0.75 $^{\circ}$ C. The pH of the water was about 8.0 in all SSS of the river Ardas and during the entire monitoring period.
2. The mean values of the above mentioned parameters of the waters of the rest of the surface aquatic systems of the basin including also of the soil drainage canals were at about twice higher levels whereas the respective mean values for the water of the irrigation wells were at higher levels than those found for the surface waters with the exception of some wells having the same quality characteristics as those found for the river Ardas.
3. The irrigation quality of surface and ground waters available in the basin of the river Ardas, according to the American Classification System, was Good and Intermediate to Good with the exception of some soil drainage canals and irrigation wells which were found to have irrigation quality Intermediate to Moderate.

4. Concentration levels higher than the limits of the Environmental Quality Standards (EQS) were found only for Cd, Pb, Zn and Sn. However the most commonly found heavy metals in both surface and groundwater bodies were Pb and Mn. Concentrations of Mn as high as 6.0ppm were found in groundwater while the highest concentrations found in surface waters were in the range of 0.5 to 1.0ppm
5. High concentrations of Pb and Mn were also found in the sediments of the river Ardas. The concentrations of Pb, As and Mn increased along the course of the river Ardas towards its discharge area into the river Evros and therefore pollution sources of these metallic elements might have been also present into the Greek territory. On the other hand, it appears that the load of the river Ardas in Sn, Zn, Cr, Cu, Ni and Fe was mainly imported from Bulgaria as the respective concentrations in the sediments decreased along the course of the river into the Greek territory.
6. Given the fact that caffeine was found in all surface aquatic systems of the Ardas Basin including the river and the irrigation wells monitored it is concluded that all water bodies of the Ardas basin were recipients of municipal wastes which were not properly treated.
7. Also given the fact that the water of certain wells was found to have the same chemical characteristics as the water of the Ardas River it is concluded that the respective groundwater aquifers are replenished by the river and this is in agreement with the hydrogeological data available for this area.
8. A significant number of pesticides included in the list of the priority pollutants of EQS (Environmental Quality Standards) was found in the surface aquatic systems of the Ardas Basin, however, the respective concentrations were in exceedance of the respective EQS limits only for lindane and HCB (hexachloro-benzene).
9. A significant number of pesticides (etridiazole, lindane, diphenylamine, S-metolachlor, bentazone and DEA (metabolite of atrazine)) was detected in groundwater of the Ardas Basin and concentrations exceeding the 0.1ppb level were found in some wells.
10. The presence of pesticide residues in groundwater at concentrations of about the same levels as those found in surface waters is in agreement with the other findings concerning the communication between surface and groundwater bodies, thus confirming the fact that the soils of this river basin are very permeable and that there is fast communication between surface and groundwater suggesting also the operation of preferential flow in some areas of clayey soils.
11. During the period of 2010 - 2011 residues of about 50 active ingredients of pesticides including also some major metabolites and other conversion products were detected in the aquatic systems of the river Ardas, however, only 20 compounds (parent compounds and conversion products) were detected more than 5 times. The highest

frequency of detection was found for atrazine (75 detections) followed by S-metolachlor (58 detections) and DEA (de-ethylated-atrazine) with 38 detections. However, the highest concentrations were found for S-metolachlor (15.44ppb), DEA (1.300ppb), atrazine (0.767ppb) and etridiazole (0.458ppb). During the same period 75% of the values of pesticide residues measured were found to be in the range of 0.1 to 0.61ppb (Box and Whisker Plots). This range might be regarded as the level of the unavoidable contamination of surface water bodies in this basin occurring under the local edapho-climatic conditions and agricultural practices of farmers. All residue levels characterized as outliers or extreme values, in the respective Box and Whisker Plots, were due to point pollution sites which have been identified as the sites where farmers fill and clean their spray equipment.

12. The situation was found to be completely different during the 2012 monitoring period. The pesticides detected more than 5 times were only 14 and among these the highest frequencies of detection were found for S-metolachlor (28 times), fluometuron (24 times), bentazone (22 times), atrazine (19 times) and DEA (20 times). A range of 0.001 to 0.312ppb covers 75% of all residue values found and all values outside the above range were traced to be due to point pollution sources. Looking at the complete residue data of this period it becomes apparent that the use of pesticides was generally much limited, compared to the 2010 - 2011 period, and in addition it is evident that the use of the herbicides S-metolachlor and atrazine was more conserved while two other herbicides namely bentazone and fluometuron were more widely used.
13. It must be mentioned here that atrazine was illegally used (is not registered in EU) and from the above data is becoming apparent that the measures taken by the Greek authorities to restrict the importation and use of illegal pesticides were more effective during 2012.
14. In the river Ardas during the period of 2010 - 2012 were detected more than 5 times only 12 pesticides and among these the highest frequencies of detection were found for the insecticide chlorpyrifos ethyl (17 detections) and the fungicide etridiazole (16 detections). The distribution of 75% of data points was in the same range as mentioned above.
15. Ecotoxicological evaluation of the pesticide residue data, on the basis of the Risk Quotient, showed that aquatic organisms (fish, crustaceans and algae) living in the river Ardas were exposed to risk only two times while the frequency of risk was much higher for organisms living in the rest of the surface aquatic systems of this basin.
16. For the river Ardas the mean values for the period of 2010 - 2012 of all parameters monitored were compared with the respective values derived from a monitoring

program conducted during 1999 - 2000. It appears that the mean values for most parameters were in the same range during the two periods and only the Redox values were at significantly lower levels during 2010 - 2012. This is in agreement with the rest of the findings showing that the organic load of the river was increased during 2010 - 2012 and the strong oxidative conditions existing in the water of this river in the past have been replaced by very low oxidative conditions leading temporarily even to reductive conditions (negative Redox values).

17. Based on the presence of caffeine and pesticide residues in groundwater it is concluded that in certain areas of the Ardas basin there is immediate communication between surface and groundwater via preferential flow and most certainly the soils are very permeable leading to leaching of pesticide residues and of other compounds. Also there are indications that in certain areas the groundwater aquifers are directly replenished by the water of the river Ardas.
18. Since the river Ardas is a transboundary river originating from Bulgaria the pollution of the aquatic systems of its basin was found to be partly imported from Bulgaria and partly to be due to local point and disperse pollution sources. As far as the river Ardas is concerned a number of pesticides were detected over the 30 month monitoring period, however, among these pesticides the highest concentrations were found for the fungicide etridiazole and the herbicides pendimethalin and chlorthal dimethyl. The highest concentrations of these pesticides amounting to 0.458, 0.311, 0.113ppb, respectively, were found at the SSS 5, located close to the Bulgarian border. Etridiazole was also found in some irrigation wells and in fact at about the same concentrations as those found in the water of the river Ardas. This implies that the contamination found in groundwater was partly due to the imported pollution via the river Ardas, which as said before, replenishes some of the aquifers of its basin. The same was true for pendimethalin and chlorthal dimethyl that is their presence in the aquatic systems of the basin was due to their presence in the water of the river Ardas when entering the Greek territory.
19. By examining the variation of the concentrations of certain metallic elements in the sediments of the river Ardas is becoming apparent that the presence of Sn, Zn, Cr, Cu, Ni and Fe was due to imported pollution from Bulgaria since the highest concentrations of these elements were found in the sediments at the SSS 5 located close to the Greek-Bulgarian border. Also the presence of Pb, As and Mn in the aquatic systems of the basin was partly due to imported pollution, however, other sources must have been existed in the Greek territory as the concentrations of these elements increased in sediments along the course of the river.

20. The presence of caffeine in the water of the river at the SSS close to the Bulgarian border is a sign that in this river municipal wastes are discharged upstream of the Greek border.
21. Contamination of the aquatic systems of the basin was also due to point and disperse pollution sites located in the Greek territory. Point pollution sites were identified as the sites where washing/filling of pesticide spraying machinery was taking place.
22. The presence of diphenylamine in certain aquatic systems is an indication that gas stations and sites of garbage recycling as well burial sites are also point pollution sites.
23. Due to disperse pollution sources was primarily the presence of pesticide residues and caffeine in groundwater aquifers.
24. Taking into account that the pollution of the Ardas River from municipal wastes, pesticides and heavy metals (Sn, Zn, Cr, Cu, Ni, Fe, Pb, As and Mn) was mainly imported from Bulgaria, it is recommended that the sediments and water of the river at the Galini dam (SSS 5), located close to the Bulgarian border, are monitored on an annual and monthly basis, respectively.
25. Further investigations concerning the sources of Pb, Ad and Mn polluting the aquatic systems of the Ardas Basin is needed. A portion of the pollution is imported from Bulgaria as demonstrated by the analysis of the river sediments; however pollution sources situated in the Greek territory do exist. Lead is one of the most significantly toxic metals and its presence in a large number of surface and ground water sampling sites needs further investigation.
26. For the pesticides etridiazole, S-metolachlor and bentazone which are registered for use in Greece, their respective registrations should be reviewed by the pertinent authorities so that the use of these pesticides to be prohibited in areas, as the Ardas River Basin, where the soils are susceptible to pesticide leaching and ground water pollution can occur.

1.2. BASIN OF THE RIVER EVROS

1. In the water of the river Evros, along its course of the Greek-Bulgarian and Greek - Turkish borders up to its Delta and discharge area into the Aegean Sea, the mean values of TDS, conductivity and salinity during the period of 2010 - 2012 were in the range of 300 to 439mg/L, 484 to 707 μ S/cm and 0.11 to 0.24PSU, respectively. During the same period the mean temperature values were in the range of 15.21 to 16.50°C giving a mean temperature increase of 1.29°C along its course into the Greek territory.

2. During the same monitoring period the mean values of TDS, conductivity and salinity at the SSS located on the rest of the surface aquatic systems (soil drainage and irrigation canals, streams, ditches etc.) were at significantly higher levels.
3. The mean values for the water of the irrigation wells were in the same range of the respective parameters of the river Evros with the exception of the wells located in the area of Feres and the river Delta for which the respective values were at two to four times higher levels. Also the values of Redox in the water of most of the wells were negative indicating the existence of reductive conditions in the respective aquifers.
4. Based on the American System of Classification of irrigation water, taking into account the values of SAR and conductivity, the irrigation quality of the river Evros in most of its course along the Greek border was Intermediate to Good quality; the quality at the SSS 4, located in the area of Peplos, was Intermediate to Moderate. The irrigation quality of the other surface aquatic systems was also Intermediate to Moderate with the exception of the drainage/irrigation canals located in the area of Feres and the river Delta in which the irrigation quality was Moderate to Bad. Intermediate to Moderate or Bad was also the irrigation quality of the irrigation wells monitored.
5. By comparing the data derived from the analysis of anions, cations including heavy metals and pesticide residue levels with the respective EQS limits it is evident that these limits were exceeded for many parameters including pesticide residues, Mn, Pb, Fe and Sn.
6. The most commonly found metallic elements in the surface and groundwater aquatic systems of the Evros River Basin were Pb, Mn and Sn and in a significant number of the SSS the respective EQS limits were exceeded. Mn was found in all SSS of surface and groundwater systems, however, extremely higher concentrations were found in the groundwater.
7. As found in the surface aquatic systems of the Evros Basin did not exceed the respective concentration limits of EQS. However, in some wells (SSS 1056, 1061, 1071 and 1094) the respective concentrations of As were in exceedance of the respective drinking water quality standards.
8. In some of the SSS located on the surface aquatic systems of the Evros Basin Cd was found and the respective concentrations exceeded the EQS limits at the SSS 1 (located on the river Evros close to Greek-Bulgarian border) and at the SSS with the code numbers 2019, 2014, 2015 and 2027. The concentrations of Cd in some irrigation wells ranged from 1 to 5ppb.
9. Concentrations of Pb higher than the reporting level of the analytical method (5ppb) were found in all SSS located on the river Evros as well in all of the rest of SSS

- located on the other surface aquatic systems of the basin. Exceedances of the respective limit of EQS were found for most SSS of the surface aquatic systems. The maximum Pb concentrations found in some of the surface aquatic systems located in the southern section of the basin were at two to five times higher levels than the respective concentrations found in the water of the river Evros; the highest concentrations of Pb were found in the Ardani-irrigation dam and the Ardani River.
10. The presence of high concentrations of Pb in the surface aquatic systems of the Evros Basin was due partly to imported pollution load via the river Evros but also partly due to natural presence of Pb in rocks and soils especially those found in the west region of the basin.
 11. Pb was also found in groundwater aquifers and in some of the wells the respective concentrations found were higher than 10ppb.
 12. Ni and Zn were rarely found and exceedances of the respective limits of EQS were only found in the water of the SSS with code number 2017 (stream of Lyra).
 13. Cu and Cr were also rarely found in the aquatic systems of the river Evros and none of the SSS there were any exceedances of the respective EQS limits.
 14. Hg was never found at concentrations higher than the respective reporting limit of the analytical method.
 15. Mn was the most commonly found element in both surface and groundwater systems. The highest concentration (11.6ppm) of Mn was found at the SSS 2017 (stream of Lyra). However, in general the highest concentrations of Mn were found in the water of the irrigation wells. The presence of these high concentrations of Mn in both surface and groundwater systems of the basin might have been partly due to the existence of natural background pollution sources (rocks and soils) and partly due to imported load via the river Evros.
 16. High concentrations of Fe were only found at the SSS 1 and 2 of the river Evros during the 2012 monitoring period. However the highest concentration of Fe (1.3ppm) was found in the stream of Lyra (code of SSS 2017). Significant concentrations of Fe were also found in irrigation wells and in some of them the respective concentrations were in exceedance of the 200ppb level.
 17. It appears that the highest concentrations of Mn (11.6ppm), Ni (24.4ppb) and Pb (22.2ppb) were found in the water of the stream of Lyra. Given the fact that this stream is originating from a mountainous area and does not receive discharges of agricultural or industrial origin the pollution of this stream is of natural background origin (rocks and soils). The same is also true for the Ardani-irrigation dam in which the load of metallic elements is most probably due to the natural background metallophoria.

18. Many pesticides included in the priority list of EQS were detected in the aquatic systems of the Evros Basin such as bentazone, lindane, chlorpyrifos ethyl, isoproturon, HCB, simazine, alachlor, MCPA, atrazine, dimethoate, trifluralin, 2.4-D, 2.4.5-T, coumaphos, endosulfan I, malathion, diuron and linuron. However, exceedances of the respective EQS limits were found only for lindane, bentazone and HCB in most of the SSS located on the surface aquatic systems including also the SSS located on the river Evros.
19. Caffeine was found in all SSS of the surface aquatic systems and in most of the irrigation wells of the Evros Basin. However, the highest concentrations were found in the water of the SSS located on the river Evros. The presence of caffeine in the ground waters of the Evros Basin is an indication that the respective aquifers are not protected and are replenished by surface water.
20. The presence of many pesticides in groundwater is another piece of proof that the groundwater aquifers are not protected and are susceptible to leaching of pesticide residues from agricultural soils. The pesticides found in groundwater aquifers of the Evros Basin at concentrations higher than 0.1ppb were etridiazole, bentazone, 2.4-D, chlorthal dimethyl, diphenylamine, quinalphos, difenoconazole and propiconazole, chlorothalonil, prometryne, atrazine and DEA.
21. The presence of difenoconazole, propiconazole, chlorothalonil and quinalphos in some irrigation wells was most probably due to direct contamination of the respective wells from point pollution sites (filling and washing of spray machinery) operating in the close perimeters of the wells whereas the presence of the rest of the pesticides mentioned above was due to disperse pollution sources due to the leaching of pesticide residues from the agricultural soils.
22. Given the fact that among the SSS of surface aquatic systems etridiazole was found only in the water of SSS located on the river Evros, the presence of etridiazole in some of the irrigation wells was most probably due to its presence in the water of the river Evros which replenishes these aquifers.
23. A significant number of pesticides was detected in the aquatic systems of the river Evros, however, among these pesticides only 24 compounds were detected more than five times during the 2010 - 2011 monitoring period and 19 compounds during the 2012 period. The pesticides which were detected with the highest frequency were the herbicides prometryne, fluometuron, bentazone, pendimethalin and S-metolachlor, the fungicides etridiazole, carbendazim and propamocarb and the insecticides lindane, chlorpyrifos ethyl and dimethoate.
24. Based on the Box and Whisker Plot treatment of the respective pesticide residue data the unavoidable environmental contamination of surface aquatic systems of the Evros

Basin, under the local edapho-climatic and agricultural practices, did not exceed the 0.7ppb level. Pesticide concentrations found at higher levels were due to point pollution sources primarily derived from sites of filling and washing of spray equipment and sites of inappropriate disposal of pesticide containers and other packaging materials.

25. Ecotoxicological evaluation of the pesticide residue data, based on the Risk Quotient, showed the the organisms (fish, crustaceans and algae) living in the aquatic systems of the Evros Basin were exposed to risk primarily due to the presence of the organophosphorus insecticides chlorpyrifos ethyl and methyl and pirimiphos methyl and to a lesser degree due to the presence of the herbicides S-metolachlor and pendimethalin. None of the other pesticides detected in the surface aquatic systems of the basin posed any risk to aquatic organisms.
26. The sediments of the river Evros were found to be rich in nitrate, phosphate and chlorite anions indicating the presence of municipal wastes. The highest concentrations of the above anions were found in the sediments of the SSS 2 located at Marasia, upstream of the discharge area of the river Ardas and of the tributary named Tounzas originating from the Turkish territory. The concentrations of Mn, Pb, Fe, Sn and Zn were among the highest found in sediments of all rivers of Macedonia - Thrace and Thessaly. The fact that the highest concentrations of the above elements were found in the sediments of the SSS 1 located close to the Greek - Bulgarian boarder and these concentrations were decreased in the sediments of the SSS located downstream is an indication that the pollution load for these elements was primarily imported from Bulgaria.
27. Comparisons of analytical data of anions, cations and pesticide residues in the water of the river Evros with respective data derived from a monitoring study conducted about 10 years ago (1999 - 2000) showed that the water quality of the river Evros at the SSS located in the area of Peplos (Code 4) has been improved in many aspects with the exception of the Redox which was decreased substantially during the 2010 - 2012 period.

1.3. BASIN OF THE RIVER ERYTHROPOTAMOS

1. In the water of the river Erythropotamos the concentrations of TDS and the values of conductivity and salinity were at relatively low levels during the 2010 - 2012 monitoring period with the mean values ranging from 222 to 391mg/L, 357 to 635 μ S/cm and 0.09 to 0.22 PSU, respectively. The mean values of pH were in the range of 7.7 to 7.91 and the respective mean values of temperature ranged from 15.4 to 17.64 $^{\circ}$ C giving a mean temperature increase of 2.24 $^{\circ}$ C along the course of the

river into the Greek territory. However, the main contribution to the above temperature increase was due to the discharge of the liquid municipal wastes of the Municipal Waste Treatment Plan (MWTP) of Didimoticho as there was a mean temperature increase of 1.31°C between the SSS located upstream and downstream of Didimoticho where the MWTP is discharging into the river.

2. The mean values of TDS, conductivity and salinity at the SSS of the drainage canals were at twice higher levels and at much higher levels were the respective values in most of the irrigation wells. Also the Redox of the irrigation wells was either negative or at low oxidative levels (<50mV).
3. According to the American Classification System of irrigation water, the irrigation quality of the river Erythropotamos was Intermediate to Good. The respective quality of the water of the drainage canals and of most of the irrigation wells included in the monitoring network of this basin was Intermediate to Moderate.
4. Based on the concentration limits of EQS and concentration limits of Directives concerning the groundwater quality exceedances of these limits were found for many parameters especially for Mn, Pb, Fe and Sn.
5. The most commonly found heavy metals in the aquatic systems of the Erythropotamos Basin were Pb, Mn and Sn and in a significant percentage of SSS there were exceedances of the respective EQS limits. Arsenic was also found in the aquatic systems of this basin, however, exceedances of the 10ppb level were found only in some irrigation wells.
6. Exceedance of the 50ppm level of nitrates was found only in two irrigation wells, however, nitrite and ammonium concentrations higher than 0.5ppm were found in many SSS but primarily these being irrigation wells. This is in agreement with the negative Redox values found in these wells.
7. The concentrations of anions in the sediments of the river Erythropotamos were at low levels compared to the respective levels found in the rest of the rivers of Macedonia-Thrace and Thessaly. The same was also true for the concentrations of heavy metals found in sediments. However, in the sediment of the SSS 9, located close to the Greek-Bulgarian border, the highest concentration of Mn was found, amounting to 2580ppm, which was the highest concentration of Mn found in sediments of all rivers investigated in the frame of this project. Also in the sediment of the SSS 11, located downstream of Didimoticho, copper was found at a relatively high concentration being among the highest concentration values found in sediments of all investigated rivers.

8. In both surface and groundwater systems of the basin caffeine was found. The presence of caffeine in groundwater is an indication that groundwater aquifers are not protected and replenished directly by surface water of the area.
9. However, groundwater was also contaminated with pesticide residues indicating that the soils of the area are vulnerable to leaching. Among the pesticides found in groundwater at concentrations >0.1ppb were included etridiazole, bentazone, 2.4-D, chlorthal dimethyl, diphenylamine and fluometuron. Diphenylamine is registered as a pesticide having, however, limited use for the protection of pome fruits stored under refrigerated conditions; diphenylamine is mainly used as antioxidant in polymers (tires), oils and other industrial processes and its presence in both surface and ground water is not due to its use as a pesticide but due to leaching from car oil spillage areas located around gas stations, tire recycling areas, garbage burial sites etc.
10. The use of the pesticides etridiazole, bentazone, 2.4-D, chlorthal dimethyl and fluometuron should be prohibited in the basin of Erythropotamos due to groundwater contamination via leaching from agricultural soils.
11. Only 17 pesticides were detected in the aquatic systems of the Erythropotamos Basin. However, some of these pesticides such as the herbicides fluometuron, pendimethalin and S-metolachlor were found at very high concentrations in the drainage canals due to the operation of point pollution sources of filling/washing spray equipment at these sites. Also the pesticides carbendazim, chlorthal dimethyl, etridiazole, trifluralin, acetochlor, PCNB were found at significant concentrations.
12. A significant number of pesticides included in the priority list of the EQS was found in the aquatic systems of the Erythropotamos Basin such as alachlor, lindane, chlorpyrifos ethyl, HCB, coumaphos, bentazone, MCPS, trifluralin, 2.4-D, dimethoate, endosulfan sulfate (metabolite of endosulfan), DDD, DDT, isoproturon and mecoprop. Exceedances of the EQS limits were found for some of the above pesticides.
13. Ecotoxicological evaluation of the pesticide residue data, based on the Risk Quotient, showed that aquatic organisms were exposed to risk due to the presence of acetochlor, chlorpyrifos ethyl, pendimethalin, prometryne and S-metolachlor.

1.4. BASIN OF THE VISTONIDA LAKE

1. During the monitoring period of 2010 - 2012, in the lake Vistonida the mean pH ranged from 8.68 to 8.55 and 8.61 to 8.20 in the surface and the water layer of the hypolimnion, respectively. The respective ranges of the temperature mean values in the surface and hypolimnion water layers were 18.10 to 16.90°C and 16.15 to 14.95°C. There was no great difference in temperature between the surface and hypolimnion water layers because the lake Vistonida is a shallow lake. In fact the

- lower mean value of temperature (14.95°C) reported above was found at the SSS with code number 504 which was also found to have the highest depth (4.10m).
2. Supersaturation with oxygen was found in the surface water layer and even in the hypolimnion water layer and this was due to the rich photosynthetic activity of the aquatic plants present in the lake.
 3. In most of the SSS of the lake Vistonida in both the surface and hypolimnion water layers the Redox was negative.
 4. The values of TDS, conductivity and salinity of the lake Vistonida had a wide seasonal variation reaching occasionally the characteristics of sea water due to the controlled communication of the lake with the sea.
 5. There was also a wide variation in the transparency of the lake water with the Secchi disk depth ranging from 2.80 m (April, 2012) to less than 0.40 m during the rest of the sampling dates.
 6. The values of TDS, conductivity and salinity also varied in the SSS located on the aquatic systems of the different areas of the basin. For instance these values were at relatively low levels in the SSS with codes 2031, 2032, 2033, 2035, 2041, 2042 and 2044, with high values at the SSS 2043, 2038 and 2043 and very high values reaching those of sea water at the SSS with code numbers 2039 and 2040.
 7. There was also great variability in the values of conductivity, TDS and salinity in the different SSS of groundwater (irrigation wells).
 8. According to the American Classification System of Irrigation water quality, the irrigation quality was Intermediate to Good only for the rivers Aspropotamos and Komchatos and the stream of Iasmos; the irrigation quality of the water of the rivers Lissos and Asprorema (this is a river discharging into the lake Ismarida), and of the stream of Potamia was Intermediate to Moderate whereas in all other surface aquatic systems of the basin including also the lake Vistonida the irrigation quality was Bad.
 9. The irrigation quality of groundwater was also variable with some wells having Good quality, others Intermediate to Moderate and there was also a number of wells, located around the lake Ismarida, having Bad quality. The bad quality was due to salination of the respective aquifers.
 10. In a significant percentage of the SSS located on either surface or groundwater systems the mean concentrations of both chlorites and sulphates were higher than 250mg/L.
 11. In all surface SSS with Bad irrigation quality the concentrations of Boron was also very high. Boron was not found in groundwater at concentrations higher than the method reporting level.

12. Low concentrations of arsenic were found in some surface water systems of the Vistonida Basin, however, only the concentrations found in the stream of Potamia (code 2044) were higher than 1.0ppb.
13. Cadmium was found in many surface aquatic systems of the basin and the respective EQS limit was exceeded in many SSS. Cadmium at concentrations higher than the method reporting level were not found in groundwater.
14. Lead was found in almost all surface aquatic systems including the lake Vistonida and in most of these SSS the annual maximum concentrations exceeded the respective EQS limit. However, Pb at concentrations higher than the method reporting level were not found in groundwater.
15. Nickel, copper and zinc were found in some aquatic systems, however, in only few SSS there were exceedances of the respective EQS limits.
16. Mercury and chromium were not found in the aquatic systems of Vistonida at concentrations higher than the respective method reporting levels.
17. In most of the SSS there was exceedance of the 2.2ppb EQS limit of Sn.
18. Mn was present in most of the aquatic systems of Vistonida, however, the respective concentrations were not as high as those found in the aquatic systems of the river Evros Basin including also the sub-basins of its tributaries Ardas and Erythrotamos.
19. Iron was commonly found in the aquatic systems of the basin and there were exceedances of 200ppb level in a substantial percentage of the SSS.
20. The concentrations of nitrates were very low in the surface aquatic systems including the lake Vistonida; higher concentrations of nitrates were found in groundwater and in two wells the respective concentrations were higher than 50ppm.
21. The concentrations of nitrites and ammonium were relatively high and in a significant percentage of SSS of both surface and groundwater systems the respective levels were higher than 0.5ppm
22. The concentrations of F⁻ were also high in many SSS including the SSS located in the lake Vistonida, however, in none of the SSS concentrations >1.5ppm were found.
23. In the sediments of the lake Vistonida the concentrations of anions were at low levels compared to the respective concentrations found in sediments of other lakes. However, these sediments were found to be very rich in heavy metals especially As, Cd, Cr and Fe.
24. The values of BOD₅ of the water of the lake Vistonida were found to be at lower levels than the method reporting level, however, high values of COD as well chlorophyll concentrations were found in the water of the lake.
25. Caffeine was found in both surface and ground waters of the basin with the respective concentrations being in the same range of values. This is an indication that all surface

- water systems are receiving municipal wastes improperly treated and furthermore an immediate communication between surface and groundwater systems is implied.
26. In the aquatic systems of the basin of the lake Vistonida 69 pesticide active ingredients were detected at least once. However, among these pesticides only the herbicides fluometuron, terbuthylazine and S-metolachlor and the insecticides malathion, and coumaphos were found at concentrations higher than 1.0ppb with the highest concentrations ranging from 1.0 to 317.6ppb for fluometuron, 1.0 to 31.5ppb for terbuthylazine and 1.0 to 11.4ppb for S-metolachlor. The highest concentration of malathion found was at the 2.05ppb level and for coumaphos at the 1.74ppb level.
 27. A significant number of pesticides was detected in the water of the lake Vistonida, however, among these pesticides the highest concentrations were found for the insecticides alphamethrin, lindane, L-cyhalothrin and the herbicide fluometuron.
 28. A significant number of pesticides was also detected in the water of the irrigation wells, however, the pesticides found at concentrations higher than the respective LOQ levels were only the herbicides 2.4-D, acetochlor, alachlor, chlorthal dimethyl, triclopyr, terbuthylazine and the insecticide acetamiprid and the fungicide imazalil. However, concentrations higher than 0.1ppb were only found in the water of the wells located in the area of Iasmos-Dialabi (code numbers 1150, 1151 and 1152) and the area of Polysito (code 1139).
 29. The presence of pesticide residues in the water of the wells included in the network is an indication that the soils of the basin are vulnerable to leaching and this is in agreement with the hydrogeological data available for the basin of Vistonida.
 30. Some of the pesticides included in the priority list of EQS were found in the aquatic systems of Vistonida Basin. In these pesticides were included lindane, HCB, chlorpyrifos ethyl, alachlor, atrazine, MCPA, dimethoate, trifluralin, 2.4-D, 2.4.5-T, bentazone, coumaphos, isoproturon, chloridazone and malathion. The concentrations found in many of the SSS were higher than the respective EQS limits.
 31. During the monitoring periods of 2010 - 2011 and 2012 only 22 and 15 pesticides, respectively, were detected more than 5 times in the surface aquatic systems of the basin of the lake Vistonida while the pesticides detected more than 5 times in groundwater were only 3 (acetochlor, fluometuron, imazalil).
 32. Among the pesticides detected in the aquatic systems of the basin of the lake Vistonida during the period of 2010 - 2011 fluometuron had the highest number of detections (89 detections) followed by prometryne, S-metolachlor and chlorpyrifos ethyl with 29, 29 and 25 detections, respectively. The 75% of the residue values for most of the pesticides found in the aquatic systems were in the range of 0.001 to 0.382ppb with the exception of fluometuron, S-metolachlor and terbuthylazine for which the

respective range was from 0.001 to 14.0ppb. However, for the latter 3 herbicides the increased range of concentrations was due to a point pollution site of filling/washing spray equipment located close to the SSS 2043. Therefore the range of 0.001 to 0.382 can be considered as the unavoidable contamination caused by pesticides used under the edapho-climatic and agricultural practices of the basin of the lake Vistonida.

33. During the monitoring period of 2012, only 15 pesticides were detected more than 5 times and among these the herbicide fluometuron, used primarily for weed control in cotton fields, was found having the highest number of detections (60 detections) followed by alphamethrin, S-metolachlor, prometryne and etridiazole with 14, 14 13 and 13 detections, respectively. The range of the unavoidable contamination of surface waters mentioned above for the 2010 - 2011 period also covers the 2012 monitoring period with the exception of 2.4-D, diphenylamine, and pendimethalin for which the respective upper range of their residues found was at 0.6ppb level and for fluometuron with the respective range reaching up to 1.2ppb. The higher range found for fluometuron was primarily due to the high concentrations of fluometuron frequently found at the SSS 2043 which, as reported above, is associated with a point pollution site of filling/washing spray equipment. For the rest of the pesticides (2.4-D, diphenylamine and pendimethalin) given the fact that these were detected with a frequency of less than 10 times their residue levels found in some aquatic systems cannot be considered as representing the contamination level of the entire basin and thus the range of 0.001 to 0.382ppb can be safely considered as the unavoidable contamination of surface aquatic systems of the basin of the lake Vistonida during the entire monitoring period (2010 - 2012).
34. In 96 cases there was ecotoxicological risk to aquatic organisms, based on the Risk Quotient, and among these only in 10 instances organisms living in the lake Vistonida were exposed to risk.
35. Groundwater salination was found in certain areas of the basin including the wells located in the perimeters of the lakes Ismarida (code numbers 1156, 1157 and 1155) and Vistonida (codes numbers 1151, 1159 and 1162) and in the area of Salpi.

1.5. BASIN OF THE RIVER NESTOS

1. During the monitoring period the pH of the water of the river Nestos ranged from 8.76 to 7.89 showing a small decrease along the course of the river from the Greek - Bulgarian border to its Delta area. The mean temperature values showed an increase along the course of the river ranging from 12.91°C at the SSS 14 at Paranesti to 16.86°C at the SSS 16 located close to the Delta.

2. The mean values of TDS and conductivity in the water of the river Nestos were at very low levels and these were decreasing along the course of the river into the Greek territory. This was probably due to the intervention of multiple water storage dams where there is a significant precipitation of suspended material. The values of TDS and conductivity were doubled in the rest of the surface aquatic systems of the basin. The values of Redox were positive in all surface SSS of the basin.
3. In about 70% of the wells monitored the mean values of TDS and conductivity were at levels lower than the respective values found for the surface waters of the respective areas and in 30% of the wells the respective values were at much higher levels. The wells with the higher TDS and conductivity values were in the area of the river Delta where it is probable that that sea water is slowly infiltrating into the groundwater aquifers. Also the Redox values in a significant proportion of the monitored wells were negative.
4. The irrigation quality of the water of the river Nestos was Good. Intermediate to Good was the irrigation quality of the water of the rest of the surface aquatic systems with the exception of the Avdira ditch having Bad quality. The irrigation quality of groundwater was Intermediate to Good with the exception of 4 wells having Bad quality and another 7 wells having Intermediate to Moderate quality.
5. Exceedances of the EQS limits concerning the concentrations of chlorites and sulphates were found only in the ditch of Avdira and a few wells.
6. In a few SSS exceedances of Boron concentrations from the 1.0ppm level were found. Also exceedances from the 1.0ppm level were found in all SSS located on the river Nestos, however, only during the 2010 monitoring period.
7. Arsenic was not found at the SSS of the river Nestos at concentrations higher than the method reporting level, however, higher concentrations were found in some SSS of surface waters exceeding the EQS limits and also significant concentrations were found in many wells.
8. Cd at concentrations exceeding the EQS limits was found in the SSS with code 16 of the Nestos River and in some other SSS of surface aquatic systems.
9. Significant concentrations of Pb were found periodically in the water of the river Nestos as well the irrigation canals supplied with water from the river Nestos; the annual maximum concentrations in all SSS of the river as well many SSS of surface aquatic systems were in exceedance of the respective EQS limit. Also Pb was found in 3 wells, however, in none of these wells the limit of 10ppb was exceeded.
10. Ni was also found periodically in the water of the river Nestos as well the irrigation canals supplied with the river water, however, only in one SSS the respective

concentration was found to be higher than the respective EQS limit of annual maximum concentration.

11. Copper was found very rarely and no exceedances of the EQS limits were found.
12. Mercury at concentrations higher than the respective reporting level of the analytical method (0.5ppb) was not found in surface SSS, however, it was found in some irrigation wells without exceedances of the 1.0ppb level. All wells containing mercury were located in the west site of the river.
13. Cr was found in some SSS, however, in none of the cases exceedances of the respective EQS limits were found.
14. Zinc was found in significant concentrations in the surface aquatic systems of the basin, however, exceedances of the respective EQS limits were found only in the SSS located on the river Nestos.
15. Sn was also found in many SSS of surface aquatic system and there were exceedances of the respective EQS limits in many SSS of irrigation/drainage canals as well at the SSS 13 and 16 of the river Nestos.
16. Mn was found in all aquatic systems of the basin with exceedances of the respective limit of 50ppb in many surface aquatic systems as well irrigation wells.
17. Fe was also found at significantly high concentrations in both surface and groundwater of the basin with exceedances of the 200ppb level at the SSS 13 and 15 of the river Nestos and in one well.
18. High concentrations of nitrates were found periodically in many SSS of the basin, however, in none of the SSS the values of the respective annual mean concentrations were in excess of the 50ppm limit.
19. Nitrites and ammonia were also found at significant concentrations in many SSS of the basin, however, exceedances of the 0.5ppm limit were found mostly in many wells.
20. Fluorides were found in many SSS of the basin, however, in none of the SSS exceedances of the 1.5ppm limit were found.
21. Sb was not found in any of the wells monitored. Al was found in some wells, however, only in one well the respective concentrations were in exceedance of the 200ppb limit.
22. High concentration of ions (nitrates, ammonia, phosphates, chlorides and fluorides) were found in the sediments of the river Nestos and among these SSS the highest concentrations were found in the sediments of the SSS 13. The high nitrate and phosphate concentrations in the sediments of the SSS 13 is an indication that the river Nestos is receiving municipal wastes during its course into the Bulgarian territory.

23. The concentrations of metals found in the sediments of the river Nestos, compared to the respective concentrations found in the sediments of the rest of the rivers included in the study, were at medium to low levels with the exception of Pb, Na and Fe. High concentrations of the latter metallic elements were found in many SSS of the river and especially at the SSS 14.
24. Caffeine was found in all SSS located on the river Nestos as well the rest of the SSS located on other surface aquatic systems. The presence of caffeine in the water of the river at the SSS 13, located close to the Greek - Bulgarian border, is confirming the fact, based on the increased concentrations of anions found in the sediments of this site, that the river Nestos is receiving municipal wastes during its course into the Bulgarian territory. Caffeine was found only in 5 wells among those monitored; most probably the aquifers of the latter wells are replenished with the water of the river Nestos.
25. In the aquatic systems of the basin 66 pesticides were detected at least once, however, the respective concentrations were at relatively low levels with concentrations very rarely exceeding the 2.0ppb level.
26. In the basin of the river Nestos permanent installations for filling / washing spray equipment located on surface aquatic systems were not found. However, point pollution sites derived from the random disposal of pesticide containers and other packaging materials were identified.
27. In many SSS of the surface aquatic systems pesticides included in the EQS priority list were detected and for some of these pesticides (alachlor, lindane, chlorpyrifos ethyl, dimethoate, HCB, mecoprop and bentazone) the respective concentrations were in exceedance of the respective EQS limits.
28. Pesticide residues were detected in 12 wells, however, all the wells found with pesticide residues at levels >0.1ppb were located in the eastern half of the basin of the river Nestos. Pesticides found at the higher concentrations in groundwater were fenamiphos (0.232ppb), chlorthal dimethyl (0.103ppb) and atrazine (0.656ppb).
29. During the monitoring period 2010 - 2011, 29 pesticides were detected more than 5 times and among these the highest frequencies of detections were found for chlorpyrifos ethyl, azoxystrobin, bentazone, terbuthylazine, S-metolachlor, HCB and etridiazole detected 90, 31, 28, 28, 24, 23 and 23 times, respectively. The 75% of the residue values were in the range of 0.001 to 0.529ppb which can be considered as the level of the unavoidable contamination of surface aquatic systems in the basin of the river Nestos occurring under the local environmental conditions and agricultural practices. All residue values found at higher levels were traced to be due to point pollution sites.

30. During the 2012 monitoring period, 19 pesticides were detected more than 5 times and among these the highest frequencies of detection were found for bentazone, chlorpyrifos ethyl, etridiazole and nicosulfuron detected 34, 24, 15 and 15 times, respectively. The residue values of 75% of the data collected were in the range of 0.001 to 0.533ppb which is about the same range as the one found for the 2010 - 2011 period. Therefore, based on a 3 year monitoring data, it is reasonable to assume that the unavoidable contamination of surface aquatic systems with pesticide residues did not exceed the 0.533ppb level.
31. In the aquatic systems of the basin in 69 instances ecotoxicological risk to aquatic organisms was found, based on the Risk Quotient. Among the 69 instances, 10 instances occurred in the water of the river Nestos due to the presence of methomyl, pirimicarb and PCNB at the SSS 13, folpet and PCNB at the SSS 14, L-cyhalothrin and PCNB at the SSS 15 and L-cyhalothrin, imidacloprid and PCNB at the SSS 16.

1.6. BASIN OF THE RIVER AGGITIS-DRAMA

1. During the entire monitoring period of 2010 - 2012, the mean values of pH in the surface aquatic systems of the basin ranged from 5.87 to 8.14 and the respective mean temperature values ranged from 10.60 to 19.66°C.
2. Also the mean values (2010 - 2012) of TDS, conductivity and Redox ranged from 180 to 300mg/L, 300 to 500 μ S/cm and 100 to 170mV, respectively.
3. The respective ranges of the groundwater aquifers were at higher levels while in a significant number of the wells monitored the respective Redox values were negative. Most of the wells with negative Redox values were found in the area of Tenagi of Fillipi and in the plain area of Drama; wells with negative Redox values were not found in the sub-basin of K. Nevrokopi.
4. The irrigation quality of the aquatic systems of the basin including surface and groundwater, based on the American Classification system, was Intermediate to Good. Concentrations of Boron higher than 1.0ppm were not found.
5. There were no exceedances of the EQS limits of chlorite and sulphate concentrations found in all surface aquatic systems; exceedances of sulfate concentrations from the respective EQS limit were found only in a few wells.
6. Caffeine was found in all SSS of surface aquatic systems of the basin and in some of them the respective concentrations were at significantly high levels.
7. Among the 121 irrigation wells monitored in the basin of Aggitis - Drama in 47 wells caffeine was found indicating that these wells were somehow receiving improperly treated municipal wastes or the respective aquifers were replenished with surface

- water receiving municipal wastes. The wells found with caffeine were dispersed all over the basin included also the sub-basin of K. Nevrokopi.
8. In the aquatic systems of the basin a significant number of pesticides detected are included in the priority list of EQS and in many SSS the respective EQS limits were exceeded. Among the SSS where exceedances of EQS limits were found is included the SSS 2071 (exceedance for HCB) located in the irrigation dam of Lefkogia. This dam is located in a hilly area with no agricultural activity taking place in the surrounding area. The only alternative for the presence of pesticides in the water of this dam was atmospheric transfer of pesticides from other areas including also the neighboring Bulgaria; pollutants were deposited on the surface of the earth included the surface of the dam by rain and other forms of precipitation.
 9. The presence of HCB and lindane in the water of the river Aggitis, downstream of the Maara Cave, was traced back to their respective presence in the water of the Lefkogia irrigation dam located in the sub-basin of K. Nevrokopi. The highest concentrations of both HCB and lindane were found in the water of the dam and the respective concentrations were decreasing along the course of the main irrigation canal of the sub-basin of K. Nevrokopi which was fed with water from the dam; the final receiver of the water of the main irrigation canal of K. Nevrokopi is the river Aggitis.
 10. In a significant number of wells (38 wells) either pesticide residues or diphenylamine at concentrations >0.1ppb were found. Concerning the wells with pesticide residues exceeding the 0.1ppb, in most wells the pesticide found at concentrations >0.1ppb was the herbicide chlorthal dimethyl; in a few wells atrazine, prometryne, dimethenamid and phorate sulfoxide were found. In two wells the presence of atrazine at 5.4ppb and of phorate sulfoxide at 1.95ppb, respectively, was traced to be due to respective point pollution sites. Most of the wells having diphenylamine concentrations higher than 0.1ppb were located in the area of Argiroupoli close to the capital City of Drama. The wells found with pesticide concentrations at levels >0.1ppb were dispersed all over the basin.
 11. During the monitoring period of 2010 - 2011 only 16 pesticides were detected more than 5 times in the surface aquatic systems. Among these pesticides the highest frequencies of detection were found for chlorpyrifos ethyl, fluometuron, terbuthylazine and prometryne detected 146, 78, 57 and 39 times, respectively. Among these pesticides with the highest detection frequencies the highest concentrations were found for terbuthylazine and chlorpyrifos ethyl which were found at 12.335 and 2.434ppb, respectively. During the same period 75% of the residue values were in the range of 0.001 to 0.7ppb with some extreme values exceeding the above range; the

latter residue values were traced to point pollution sources derived from sites of filling / washing spray machinery.

12. Among the pesticides detected more than 5 times during the 2012 monitoring period chlorpyrifos ethyl, fluometuron and terbuthylazine were found with the highest frequencies detected 44, 33 and 22 times, respectively. The 75% of the residue values were in the range of 0.001 to 0.5ppb. Therefore the overall range for the entire monitoring period ranging from 0.001 to 0.7ppb can be considered as the level of the unavoidable contamination of surface waters with pesticides used under the local environmental conditions and agricultural practices.
13. The significantly high concentrations of diphenylamine found in groundwater of a certain area of the basin (area of Argiroupoli) were probably due to a point pollution source located at an installation of car tire recycling facility located in the Industrial Park of Drama.
14. It is concluded from the above presentation that the soils of the basin of the river Aggitis are permeable allowing the leaching of nitrates and pesticide residues. Some of the pesticides found such as atrazine, prometryne, alachlor, acetochlor and lindane, are not registered anymore in Greece and probably are still present in the environment from either uses of the past or some illegal use occurring during the monitoring period. Other pesticides found in groundwater were chlorpyrifos ethyl, chlorthal dimethyl, fluometuron, and S-metolachlor. The use of the latter pesticides should be prohibited in this basin due to leaching to groundwater at levels higher than 0.1ppb. Diphenylamine was also found in groundwater at considerable concentrations especially in the wells located in an area close to the Industrial Park of Drama (area of Argiroupoli).
15. In the basin of the river Aggitis, during the period of 2010 - 2012, in 107 instances there was ecotoxicological risk to aquatic organisms due to the presence of pesticide residues; ecotoxicological risk was evaluated on the basis of the Risk Quotient.

1.7. BASIN OF THE RIVER STRYMONAS

1. During the monitoring period of 2010 - 2012, the mean values of pH in all SSS of the basin including also the SSS located in the lake Kerkini ranged from 8.0 to 8.5.
2. During the same period the mean temperature values at the SSS located on the river Strymonas ranged from 17.25 to 18.18°C while the respective values at the SSS of the surface water layer of the lake Kerkini ranged from 19.38 to 19.80°C and between 16.80 to 17.70°C in the hypolimnion layer of the lake. The difference in temperature between the surface water layer and the water layer of the hypolimnion was small since the lake Kerkini is a shallow lake with the water level ranging from 2.2 to 6.05m.

The lowest water level was found during the measurements made on September, 2011. The Secchi disk depth was also found to have a wide variation ranging from 0.40 to 3.0m with the smaller values measured again during the September, 2011 measurement and sampling session.

3. The dissolved oxygen content in both surface and hypolimnion layers of water as well the respective % oxygen saturation levels were at adequate levels at all measurement sessions except for the measurements made on May 2012 when low oxygen concentrations were measured ranging from 3.66 to 1.04ppm in the hypolimnion layer of the lake. Frequently supersaturation conditions with oxygen were found in the surface layer of the lake due to the intensive photosynthetic activity of the aquatic plants.
4. The mean values of TDS and conductivity at the SSS of the river Strymonas with the exception of the SSS with code number 20 and at all SSS of the lake Kerkini, were at very low levels of about 200ppm and 300 μ S/cm, respectively. At the SSS 20 which is located upstream of the river Delta the values of the above parameters were about at twice higher levels; the increased conductivity and the TDS content of the water at the SSS 20 was due to the infiltration of sea water especially during the periods when the river flow was low.
5. The Redox values at the SSS located on the river Strymonas were at very low levels especially at the SSS 17, located closer to the Bulgarian border; the Redox values were even negative during July to September and occasionally in November. Also reductive conditions (negative Redox values) were found in the water of lake Kerkini especially at the SSS located at the hypolimnion layer of the lake.
6. In the highest proportion of the irrigation wells monitored the conductivity and TDS values were in the same range of values as those found for the surface waters with the exception of the wells with code numbers 1371 to 1378 in which the respective values were at much higher levels.
7. According to the American Classification System of Irrigation water quality, the quality of the water of the river Strymonas including also the lake Kerkini was Intermediate to Good with the exception of the water at the SSS 20 where the quality was Intermediate to Moderate. The irrigation quality was Intermediate to Good with a few exceptions being Intermediate to Moderate in the rest of the surface aquatic systems as well the irrigation wells.
8. Exceedances of the EQS limit of chlorite concentrations was found for the SSS 20 and some wells located in the area of N. Zichni.
9. Concentrations of Boron higher than 1.0ppm were found at the SSS 19 of the river Strymonas and some other surface aquatic systems.

10. Arsenic at concentrations not exceeding the EQS limit were found in many SSS of surface waters. In a number of irrigation wells (codes 1340, 1338, 1336 and 1368) As concentrations in exceedance of the 10ppb were found. The increased concentrations of As in groundwater of the areas of Alistrati (wells with codes 1240, 1338 and 1336) and Iraclia (well with code 1368) are related with the existence of respective geothermal sites.
11. Mercury at concentrations higher than the method reporting level were not found. Cd was found in some SSS at concentrations higher than the respective reporting level of the analytical method without exceedances of the respective EQS limits. Cu and Cr were also found at concentrations higher than the respective method reporting levels, however, in none of the SSS exceedances of the EQS limits were found. The highest concentration of Cr amounting to 33ppb was found in the river Ammoudopotamos which is discharging into the lake Kerkini.
12. Pb was found in many SSS located on the surface aquatic systems and in a high proportion of these sites exceedance of the EQS limit was found. Also Pb was found in a number of irrigation wells with exceedance of the 10ppb level in a number of wells located in the area of Alistrati and the area of Valterou-Chorterou-Gefyroudi.
13. Nickel at low concentrations was found occasionally in the water of the river Strymonas and in some other SSS located on surface aquatic bodies. However, higher concentrations were found in some wells with exceedance of the respective limit in two wells located in area of Pontismeno.
14. Zn and Sn at concentrations higher than the respective reporting levels of the analytical methods were found in a significant number of SSS located on the surface aquatic systems of the basin, however, only in a few cases respective exceedances of the EQS limits were found.
15. Mn and Fe were in abundance in both surface and groundwater aquifers of the basin and in many SSS, especially irrigation wells, there were exceedances of the respective limits.
16. Seasonally medium level concentrations of nitrates were found in the SSS of the basin, however, exceedances of the 50ppm level were found in a significant number of wells located in the areas of Toumba, Chortero and Valtero.
17. Nitrites were also found at significant concentrations in many SSS with exceedances of the 0.5ppm level in both surface and groundwater sites.
18. Ammonia and fluorites were found at relatively low concentrations.
19. Sb was not found in groundwater at levels higher than the method reporting level. Al was found in some wells with the respective concentrations exceeding the respective limit in two wells.

20. High concentrations of Pb were found in the sediments of the lake Kerkini, however, even higher concentrations of Pb were found in the sediments of the river Strymonas especially at the SSS located downstream of the lake Kerkini. This is suggesting that while the presence of Pb in the sediments of the lake Kerkini might be related to pollution imported from Bulgaria, there is/are additional source(s) located downstream of the lake. In the basin of the river Strymonas there is a big number of uncontrolled garbage burial sites (X.A.D.A.) and it is suspected that these sites are sources of heavy metals polluting the sediments and water of the river. Also high Cd concentrations were found in the sediments of the lake Kerkini. In fact the concentrations of Pb and Cd found in the sediments of the lake Kerkini were the highest found in sediments of all lakes included in the study area. Also very high were the concentrations of As, Mn and Fe in the sediments of both the river Strymonas and the lake Kerkini. In medium levels, compared to the concentrations found in the sediments of other lakes, were the concentrations of Cu, Zn and B and at low levels the concentrations of Ni, Sn and Cr. At medium levels were also found the concentrations of nitrates, nitrites, ammonia and phosphates and at low levels were the concentrations of chlorites and fluorites.
21. Significant concentrations of chlorophyll were measured in the surface water layer of the lake Kerkini in the samples collected in September of 2011 and at this session also low concentrations of dissolved oxygen were found at the hypolimnion layer of the lake while the Secchi disk depth was found to have the lowest value among all values measured during the entire monitoring period.
22. Caffeine was found in all surface aquatic systems of the basin including the river Strymonas. This is an indication that the river Strymonas was receiving improperly treated municipal wastes upstream in the Bulgarian territory and this load was further increased along the course of the river towards the Delta area. Caffeine, however, was found in only in one well (code 1351) and only once. This well is located in the area of Chortero. The absence of caffeine from groundwater, even though caffeine was present in all surface aquatic bodies monitored, is an indication that the aquifers of the wells monitored are protected and there is no communication between surface and groundwater systems.
23. Pesticide residues were found in all surface aquatic systems of the basin including the SSS located in the lake Kerkini. Pesticide residues were found only in a limited member of wells with the respective concentrations not exceeding the respective trace levels. Only in one well (code 1378) atrazine was found at the level of 0.183ppb. The absence of pesticide residues from groundwater is in agreement with the conclusion made above concerning the absence of caffeine from groundwater

- indicating that the groundwater aquifers are protected and there is no communication between surface and ground water.
24. In the surface aquatic systems of the basin of the river Strymonas 76 pesticides were detected at least once. The respective concentrations were at relatively low levels and in none of the instances the respective residue levels found were higher than 3.0ppb level.
 25. At the SSS 17 located on the river Strymonas downstream from the Greek-Bulgarian border many pesticides were detected and in these were included 2.4-D, acetochlor, a-HCH, alphamethrin, atrazine, lindane, chlorpyrifos ethyl, chlorthal dimethyl, etridiazole, fenarimol, HCB, pendimethalin, pirimiphos methyl, propamocarb, simazine, S-metolachlor, terbuthylazine, thiamethoxam and triclopyr. However, most of these pesticides were found at either trace levels or concentrations not exceeding the 0.1ppb level and very rarely concentrations exceeding the 0.5ppb level were found.
 26. The pesticides detected at the SSS 17 of the river Strymonas were also detected in the water of the lake Kerkini, however, at concentrations >0.1ppb were found only chlorthal dimethyl, etridiazole and 2.4-D.
 27. In the surface aquatic systems of the basin of the river Strymonas pesticides included in the priority list of EQS were found and in these were included chlorpyrifos ethyl, atrazine, lindane, HCB, simazine, trifluralin, bentazone, alachlor, and 2.4-D. However, exceedances of the EQS limits in 90% of the cases were due to lindane.
 28. During the period of 2010 - 2011 only 50 pesticides were detected more than 5 times and among these chlorpyrifos ethyl had the highest frequency followed by fluometuron and prometryne detected 154, 98 and 70 times, respectively. During the same period 75% of the residue values were in the range of 0.001 to 0.687ppb which could be considered as the level of the unavoidable contamination of surface aquatic systems occurring under the local environmental conditions and agricultural practices. However, concentrations reaching the 3.0ppb level were found for atrazine, terbuthylazine and fluometuron derived from point pollution sites of filling / washing spray equipment.
 29. During the 2012 monitoring period only 18 pesticides were detected more than 5 times and among these at the highest frequencies were found fluometuron, chlorpyrifos ethyl, 2.4-D and S-metolachlor detected 38, 30, 28 and 26 times, respectively. The range of the 75% of the residue values varied between 0.001 to 0.463ppb which could be considered as the level of unavoidable contamination of surface waters during 2012. However, for the pesticides S-metolachlor, molinate and 2.4-D extreme values reaching the 0.71ppb were found.

30. During the monitoring period of 2010 - 2012, in 96 instances there was ecotoxicological risk to aquatic organisms, based on Risk Quotient. Most of the risk cases were due to the presence in aquatic systems of organophosphorus and pyrethroid insecticides and to lesser degree due to the presence of the herbicides acetochlor, S-metolachlor and terbuthylazine.
31. Frequently ecotoxicological risk to aquatic organisms of the lake Kerkini existed due to the presence in significant concentrations of the insecticides alphas-methrin and pirimiphos methyl and of the fungicide PCNB.

1.8. BASIN OF THE LAKE DOIRANI

1. Doirani is a transboundary lake divided in a about a ratio of 1:2 between Greece and FYROM. This is a shallow lake with the highest depth measured, in the section of lake under the Greek territory, not exceeding the 6.5m. The lowest water level ranging from 5.7 to 4.2m was found during the sampling session of October, 2010 and the highest , ranging from 6.2 to 6.5m, in May, 2011. The Secchi disk depth was only 0.75m in October of 2010 and was improved from 2.2 to 2.5m in April 2012.
2. The concentrations of dissolved oxygen as well the respective % water saturation levels in oxygen were at adequate levels in both surface and hypolimnion water layers of the lake.
3. During the monitoring period the pH of the lake Doirani was about 8.5 and ranged from 6.58 to 8.1 in the rest of surface aquatic systems of the basin while pH values ranging from 6.0 to 7.7 were found in the irrigation wells.
4. The mean temperature in the three SSS of the lake Doirani ranged from 15.5 to 16.40°C in the surface layer and from 14.50 to 14.73°C in the hypolimnion layer.
5. The values of TDS, conductivity and Redox in the water of the lake were at significantly higher levels than the respective levels found in groundwater of the basin.
6. The irrigation wells monitored were providing water with completely different physicochemical parameters than those found for the water of the lake with the exception of one well and an artesian spring located in the town of Amarada which had quality characteristics similar to those of the lake water. The respective mean values of physicochemical parameters found in most of the rest of the surface aquatic systems were at higher levels than those found in groundwater, however, they were at much lower levels than those found in the water of the lake. This is an indication that the water of the lake is replenished by springs or other sources of water completely different from those sources replenishing the groundwater aquifers or the surface waters of the basin located under the Greek territory.

7. The Redox values were positive in all SSS even though in a few wells the Redox values were at very low levels <30mV.
8. According to the American Classification System of water irrigation quality, the quality of the water of the lake was Intermediate to Moderate while much better irrigation quality was found in the rest of the surface aquatic systems of the basin. Also the irrigation quality of the wells, with the exception of only one well, was much better than the respective quality of the water of the lake Doirani. Bad irrigation quality was found only at one SSS located on a stream discharging into the river of Doirani (code 2272). The concentrations of Boron were at relatively low levels in all SSS with the exception of the SSS 511 / 512 of the lake where concentrations >1.0ppm were found.
9. The concentrations of chlorites and sulphates were at relatively high levels with exceedances of the respective EQS limits in one well (code 1463) and two SSS of surface aquatic systems (codes 2272 and 2281).
10. Arsenic concentrations higher than the method reporting level were found only in the water of lake Doirani, however, there was no exceedance of the respective EQS limit.
11. Cd at concentrations exceeding the EQS limits were found at the SSS 515 and 511 of the lake Doirani as well at the SSS 2277 located on a stream discharging into the lake and also exceedances were found in a few other SSS of surface waters.
12. Pb at concentrations higher than the 7.2ppb EQS limit were found in one SSS of the lake Doirani as well in a few other SSS of surface waters. Also Pb was found in a significant proportion of the monitored wells, however, exceedance of the 10ppb level was found only in one well. According to the existing geological data the presence of Pb in the water, surface and groundwater, of the basin is related to the rich presence of metals in the natural background of rocks and soils of the basin. In fact, it is known that in the area of the basin located under the territory of FYROM there is in operation of a metal extracting mine.
13. Ni at low concentrations was found in many SSS, however, exceedance of the 20ppb level was found only in the water of one well.
14. Copper and mercury were not found in the aquatic systems of the basin at concentrations exceeding the respective reporting levels of the analytical methods.
15. Cr and Zn were found in some SSS of the basin, however, in none of the cases concentrations higher than the respective EQS limits were found.
16. Sn was found in almost all SSS of surface water of the basin with the exception of those located in the lake Doirani; in all SSS the respective concentrations found were higher than the 2.2ppb of the EQS annual mean concentration limit.

17. Mn and Fe were commonly found in both surface and ground waters of the basin and exceedances of the respective limits were found both in surface waters and irrigation wells.
18. The concentrations of nitrates in the water of the lake were seasonally below the reporting level of the method and this was especially true for the SSS located in the central area of the lake closer to the FYROM border line. Low to medium concentrations of nitrates were found in the other surface and ground water SSS. Exceedance of the 50ppm limit was found only at the SSS 2272.
19. Nitrites above the method reporting level were found in some SSS of the basin, however, annual mean concentrations exceeding the 0.5ppm level were found only at the SSS 514 / 515 of the lake and the SSS 2272.
20. Ammonia at levels above the reporting level of the method were found in some SSS of the basin and exceedances of the respective limit of 0.5 were found only at the SSS 511, 512, 515 and 516 of the lake Doirani.
21. Fluorites at significantly high concentrations were found in many SSS of surface and groundwater sites with the respective mean values exceeding the 1.5ppm limit in all SSS located in the lake Doirani and in a significant number of SSS of other surface aquatic systems; exceedance of the 1.5ppm level of fluorites was found only in one well (code number 1460).
22. The concentrations of phosphates and total phosphorous were at low levels or at levels not exceeding the respective reporting levels of the analytical methods.
23. Sb was not found in groundwater at concentrations higher than the method reporting level. Aluminum was found in some wells with exceedance of the 50ppb limit in the well with code 1458.
24. Caffeine was found in all surface and groundwater SSS of the basin. The higher concentrations were found in samples of surface waters indicating that all surface waters were receiving municipal wastes improperly treated. Certainly leaching of caffeine into groundwater could be the mechanism explaining the presence of caffeine in groundwater. Apparently there is communication between surface and groundwater aquifers of the basin, however, there is no communication between groundwater with the lake.
25. In the SSS of the basin 80 active ingredients of pesticides, including also major metabolites and conversion products, were detected at least once. This is a significantly high number of pesticides considering the small size of the basin and the even smaller portion of the area devoted to agriculture.
26. A number of pesticides included in the priority list of EQS was found in the surface aquatic systems of the basin and for some of them (lindane, chlorpyrifos ethyl,

- coumaphos, MCPA and diuron) the respective concentrations were higher than the respective EQS limits.
27. The pesticides found at the highest concentrations were chlorpyrifos ethyl, diuron, tebuconazole, fluometuron, MCPA, methoxyfenozide, terbuthylazine, S-metolachlor and dimethenamid; the respective concentrations of these compounds ranged from 6.6 to 1.0ppb. However, most of the highest concentrations were found at the SSS with code 2283; close to this SSS a point pollution source due to filling / washing of spray equipment was identified.
 28. Many pesticides such as chlorpyrifos ethyl, chlorthal dimethyl, flutriafol, terbuthylazine and lindane were also found in groundwater of the basin. Diphenylamine was also found in groundwater. The presence of pesticides in groundwater is in agreement with the presence of caffeine in groundwater, as reported above, proving that the groundwater aquifers are not protected and are vulnerable to leaching.
 29. In a significant proportion of the wells monitored the concentrations of diphenylamine found were >0.1ppb.
 30. Some pesticides such as lindane, etridiazole, alphasmethrin and boscalid were also detected in the samples taken from the SSS of the lake.
 31. In the sediments of the lake Doirani high concentrations of nitrates, phosphates, fluorites, chlorites and metallic elements such as As, Cd, Pb and Mn were found.
 32. During the period of 2010 - 2012 the variation of 75% of the pesticide residue values found in surface aquatic systems ranged from 0.01 to 0.5ppb and this range could be considered as the level of the unavoidable contamination of surface aquatic systems under the local environmental conditions and agricultural practices; all residues values found at levels exceeding the above range were traced to be due to point pollution sites.
 33. During the period of 2010 - 2012, in 37 cases there was ecotoxicological risk to aquatic organisms, based on the Risk Quotient. Seven of the above 37 cases occurred into the lake environment due to the presence in the water of the lake of residues of different pyrethroid insecticides.

1.9. BASIN OF THE RIVERS AXIOS-LOUDIAS

1. The mean pH values in the four SSS located on the river Axios ranged from 7.83 to 8.15; the respective mean values in the SSS of the river Loudias were 7.61 to 7.75. The mean temperature of the water in the river Axios at the SS in Axioupoli, the closest to the Greek - FYROM boarder, was 16.34 while 16.78°C was the mean temperature at the SSS located close to the Delta; there was a 0.5°C increase in the mean temperature along the course of the river in the Greek territory. In the river

Loudias the respective mean temperature values were 22 and 18.04°C having a 4°C difference along the course of the river.

2. The mean values of TDS, conductivity and Redox at the SSS of surface waters including those located on the river Axios were at low levels while higher values were found at the SSS located on the river Loudias. The respective values for the SSS located on the soil drainage canals in the south section of the basin were at much higher levels due to soil drainage processes. In the south section of the basin is in operation an organized open channel irrigation system and a respective separate system for soil drainage. In the rest of the basin the old soil draining system is now used for irrigation purposes and thus the physicochemical characteristics of the water in these channels during the irrigation period are mostly similar to those of the irrigation water source (water from the river Axios) while during the rest of the period the water of these channels is greatly affected by the soil drainage processes. The respective values in the underground aquifers in some areas were in the same range of the surface waters while in other areas were at much higher levels. The respective values in some of the surface SSS located close to discharge areas of streams and drainage channels into the sea were at much higher levels due to infiltration of sea water.
3. According to the American Classification System of irrigation quality, the quality of the water of both rivers, Axios and Loudias, was Intermediate to Good with the exception of the water at the SSS with code 25 of Loudias located upstream of its discharge area into the Thermaikos Bay, where the irrigation quality was Bad. Bad was also the irrigation quality of water discharged into the Thermaikos bay via different ditches; Bad was also the irrigation quality at some SSS located on inland streams and ditches. In the rest of the SSS the irrigation quality was Intermediate to Good or Intermediate to Moderate.
4. There were not exceedances of the EQS limit in the chlorite concentrations at the SSS of the rivers Axios and Loudias, however, there were exceedances in many SSS located either close to the sea and even inland. Exceedances of the 250mg/L limit were also found in some wells located close to Chalkidona and Koufalia.
5. Boron at concentrations higher than 1.0ppm were found mainly during the 2010 monitoring period.
6. Arsenic at low concentrations was found at the SSS located on both rivers, Axios and Loudias, and at some SSS of other surface water bodies without, however, finding exceedances of the respective EQS limit. Significantly higher concentrations were found in the water of wells reaching the 125ppb level in a well with code number 1445. All the wells with high As levels were located close to the river Axios in the area

- of Prochoma. The high As levels in groundwater are related to high levels of As present in the natural background of the area.
7. Cd at concentrations higher than the respective reporting limit of the analytical method were found at two SSS located on the river Loudias and some SSS of other surface waters located in the sub-basin of the river Loudias. In all these SSS the respective EQS limits of either the annual mean or annual maximum concentrations were found to be exceeded.
 8. Pb was found in almost all SSS of surface aquatic systems of the basin with the respective concentrations exceeding the respective EQS limits. Pb was also found in a significant number of wells and in a number of wells the respective concentrations were higher than the 10ppb level.
 9. Ni was found in some SSS of surface water and only in a few SSS the respective concentrations were in exceedance of the respective EQS limit.
 10. Cu was rarely found in the aquatic systems of the basin.
 11. In none of the SSS of the basin the respective concentrations of mercury were higher than the reporting level of the analytical method.
 12. Cr was found in some SSS, however, no exceedances of the EQS limits were found.
 13. Zn was found in a number of SSS of the basin, however, exceedances of the respective EQS limit were found only at the SSS 25, 26 and 27 located on the river Loudias and only during the 2010 monitoring period.
 14. Sn was also found in most of the SSS of the surface aquatic systems of the basin and in most of these sites the respective concentrations were in exceedance of the respective EQS limit.
 15. Mn and Fe were found at significant concentrations in both surface and groundwater systems of the basin with exceedances of the respective limits in a significant number of SSS of surface and groundwater.
 16. Seasonally high concentrations of nitrates were found with exceedances of the 50ppm limit only in groundwater and specifically in 5 wells located all over the basin.
 17. Nitrites and ammonia in significant concentrations exceeding the 0.5ppm were found in a number of SSS located on surface water and also in a few wells.
 18. Fluorides were found in many SSS of the basin, however, the respective concentrations were never found in exceedance of the 1.5ppm level.
 19. Sb and Al were not found in ground water of the basin at concentrations higher than the respective reporting levels of the analytical methods.
 20. Some of the pesticides included in the priority list of EQS were found in the surface aquatic systems of the basin and exceedances of the respective EQS limits were

- found for lindane, chlorpyrifos ethyl, bentazone, atrazine, malathion, 2.4-D, MCPA, propanil, linuron and HCB.
21. Caffeine was found in all SSS of surface water and in almost all SSS (wells) of groundwater. The presence of caffeine in surface water is an indication that these aquatic systems are receiving municipal wastes improperly treated, while the presence of caffeine in groundwater indicates that there is immediate communication between surface and groundwater systems of the basin.
 22. Many pesticides were detected in groundwater SSS and in a number of wells (9 wells) the respective concentrations of pesticides detected were >0.1ppb. In the pesticides found in groundwater at concentrations >0.1ppb were included alachlor, fluometuron, ioxynil, prometryne, bentazone and 2.4-D. Diphenylamine was also found in some wells at concentrations >0.1ppb.
 23. During the monitoring period of 2010 - 2012, in the aquatic systems of the basin of the rivers Axios and Loudias 130 active ingredients of pesticides, including also major metabolites and conversion products, were detected at least once.
 24. During the monitoring period of 2010 - 2011, in the SSS of the surface aquatic systems of the basin 62 pesticides were detected more than 5 times. The frequency of detection for some of these pesticides was very high and in these were included chlorpyrifos ethyl, prometryne fluometuron and tebuconazole detected 366, 308, 273 and 165 times, respectively. The range of 75% of the residue values was from 0.001 to 1.777ppb which can be considered as the range of the unavoidable contamination of surface water systems under the local environmental conditions and agricultural practices. All residues values higher than the upper border of the variation were traced to be due point pollution sites.
 25. During the monitoring period of 2012 in the SSS of the surface aquatic systems of the basin 37 pesticides were detected more than 5 times; the highest frequency of detection was found for fluometuron, followed by chlorpyrifos ethyl, bentazone, tebuconazole, 2.4-D, prometryne and imidacloprid with 140, 119, 115, 74, 60, 54 and 51 detections, respectively. The 75% of the residue values ranged from 0.001 to 0.57ppb and most of the higher residue values found were traced to be due to point pollution sites. The above range can be considered as the unavoidable contamination of surface aquatic systems occurring under the local environmental conditions and agricultural practices of farmers operated in the basin of the rivers Axios and Loudias.
 26. In the SSS located on both rivers, Axios and Loudias, during the entire monitoring period of 2010 - 2012, 37 pesticides were detected more than 5 times and among these detected more than 50 times were included chlorpyrifos ethyl (190 detections), prometryne (115 detections), fluometuron (97 detections), tebuconazole (92 detections),

S-metolachlor (54 detections), bentazone (51 detections) and imidacloprid (50 detections). The range of 75% of the residue values was from 0.001 to 0.852ppb while extreme values found for different pesticides were traced to be due to point pollution sites.

27. Due to the presence of pesticide residues in the surface aquatic systems of the basin in 426 cases there was ecotoxicological risk to aquatic organisms, based on the Risk Quotient. Risk to aquatic organisms was caused by the presence of pesticide residues of the organophosphorus insecticides chlorpyrifos ethyl, ethion, malathion, profenofos, pirimiphos methyl, of the pyrethroid insecticides deltamethrin, bifenthrin, L-cyhalothrin, alphamethrin and other insecticides / acaricides / nematicides like diflubenzuron, imidacloprid, carbaryl, methomyl, methoxychlor, fipronil and lindane and rarely due to the presence of the herbicides lenacil, fluometuron, acetochlor, prometryne, S-metolachlor and atrazine.
28. In the sediments of both rivers high nitrate, ammonia, phosphate, As, Pb, Zn and Fe concentrations were found. In addition in one of the sediment samples taken from the SSS 27 of the river Loudias mercury was found at the concentration of 16.2ppm.

1.10. BASIN OF THE LAKES LANGADA-VOLVI AND MYGDONIAS

1. The mean values of pH during the 2010 - 2012 monitoring period at the SSS located in the lake Volvi ranged from 8.0 to 8.5 while the respective mean for the lake Koronia was about 9.0.
2. The mean values of temperature at the SSS of the lake Volvi ranged from 22.35 to 23.13°C in the surface water layer and from 16.58 to 18.15°C in the hypolimnion layer of water.
3. The concentrations of dissolved oxygen and the respective % oxygen saturation values in the hypolimnion layer of the lake Volvi were at low levels especially during the 2011 monitoring period.
4. During the entire monitoring period the Redox values were negative in almost all SSS of the lake Volvi indicating the existence of reductive conditions especially at the hypolimnion layer of water.
5. The Secchi disk depth was at relative low levels during the entire monitoring period ranging from 1.0 to 1.7 m at all SSS of the lake Volvi.
6. During the monitoring period the water level of the lake Volvi ranged from 18.00 to 19.50 m in the area of Rentina-Mikri Volvi and from 13.0 to 14.5 m in area of Loutron Volvis.
7. The mean values of conductivity and TDS were at relatively high values at all SSS located in the lake Volvi. Also in all SSS located on surface water bodies in the area

of Nymfopetra were at much higher values compared to the respective values found in the rest of the surface aquatic systems including those found for the water of the lake Volvi. In the lake Koronia (only two samples were analyzed) the respective values were at much higher values namely at 8.000mg/L for TDS and 10.000 μ S/cm for conductivity.

8. In about 50% of the wells the mean values of TDS and conductivity were in the same range of values with the respective values found for the lake Volvi while in the rest of the wells the respective values were at much higher levels. Also the Redox values in many wells were negative while in the rest of the wells the respective values were at the low oxidative state (<50mV).
9. According to the American Classification System of water irrigation quality, the quality of the water of the lake Volvi was Intermediate to Moderate while the respective quality of the water of lake Koronia was Bad. Intermediate to Good and also Intermediate to Moderate was the irrigation quality of the rest of the surface aquatic systems. Also Intermediate to Good was the quality of the water of most of the wells with a few wells having Intermediate to Moderate quality. The Boron concentrations were at low levels except for the period of 2010 when concentrations >1.0ppm were found in the SSS of the lakes Volvi and Koronia and in a few other SSS.
10. Chlorite concentrations exceeding the EQS limit were found in the lake Koronia and in certain streams and ditches discharging into both lakes. Exceedances of the sulphate EQS limit were found only in the water of the lake Koronia and one stream with the code 2227.
11. Arsenic in significant concentrations was found in the SSS of the lake Volvi, however, there were no exceedances of the annual mean concentration limit of EQS. Exceedance of the 10ppb limit for groundwater quality was found only in one well (code 1589).
12. Cadmium was found rarely in the aquatic systems of the basin of Mygdonia and exceedance of the EQS limit was found only once at a SSS located on a surface aquatic system.
13. Lead was found in many SSS of the basin and exceedances of the EQS 7.2ppb limit of annual maximum concentration were found in many SSS including the SSS located on the lake Volvi and many streams. Also Pb at a level higher than 10ppb was found in a well (code 1577) located at the town of Apollonia.
14. Nickel at low concentrations was found in some SSS of the basin.
15. Mercury was never found at concentrations higher than the respective reporting level of the analytical method while Cu was found above the respective reporting level of the method only in one well.

16. Cr was found in a number of SSS of surface and groundwater without the respective concentrations exceeding either the EQS limits or the limits of 98 / 83 Directive concerning drinking water quality.
17. Zn and Sn at concentrations higher than the respective reporting levels of the analytical methods were found in some SSS with exceedances of the respective EQS limits mainly for Sn.
18. Mn and Fe at significant concentrations were found in many SSS with exceedances of the 50ppb level in many surface and groundwater aquatic systems.
19. Low to medium levels of nitrates were found in SSS located on surface aquatic systems of the basin, however, in a number of wells the respective concentrations were higher than the 50ppm limit.
20. Nitrates at low levels were found in the lake Volvi, however, in one of the SSS (code 531) and also in some hypolimnion SSS the respective nitrate concentrations were below the respective reporting level of the analytical method. Nitrates were not found in any of the two samples taken from the lake Koronia.
21. Nitrites were found in many SSS of both surface and groundwater with exceedances of the 0.5ppm level in both surface and groundwater SSS.
22. Ammonia was found in some SSS and only in one SSS (2205) concentrations >0.5ppm were found.
23. Fluorides were found at significant concentrations in many SSS, especially in the SSS of the lake Volvi, streams and groundwater.
24. Sb was not found in groundwater of the basin. Al was found in some wells with the respective concentrations being >200ppb.
25. Caffeine was found in all wells monitored, in both of the lakes and in all samples taken from the rest of the surface aquatic systems. Some of the wells included in the monitoring network of this specific basin were dip wells supplying drinking water to a significant proportion of the population of the basin. The fact that caffeine was detected in the water of dip wells is a strong evidence that municipal wastes improperly treated and disposed have caused a wide range pollution of both surface and especially groundwater aquifers.
26. During the monitoring period 61 pesticides were detected at least once in the aquatic systems of the basin of the lakes Koronia - Volvi, however, among these pesticides only pendimethalin, propyzamide, molinate, fuometuron, carbaryl, dimethenamid, chlorthal dimethyl and etridiazole were found in significant concentrations. The highest concentration (2.64ppb) was found for pendimethalin in a surface SSS and propyzamide (2.138ppb) in a well (code number 1600).

27. In the samples collected from the lake Volvi many pesticides were detected such as chlorthal dimethyl, pirimiphos methyl, chlorpyrifos ethyl, S-metolachlor, fluometuron and fenvalerate, however, only the pyrethroid insecticide fenvalerate was found once at a concentration of 0.152ppb while the rest of the compounds were found at trace levels. Also in one of the samples taken from the lake Koronia fluometuron was detected.
28. Some of the pesticides detected in the surface aquatic systems of the basin are included in the priority list of EQS. These pesticides were chlorpyrifos ethyl, atrazine, bentazone, HCB, lindane, malathion, 2.4-D, chloridazone, dimethoate, mecoprop and linuron and in some SSS exceedances of the respective EQS limits for lindane and chlorpyrifos ethyl were found.
29. During the monitoring period of 2010 - 2011 only 5 pesticides were detected more than 5 times and in these were included chlorpyrifos ethyl, etridiazole, fluometuron, pirimiphos methyl and S-metolachlor. The residue data collected for this period were very limited to be subjected to any statistical analysis concerning the estimation of the unavoidable contamination of surface waters under the local environmental conditions and agricultural practices.
30. During 2012 also a limited number of pesticides (11) were detected more than 5 times and the highest number of detections was found for the herbicide chlorthal dimethyl (16 detections), followed by the insecticides lindane and chlorpyrifos ethyl detected 16 and 15 times, respectively. The range of 75% of the residue values was from 0.001 to 0.887ppb; there were also extreme values extending up to 1.2ppb level. However, the overall pesticide residue data collected were very limited to reach any conclusion concerning the level of the unavoidable contamination of aquatic systems from pesticides under the local environmental conditions and agricultural practices. It must be mentioned that the data were limited due to the fact that only from a few SSS of surface waters, including the SSS located on the two lakes, samples were taken on a regular basis because most of the other surface aquatic systems of the basin (streams, ditches, soil drainage canals, irrigation canals and even rivers etc.) were without water during the entire monitoring period.
31. In groundwater of the basin a significant number of pesticides was detected and in these were included pymetrozine, flonicamid, propyzamide, ethofumesate, dimethenamid, alachlor, chlorpyrifos ethyl, chlorthal dimethyl, fipronil, imidacloprid, dimethomorph, dimethoate, lindane, a-HCH, d-HCH, PCNB, propoxur, etridiazole, bentazone, folpet and S-metolachlor. Diphenylamine was also detected. Some of the pesticides (chlorthal dimethyl, fipronil, dimethenamid, dimethomorph and propyzamide and

- also diphenylamine) were found in groundwater at concentrations >0.1 ppb. About 25% of the wells monitored were found with pesticide residues at levels >0.1 ppb.
32. Caffeine was detected 58 times in 41 wells with the 75% of the concentrations ranging from 0.113 to 0.856ppb. There was also an extreme value of 10.3ppb found in one well. Obviously one of the main pollutants of groundwater was caffeine and this was due to the fact that still municipal wastes were either improperly disposed in ditches or the treatment facilities of municipal wastes and sewage were improperly operating discharging into the surface aquatic systems liquid wastes still rich in caffeine and most probably in other more persistent and dangerous compounds. Also the wide presence of caffeine as well of pesticides in groundwater, as presented above, is strong evidence that the soils of the basin are permeable to leaching and there is immediate communication between surface and groundwater aquifers.
 33. Only in 32 cases there was ecotoxicological risk to aquatic organisms based on Risk Quotient and among these 6 cases occurred in the aquatic system of the lake Volvi due to the presence of the organophosphorus insecticide pirimiphos methyl and of the pyrethroid insecticide fenvalerate.
 34. Extremely high concentrations of both ions and cations were found in the sediments of the lake Volvi. High concentrations of nitrates (0.5g/kg), ammonia, phosphates, chlorites and fluorites were found especially in the sediment at the SSS located in the area of Rentina. In the sediments of Volvi, especially in the sediments of SSS at Rentina, extremely high concentrations of Fe and B were found being the highest concentrations found among all the lakes included in the project. The concentrations Fe at this SSS ranged from 72.6 to 70.5g/kg and the respective concentration of Boron was 210ppm. Also the concentrations of Na, Mn, Pb and Sn were among the highest found among all other lakes included in the project while the concentrations of Ni, Cu and Zn were at intermediate levels compared to the concentrations found in the sediments of the other lakes. Also at low levels, compared to the other lakes, were the concentrations of As and Cd in the sediments of the lake Volvi. In one of the sediments pesticide residues were also detected, however, the respective concentrations were $<LOQs$.
 35. In the sediments of the lake Koronia the highest concentration of chlorites (30.9 g/kg) was found among all the lakes included in the study area. The respective concentration of chlorites in the sediments of the lake Volvi was 2.5 g/kg. Also the concentrations of nitrites, ammonia, fluorites, arsenic and cadmium were at very high levels in the sediments of the lake Koronia; in fact the concentration of Cd (27.1ppm) found in one of the sediments of the lake Koronia was the highest value found among the sediments of all lakes.

1.11. BASIN OF THE RIVER MOGLENITSA

1. The mean values of pH at the SSS of surface waters of the basin of the river Moglenitsa or Almopeos, a tributary of the river Aliakmonas, ranged around 8.0.
2. The mean values of conductivity and TDS were at medium to low levels. The Redox values were at relatively high oxidative conditions.
3. The TDS and conductivity values in the SSS of groundwater were at about the same range as those found for the surface water.
4. Caffeine was found in all SSS of surface water and only in about 30% of the monitored wells caffeine was found.
5. According to the American Classification System of water irrigation quality, the quality of both surface and ground waters of the basin was Intermediate to Good or Good with a few exceptions having irrigation quality Intermediate to Moderate. The concentrations of Boron were at levels lower than the method reporting level, except for the concentrations found in two wells (codes 1512 and 1515) which were >1.0ppm.
6. There were no exceedances of the EQS limits in the concentrations of chlorites and phosphates found in all SSS of the basin.
7. Arsenic was found in many SSS, however, in none of the surface water SSS concentrations exceeding the EQS limit were found. Concentrations of As higher than the respective limit for groundwater (10ppb) were found in a number of wells most of which were located along the course of the river Moglenitsa.
8. Cd at concentrations higher than the respective method reporting level were found in some SSS and in one of the SSS (code 2300) a concentration of 21.80ppb was found. Cd was also found in groundwater, however, in none of the wells concentrations higher than 5ppb were found.
9. Lead was found in almost all SSS located on surface water and exceedances of the 7.2ppb EQS limit of annual maximum values were found in many SSS. Pb was also found in some wells, however, in none of the wells concentration levels higher than 10ppb were found.
10. Cu and Hg at concentration levels higher than the respective analytical method reporting levels were not found, while Ni and Cr were found at some SSS at low levels without any exceedances of the respective EQS limits.
11. Zinc was found in many SSS of the basin, however, only in one SSS (code 2297) the respective annual mean concentration exceeded the respective EQS limit.
12. Sn was found in almost all SSS of surface water and the respective annual mean concentrations recorded during the 2011 monitoring period exceeded the respective EQS limit of 2.2ppb.

13. Mn was found in almost all SSS of the surface water as well in many wells with the respective concentrations exceeding the 50ppb level in a few SSS of surface water and some wells. The highest concentration of 2.0ppm was found in a well with code number 1505.
14. Fe was also found in significant concentrations in both surface and ground waters, however, exceedances of the 200ppb limit of the annual mean concentration was found only in a few wells with the highest concentration of 0.92ppm found in the well with code 1505.
15. Low concentrations of nitrates were found in both surface and ground waters of the basin with exceedance of the 50ppm limit found only in one well (code 1528).
16. Nitrites were found in some SSS of the basin and exceedances of the 0.5ppm limit were found in a few wells.
17. Ammonia was found at low concentrations in many SSS with the exception of a SSS (code 2294) where a very high concentration of ammonia (18.1ppm) was found during the monitoring period of 2012.
18. Fluorides at low concentrations were found in many SSS of the basin and in none of the SSS the limit of 1.5ppm was exceeded.
19. Sb was not found in the water of the wells monitored. Al was found in only two wells, however, at concentrations lower than the 200ppb limit.
20. In the aquatic systems of the basin 61 pesticides were detected at least once and among these only the insecticide chlorpyrifos ethyl was found at a concentration higher than 1.0ppb (1.357ppb) while all other pesticides were found at concentrations <1.0ppb. Among the latter pesticides the highest concentrations were found for the fungicide etridiazole in groundwater. Pesticide residues were found in many of the wells monitored at concentrations >0.1ppb, indicating that the soils of this basin are vulnerable to leaching.
21. Many pesticides found in surface SSS are included in the priority list of EQS, however, only the concentrations of chlorpyrifos ethyl and lindane were found to be in excess of the respective EQS limits.
22. During the monitoring period of 2010 - 2011 only 15 pesticides were detected more than 5 times and among these the highest frequency of detection was found for chlorpyrifos ethyl (61 detections). The variation of 75% of the residue levels were in the range of 0.001 to 0.492 which can be considered as the level of the unavoidable contamination of surface water under the local environmental conditions and agricultural practices.
23. During the monitoring period of 2012, only 7 pesticides were detected more than 5 times and among these the fungicides etridiazole and HCB had the highest

frequencies of detection. The range of the 75% of the residue values was about the same as the one found for the 2010 - 2011 period.

24. In 34 cases there was ecotoxicological risk to aquatic organisms based on the Risk Quotient. Among these cases 25 were due to the presence of residues of the insecticide chlorpyrifos ethyl and the rest were due to the presence of residues of L-cyhalothrin, methomyl, oxadiazon, imidacloprid, diflubenzuron, carbendazim and PCNB.

1.12. BASIN OF THE LAKE VEGORITIDA

1. In the basin of the lake Vegoritida, also known as the basin of Eordea, there are four lakes communicating between each other via natural flow of water due to existing elevation differences among them. At the highest elevation is the lake Zazari, followed by the lakes Chimaditida and Petron while the lake Vegoritida is at the lowest elevation.
2. In the lake Vegoritida the mean values of pH ranged from 8.29 to 8.64 and from 7.96 to 8.07 in the surface and hypolimnion layers, respectively. In the other three lakes sampling and in situ measurements were made from the surface water layer only and from two SSS from the lakes Zazari and Chimaditida, respectively and from one SSS from the lake Petron. The respective mean values in these lakes were 8.41 and 8.53 in the lake Zazari, 8.19 and 7.75 in the lake Chimaditida and 8.46 in the lake Petron. The mean water temperature in the lake Vegoritida ranged from 17.55 to 16.60°C in the surface layer and from 10.35 to 10.08°C in the hypolimnion layer. There is a significant difference in temperature, about 7°C, between the surface water layer and the hypolimnion water layer of the lake Vegoritida since this lake is very deep in fact being the deepest lake of Greece.
3. The respective temperature mean values in the other three lakes were 18.9 to 20.15 in the lake Zazari, 20.73 to 19.65 in the lake Chimaditida and 22.48°C in the lake Petron.
4. In all lakes the dissolved oxygen content as well the respective % saturation of the water in oxygen were at adequate high levels and frequently supersaturation of the surface water in oxygen was measured due to the photosynthetic activity during the day of the aquatic plants grown in the lakes. Low oxygen content (1.99ppm) was found only once, in June of 2011, at the hypolimnion layer of the lake Vegoritida at the SSS (code 552) located in the area of the town of Arnissa.
5. During the monitoring period (2010 - 2012) there was a great variation in the transparency of the water of the lake Vegoritida with the Secchi disk depth ranging from 1.70 to 5.40, 1.50 to 5.30, and 1.60 to 5.50 m at the three SSS while the water

level of the lake ranged from 36 to 39.50 m at the SSS located in the area of Arnissa, 20.30 to 26.00 m in the area of Perea and 21.50 to 24.50 m in the area of Saint Panteleimona. In all SSS of the lake Vegoritida the higher water levels were measured in June of 2011 and the lowest in October of 2010.

6. Among the four lakes, the lowest values of TDS and conductivity were always found in the water of the lake Zazari, followed by those found in Chimaditida and Vegoritida and the highest values were found in the lake Petron. In the lake Petron were also found the highest concentrations of chlorites, sulphates, potassium, magnesium and sodium. Also in this lake mercury was found associated, however, with the material suspended in the water.
7. Among the SSS located on the rest of the surface aquatic systems the highest TDS and conductivity values were found at the SSS located on the ditch Amyntas which is connecting the lake Chimaditida with the lake Petron. The values of TDS and conductivity were increasing along the course of Amyntas towards the lake Petron with the respective mean values at the SSS 2330, located upstream of the discharge of Amyntas into the lake, reaching the levels of 845mg/L and 1317 μ S/cm. The respective mean values at the SSS located on the ditch of Soulou which is traversing another area where the National Electric Company is operating many coal fired power plants, were at much lower levels. The mean values of TDS and conductivity at the SSS of groundwater were at much higher levels compared to the levels found in any of the SSS of surface waters; especially increased levels of TDS and conductivity were found in the wells located in the area of the lake Petron. The mean values of TDS and conductivity in the wells surrounding the lake Petron were in the same range of values with the respective mean values found in the water of the lake indicating that there is communication between the lake and the groundwater aquifers.
8. In many of the irrigation wells monitored the Redox values were negative.
9. According to the American Classification System of irrigation quality, the quality of the water of the lakes Vegoritida and Chimaditida was Intermediate to Good; the quality of the lake Zazari was Good and that of the lake Petron was Intermediate to Moderate. Intermediate to Moderate was also the irrigation quality of the rest of the aquatic systems of the basin including also the irrigation wells. Concentrations of Boron higher than 1.0ppm were found in most of the surface aquatic systems including the lakes with the exception of the lake Zazari; in the lake Zazari the concentrations of Boron were below the reporting level of the analytical method.
10. The mean concentrations of chlorites and sulphates, in both surface and groundwater systems, were at levels lower than the respective EQS limits.

11. As at a low concentration was found only once at the SSS 552 (hypolimnion) of the lake Vegoritida.
12. Cd at concentrations higher than the method reporting level were found in many SSS located on surface aquatic systems including the lakes as well the two main ditches of the basin, Amyntas and Soulou. The respective concentrations were in exceedance of either the annual mean or the annual maximum concentration of the EQS limits at the SSS of the lake Zazari, the lake Vegoritida, the ditches of Soulou and Amyntas, the irrigation dam of Perdikas, the stream of Aetos and many other SSS located on other surface aquatic systems. However, the highest concentrations of Cd were found in the water of the lake Zazari.
13. Significant concentrations of Pb were also found in many SSS located on surface aquatic systems with the respective concentrations exceeding the respective EQS limits at the SSS of the lakes Zazari, Chimaditida and Vegoritida and many SSS located on other surface aquatic systems. Lead was not found in groundwater.
14. Low concentrations of Ni were found in many SSS of surface water of the basin, however, the respective concentrations were lower than the respective EQS limit of 20ppb with the exception of the SSS 2330 located on the ditch Amyntas in which there was exceedance of the respective EQS limit.
15. Cu and Cr were found in a few SSS without, however, of any exceedances of the respective EQS limits.
16. Hg at concentrations higher than the respective method reporting level was found only at the SSS 573 of the lake Petron.
17. Zn was found in many SSS of the basin, however, exceedance of the respective EQS limit was found only at the SSS 561 of the lake Zazari.
18. Sn was found in most SSS of the surface aquatic systems of the basin including the lake Vegoritida and in all these SSS there were exceedances of the respective EQS limit.
19. Significant concentrations of Mn and Fe were found in many SSS of surface and groundwater system with exceedances of the respective limits.
20. According to the data reported above, among the four lakes of the Eordea basin the lake Petron appeared to have the highest values of conductivity, TDS and salinity due to the high concentrations of the water in sulphate and chlorite ions and also high concentrations of K, Na and Mg cations. However, in this lake the concentrations of the soluble forms of heavy metals were below the respective EQS limits; mercury was found in suspended form. Exceedances of the EQS limits of heavy metal concentrations were found in the water of the lakes Chimaditida (exceedance in Pb),

- Vegoritida (exceedances in As, Cd, Pb and Sn) and in the lake Zazari with exceedances of the respective EQS limits in Cd, Pb, Zn, Mn and Fe.
21. In the two main ditches Amyntas and Soulou exceedances of the EQS limits for Cd, Pb, Ni, Sn and Mn were found at the SSS of Amyntas and in Cd, Pb, Sn and Mn at the SSS located on Soulou.
 22. In the water of streams discharging into the lake Zazari such as the stream of Scklithrou, Aetou and Valtonerou exceedances of the EQS limits were found for Pb, Mn and Fe (Scklithrou), Cd, Pb, Mn and Fe (Aetou) and Pb, Sn, Mn and Fe (Valtonerou). Thus in lake Zazari, in addition to the natural background rich in heavy metals extra loads of heavy metals are discharged via the above mentioned streams.
 23. Exceedances of the EQS limits were found in other SSS such as the dam of Perdika (exceedances in Cd, Pb, Sn and Mn), the stream of Pontokomi (exceedances in Pb and Sn), stream of Galateia (exceedances in Cd, Pb and Mn) and the stream of Pedinou (exceedances in Cd, Pb and Sn). In the streams originating from the mountains Vermion and Voras and discharging into the lake Vegoritida exceedances of the EQS limits were found only for Sn and Mn. In a stream (Xynou Nerou) discharging into the lake Petron for none of the metallic elements exceedances were found.
 24. In some groundwater SSS exceedances of the respective groundwater limits were found; in some of the wells the Redox values were negative.
 25. The concentrations of nitrates in both surface and groundwater systems were at medium to low levels without exceedances of the 50ppm limit.
 26. Relatively high concentrations of nitrites were found in many SSS exceeding the 0.5ppm level in the lakes Vegoritida and Chimaditida, in the SSS located in many streams and ditches and in some wells.
 27. Ammonia in significant concentrations was found in some SSS with exceedances of the 0.5ppm limit in the lake Zazari and some SSS located on streams of the basin.
 28. Fluorites at low concentrations were found in most of the SSS, however, exceedances of the 1.5ppm limit were found in the water of the lakes Zazari and Chimaditida and also in some wells.
 29. Sb was not found in any of the SSS of the basin at concentrations higher than the respective method reporting level. Al was found in some wells.
 30. The load of pollutants discharged into the lakes of this basin over the years was shown in the composition of their respective sediments. In the sediments of these lakes in addition to the high concentrations of nitrates, ammonia, nitrites, chlorites and phosphates were also found high concentrations of metallic elements such as Ni, Sn, Zn, Cr and Fe with the respective concentrations being the highest among those found in sediments of all lakes included in the study area. Pesticide residues were

also found in the sediments, however the concentrations of all pesticide detected, with the exception of fluometuron, were at trace levels; fluometuron was found at 0.9ppm in the sediment of the lake Vegoritida.

31. Caffeine was found in all surface aquatic systems including the lakes Vegoritida, Zazari and Chimaditida; caffeine was not found in the water of the lake Petron. Also caffeine was not found in groundwater except for three wells two of them located in the area of the lake Petron in which caffeine was found.
32. The fact that caffeine was not found in all wells, whereas caffeine was present in all surface aquatic systems, is an indication that groundwater aquifers are protected and thus there is not communication with surface waters. This opinion is also supported by the fact, as will be discussed below, that pesticide residues were found only in a few wells.
33. The fact that caffeine was found in all surface aquatic systems is a clear sign that all the ditches, streams and lakes, except for the lake Petron, were receiving municipal wastes inadequately treated. In agreement to the above statement is the finding that increased concentrations of phosphates and other elements and ions were present in the sediments of these lakes.
34. Pesticide residues were found in all lakes however at trace levels. In these pesticides were included chlorpyrifos ethyl, atrazine, DEA, etridiazole, prometryne and S-metolachlor.
35. Pesticide residues were found only in 5 wells and among these only in one well (code number 1542), located close to the village of Pelargos, the respective concentrations found were at extremely high levels. Local investigation of the area showed that the aquifer of this well might have been directly polluted by an installation of filling / washing of pesticide spray equipment.
36. In the aquatic systems of the basin about 100 pesticide active ingredients including also major metabolites and conversion products were detected at least once. A significant number of these pesticides is included in the priority list of EQS. However exceedances of the respective EQS limits were found only for chlorpyrifos ethyl and lindane.
37. During the period of 2010 - 2011 more than 5 times were detected 34 pesticides with the highest frequencies of detection found for chlorpyrifos ethyl, terbuthylazine, etridiazole and S-metolachlor with 93, 33, 27 and 20 detections, respectively. The range of the 75% of the residue values was from 0.001 to 0.633, however, there were extreme values reaching 2.2ppb for lindane, metalaxyl and thiamethoxam which were traced to point pollution sites. Thus the range of pesticide residues from 0.001 to 0.633ppb can be considered as the level of the unavoidable contamination of surface

aquatic systems of the basin under the local environmental conditions and agricultural practices. During 2012 only 19 compounds were detected more than 5 times and among these the highest frequencies of detection were found for 2,4-D and chlorpyrifos ethyl. The range of the 75% of the residue values was from 0.001 to 0.544ppb which can be considered as the unavoidable contamination. However, during 2012 there were many extreme values for diflufenzuron which were traced to point pollution sites of installations of filling / washing of spray equipment.

38. In 68 instances occurred ecotoxicological risk to aquatic organisms living in the surface aquatic systems of the basin, based on the Risk Quotient. Among these instances of toxicological risk only 6 instances occurred in the lakes, twice in Vegoritida, once in the lake Petron, once in Zazari and twice in Chimaditida. The risk was caused primary due to the presence of the organophosphorus pesticides chlorpyrifos ethyl and pirimiphos methyl.

1.13. BASIN OF THE LAKE KASTORIAS

1. The mean values of pH ranged from 8.15 to 8.42 and from 7.96 to 8.23 in the surface and hypolimnion layers, respectively, of the lake of Kastorias. The respective mean temperature values ranged from 22.7 to 22.93 and 19.83 to 20.83°C. There was small difference in temperature between the surface and hypolimnion layers because the lake of Kastorias is a shallow lake and at the deepest area of the lake the water level was ranging from 5.6 to 5.8m.
2. The Secchi disk depth ranged between 0.5 to 3.7m, 0.9 to 1.60 and 0.60 to 4.4m in the three SSS of the lake. The lowest Secchi disk depth values were found during the 2011 monitoring period.
3. The dissolved oxygen content of the lake water as well the % saturation of water in oxygen were at adequately high levels (dissolved oxygen >6ppm) in both surface and the hypolimnion layers of water with the exception of the measurements made in october of 2010 when very low oxygen content was found especially in the hypolimnion layer of water. Also during the 2011 measurement period the Redox of the water at all SSS of the lake was negative.
4. The mean values of TDS and conductivity were at low levels during the entire monitoring period.
5. According to the American Classification System of water irrigation quality, the quality of the water of the lake of Kastorias was Intermediate to Good. Also Intermediate to Good or Good was the irrigation quality of the rest of the surface aquatic systems and of all irrigation wells monitored. In some SSS of surface water Boron concentrations >1.0 were found.

6. The concentrations of chlorites and sulphates were at relatively low levels without exceeding the respective EQS limits.
7. As was found in the SSS of the lake Kastorias, however, there were no exceedances of the respective EQS limits.
8. Cd at concentrations higher than the method reporting level were found in one of the SSS of the lake Kastorias and in some of the SSS located on other surface aquatic systems of the basin and exceedances of the EQS limits were found in these SSS. Cd was also found in irrigation wells, however, in none of the wells the respective concentrations were >5ppb.
9. Significant concentrations of Pb were found in some SSS of surface water of the basin including the lake of Kastorias (SSS 604) with exceedances of the respective EQS limits. Pb was also found in groundwater however no exceedances of the 10ppb were found.
10. Ni at concentrations higher than the method reporting level were found in samples of the SSS 604 of the lake without exceeding the respective EQS limits. However, high concentrations of Ni were found in two wells (code numbers 1614 and 1626).
11. Cu was found in significant concentrations only in groundwater of the basin, however, there were not exceedances of the respective groundwater limit.
12. Hg at concentrations higher than the method reporting level were not found.
13. Cr was found in a few SSS without the respective concentrations exceeding the respective EQS limits or the limits concerning groundwater.
14. Zn was found in significant concentrations in surface aquatic systems of the basin with exceedances of the respective EQS limits in the lake (code 604) and other SSS with codes 2348, 2349, 2395 and 2397.
15. Sn was also found in significant concentrations in surface aquatic systems of the basin with the respective concentrations exceeding the respective EQS limits in the SSS with code numbers 2346, 2347 and 2391.
16. Significantly high concentrations of Mn were found in both surface and ground water of the basin with the respective annual mean concentrations exceeding the 50ppb limit in all surface aquatic systems, including all SSS located in the lake of Kastorias and in almost all irrigation wells. The highest concentrations (around 2.0ppm) of Mn were found during the 2012 sampling period in the wells with code numbers 1626 and 1627.
17. Fe was also in abundance in the aquatic systems of the basin of Kastorias with exceedances of the 200ppb level in the SSS 606 of the lake and some streams discharging into the lake. However, the highest concentrations of Fe were found in

groundwater (in most of the wells monitored) and concentrations as high as 6.6ppm were found in some wells.

18. The concentrations of nitrates were at relatively low levels in all surface aquatic systems, however, significantly higher concentrations were found in some irrigation wells exceeding the 50ppm limit in the wells with codes 1619, 1623, 1616, 1614 and 1612. Most of the latter wells were located in about the central area of the eastern section of the basin where it appears that there was groundwater pollution with nitrates.
19. Nitrites in significant concentrations exceeding the 0.5ppm level were found in the SSS located in the lake of Kastorias as well in other SSS of the rest of the aquatic systems.
20. The concentrations of ammonia were at low levels in the surface aquatic systems with the exception of the SSS 601 and 604, located in the lake Kastorias, in which concentrations higher than 0.5ppm were found and this is in agreement with the negative Redox measurements made at these sites.
21. There was great seasonal variation in the concentrations of nitrates in the SSS of the lake of Kastorias which seasonally were found to be at concentrations lower than the reporting level of the analytical method.
22. In all aquatic systems of the basin including the lake of Kastorias the concentrations of phosphates and total phosphorus content were at relatively high levels indicating that most probably these aquatic systems were still receiving municipal wastes. This finding was unexpected because the city of Kastoria as well all other towns and villages surrounding the lake are connected to a central sewage system and after appropriate treatment, liquid wastes are discharged into a ditch which is discharged into the river Aliakmona. High phosphate concentrations were also found in groundwater wells. This pollution of surface as well groundwater was most probably due to municipal wastes still disposed in ditches and streams discharged into the lake and due to the fact that there is communication between surface and groundwater, groundwater was also polluted. This is in agreement with the fact that caffeine was found in all SSS of surface water including the SSS located in the lake and also in all irrigation wells monitored.
23. In the sediments of the lake of Kastorias high concentrations of nitrates, ammonia, phosphates, As, Cd, Mn, Pb, Ni, Cu and Zn were found.
24. Some pesticides included in the priority list of EQS were found in the surface aquatic systems of Kastorias such as alachlor, atrazine, bentazone, lindane, chlorpyrifos ethyl and HCB, however, exceedances from the respective EQS limits were found only for chlorpyrifos ethyl and lindane.

25. Pesticide residues were also found in groundwater and in two wells pesticide residues at concentrations >0.1ppb were found. Both of these wells are located close to a facility of filling / washing spray equipment and it is most probable that the contamination of the aquifer was directly related to this point pollution source.
26. During the monitoring period in the aquatic systems of the basin of Kastorias 62 pesticides were detected at least once.
27. In the water of the lake of Kastorias the following pesticides were detected: chlorpyrifos ethyl, HCB, pendimethalin and bifenthrin. In groundwater the following pesticides were detected in significant concentrations: chlorthal dimethyl, fenoxycarb, myclobutanil, fluquinconazole, cyproconazole and tebuconazole.
28. The highest concentrations of pesticides were found in two SSS with code numbers 2390 and 2392. The pollution in both sites was traced to point pollution sites of installations of filling/washing spray equipment.
29. The pesticides detected more than 5 times in the aquatic systems of the basin were only 12 and among these the highest frequencies were found for chlorpyrifos ethyl, terbuthylazine, fluquinconazole and S-metolachlor with 59, 16, 15 and 13 detections, respectively.
30. During the 2010 - 2011 monitoring period 75% of pesticide residue values determined in the SSS of surface aquatic systems were in the range of 0.001 to 0.863ppb which can be considered as the level of unavoidable contamination of surface waters of the basin under the local environmental and agricultural practices. Residue values exceeding the above range were traced to point pollution sources. During 2012 only chlorpyrifos ethyl was detected more than 5 times and the range of its residues was from 0.001 to 0.12ppb which can be considered as the level of the unavoidable contamination of surface aquatic systems during that period.
31. In 35 instances there was ecotoxicological risk to aquatic organisms on the basis of the Risk Quotient, however, none of these cases occurred in any of the SSS located in the lake of Kastorias.

1.14. BASIN OF THE LAKES PRESPE

1. The pH of the water of both lakes, Small and Big Prespa, and at both sampling depths (surface and hypolimnion) was around 8.0 with small variations among the different SSS of each lake. The mean temperature in the water of the Big Prespa was ranging from 19.75 to 18.73°C and between 12.18 and 11.95°C in the surface and hypolimnion layer of water, respectively. In the Small Prespa the mean temperature ranged from 18.35 to 19.03°C and 15.30 to 17.48°C, respectively.

2. The dissolved oxygen content as well the % saturation in oxygen were in adequate levels in both lakes and both depth layers. However, negative Redox values were found in both lakes during the two sampling sessions and in situ measurements performed during 2011.
3. The values of TDS, conductivity and salinity were at low levels in both lakes. However, the Secchi disk depth as well the depth of both lakes exhibited a very wide variation during the 2010 - 2012 monitoring period. In the Big Prespa the Secchi disk depth ranged from 2.5 to 0.4m and the water level from 13.0 to 20.3m. In the Small Prespa the Secchi disk depth ranged from 0.4 to 2.0m and the water level from 4.9 to 7.5m.
4. According to the Americal Classification System of water irrigation quality, the quality of surface water including the water of the Big Prespa was Good while the irrigation quality of the water of the Small Prespa was Intermediate to Good. Also Intermediate to Good was the irrigation quality of the irrigation wells.
5. The concentrations of chlorites and sulphates were at relatively low levels in all aquatic systems of this basin. Boron concentrations >1.0 were found only in the water of one well.
6. Nitrate concentrations were at low levels in the water of both lakes during the 2010 monitoring period, however, extremely high concentrations of nitrates were found in the lakes during the rest of the monitoring period and concentrations exceeding the 50ppm level were found at the SSS with code 612 of the Big Prespa. Medium to seasonally high concentrations of nitrates were also found in the water of streams discharging into the lakes, however, in none of the respective SSS the annual mean concentrations exceeding the 50ppm level were found. Nitrates at a concentration exceeding the 50ppm limit were found in one of the wells included in the monitoring network of the basin.
7. Significantly high concentrations of nitrites were also found in all SSS of both lakes with annual mean values exceeding the 0.5ppm level. Exceedances of the 0.5ppm level were also found in SSS of other surface aquatic systems as well groundwater sites.
8. Medium to low concentrations of ammonia were found in most SSS of the basin; ammonia concentrations exceeding the 0.5ppm level were found only in one SSS of the Big Prespa.
9. Fluorites were found in all SSS of surface and groundwater, however, in none of the SSS the respective concentrations exceeded the 1.5ppm level.
10. As, Cu and Hg at concentrations higher than the respective reporting levels of the analytical methods were not found.

11. Concentrations of Cd higher than the method reporting level were found in many SSS of surface and groundwater with exceedances of the respective EQS limits at the SSS with code 611 of the Big Prespa and many SSS of the rest of the surface aquatic systems. Cd was also found in wells, however, in none of the wells the respective annual mean concentrations exceeded the 5ppb level.
12. Significant concentration of Pb were found in certain SSS of surface water with exceedances of the EQS limits in the surface and hypolimnion layers of both lakes and at the SSS with codes 2363, 2365, 2369, 2374 and 2375. The highest concentration of Pb (43.0ppb) was found during the 2011 sampling period. Low concentrations of Pb were also found in groundwater, however, in none of the wells exceedance of the 10ppb level was found.
13. Low concentrations of Ni were found in certain SSS of the basin and in none of the SSS exceedance of the respective EQS limit was found.
14. Significant concentrations of Zn were found in some SSS and exceedances of the respective EQS limit were found in Big Prespa and some streams discharging into the lakes.
15. Significant concentrations of Mn were found in all surface aquatic systems of the basin including the two lakes.
16. Significant concentrations of Fe were also found in all surface aquatic systems of the basin with annual mean concentrations exceeding the 200ppb level in most of the sites. The highest concentration (7.358ppm) of Fe was found in a stream (code 2363) discharging into the Small Prespa. Fe was also found in groundwater, however, in none of the wells the respective concentrations exceeded the 200ppb level.
17. Sb and Al at concentrations higher than the respective reporting levels of the analytical methods were not found.
18. The concentrations of nitrates, ammonia and phosphates found in the sediments of the lakes Big and Small Prespa were among the highest found in the sediments of all lakes included in the study area. The concentrations of metals such as As, Pb, Sn, Zn and Fe were also among the highest found in sediments of these lakes. The highest concentrations were found in the sediments of the Big Prespa at the SSS 612 which is located close to FYROM.
19. In the aquatic systems of the basin pesticides were also detected which are included in the priority list of EQS such as HCB, chlorpyrifos ethyl, lindane, isoproturon, alachlor, bentazone, atrazine, dimethoate, coumaphos, endosulfan sulphate, 2.4-D and trifluralin. Exceedances of the respective EQS limits were found only for lindane detected in the water of Small Prespa and some SSS located on streams.

20. Pesticide residues were also found in groundwater including the wells with the codes 1631, 1632, 1634 1635, 1637 and 1638. In the pesticides found in groundwater were included chlorthal dimethyl, HCB, etridiazole, pirimiphos methyl, PCNB, alphamethrin, carbendazim, tebuconazole, diuron, and myclobutanil. Pesticides found at concentrations >0.1ppb in groundwater were only the fungicides etridiazole and tebuconazole. Diphenylamine was also found in groundwater at concentrations >0.1ppb. The fact that almost all pesticides found in surface waters were also found in groundwater is a sign that the soils of this basin are very permeable and leaching of pesticides from agricultural soils is a mechanism of groundwater pollution.
21. High concentrations of phosphates and total phosphorus found in the water of the lakes as well in some in the surface aquatic systems is an indication that pollution was due to municipal wastes discharged in both lakes. High concentrations of phosphates and total phosphorus were also found in some wells indicating that groundwater is directly replenished by surface water and also septic tanks still operating in most rural areas of the basin are directly leaching into groundwater aquifers.
22. Caffeine was found in all SSS of surface water including both lakes and all streams discharging into these lakes as well in most of the wells monitored. This is in agreement with what was reported above concerning the discharge of municipal wastes polluting both surface and groundwater.
23. In the water of these lakes many pesticides were detected at least once such as HCB, pirimiphos methyl, etridiazole, pentachlorophenol, lindane, chlorthal dimethyl, alphamethrin, propoxur, isoproturon, PCNB, pendimethalin, malathion and chlorpyrifos ethyl. However only the fungicide etridiazole was found in significant concentrations ranging from 0.2 to 0.5ppb. The same range of pesticides reported above were also found in the rest of the surface as well groundwater of the basin.
24. In this basin no point pollution sources due to filling/washing of pesticide spray equipment were detected even though there was a such permanent installation close to the bed of the river of Saint Germanos.
25. During the period of 2010 - 2011 more than 5 times were detected only 20 pesticides. Among these the highest frequencies of detection were found for chlorpyrifos ethyl (36 detections), HCB (22 detections), etridiazole (15 detections) and propargite (13 detections). For these 20 pesticides 75% of the residue values were in the range of 0.001 to 0.633ppb with only very few values exceeding slightly this range. Thus it is reasonable to accept that the unavoidable contamination of surface water did not exceed the 0.633ppb level under the environmental and agricultural practices of this basin.

26. The number of pesticides detected more than 5 times during the 2012 monitoring period was much smaller with the respective concentrations found at much lower levels. Thus the range of 0.001 to 0.633ppb could also cover the unavoidable contamination of surface water under the local edaphoclimatic and agricultural practices during the entire monitoring period of 2010 - 2012.
27. Based on Risk Quotient, ecotoxicological risk occurred 23 times due to the presence of chlorpyrifos ethyl, alphas-methrin, carbendazim, PCNB and propargite. Risk to aquatic organisms occurred only once in the Small Prespa due to the presence of the fungicide PCNB.

1.15. BASIN OF THE RIVER ALIAKMONAS

1. The mean values of pH for the entire monitoring period at the SSS located on the river Aliakmona, the longest river of Greece, ranged between 8.0 to 8.3 while the respective mean values for the rest of the surface aquatic systems ranged between 7 to 8.
2. The mean values of TDS and conductivity in all surface aquatic systems of the basin were <500mg/L and <800 μ S/cm, respectively, while the respective mean values in groundwater were at much higher levels. In two wells the Redox values were negative.
3. According to the American Classification System of water irrigation quality the quality of the water of the river Aliakmonas was Intermediate to Good. Intermediate to Good was also the quality of the rest of the surface aquatic systems of the basin with a few exceptions having Intermediate to Moderate quality and a few with Good quality. Also Intermediate to Good or Intermediate to Moderate was the irrigation quality of the wells monitored. Concentrations of Boron higher than 1.0ppm were found only at the SSS of the river Aliakmonas and only during the 2010 monitoring period.
4. The concentrations of chlorites and sulphates were at relatively low levels in all aquatic systems of the basin and in none of the cases there were exceedances of the respective EQS limits.
5. In all SSS located on the river Aliakmonas and its tributaries there were exceedances of the EQS limits concerning the concentrations of metallic elements found such as Pb, Cu, Zn, Mn, Fe, Ni and Mn, while at the SSS located close to the river Delta (code 29) there was only exceedance of the EQS limit in the concentrations of Zn. However, the presence of heavy metals in excessive concentrations in the aquatic systems of the river Aliakmonas was a transient situation occurring once or twice per year.
6. The concentrations of nitrates, nitrites, phosphates, chlorites, fluorites and of heavy metals, except for Cr, were in moderate levels in the sediments of the river compared

to the respective concentrations found in the sediments of the rest of the rivers included in the study area, and the higher concentrations were found in the sediments of the SSS 29. In the sediment of the SSS 30 the highest concentration of Cr (369.3ppm) was found; this value was the highest found among the sediments of the other SSS of the river as well the sediments of all other rivers included in the study.

7. Exceedances of the respective limits of groundwater quality were found for the concentrations of Pb, Cr and Mn, respectively, found in certain wells.
8. Low to medium concentrations of nitrates were found in all aquatic systems of the basin and exceedances of the 50ppm level were found only in three wells.
9. The concentrations of nitrites and ammonia were at low levels in most of the SSS of the surface aquatic systems of the basin and exceedances of the respective levels were found only in a few SSS, however, exceedances were found in most of the wells monitored. The highest concentration of nitrites of 23.93ppm was found in one of the wells (code 1647). In the same well the concentrations of ammonia were also high, while negative Redox values were recorded; this well was most probably polluted with municipal wastes.
10. High concentrations of nitrites and ammonia were also found in all SSS of surface aquatic systems located downstream of installations treating municipal wastes.
11. Caffeine was found in all SSS of the surface aquatic systems of the basin. Caffeine was found only in two wells.
12. During the monitoring period of 2010 - 2012, 130 active ingredients of pesticides including also major metabolites and conversion products were detected at least once in the surface aquatic systems of the basin. A total of 1924 detections of pesticides were recorded, however, 650 of them were detected in samples taken from a SSS with code number 2383 located on a drainage canal of Central Macedonia. In this SSS high concentrations of many pesticides ranging from 5 to 50ppb and even reaching the 300ppb level were found. The increased pollution at this site was due to the operation at this site of a permanent installation of filling / washing of pesticide spray equipment. Due to this installation pesticide formulation containers and other packaging materials were improperly disposed and frequently were floating on the surface of this specific aquatic system.
13. Many pesticides included in the EQS priority list were found in the aquatic systems of the basin and in many SSS located mainly in the region of the basin included in Central Macedonia (SSS with codes 2302, 2303, 2344, 2380, 2383 and 2384) exceedances of the respective limits were found. However, in most instances only the concentrations of either lindane and/or chlorpyrifos ethyl were in exceedance of the respective EQS limits.

14. During the monitoring period of 2010 - 2011, 57 pesticides were detected more than 5 times and among these the highest frequencies of detection were found for chlorpyrifos ethyl (156 detections), followed by the fungicides tebuconazole and boscalid with 109 and 62 detections, respectively. For the 2012 monitoring period a smaller number of pesticides, 40 compounds, were detected more than 5 times and the highest frequencies were found for chlorpyrifos and tebuconazole with 72 and 45 detections, respectively.
15. In the section of the basin located in the region of West Macedonia 75% of the pesticide residue values found did not exceed the 0.5ppb level during the 2010 - 2011 period and the level of 1.0ppb during the 2012 monitoring period. In the region of the basin located in Central Macedonia, the above ranges were extending up to 9.0ppb for 2010 - 2011 and 2.0ppb for the 2012 period. However, due to the fact that multiple point pollution sites were identified in the region of Central Macedonia derived from sites of filling / washing of pesticide spray equipment and improper disposal of pesticide formulation containers it was impossible to give an estimate of the unavoidable contamination of surface aquatic systems occurring in this section of the basin.
16. In the samples collected from the SSS located on the river Aliakmona, 8 pesticides were only detected more than 5 times during the entire monitoring period (2010 - 2012) and with the highest frequencies were found chlorpyrifos ethyl, tebuconazole and chlorthal dimethyl with 46, 14 and 14 detections, respectively. The range of 75% of residue concentrations found was from 0.001 to 0.06ppb with the exception of a few extreme values of etridiazole residues reaching 1.179ppb at the SSS 29.
17. During the period of 2010 - 2012, in 341 instances there was ecotoxicological risk to aquatic organisms, based on Risk Quotient, however, among these instances 189 (55.4% of the cases) occurred at the SSS 2383 related to a point pollution site of filling/washing pesticide spray equipment. Another significant number of occurrences of ecotoxicological risk (34 cases) was also due to point pollution sites related to other SSS of the basin. In fact only 118 cases of ecotoxicological risk were due to contamination of aquatic systems of the basin with pesticides derived from dispersed pollution sources.

1.16. BASIN OF THE FORMER LAKE KALLIPEFKI

1. The mean values of pH during the entire monitoring period was about 7.5 in the surface water and about 8.0 in the two of the 3 wells of the basin while the mean pH in the third well was less than 7.

2. The mean values of TDS, conductivity and of Redox were at low levels. In fact the values of Redox in one of the SSS (code 2501) of surface water was frequently at the negative site (reductive conditions). This site is located close to the discharge of the liquid municipal wastes of the small community of Kallipefki into the central drainage canal of the basin. The municipal wastes after a preliminary precipitation process are discharged into the main drainage canal which was originally build to drain the lake of Kallipefki. This main drainage canal in addition to draining the entire basin is also used as irrigation canal; groundwater abstracted from 3 wells is discharged into the above canal to be distributed for irrigation purposes in the entire basin.
3. Among the three existing wells in the basin one was highly polluted due to the discharge of the municipal wastes of Kallipefki, as said above. In this well the Redox was negative and the concentrations of nitrates, ammonia and phosphates were at considerably higher levels compared to the levels found in the rest of the aquatic systems of the basin.
4. According to the American Classification System of irrigation quality the quality of the water of Kallipefki was Good or Intermediate to Good with the exception of one well (code 1962) in which the water quality was Intermediate to Moderate. The alkalinity, SAR, hardness and the concentrations of Boron, chlorites and sulphates were at low levels in both surface and groundwater sites except for the well 1962 in which all parameters were at much higher levels. However, in none of the cases there were exceedances of the respective EQS limits.
5. As, Hg and Sn at concentrations higher than the respective method reporting levels were not found. Cd was found in two SSS of surface water and there were exceedances of the respective EQS limit. Pb was found in all SSS of surface water with exceedances of the EQS 7.2ppb limit. Lead was not found in groundwater.
6. Ni, Cr, Cu and Zn were rarely found and at low concentrations with exceedances of the EQS limit only of Ni in one SSS (code 2504) and only during the 2012 monitoring period.
7. Mn and Fe were found in most SSS of surface water with exceedances of the respective EQS limits. Fe was not found in groundwater; Mn was found with exceedance of the 50ppb level in the well with code number 1962.
8. Low concentrations of nitrates, nitrites, ammonia, fluorites and sulphates were found in surface and ground waters of Kallipefki, however, the highest concentrations were found at the SSS 2501 and the well 1962 which were both polluted with the municipal wastes of the community of Kallipefki.
9. In the surface aquatic systems of Kallipefki many pesticides were detected which are included in the priority list of EQS such as chloridazone (pyrazone), chlorpyrifos ethyl,

bentazone, 2,4,-D, endosulfan I, endosulfan sulphate, HCB, atrazine, lindane and MCPA and there were exceedances of the respective EQS limits.

10. Caffeine was found in all SSS located on the surface and groundwater sites. Apparently caffeine contained in the municipal wastes of the community of Kallipefki discharged into the central drainage canal of the basin is transferred into the phreatic horizon from which the well with code 1962 is abstracting water. Apparently the phreatic horizon is in communication with deeper aquifers from which water is abstracted with the other two wells of the basin.
11. In the surface aquatic systems of Kallipefki 35 pesticides were detected and among these the highest concentrations were found for atrazine (1.935ppb), 2,4-D (1.115ppb), triclopyr (0.157ppb), chlorthal dimethyl (0.14ppb), bentazone (0.138ppb), ethoprophos (0.138ppb) and at lower concentrations were found the rest of the compounds detected.
12. During 2010 - 2011 monitoring period only 4 pesticides were detected more than 5 times and 3 compounds during the 2012 period. The range of 75% of the residue values was from 0.001 to 0.705ppb for the 2012 and from 0.001 to 0.1ppb for the 2010 - 2011 period. Consequently the range of 0.001 to 0.705ppb could be considered as the level of the unavoidable pollution of surface water under the local edaphoclimatic conditions and agricultural practices.
13. Pesticide residues were not detected in groundwater.
14. Based on the Risk Quotient, in 16 cases risk to aquatic organisms was detected and this risk was due to the presence of endosulfan I, alphamethrin, chlorpyrifos ethyl and atrazine.
15. Diphenylamine was rarely found in the aquatic systems of Kallipefki and the respective concentrations were never >0.1ppb.

1.17. BASIN OF THE RIVER TITARISIOS

1. The values of conductivity and TDS in all SSS of the basin (surface and groundwater) were at levels <600 μ S/cm and <350mg/L, respectively, while the Redox values were ranging at low oxidative states (75 - 125mV). The mean values of pH were ranging from 7.77 to 8.37.
2. The concentrations of chlorites, nitrates, sulphates, nitrites, ammonia, phosphates, fluorites and total phosphorus content, with a few exceptions, were at low levels. The concentrations of Boron were below the reporting level of the respective method of analysis.
3. The values of the irrigation parameters were also at very low levels indicating that the waters of the basin have low SAR values and hardness with the overall irrigation

quality ranging from Intermediate to Good according to the American Classification System of water irrigation quality.

4. As concentrations higher than the reporting level of the analytical method were never found while Cd was found at higher concentrations than the respective reporting level of the method in a few SSS with the respective annual maximum concentrations exceeding the respective EQS limits at the SSS of Titarisios located upstream of its discharge into the Pinios River and a few other SSS located upstream.
5. Pb was found in almost all SSS of the basin at levels higher than the respective reporting level of the analytical method with the annual maximum concentrations exceeding the 7.2ppb of EQS limit in all SSS located on the river Titarisios and its tributaries. Pb was also found in considerable concentrations in the water of all irrigation wells included in the monitoring network of the basin with the respective concentrations exceeding the 10ppb limit of the 98/83 Directive in all wells except one with code number 1805.
6. Ni, Hg and Cu were not found in surface water at concentrations higher than the respective reporting levels of the analytical methods. Cu and Cr were found in some wells at low levels not exceeding the respective limits of the EU Directive concerning the ground water protection.
7. Zn and Sn were found at considerable concentrations in surface water with the respective concentrations exceeding the EQS limits.
8. Mn and Fe were found in both surface and groundwater SSS without the respective concentrations exceeding the respective limits with the exception of one well in which Fe concentrations higher than 200ppb were found.
9. Caffeine was found in all SSS of surface water indicating that all surface aquatic systems including the river Titarisios were receiving municipal wastes not adequately treated. Caffeine was not found in irrigation wells indicating that at least in the area of these wells there is no communication between surface and groundwater systems.
10. In the aquatic systems of the basin of the river Titarisios 37 pesticide active ingredients were detected at least once. However, the concentrations found were at relatively low levels. The highest concentration of 0.423ppb was found for the herbicide fluometuron while lower concentrations of 0.247, 0.232, 0.215 and 0.143ppb were found for tebuconazole, carbendazim, 2.4-D and prometryne, respectively.
11. A few pesticides including alachlor, bentazone, fluometuron and terbuthylazine were detected in groundwater, however, the respective concentrations never exceeded the 0.1ppb level.

12. In the surface aquatic system of the basin some pesticides were detected which are included in the priority list of EQS. These pesticides are: chlorpyrifos ethyl, isoproturon, 2.4-D, lindane, alachlor, atrazine, dimethoate, bentazone, HCB, chloridazone, MCPA and fenthion. Among these pesticides exceedance of the respective EQS limit was found only for fenthion at the SSS with code 2431.
13. During the monitoring period of 2010 - 2011 only 2 pesticides were detected more than 5 times and these were chlorpyrifos ethyl and prometryne. The concentration mean values were low and the upper range of the 75% of the residue values did not exceed the 0.1ppb level. During 2012, 3 pesticides were detected more than 5 times and in these were included 2.4-D, triclopyr and lindane. The 75% of the concentration values did not exceed the 0.15ppb level which can be considered as the level of the unavoidable contamination of surface water of the basin under the local edaphoclimatic conditions and agricultural practices. Diphenylamine was also detected in the aquatic systems of the basin with a frequency of detection higher than 5.
14. During the period of 2010 - 2012 in 6 cases there was ecotoxicological risk to aquatic organisms, based on the Risk Quotient. Among the pesticides responsible for the risk were included acetochlor, alachlor, atrazine, carbendazim, lindane, chlortoluron, chloropropylate, fenthion, HCB, isoproturon and prometryne. There were indications that some of the pesticides reported above were present in the aquatic systems of the basin due to atmospheric transport from elsewhere (main plain area of Thessaly) and were deposited in this area via different forms of precipitation (rain, snow etc.).

1.18. BASIN OF THE RIVER PINIOS

1. During the monitoring period of 2010 - 2012 the mean values of pH ranged from 7.5 to 8.32 in the water of the SSS located on the Pinios River and its tributaries (Lithaios, Pamisos and Portaikos). The same was about also the range of pH variation in the water of the SSS located on the rest of the surface aquatic systems as well the irrigation wells of the Pinios Basin.
2. The mean values of Redox were positive in all SSS of surface water and the respective values of TDS, conductivity and salinity were at low levels with the exception of the respective values at the SSS 35 and 2402 in which the mean values were at much higher levels. Presumably at the SSS 35 located on the Pinios River upstream of its Delta the water quality of the river was affected by the infiltration of sea water during the periods of low flow rates of the river.
3. The respective mean values in the samples of the monitored irrigation wells were at the same about levels as those found for the surface water with the exception of only

one well, located close to Gyrtoni, in which the respective values were at extremely high levels with the TDS ranging from 2631 to 1961mg/L, the salinity from 2.14 to 1.58PSU and the conductivity from 4048 to 3024 μ S/cm.

4. The Redox values in all monitored wells, with the exception of only 4 wells located in a hilly area close to the river Delta, were either negative or were at very low oxidative states.
5. The mean values of the concentrations of chlorites, nitrates and sulphates of the surface water systems were at low levels with the exception of the SSS 35 in which the respective mean values were at much higher levels.
6. The mean values of nitrate concentrations in the water of the irrigation wells were at low levels <5.0ppm in about 60% of the monitored wells. In a small number of wells (6 wells) the respective values ranged from 36.6 to 70.9ppm and in rest of the wells the nitrate concentrations ranged from 5.1 to 20.0ppm. The wells with nitrate concentrations exceeding the 50ppm level are located in the area of Koilada, an intensively cultivated area close to the Capital City of Thessaly, Larisa.
7. The mean values of the concentrations of chlorites and sulphates in the water of the irrigation wells were at low levels with the exception of two wells in which the respective mean values were at much higher levels. One of the wells is located on a hilly area close to the river Delta and presumably the respective aquifer of the well is affected by the infiltration of sea water; the other well with high chlorite and sulfate concentrations is located in Gyrtoni which as reported above was also found with extremely high mean values of TDS, conductivity and salinity.
8. The concentrations of nitrites, ammonia, phosphates, total phosphorus content and fluorites were at relatively low levels in all SSS located on the surface aquatic systems of the basin with the exception of the SSS with code numbers 36, 37, 38 and 40 located on the Pinios River in which extremely high concentrations of total phosphorus were found. These high phosphorus concentrations were traced to be due to the disposal of animal wastes close to the bed of the river at the SSS 40 which were later carried further to the sites located downstream.
9. The mean concentrations of phosphates, total phosphorus and fluorites were also very high at the SSS 76 located on the Pamisos River, a tributary of Pinios; this was also a case suspected to be due to the disposal of municipal wastes upstream of the SSS 76.
10. The mean concentrations of total phosphorus, phosphates and nitrites were also high in a significant number of wells located in the area of Proastio (Province). This is an indication that there is an extensive contamination of groundwater with municipal wastes and wastes from domestic animal raising facilities.

11. The values of SAR were <1.0 for most of the SSS of surface water with the exception of the SSS 35, 76 and 2410; in the latter SSS the respective values of SAR were in the range of 2.5 to 5.0. The SAR values of the irrigation wells were generally at higher levels than the respective levels found for the surface water.
12. According to the American Classification System of water irrigation quality the quality of the water of the river Pinios including also its tributaries Lithaios, Pamisos and Portaikos was Good to Intermediate quality with the exception of the water at the SSS 35 in which the quality was Moderate to Bad. Intermediate to Good was also the irrigation quality of most of the rest of the surface aquatic systems of the basin. Intermediate to Good or Intermediate to Moderate was also the irrigation quality of the wells monitored with the exception of one well (Gyrdoni) in which the quality was Moderate to Bad.
13. Boron concentrations $>1.0\text{ppm}$ were found in most of the SSS of surface aquatic systems of the basin only during the 2010 monitoring period. Boron was also found in some irrigation wells, however, concentrations $>1.0\text{ppm}$ were rarely found (were found only in three wells).
14. Arsenic concentrations were generally at low levels in all aquatic systems without exceeding the respective EQS limit. Among the monitored wells only in one well the arsenic concentrations were found to be $>10\text{ppb}$.
15. Low concentrations of Cd were found in some of the SSS of surface water and irrigation wells, however, exceedances of the respective EQS or 83 / 98 Directive limits were found only at the SSS with the codes 56, 2406, 2409, 2410 and 2412. The highest concentration of cadmium (3ppb) was found at the SSS 2412.
16. Significantly high concentrations of Pb were found in many SSS of both surface and groundwater SSS. With respect to the concentrations found in surface aquatic systems exceedances of the respective EQS limit of the annual maximum concentration were found for most of the sites. In a number of irrigation wells the Pb concentrations were $>10\text{ppb}$; the highest concentration of Pb (84.3ppb) was found in the water of the well with code number 1719.
17. Significant concentrations of Ni were found in both surface and ground waters of the Pinios basin, however, exceedances of the EQS limit were found only at the SSS 42, 43, 44, 46 of the Pinios River and the SSS 82 of Portaikos River.
18. Cu and Cr were rarely found in both surface and ground waters of the basin, while Hg was never found at concentrations higher than the method reporting level.
19. Zn was found at significant concentrations in most of the SSS of the surface aquatic systems with exceedances of the respective EQS limits in most of the SSS located on

- the Pinios River and its tributaries. Also significant concentrations of Sn were found with exceedances of the EQS limit in most of the SSS of the surface aquatic systems.
20. Significant concentrations of Mn were also found in both surface and groundwater SSS of the basin and exceedances of the respective limits were found only at the SSS of groundwater.
 21. The concentrations of Fe were also high in both surface and groundwater SSS with exceedances of the respective EQS and 83/98 Directive limits at the SSS of the rivers and a small number of wells.
 22. Exceedances of the EQS and 83 / 98 Directive limit of nitrates were found in two SSS of surface water and in 3 irrigation wells (codes 1714, 1714 and 1716), respectively.
 23. Concentrations of nitrites higher than 0.5ppm were found in many surface SSS and in a significant number of wells. Only in the SSS 54, 91 and 2309 ammonia concentrations >0.5ppm were found. Fluorite concentrations were relatively at low levels and only the respective concentrations at the SSS 51, 76 and 2410 were >1.5ppm.
 24. Very high concentrations of nitrates were found in the sediments of the rivers with the respective concentrations reaching 700 and 415ppm at the SSS 76 and 72 of the tributary Pamisos. Increased concentrations of phosphates were also found in the sediments of all rivers.
 25. Increased concentrations of heavy metals, among the highest found in the sediments of rivers included in the study area, were found in the sediments of the rivers of the Pinios basin. It is very probable that the increased levels of metallic elements in the sediments of Pinios and its tributaries were due to erosion of rocks and soils (natural metallophoria) occurring during extreme weather conditions of rainfall and other forms of precipitation.
 26. Caffeine was found in all SSS of surface aquatic systems of the Pinios basin and in all irrigation wells with the exception of 3 wells located in a hilly area close to the river Delta. The presence of caffeine in both surface and groundwater is in agreement with the increased concentrations of phosphates and total phosphorus found in some SSS of surface water and irrigation wells and the fact that reductive conditions (negative Redox readings) were existing in most of the groundwater SSS of the Pinios basin. It appears that municipal and animal wastes inadequately treated and discharged into the surface aquatic systems have caused a substantial deterioration of water quality in both surface and groundwater aquatic systems.
 27. In the aquatic systems of the Pinios River Basin 110 active ingredients of pesticides including also major metabolites and other conversion products were detected at least once. Among the above 110 organic compounds at the highest concentrations

- were found the following: prometryne (29.748ppb), fluometuron (15.483ppb), captan (10.772ppb), and atrazine (5.705ppb).
28. Many pesticides included in the priority list of EQS were found in the surface aquatic systems of the Pinios Basin and in these were included alachlor, atrazine, chlorpyrifos ethyl, HCB, endosulfan sulphate, lindane, d-HCH, 2,4-D, linuron, dimethoate, malathion, fenthion, isoproturon, MCPA, trifluralin, bentazone, chloridazone (pyrazone), heptachlor epoxide, simazine and diuron. Exceedances of the respective EQS limits were found in most of the SSS and these were due to the presence of lindane, malathion, chlorpyrifos ethyl, atrazine and alachlor.
 29. Many pesticides were also found in groundwater and in the pesticides found at concentrations >0.1ppb were included prometryne, chlorthal dimethyl, fluometuron and bentazone. In a number of wells diphenylamine was also found at concentrations >0.1ppb. The wide presence of pesticide residues in groundwater along with the presence of other contaminants including caffeine, diphenylamine, increased concentrations of phosphates, total phosphorus and nitrites and the existence of reductive conditions in most of the wells monitored indicate that there is direct communication between surface and ground water and agricultural soils of the basin are vulnerable to leaching leading to further groundwater contamination with pesticide residues.
 30. During the monitoring period of 2010 - 2011 the pesticides detected more than 5 times were 39 and the highest frequencies of detection were found for chlorpyrifos ethyl (266 detections), imidacloprid (46 detections), fluometuron (246 detections), prometryne (201 detections), S-metolachlor (137 detections), terbuthylazine (122 detections), and the fungicide etridiazole with 58 detections.
 31. During the 2010 - 2011 monitoring period 75% of the residue values found in surface aquatic systems of the Pinios Basin were in the range of 0.010 to 0.425ppb; residue values exceeding the above range were found only for lindane, atrazine and prometryne; the latter pesticides were used illegally.
 32. During the 2012 monitoring period 22 pesticides were detected more than 5 times and among these the compounds with the highest numbers of detections were chlorpyrifos ethyl, lindane, pirimiphos methyl, fluometuron, prometryne, S-metolachlor, chlorthal dimethyl, terbuthylazine and etridiazole. The 75% of the residue values were in the range of 0.010 to 0.18ppb, however, for some of the pesticides such as 2,4-D, acetochlor, lindane, chlorpyrifos ethyl, chlorthal dimethyl, dimethenamid, ethalfluralin, fluometuron, prometryne and S-metolachlor there were also higher concentration values ranging from 0.172 to 2.231ppb; most of the latter increased residue levels were found at the SSS 52 of Lithaios River and were traced

to a nearby point source of pollution caused by filling and washing of pesticide spray equipment.

33. In the irrigation wells of the Pinios Basin among the pesticides detected more than 5 times were included lindane, chlorthal dimethyl, fluometuron, prometryne, S-metolachlor and terbuthylazine, however, only chlorthal dimethyl, prometryne and fluometuron were found at concentrations >0.1 ppb.
34. During the monitoring period of 2010 - 2012 there were 195 cases of ecotoxicological risk to aquatic organisms, based on the Risk Quotient. Among these cases 65 cases occurred in drainage/irrigation canals, and 130 cases occurred at the SSS located on the river Pinios and its tributaries.

1.19. BASIN OF THE RIVER ENIPEAS

1. The mean values of TDS, conductivity and salinity in the water of the river Enipeas, a tributary of the river Pinios, and its tributary Sofaditis as well in the SSS located on the rest of the surface aquatic systems of the basin were at relatively low levels. However, the respective values in the groundwater SSS were at double the size. In the groundwater SSS the Redox was frequently negative; the Redox values in the surface aquatic systems were generally >100 mV.
2. The lowest mean values of TDS, conductivity and salinity were found in the water of the conservation dam at Mitropoli (SSS 2417); this dam is supplied with water from the Plastira Lake (the latter lake was not included in the study area).
3. The mean values of the concentrations of chlorites and sulphates were at relatively low levels in all SSS of the basin. Also at low levels were the mean values of the nitrites, ammonia and fluorites with a few exceptions with the respective concentrations exceeding the 0.5ppm level. However, the concentrations of phosphates and of total phosphorus content were at relatively high levels in all SSS with the highest values found in the water of the SSS of groundwater monitoring sites. Among the SSS of the surface aquatic system of the basin the highest concentrations of phosphates and total phosphorus were found at the SSS with code number 64 which is located on the river Sofaditis, upstream of its discharge into the river Enipeas. However, high concentrations of phosphates and total phosphorus were also found in a significant number of groundwater sites. These data, along with the negative Redox values, indicate that the groundwater aquifers in the basin of the river Enipeas and its tributary Sofaditis were polluted with municipal wastes and since the concentrations in groundwater were not as high as in the surface water it is very probable that contamination was mostly due to leaching from septic tanks.

4. According to the American Classification System of water irrigation quality the quality of both surface aquatic systems and groundwater aquifers was Intermediate to Good quality. In a small percentage of irrigation wells the quality was Intermediate to Moderate.
5. Concentrations of Boron higher than 1.0ppm were found in some SSS of the surface aquatic system of the basin whereas concentrations >1.0ppm were never found in the water of the irrigation wells.
6. As was found at significant concentrations in many surface SSS, however, the respective levels of EQS limits were never exceeded. Significant concentrations of arsenic were also found in groundwater, however, only in one well the limit of 10ppb was exceeded.
7. Cd at low concentrations was found in many SSS of surface water, however, in none of the sites the EQS limit was exceeded. Cd at concentrations higher than the respective reporting level of the analytical method were also found in the water of many wells, however, in none of these cases concentrations higher than 5ppb were found.
8. Significant concentrations of Pb were found in many SSS of surface water, however, in none of the sites the respective EQS limit of 7.2ppb of annual mean concentration was exceeded; in many SSS there was, however, exceedance of the annual maximum concentration limit of the EQS. Significant concentrations of Pb were also found in irrigation wells, however, in none of the wells the maximum permissible level of 10ppb was exceeded.
9. Ni was found in significant concentrations in many SSS of surface water of the basin, however, the annual mean values in none of the cases exceeded the respective EQS limit. In some SSS there were exceedances of the EQS limit of the annual maximum concentration. Nickel was also found in irrigation wells, however, in none of the cases the respective concentrations found exceeded the 15ppb level.
10. Cu was not found in the surface water of the basin; it was found in substantial concentrations in groundwater, however, in none of the wells the respective annual mean concentrations exceeded the 2000ppb limit of the Drinking water Directive 83 / 98.
11. Hg was never found at concentrations higher than the respective reporting level of the analytical method.
12. Cr was found in some SSS of surface water of the basin, however, in none of the SSS the respective annual mean concentration values exceeded the respective EQS limit. Cr was also found in substantial concentrations in many irrigation wells especially in wells located in the areas of Farsala and Sofades, however, in none of

- these wells the respective concentrations exceeded the 50ppb limit. This limit was exceeded only in one well located in the area of Palama.
13. Zn was found in certain SSS of surface water at concentrations as high as 400ppb, however, the respective annual mean concentrations exceeded the respective EQS limit in the water of the SSS 61 and 62 located on the river Enipeas and at the SSS 73 and 74 located on the river Sofaditis.
 14. Significant concentrations of Sn were found in many SSS of surface water and in many of them exceedances of the respective 2.2ppm limit of the EQS (annual mean concentration) were found.
 15. Significant concentrations of Mn and Fe were found in both surface and ground water SSS of the basin and exceedances of the respective limits (EQS and Drinking water Directive 83 / 98) were found for both surface and ground waters.
 16. Low to moderate concentrations of nitrates were found in surface water SSS of the basin, however, significant concentrations of nitrates were found in groundwater exceeding the 50ppm level in many irrigation wells and especially the wells located in the plain area of Farsala where definitely there was groundwater pollution from nitrates.
 17. Concentrations of nitrites and of ammonia higher than 0.5ppm were found in some surface SSS and also some irrigation wells.
 18. Significant concentrations of Sb and Al were found in groundwater of the basin and especially in a significant number of irrigation wells located in the area of Sofades. In fact the Al annual mean concentrations in three of the wells located in area of Sofades were 3388, 10620 and 685ppb, respectively.
 19. It is apparent that the groundwater of the basin of the river Enipeas with the increased concentrations of phosphates, total phosphorus, nitrites, the existence of reductive conditions (negative Redox values) and also the increased concentrations of As, Pb, Ni, Cu, Cr, Mn, Fe, Sb and Al is highly contaminated. The highest number of wells with decreased water quality were located in the area of Sofades in the sub-basin of the river Sofaditis. Along the course of the river Sofaditis there is a number of X.A.D.A. (uncontrollable sites of burial of municipal solid wastes) and some of the them are located in fact in close proximity to the river bed. These X.A.D.A., so far did not appear to have affected significantly the quality of the surface water body, however, apparently leaching processes of metallic elements and different anions from these sites might have been responsible for the degradation of the groundwater quality.
 20. Analyses of sediments taken from the rivers Enipea and Sofaditis have shown excessively increased concentrations of nitrates and phosphates in the sediment of the SSS 68 of Enipeas; this was probably due to a road transportation accident of

nitrate and phosphate fertilizers. Increased concentrations of As, Mn, Cu, Zn, Sn, Cr, among the highest found in river sediments, were found in the sediments of the SSS 68 and 67. It is probable that these high metal concentrations found in the sediments of the river Enipeas in the mountainous area of Mantasia (SSS 68) and further down (SSS 67) were due to discharge of runoff liquid wastes derived from the Metallion mine of the Xyniada basin and the increased concentrations of metals in the natural background. High concentrations of heavy metals were also found in the sediments of the river Sofaditis.

21. Caffeine was found in all SSS of surface water and also groundwater. The presence of caffeine in groundwater in combination with the high concentrations of phosphates and total phosphorus content and also the fact that in many areas groundwater was under reductive conditions (negative Redox values) is a clear evidence that groundwater was highly polluted from municipal wastes either draining from septic tanks of rural areas and/or surface water receiving discharges of municipal wastes are replenishing groundwater aquifers. Given the fact that also higher concentrations of TDS and values of conductivity and salinity were found in groundwater than those found in surface water bodies is becoming apparent that the soils of the area are vulnerable to leaching leading to progressive degradation of groundwater aquifers. This is also in agreement with the fact that many pesticides frequently found in surface water SSS were also found in groundwater SSS. Among the pesticides found in groundwater at concentrations >0.1 ppb were included prometryne, chlorthal dimethyl, bentazone and lindane. Also diphenylamine was found in some irrigation wells at concentrations >0.1 ppb. The presence of diphenylamine in groundwater might be related to the presence of X.A.D.A. sites, which as said above, might be also responsible for the presence of heavy metals in groundwater.
22. In the aquatic systems of the Enipeas basin 95 active ingredients of pesticides and conversion products were detected at least once. Among the above 95 compounds in those found with the highest concentrations were included the herbicides fluometuron, prometryne, terbuthylazine and S-metolachlor.
23. The highest concentrations of pesticides ranging from 70 to 5ppb were found at the SSS with code numbers 2453, 2454, 2452, 2451 and 2456. Close to all above SSS, except for the SSS 2451, point pollution sources were identified located at sites of filling / washing of pesticide spray equipment and improper disposal of containers and other packaging materials of the pesticide formulations used. The pollution caused by the above point pollution sites was additively shown in the concentrations of pesticides found in the water of the Enipeas River at the SSS 65, located at Vlochos,

- and further downstream at the SSS 61 which is located upstream of the Enipeas discharge into the Pinios River.
24. Furthermore the increased concentrations of pesticides found in the water of the Enipeas River at the SSS 65 were also due to the load of pesticides carried by the river Farsaliotis, a tributary of Sofaditis, which is discharged into the Enipeas River upstream of the SSS 65. The pollution load from pesticides in the river Enipeas was also due to the load carried by its tributary Kalentzis discharging into the Enipeas river upstream of the SSS 61.
 25. The pesticide with the highest frequency of detection in the water of the river Enipeas was the herbicide fluometuron; the highest concentrations were found at the SSS 65 and slightly lower concentrations were found at the SSS 61. Also the highest concentrations of fluometuron during both the 2011 and 2012 cultivation/growing season were found during the months of April to June.
 26. Similar was the profile of fluometuron concentration variations in the river Sofaditis at the SSS located upstream of its discharge into the river Enipeas, however, the respective concentrations were at lower levels ranging from 2 to 4ppb during the April to June cultivation period of both 2011 and 2012 growing years.
 27. Many pesticides included in the EQS list of priority pollutants were found in the surface aquatic systems of the basin of Enipeas such as chlorpyrifos ethyl, alachlor, dimethoate, lindane, simazine, 2,4-D, MCPA, bentazone, mecoprop, trifluralin, HCB, malathion, endosulfan I, endosulfan II, endosulfan sulphate, isoproturon, linuron, diuron and different isomers of hexachlorobenzene. In a significant number of SSS the respective annual mean concentrations or annual maximum concentrations were in exceedance of the respective EQS limits.
 28. During the monitoring period of 2010-2011 only 24 compounds were detected more than 5 times and the respective number of pesticides during the 2012 growing season was 22.
 29. During the period of 2010 - 2011, based on Box & Whisker Plots, 75% of pesticide residue values collected were in the range of 0.010 to 1.423ppb and the rest of values exceeding the above range, characterized as outliers and extreme values, were traced to point pollution sources as described above under item 23.
 30. During 2012 the pesticides with the highest frequencies of detections were: fluometuron (173 detections), chlorpyrifos ethyl (103 detections) and S-metolachlor (104 detections) while the frequency of detections for prometryne was decreased to 79 detections, apparently due to more effective measures taken by the Authorities, to restrict and avoid the use of illegally imported and used pesticides.

31. The unavoidable pollution caused to surface aquatic systems of the Enipeas Basin did not exceed the 1.423ppb level during 2010 - 2011 and the 0.163ppb level during 2012. Most of the pesticide detections with concentrations exceeding the above ranges, respectively, were traced to point pollution sources of operating sites of filling / washing of pesticide spray equipment and improper disposal of agricultural wastes.
32. In the groundwater of the Enipeas basin the following pesticides were found at concentrations exceeding the 0.1ppb level: lindane, chlorthal dimethyl and prometryne. Diphenylamine was also found in some irrigation wells at concentrations exceeding the 0.1ppb level.
33. Ecotoxicological risk to aquatic organisms, based on Risk Quotient, occurred in 262 instances in the aquatic systems of the Enipeas basin and were due to the presence of the insecticides / acaricides endosulfan, bifenthrin, chlorpyrifos ethyl and methyl, malathion, pirimiphos ethyl and methyl, alphasmethrin, imidacloprid, and thiamethoxam, the fungicide PCNB and the herbicides S-metolachlor, triasulfuron, terbuthylazine, acetochlor, terbutryn, terbuthylazine, prometryne, ethalfluralin, pethoxamid and fluometuron.
34. Diphenylamine was frequently detected in the aquatic systems of the basin of Enipeas in both surface and groundwater, however, the highest concentrations were found in the water samples taken from the SSS located on the river Enipeas.

1.20. BASIN OF THE FORMER LAKE XYNIADA

1. The mean values of conductivity, salinity and TDS for the entire monitoring period of 2010 - 2012 were generally at low levels with the exception of the respective values at two SSS, namely 2478 and 2477, which are located in about the central region of the basin. This region has also the lowest elevation and is most probably the deepest region of the former lake and thus the entire basin is draining towards this area. The SSS with code number 2477 is located on the central drainage canal of the basin and at this site the Redox of the water during most of the monitoring period was negative whereas in the rest of SSS located on either the same central drainage canal or other surface aquatic systems of the basin the Redox values were positive indicating oxidative conditions. The mean values of the above mentioned parameters in the water of the irrigation wells were at lower levels compared to the respective levels found for the surface water systems.
2. According to the American Classification System of water irrigation quality the quality of both surface and groundwater systems of the basin was Intermediate to Good and in some cases was Intermediate to Moderate. The mean values of Boron concentrations in all SSS located on the surface aquatic system were <1.0ppm and

- they were below the method reporting level in the water of the irrigation wells monitored.
3. The mean values of the concentrations of chlorites and sulphates were at low levels in both surface and groundwater systems. However, the respective mean values of nitrates were at significantly higher levels and also exceeding the 50ppm limit in a few wells.
 4. The mean values of the concentrations of nitrites, ammonia, phosphates, total phosphorus and fluorites were at relatively low levels at all SSS monitored with the exception of the SSS 2477 in which the respective mean values were at very high levels and this was in agreement with the rest of the parameters monitored at this SSS including also the negative Redox values.
 5. The concentrations of the metallic elements of Sb, Cd, Se, Cu, Hg, Zn and Sn at the SSS of the basin were at levels below the respective reporting levels of the analytical methods. Aluminum and Fe at low levels were found only in the water of samples taken from the SS 2481 while low concentrations of As and Cr were found at certain SSS.
 6. Lead was found in the water of almost all SSS with the respective annual maximum concentrations exceeding the 7.2ppb EQS limit at the SSS with code numbers 2472, 2474, 2477 and 2480.
 7. Caffeine was found in all surface and groundwater SSS and therefore it is reasonable to assume that municipal wastes not adequately treated are discharged into these aquatic systems. On the other hand the presence of caffeine in groundwater is an indication that there is communication between surface and groundwater systems.
 8. In the aquatic systems of the Xyniada Basin 49 active ingredients of pesticides were detected at least once. The highest concentrations were found for the herbicides propyzamide (16.414ppb), ethofumesate (7.371ppb) and lenacil (2.25ppb), the insecticide lindane (0.67ppb) and the fungicide flutriafol (0.302ppb). Apparently these pesticides were more commonly used in this basin where tomatoes, lentils and other beans were grown. However, most of the high concentrations reported above were found in samples taken from the SSS 2478; the pollution at this site was related to a point pollution activity of filling/washing pesticide spray machinery at this site.
 9. Many pesticides included in the priority list of the EQS were found in the aquatic systems of Xyniada including chlorpyrifos ethyl, trifluralin, atrazine, alachlor, HCB, malathion, 2.4-D, bentazone, MCPA and lindane. However, exceedances of the EQS limits were found only for lindane, MCPA and malathion.
 10. In the monitored irrigation wells only chlorpyrifos ethyl was found and the respective concentrations were always less than 0.1ppb.

11. During the 2010 - 2011 monitoring period chlorpyrifos ethyl had the highest frequency of detections (26 detections), followed by the herbicides S-metolachlor (15 detections) and terbuthylazine (11 detections). The respective concentrations were at very low levels with 75% of residue data values not exceeding the 0.06ppb level. During 2012 only the fungicide boscalid was detected more than 5 times and 75% of its residue data collected did not exceed the 0.12ppb level. Most of the pesticide residue findings higher than the above levels were due to a point pollution source related to a site of filling / washing of pesticide spray equipment.
12. Ecotoxicological risk occurred only 16 times in the surface aquatic systems of the basin of Xyniada during the 2010 - 2012 monitoring period. Most of the instances of risk occurred in the water of the SSS with code 2478. In general, ecotoxicological risk to aquatic organisms was caused primarily due to the presence in the surface aquatic systems of the pesticides chlorpyrifos ethyl and methyl, L-cyhalothrin, malathion, lindane, PCNB, lenacil, acetochlor, propyzamide and ethofumesate.
13. Diphenylamine was detected only 3 times and at concentrations not exceeding the respective LOQ level.

1.21. BASIN OF THE FORMER LAKE KARLA

1. Due to the high conductivity, TDS, salinity and SAR values the aquatic systems of the former lake Karla, including both surface and groundwater, according to the American Classification System of water irrigation quality, had quality Intermediate to Moderate with the exception of the aquatic systems of the south-east region of the basin including also the water reservoirs of Kalamaki and Kanalia which had Bad irrigation quality.
2. The Redox values in most of the aquatic systems were at the low oxidative states with the exception of the water of a stream named Trypa in which the Redox values were always negative due to the presence of hydrogen sulfide (H₂S).
3. High concentrations of nitrates, nitrites, ammonia, phosphates and fluorites were found in the surface aquatic systems in the area of Nikea, N. Lefkis and Karias, located south of the City of Larisa. The presence of increased concentrations of the above anions and ammonia was probably due to the discharge of municipal wastes into these aquatic systems.
4. The mean values of the concentrations of chlorites and sulphates were >250mg/L in all aquatic systems located in the south-east region of the basin.
5. Arsenic was found in many aquatic systems of the basin, however, the respective concentrations did not exceed the EQS limits. Exceedance of the 10ppm limit of As was found only in one well located in area of Stefanoviki.

6. Low concentrations of Cd were found in certain aquatic systems of the basin and there were exceedances of the EQS limits in a number of cases.
7. Considerable concentrations of Pb were found in all aquatic systems of the Karla basin and in many circumstances the EQS limits were exceeded. Lead in considerable concentrations was also found in groundwater, however, in none of the wells monitored the respective annual mean values exceeded the 10ppb limit.
8. Low concentrations of Ni, Cu and Cr were found in some aquatic systems with no exceedances of either the EQS or the 98 / 83 Directive permissible limits.
9. Mercury was never found at concentrations higher than the respective method reporting level.
10. Zn, Fe and Sn were found in many SSS of the basin and there were exceedances of the respective EQS limits. However, most of the exceedances of the EQS limits were found in the water of the SSS with code number 2435 which is located on the Pinios River; the water provided for irrigation purposes in the Karla Basin is abstracted from the Pinios River.
11. Substantial concentrations of Mn were found in both surface and groundwater systems of the basin.
12. Caffeine was found in all surface aquatic systems monitored in the basin of Karla. However, caffeine was found only in one well.
13. In the aquatic systems of the Karla Basin 63 active ingredients of pesticides including also major metabolites and other conversion products of pesticides were detected at least once. However, among the above 63 compounds at higher concentrations were found only fluometuron, prometryne, S-metolachlor, lindane, trifluralin, alachlor and tebuconazole.
14. Pesticide residues were also found in groundwater of the basin. The highest concentrations were found for fluometuron (0.07ppb), prometryne (0.16ppb) and S-metolachlor (0.93ppb).
15. A number of pesticides included in the priority list of EQS was found in the surface aquatic systems of the Karla Basin. However, exceedances of the respective EQS limits were only found for lindane, chlorpyrifos ethyl, bentazone, 2.4-D and trifluralin.
16. The annual mean values of the concentration totals of all pesticides found at a certain SSS were in the range of <5.0 to 0.5<. However, by tracing the source of these pesticides, it appeared that at a certain sampling date the highest concentrations were present in the water abstracted from the Pinios River and diverted into the surface irrigation system of the basin.
17. During the monitoring period of 2010 - 2011 only 15 pesticides were detected in the aquatic systems of the Karla Basin more than 5 times and among these the herbicide

prometryne was found with the highest frequency of detections (103 detections) followed by the insecticide chlorpyrifos ethyl (99 detections) and the herbicides, fluometuron, S-metolachlor and terbuthylazine with 95, 36 and 31 detections, respectively. However, among all the pesticides detected the highest concentrations, that is 2.462, 1.038 and 0.592ppb, were found for fluometuron, prometryne and S-metolachlor, respectively. According to the Box and Whisker Plot statistical evaluation 75% of the pesticide residue values found in the surface aquatic systems of the basin were in the range of 0.010 to 0.305ppb which can be considered as the level of the unavoidable surface water contamination in this basin. Pesticide residues found at higher concentrations were due to point pollution sources. However, it should be reported here that most of the pesticide residue data included in the above analysis were present in the aquatic systems of this basin due to their presence in the irrigation water, which as said above, was abstracted from the river Pinios. Therefore the above mentioned unavoidable surface water contamination was not really unavoidable and was not directly related to the agricultural practices of farmers of this basin.

18. During the monitoring period of 2012 only 17 pesticides were detected more than 5 times with the highest frequencies of detection found for fuometuron (90 detections), prometryne (57 detections), chlorpyrifos ethyl (44 detections) and S-metolachlor (39 detections). The herbicides fluometuron and prometryne, both used for weed control in cotton fields, were found with the highest concentrations amounting to 5.311 and 1.791ppb, respectively. According to the statistical analysis, 75% of the residue data recorded for 2012 ranged from 0.01 to 0.514ppb.
19. Ecotoxicological evaluation of the pesticide residue data, based on the Risk Quotient, has shown that during the monitoring period of 2010 - 2012 there were 63 instances of risk situations to aquatic organisms and among these 12 cases occurred in the abstraction site of Pinios River (SSS with code number 2435). At this SSS the ecotoxicological risk was due to chlorpyrifos ethyl and methyl, L-cyhalothrin, PCNB, acetochlor, lindane and diazinon. In the other SSS of the basin risk to aquatic organisms was due to mainly insecticide residues used for cotton insect protection such as chlorpyrifos ethyl and methyl, L-cyhalothrin, alphasmethrin, imidacloprid, pirimiphos methyl, phosmet, the fungicides folpet and carbendazim and the herbicides ethalfluralin, prometryne, S-metolachlor and pendimethalin.
20. Diphenylamine was rarely detected in the aquatic systems of the basin (16 detections) and the respective concentrations did not exceed the 0.1ppb level. The highest concentration (0.087ppb) of diphenylamine was found in the water of the artificial lake

of Kanalia. Obviously even these low concentrations of diphenylamine were not due
its use as a pesticide but due to its presence in motor oils.

2. PROPOSED ENVIRONMENTAL INDICATORS

- a. It has been proven by the survey undertaken for the current chemical quality status of the surface and groundwater systems in all river and lake basins of Macedonia-Thrace and Thessaly that caffeine is an appropriate indicator for assessing the pollution originating from municipal wastes.
- b. The monitoring of diphenylamine might evolve as a suitable indicator for the assessment of the pollution of surface and ground waters caused by the operation of gas stations, garbage collection and burial sites and synthetic polymer recycling sites (car tires etc.).
- c. As far as the use of pesticides in the crop protection is concerned, it is concluded that under the climatic and soil conditions, the use of agricultural land and the respective agricultural practices for each basin, the unavoidable contamination of the surface water of all basins that were included in the present survey during the years 2010 - 2012 (two full consecutive cultivation periods) did not exceed the 1.0ppb level for each one of the pesticides used, with the exceptions of the Axios-Loudias basin where during the 2010 - 2011 period the maximum level of unavoidable contamination reached the 1.8ppb level, while in the portion of the basin of the river Aliakmona situated in Central Macedonia during the 2010 - 2011 period the maximum level of unavoidable contamination reached the 9.0ppb level and during the 2012 period the 2.0ppb level. All the other pesticide detections above the aforementioned levels were due to either point pollution sources caused by the unsuitable permanent installations of washing / filling of spraying equipment or occasional point pollution sources caused by the uncontrollable practice of certain farmers who tended to wash their spraying equipment or to dispose off empty pesticide containers by the banks of streams and drainage / irrigation canals.

3. GENERAL PROPOSALS FOR TAKING MEASURES OF ENVIRONMENTAL PROTECTION

It is of urgency the construction of permanent installations for the washing/filling of the pesticide spraying equipment situated far from streams and drainage/irrigation canals, constructed according to scientific demands for the rapid degradation of pesticides into products that do not pose any risk to neither humans or the environment (construction of biobeds).

Establish a compensatory tariff for the recycling of empty pesticide containers. The containers should be collected by the relevant Pesticide Retail Stores of each area and under the responsibility of the trading companies they should be sent to appropriate destruction sites.

4. SPECIFIC PROPOSALS CONCERNING THE DIFFERENT RIVER / LAKE BASINS

1. Basin of the river Ardas

- Given the fact that the pollution of the river Ardas from municipal wastes, pesticide residues and heavy metals (Sn, Zn, Cr, Cu, Ni, Fe, Pb, As and Mn) is primarily imported from Bulgaria the analysis of water and river sediments on an annual basis is recommended.
- Further investigation is required concerning the sources of Pb, As and Mn found in the aquatic systems of the basin and especially the groundwater aquifers.
- The registration of the pesticides etridiazole, S-metolachlor and bentazone should be revised and their use should be prohibited in the basin of the river Ardas since these pesticides were found in groundwater at concentrations exceeding the maximum permissible level of 0.1ppb.

2. Basin of the river Evros

- The fact that in a significant number of irrigation wells increased concentrations of many metallic elements exceeding the respective limits of drinking water quality were found, for instance Fe, Cd and Pd in the well 1072 (Orestiada), Fe, As and Cd in the well 1071 of N. Vyssa, Fe, AS and Cd in the well 1061 of Didymoticho, Fe and As in the well 1056 of Didymoticho, Fe and Cd in the well 1052 of Pythio and 1049 of Thourio, and also because of the fact that pesticide residues were found in concentrations above the limit of 0.1ppb in a considerable number of irrigation wells, the quality control of the water of all drinking water wells of the basin should be mandatory.
- Investigation for the presence of heavy metals in fish living in the dam of Ardani - Kavissou, and possibly the prohibition of recreational fishing activity for the inhabitants of the nearby areas should be undertaken, taking into account the fact that in the water of this dam considerable concentrations of heavy metals were measured.

3. Basin of the river Erythropotamos

- Because of the pollution of ground water caused by municipal wastes, it is mandatory to carry out a quality control for all drinking water wells and the implementation of relevant measures like the construction of a central urban drainage network and sewage system covering the whole basin of the river Erythropotamos for the replacement of private septic tanks.

- The use of pesticides which were found to leach to the ground water of Erythropotamos basin like etridiazole, bentazone, 2.4-D, chlorthal dimethyl and fluometuron should be forbidden in that area.
 - Measures should be taken for the prevention of the pollution of the ground water by diphenylamine. The proposed measures include the control of gas stations especially concerning actions of disposal of used oils, of the watertightness of waste collection and burring sites, and of waste recycling sites.
4. Basin of Rodopi-Vistonida
- More efficient management of municipal wastes and garbage disposal sites should be considered.
 - Take measures to prevent salination of groundwater.
5. Basin of the river Nestos
- The presence of mercury in ground water (irrigation wells 1171, 1172, 1175, 1181, 1189) at levels exceeding the reporting limit (0.5ppb) of the analytical method necessitates the investigation for the presence of mercury in all existing wells of the basin and especially those supplying drinking water.
 - More efficient management of garbage and of both municipal and animal wastes is needed.
 - Take measures to prevent salination of groundwater.
6. Basin of the river Aggitis-Drama
- It is necessary to investigate the presence of diphenylamine in all of the drinking water wells of the basin.
 - It is necessary to further investigate the source(s) of pollution of ground water by diphenylamine and especially in the region of the Industrial Zone of Drama.
 - The presence of As in all irrigation and drinking water wells and in the agricultural products of the Paggaion region should be investigated.
 - Take measures to reduce the presence of increased concentrations of nitrates in groundwater.
7. Basin of the river Strymonas
- Taking into consideration the fact that by the monitoring survey undertaken it was deduced that the most significant pollution of the surface waters of the Strymon River basin (including the lake Kerkini) is caused by municipal wastes, the appropriate management of municipal wastes is mandatory.

8. Basin of the lake Doirani

- It is urgent to further investigate the presence of diphenylamine in the ground water in order to identify the pollution source(s) and to limit the further downgrade of the quality of ground water.

9. Basin of the rivers Axios-Loudias

- It is urgent to further investigate the levels of pesticide residues and of diphenylamine in all of the drinking water wells of the basin.
- Taking of measures for the limitation of groundwater pollution by prohibiting the use of pesticides found in ground water at concentration exceeding the 0.1ppb limit.

10. Basin of the lakes Volvi-Langada and Mygdonia

- Given the fact that one of the major environmental problems in this basin was identified as the pollution of ground water with municipal wastes the construction of an intergraded sewage system covering all rural and urban areas of the entire basin and the proper treatment of the municipal wastes before being discharged into a certain aquatic system is required.
- The selection of proper sites with non-permeable soils for the storage of recycled materials is required to avoid further contamination of groundwater aquifers.
- Prohibition of use of pesticides found in groundwater at concentrations >0.1ppb.

11. Basin of the river Moglenitsa

- The use of the fungicide etridiazole should be prohibited for use in this basin due to the fact that concentrations >0.1ppb can leach to groundwater
- Due to the fact As, Mn and Fe were found in certain irrigation wells exceeding the respective limits of drinking water quality the investigation of the water quality of all wells supplying drinking water should be undertaken.

12. Basin of the lake Vegoritida

- Improvement of municipal waste management systems to further reduce the input of wastes discharged into the lakes.
- Further investigation is required concerning the sources of heavy metals in the streams of Scklithrou and Aetou and the lake Zazari.

13. Basin of the lake Kastorias

- Better management of municipal wastes from all urban and rural areas to reduce further contamination of surface and groundwater systems of the basin.
- Take measures to reduce the presence of increased concentrations of nitrates in groundwater.

14. Basin of the lakes Prespa

- Better management of municipal wastes from all urban and rural areas to reduce contamination of surface and groundwater systems of the basin.
- Given the fact that the pollution of the lake Big Prespa is partly imported from Albania and/or FYROM the monitoring of the water quality of this lake, at least on an annual basis, is required.

15. Basin of the river Aliakmon

- Improved management and disposal of municipal wastes is required.

16. Basin of the former lake Kallipefki

- The construction of a facility treating municipal wastes before being discharged into the surface aquatic system of the basin is required.
- The construction of a closed irrigation system is required.

17. Basin of the river Titarisios

- Better management of municipal wastes from all urban and rural areas to reduce contamination of surface and groundwater systems of the basin is required.
- Investigation about the presence of pesticide residues in the atmosphere of the basin as well the different forms of precipitation (rain, snow) is required.

18. Basin of the river Pinios

- Better management of municipal wastes from all urban and rural areas to reduce further contamination of surface and groundwater systems of the basin.
- Take measures to reduce the presence of increased concentrations of nitrates in groundwater.
- Given the fact that a significant proportion of the irrigation wells included in the monitoring network was found to provide water of reduced quality the general monitoring of all wells providing drinking water should be undertaken.
- Take measures to prevent salination of groundwater in the area of the Pinios Delta.

19. Basin of the river Enipeas

- Better management of municipal wastes from all urban and rural areas to reduce further contamination of surface and groundwater systems of the basin.
- Further investigation about the sources of heavy metals in the groundwater aquifers of the area of Sofaditis River is required.
- Measures should be taken to reduce further contamination of groundwater with nitrates.

20. Basin of the former lake Xyniada

- Better management of municipal wastes from all rural areas to reduce contamination of surface and groundwater systems of the basin is required.

21. Basin of the former lake Karla

- The water quality of the river Pinios, providing the main source of water in the surface aquatic systems of this basin including irrigation water, should be monitored regularly at the water abstraction sites.