ARISTOTLE UNIVERSITY OF THESSALONIKI
DEPARTMENT OF GEOLOGY
Laboratory of Engineering Geology and Hydrogeology

Research Project (Code 97824)

Groundwater depletion. Are Eco-friendly Energy Recharge Dams a solution?

REPORT OF WORK PACKAGE 4 / (WP4/D4-3)

GroundwateR DePLETION

PRINCIPAL INVESTIGATOR:
KAZAKIS NERANTZIS
Dr. HYDROGEOLOGIST

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& Innovation H.F.R.I.

H.F.R.I.
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1 Introduction

Within this report are presented all analysis that obtained in the framework of work package 4 and the corresponding thematic maps. For the production of the thematic maps was used the software of QGIS and ARCMAP. Additionally, is included the submitted special issue and the published articles until 12-2-2024. The analysis of the results are presented in the corresponding publications.

2 Chemical analysis

In this section are presented the results of the chemical analysis in tables and the thematic maps that produced by the elaboration of the field data collection and laboratory measurements from the period of September 2021 and May 2022.

2.1 Coastal area of eastern Thermaikos Gulf and Anthemountas basin

The results of the Coastal area of eastern Thermaikos Gulf and Anthemountas basin are presented in the following tables and thematic maps. The maximum value of temperature occurs in GD15 during the period of May 2022. The mean value of pH in groundwater samples is 7.5, while the mean value of electrical conductivity is 1760 μS/cm, while the maximum value is 10.500 μS/cm in GD17 during the period of September 2021. The maximum concentration of Cl occurs in GD17 during the period of September 2021. The highest concentration of nitrate is 212 mg/L during the period of September 2021 in GD17, while the concentration reaches 336 mg/L in the period of May 2022. Elevated concentration in trace elements occur due to geothermal fluids and depicted mainly in the concentrations of Arsenic and Ferus which has been explained in literature.

Table 2.1 Chemical analysis from Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm)	Total hardness (oF)	HCO_3 (mg/L)	CO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)
GD1	22.9925	40.50909	17.4	48	7.7	849	33.3	397	ND	61.4	16.8	ND	21.2	0.13	ND	48.1	1.94	69	38.9	0.05	0.48
GD2	23.08819	40.49143	18	90	8	954	44.4	458	ND	56	73	0.017	10.7	0.2	ND	45	1.34	92	52	ND	0.4
GD3	23.10448	40.47423	18.1	6	7.5	1487	27.14	477	ND	76	53	0.56	34.1	0.13	ND	245	1.88	54	33	ND	0.48
GD4	23.27123	40.4389	18.5	30	8	861	49	567	ND	8.7	4.8	ND	23.2	0.08	ND	7.4	0.94	23	105.1	ND	0.08
GD5	23.18841	40.43533	19	14	7.9	574	27	329	ND	15	23	ND	ND	0.03	ND	21.3	0.6	39	42	ND	0.19
GD6	23.12349	40.50948	17.2	5	7.4	639	22.2	281	ND	36	40	ND	17	0.09	ND	52	4.1	51	23	ND	0.23
GD7	23.05491	40.54409	17.6	20	8.2	592	26.9	323	ND	23	11	ND	12.3	0.03	ND	23	1.5	32	46	ND	0.13
GD8	23.00418	40.38698	17.8	-40	7.2	1938	61.9	817	ND	247	40	ND	5	0.12	ND	202	7	124	75	0.19	2.63
GD9	23.24645	40.33057	19.1	34	7.1	1339	54	665	ND	127	32	0.015	13	1.04	ND	103	7.9	124	56	0.13	0.69
GD10	23.25203	40.25859	19.2	-10	7.5	1914	63.1	470	ND	320	54.1	ND	72	0.05	ND	148.1	2.4	104	90.1	0.03	0.83
GD11	23.14469	40.27987	18.6	110	7.5	1443	48.5	525	ND	157	32	ND	91.8	0.04	ND	125	2.5	92	62	0.11	1.42
GD12	23.12558	40.31333	18.2	10	6.9	1536	60.5	793	ND	115	36	ND	2	0.15	ND	111	5.4	153	54	0.11	1.08
GD13	23.16525	40.32053	18.9	-5	7.1	1652	67.3	796	ND	156	32	ND	13	0.07	ND	105	13	192	47	0.26	0.85
GD14	23.0892	40.34689	19.4	10	7.2	1556	48.8	726	ND	135	88	ND	ND	0.14	ND	175	4.7	90	64	0.08	1.17
GD15	22.94995	40.38177	19.5	100	7.6	1050	36.7	390	ND	105	46	ND	21	ND	ND	75	3.5	68	47.8	0.03	1.79
GD16	22.94272	40.42308	17.7	-10	7.5	833	32.445	378	ND	66	25	ND	11	ND	ND	67	2.7	76	25	0.03	1.06
GD17	22.82923	40.48872	19	120	7.4	10522	252.6	372	ND	3195	546	ND	212	0.08	ND	1365	46.8	352	400	0.04	5.21

Table 2.2 Chemical analysis from Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

Sample	X	Y	NH_4 (mg/L)	Sb (μg/L)	Se (μg/L)	As (μg/L)	Cd (μg/L)	Cr(VI) (μg/L)	Cr (μg/L)	Cu (μg/L)	Fe (μg/L)	Pb (μg/L)	Mn (μg/L)	Ni (μg/L)	Co (μg/L)	Mo (μg/L)	Zn (μg/L)	Hg (μg/L)	SiO_2 (mg/L)	B (mg/L)	T.O.C. (mg/L)
GD1	22.9925	40.50909	ND	ND	ND	6.1	ND	9	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	23.4	1.17	ND
GD2	23.08819	40.49143	ND	ND	8.2	ND	ND	7	7	ND	ND	ND	40	25	3.3	ND	30	ND	17.8	ND	ND
GD3	23.10448	40.47423	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	ND	25.2	1.5	ND
GD4	23.27123	40.4389	ND	ND	ND	ND	ND	10	10	ND	134	ND	20	ND	ND	ND	ND	ND	28.5	ND	ND
GD5	23.18841	40.43533	ND	ND	ND	11.5	ND	ND	ND	ND	ND	ND	20	ND	ND	ND	ND	ND	41.5	ND	ND
GD6	23.12349	40.50948	ND	ND	ND	ND	ND	ND	ND	ND	157	ND	ND	ND	ND	ND	ND	ND	14.4	ND	ND
GD7	23.05491	40.54409	ND	ND	ND	ND	ND	6	6	ND	149	ND	20	ND	ND	ND	70	ND	14.2	ND	ND
GD8	23.00418	40.38698	0.05	ND	ND	2	ND	ND	ND	ND	491	ND	20	ND	ND	ND	ND	ND	33.5	2.4	ND
GD9	23.24645	40.33057	0.07	ND	ND	426	ND	ND	ND	ND	166	ND	20	ND	ND	3	ND	ND	25.6	1.5	ND
GD10	23.25203	40.25859	0.09	ND	2.8	ND	ND	5	5	ND	201	ND	ND	ND	ND	ND	ND	ND	30.4	0.19	ND
GD11	23.14469	40.27987	ND	ND	ND	3.2	ND	3	3	ND	152	ND	470	ND	ND	5.1	ND	ND	41.3	0.61	ND
GD12	23.12558	40.31333	0.15	ND	ND	60	ND	ND	ND	ND	270	ND	20	1.5	ND	ND	ND	ND	35.4	2.3	ND
GD13	23.16525	40.32053	0.1	ND	ND	500	ND	ND	ND	ND	184	ND	30	2.6	ND	2.6	ND	ND	37.4	3.6	ND
GD14	23.0892	40.34689	0.09	ND	3	33.3	ND	ND	ND	ND	284	ND	100	ND	ND	ND	ND	ND	25.2	0.6	ND
GD15	22.94995	40.38177	ND	ND	ND	ND	ND	6	6	ND	162	ND	ND	ND	ND	ND	60	ND	23.9	ND	ND
GD16	22.94272	40.42308	ND	ND	ND	ND	ND	ND	ND	ND	450	ND	30	ND	ND	2.6	420	ND	24.4	ND	ND
GD17	22.82923	40.48872	ND	ND	4.4	2	ND	9	9	ND	157	ND	20	ND	ND	ND	360	ND	26.1	ND	1.01

Table 2.3 Chemical analysis from Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm)	Total hardness (oF)	HCO_3 (mg/L)	CO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)
GD1	22.9925	40.50909	18.1	50	8.1	742	29.9	375	ND	61	14	ND	18	0.12	ND	58	1.7	59	37	ND	0.46
GD2	23.08819	40.49143	18	88	8.3	796	30.3	412	ND	60	70	ND	12	0.26	ND	56	1.9	100	60	ND	0.31
GD3	23.10448	40.47423	18.3	9	7.4	1437	18.0	747	ND	92	61	ND	53	0.12	ND	310	2.0	64	5	ND	0.5
GD4	23.27123	40.4389	19	28	8.1	818	47.5	573	ND	11	27	ND	6	0.08	ND	20	1.1	17	105	ND	0.16
GD5	23.18841	40.43533	19.2	16	7.8	567	25.7	336	ND	18	17	ND	ND	0.03	ND	28	0.7	47	34	ND	0.22
GD6	23.12349	40.50948	17.9	10	7.3	585	21.3	262	ND	38	38	ND	13.5	0.080	ND	49	4.6	49	22	ND	0.3
GD7	23.05491	40.54409	17.8	22	8.3	544	26.1	293	498	28	14	ND	10	ND	ND	19	0.9	27	47	ND	0.16
GD8	23.00418	40.38698	19.1	-110	7.2	1906	64.5	805	ND	284	34	ND	5	ND	ND	210	3.8	128	79	ND	2.2
GD9	23.24645	40.33057	1.3	30	7.3	1416	56.4	695	ND	135	12	0.070	22	0.4	ND	99	9.0	125	61	0.13	0.74
GD10	23.25203	40.25859	19.4	-9	7.3	4375	170.6	366	ND	1207	123	0.030	49	0.06	ND	211	5.0	243	267	0.04	1.72
GD11	23.14469	40.27987	18.8	100	7.4	1475	59.1	512	ND	171	115	ND	38	0.04	ND	101	3.4	95	86	0.09	1.7
GD12	23.12558	40.31333	18.9	8	7.1	1482	60.1	801	ND	121	40	ND	5	0.19	ND	102	6.1	180	60	0.15	1.1
GD13	23.16525	40.32053	19	-9	6.9	1598	60.9	689	ND	165	34	ND	32	1.14	ND	105	13.6	168	46	0.23	0.78
GD14	23.0892	40.34689	19.7	10	7.2	1675	50.4	811	ND	172	64	0.015	ND	0.15	ND	214	6.5	85	71	0.08	1.28
GD15	22.94995	40.38177	19.8	88	7.7	1054	40.4	390	ND	137	46	ND	37	0.070	ND	82	4.3	68	57	0.02	1.82
GD16	22.94272	40.42308	18.2	5	7.5	806	31.6	403	ND	71	29	ND	6	ND	ND	67	3.1	80	28	ND	1.04
GD17	22.82923	40.48872	19.3	100	7.4	8806	237.9	2470	ND	2703	487	ND	336	0.09	ND	1147	33.6	382	346	0.03	4.2

Table 2.4 Chemical analysis from Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm)	Total hardness (oF)	HCO_3 (mg/L)	CO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)
GD1	22.992502	40.5090904	18.1	50	8.1	742	29.9	375	ND	61	14	ND	18	0.12	ND	58	1.7	59	37	ND	0.46
GD2	23.088188	40.4914284	18	88	8.3	796	30.3	412	ND	60	70	ND	12	0.26	ND	56	1.9	100	60	ND	0.31
GD3	23.104479	40.4742317	18.3	9	7.4	1437	18.0	747	ND	92	61	ND	53	0.12	ND	310	2.0	64	5	ND	0.5
GD4	23.271233	40.4388962	19	28	8.1	818	47.5	573	ND	11	27	ND	6	0.08	ND	20	1.1	17	105	ND	0.16
GD5	23.188406	40.4353333	19.2	16	7.8	567	25.7	336	ND	18	17	ND	ND	0.03	ND	28	0.7	47	34	ND	0.22
GD6	23.123489	40.5094757	17.9	10	7.3	585	21.3	262	ND	38	38	ND	13.5	0.080	ND	49	4.6	49	22	ND	0.3
GD7	23.054911	40.5440865	17.8	22	8.3	544	26.1	293	498	28	14	ND	10	ND	ND	19	0.9	27	47	ND	0.16
GD8	23.004177	40.3869781	19.1	-110	7.2	1906	64.5	805	ND	284	34	ND	5	ND	ND	210	3.8	128	79	ND	2.2
GD9	23.246452	40.3305702	19.3	30	7.3	1416	56.4	695	ND	135	12	0.070	22	0.4	ND	99	9.0	125	61	0.13	0.74
GD10	23.252026	40.2585869	19.4	-9	7.3	4375	170.6	366	ND	1207	123	0.030	49	0.06	ND	211	5.0	243	267	0.04	1.72
GD11	23.144691	40.2798691	18.8	100	7.4	1475	59.1	512	ND	171	115	ND	38	0.04	ND	101	3.4	95	86	0.09	1.7
GD12	23.12558	40.3133316	18.9	8	7.1	1482	60.1	801	ND	121	40	ND	5	0.19	ND	102	6.1	180	60	0.15	1.1
GD13	23.165255	40.3205338	19	-9	6.9	1598	60.9	689	ND	165	34	ND	32	1.14	ND	105	13.6	168	46	0.23	0.78
GD14	23.089195	40.3468857	19.7	10	7.2	1675	50.4	811	ND	172	64	0.015	ND	0.15	ND	214	6.5	85	71	0.08	1.28
GD15	22.949951	40.3817711	19.8	88	7.7	1054	40.4	390	ND	137	46	ND	37	0.070	ND	82	4.3	68	57	0.02	1.82
GD16	22.942722	40.4230843	18.2	5	7.5	806	31.6	403	ND	71	29	ND	6	ND	ND	67	3.1	80	28	ND	1.04
GD17	22.829231	40.4887161	19.3	100	7.4	8806	237.9	2470	ND	2703	487	ND	336	0.09	ND	1147	33.6	382	346	0.03	4.2

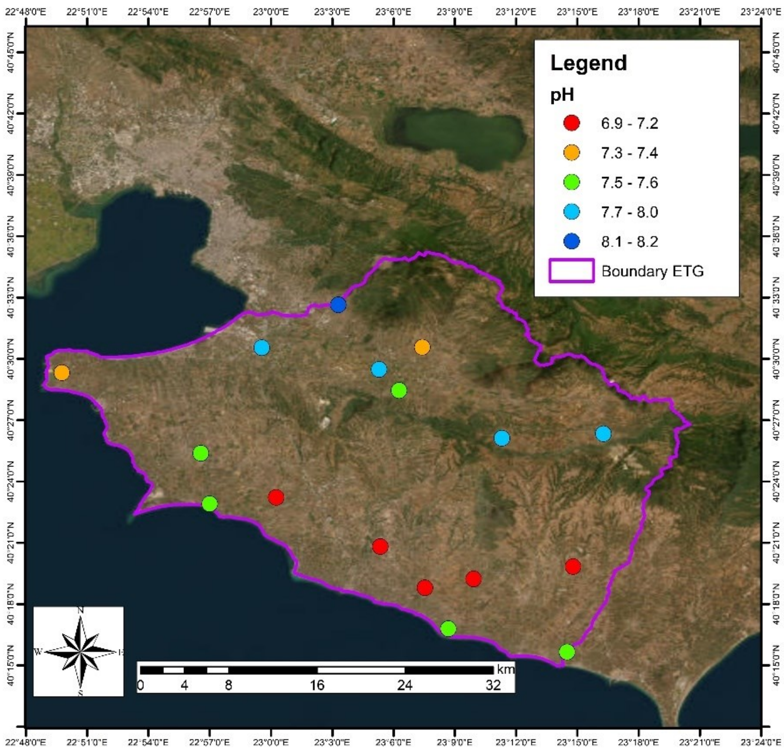

Figure 2.1 Distribution of pH in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

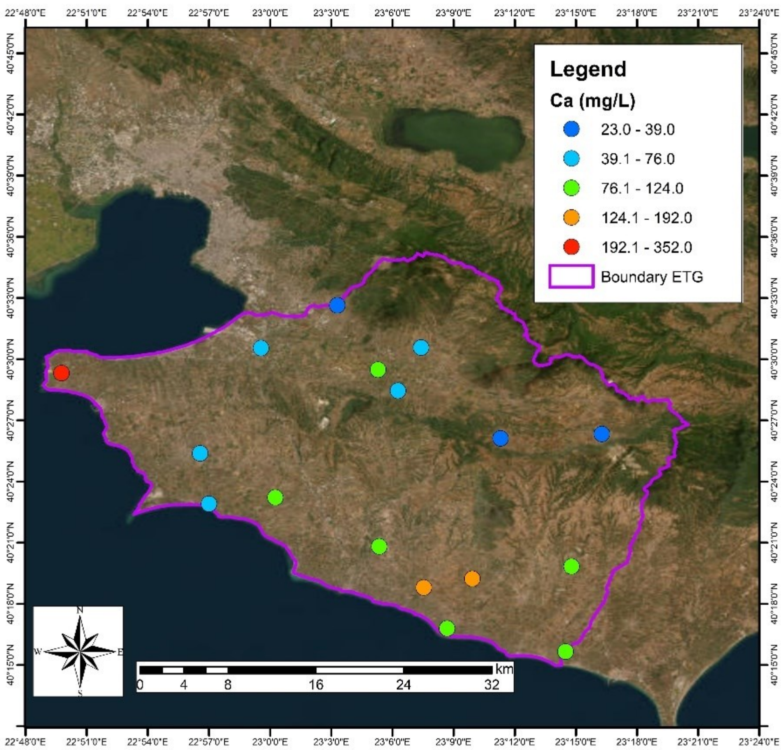

Figure 2.2 Distribution of Ca in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

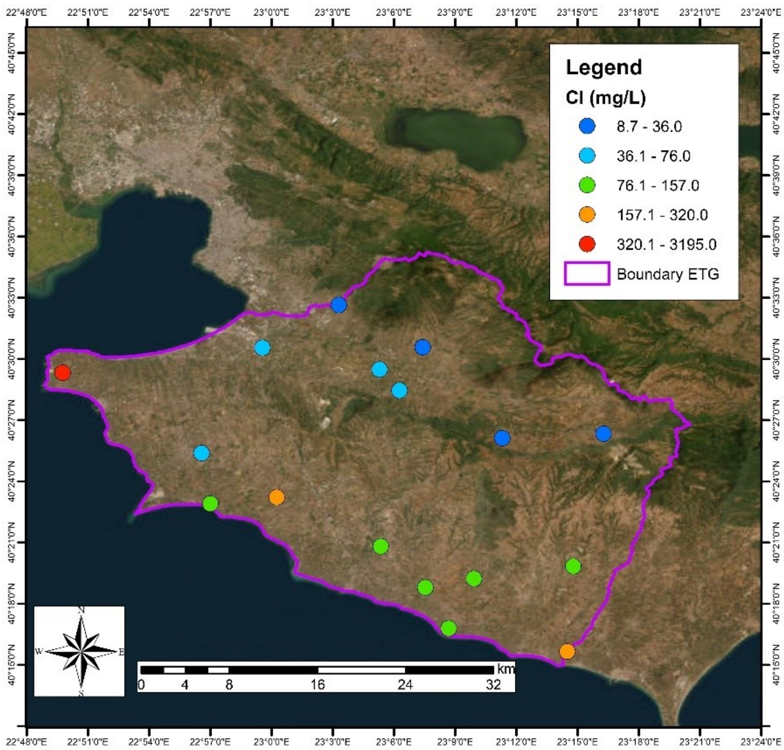

Figure 2.3 Distribution of Cl in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

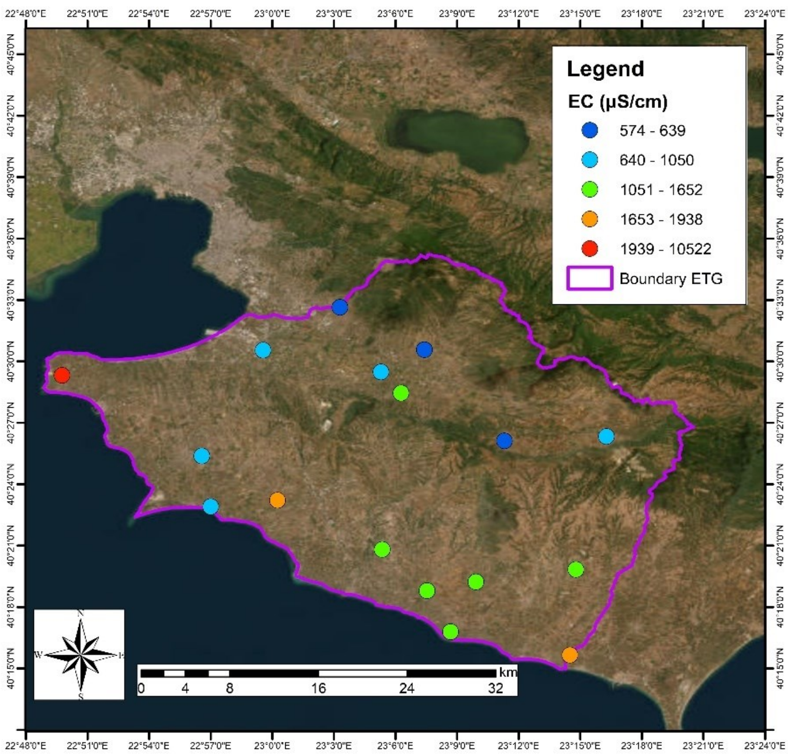

Figure 2.4 Distribution of EC in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

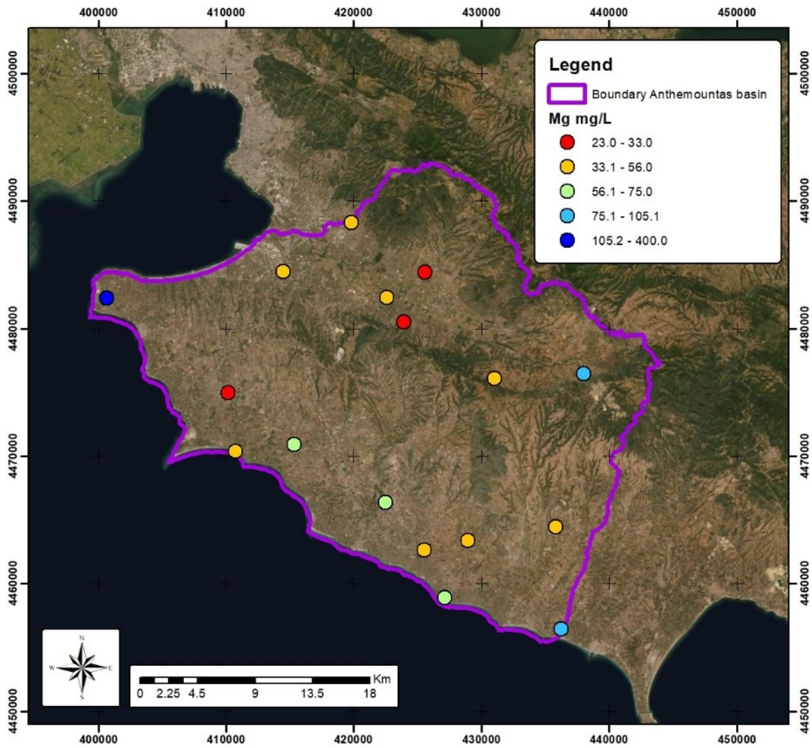

Figure 2.5 Distribution of Mg in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

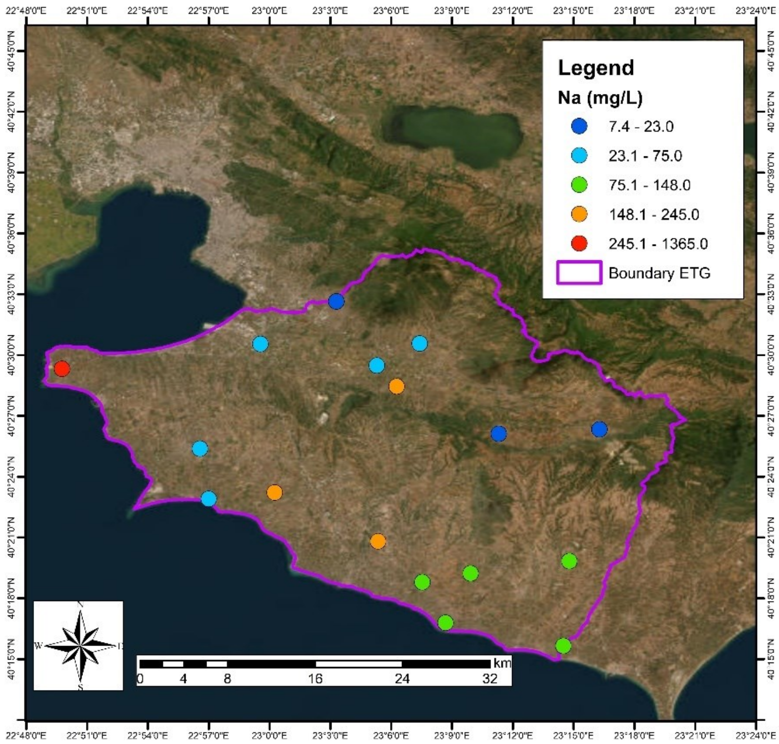

Figure 2.6 Distribution of Na in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

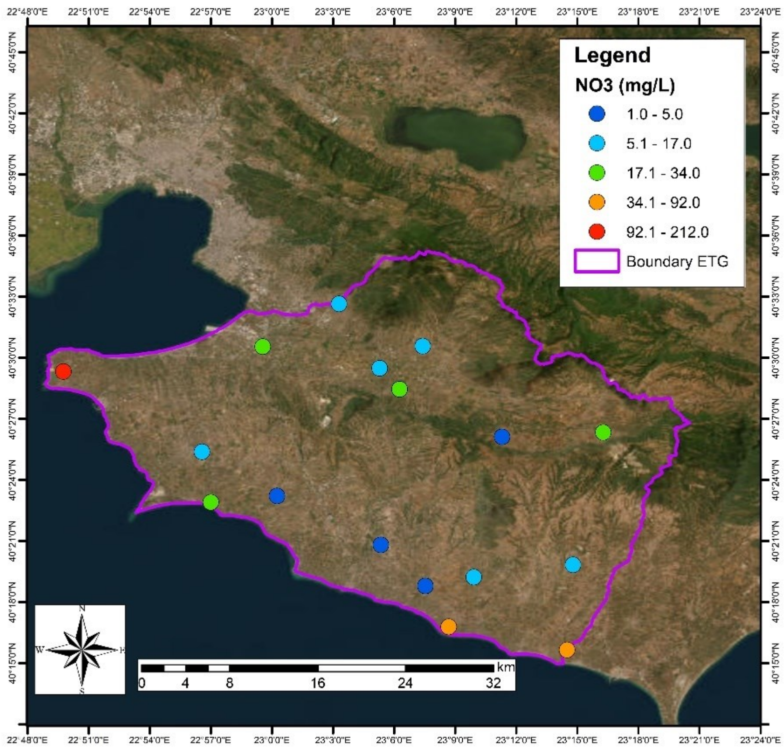

Figure 2.7 Distribution of NO_3 in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period September 2021.

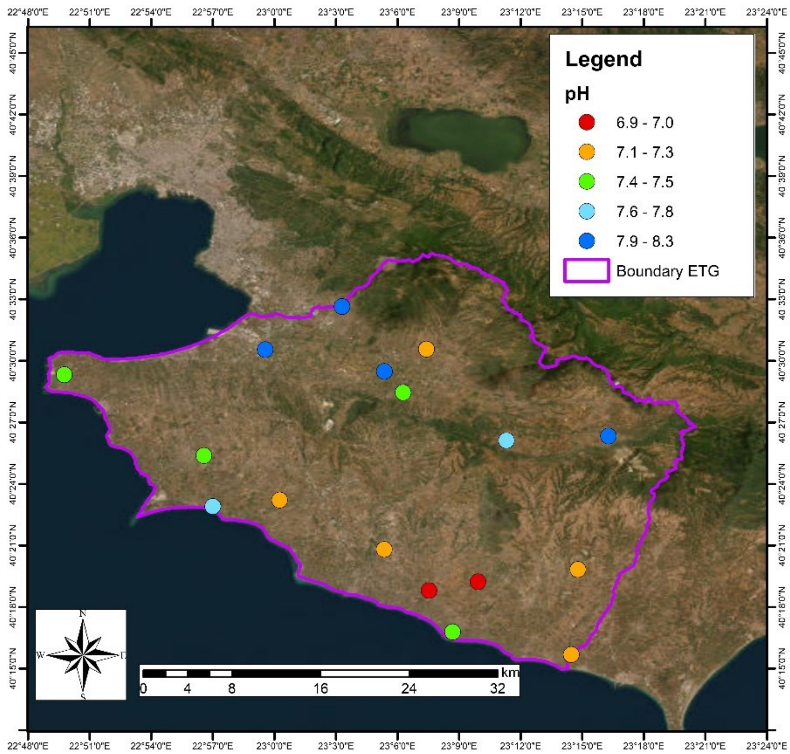

Figure 2.8 Distribution of pH in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

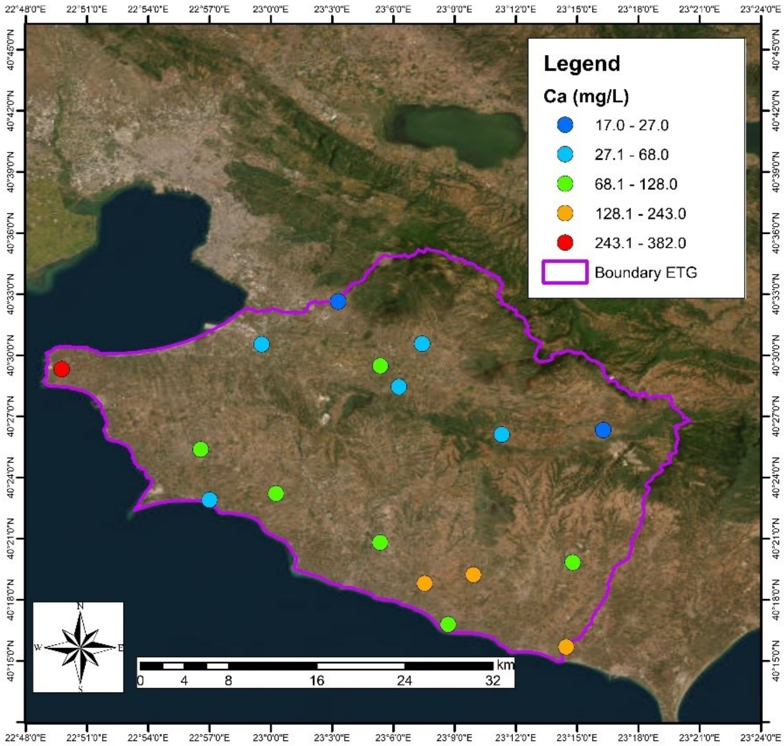

Figure 2.9 Distribution of Ca in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

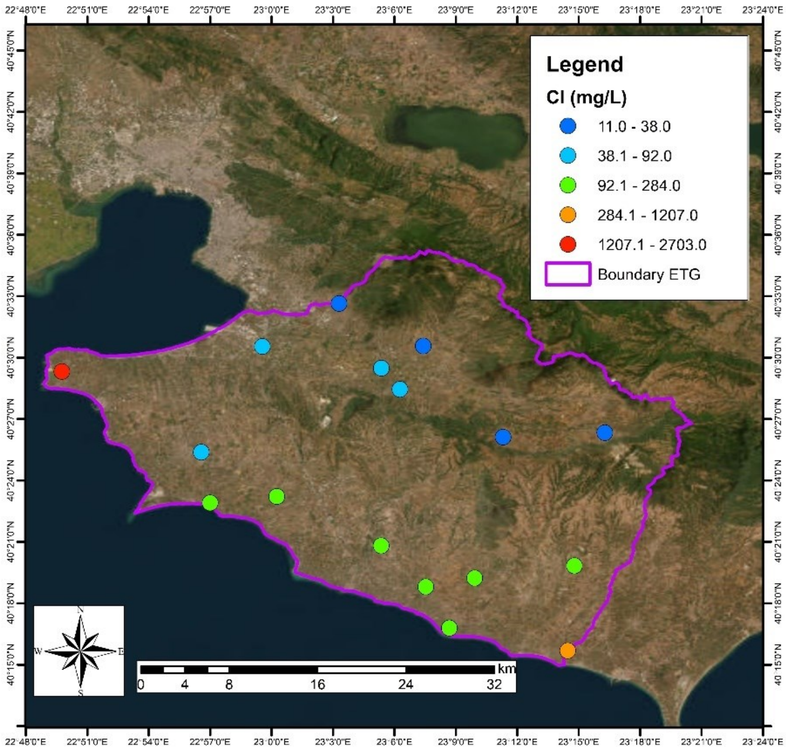

Figure 2.10 Distribution of Cl in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

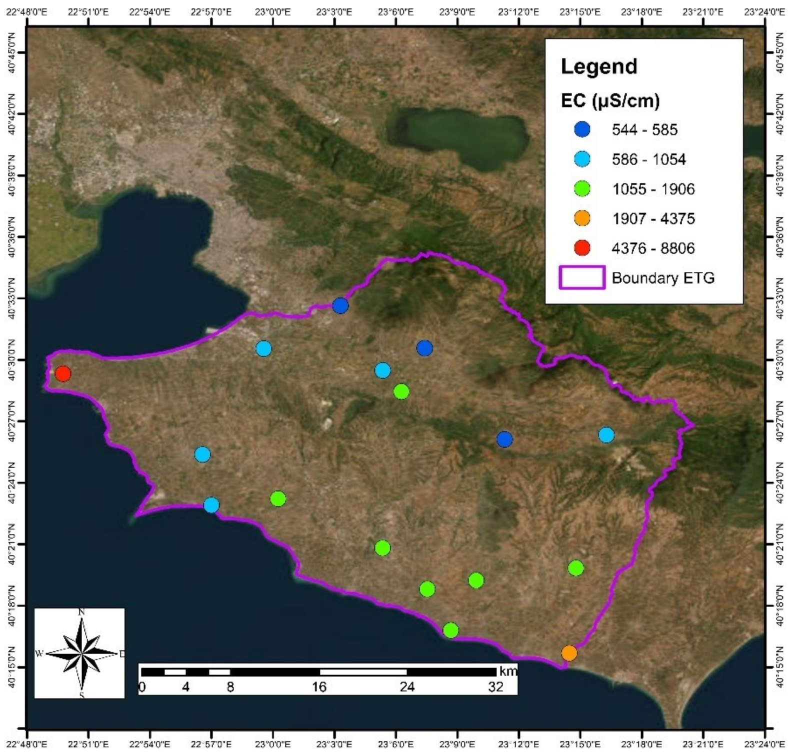

Figure 2.11 Distribution of EC in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

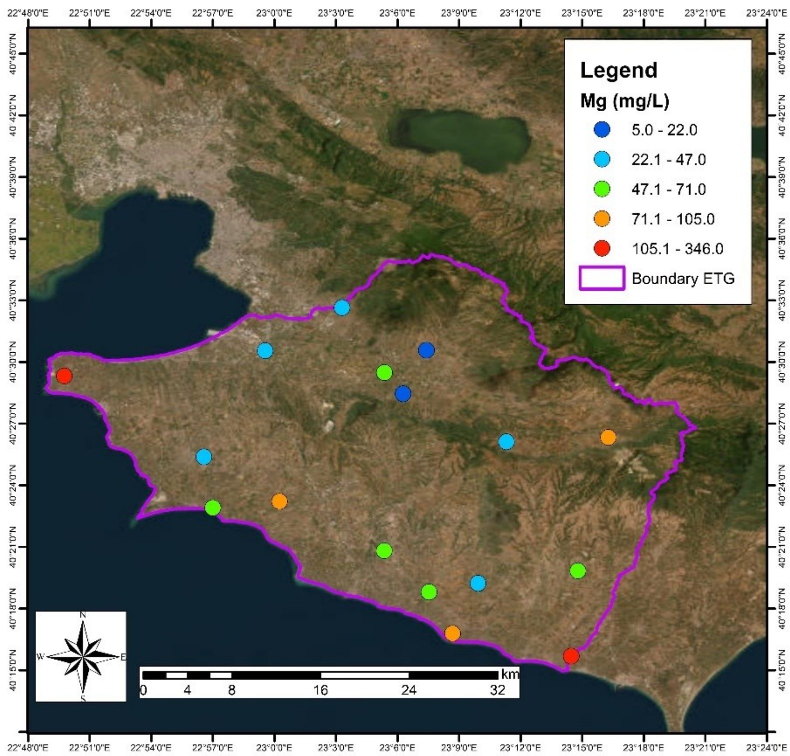

Figure 2.12 Distribution of Mg in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

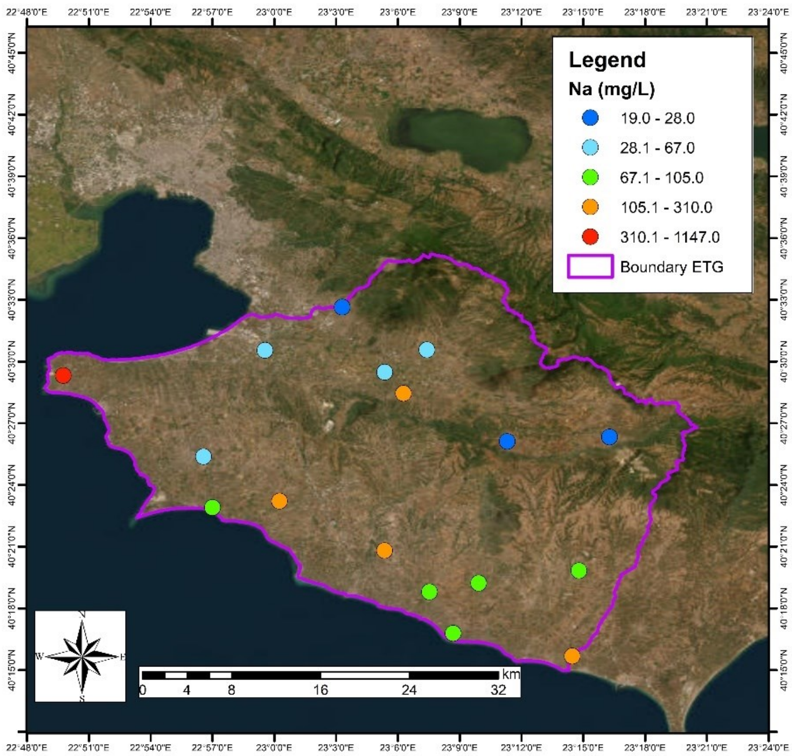

Figure 2.13 Distribution of Na in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

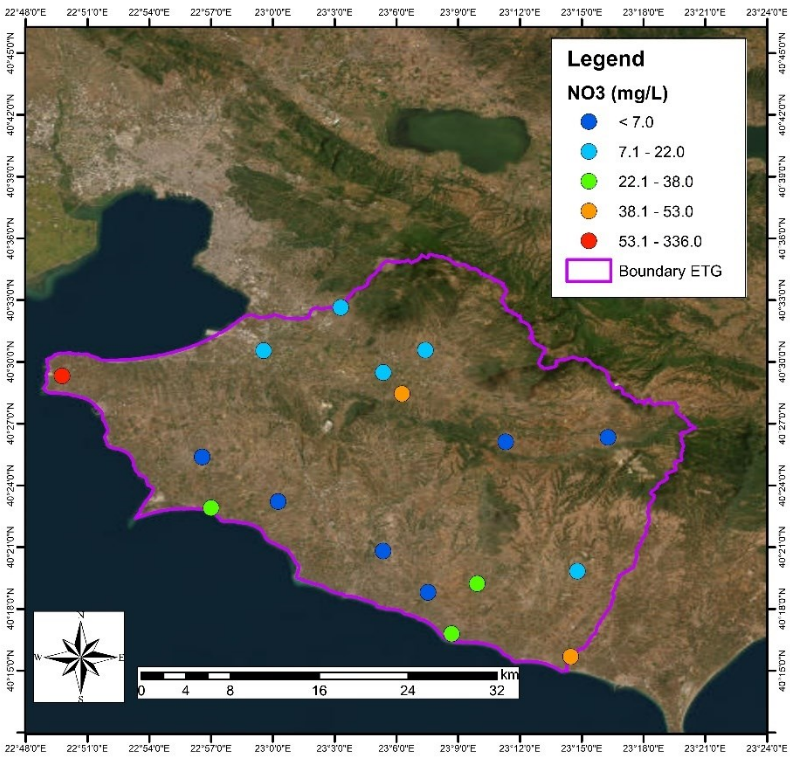

Figure 2.14 Distribution of NO_3 in Coastal area of eastern Thermaikos Gulf and Anthemountas basin for the period May 2022.

2.2 Mouriki basin

The results of the Mouriki basin are presented in the following tables and thematic maps. The mean value of temperature is 18.1 °C and 17.7 °C for the periods of September 2021 and May 2022, respectively. The mean value of pH in groundwater samples is 7.5. The maximum value of electrical conductivity is 773 μS/cm, while the minimum value is 250 μS/cm in GM6 during the period of September 2021. The concentration of chloride and sodium are relatively low in the site. The highest concentration of nitrate occurs in GM7 during May 2022 with value 49mg/L. The mean concentration of nitrate is 19 mg/L for both studied periods. Trace and potential toxic elements have also low concentrations.

Table 2.5 Chemical analysis from Mouriki basin for the period September 2021.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm)	Total hardness (oF)	HCO_3 (mg/L)	CO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)
GM1	21.5244	40.50202	17.9	8	7.5	413	20.9	250	ND	10	17	ND	ND	0.03	ND	10	4.7	49	21	ND	0.17
GM2	21.59678	40.52301	18.5	11.2	6.8	381	15.1	183	ND	17	19	ND	27	0.06	ND	27	4.3	34	16	ND	0.21
GM3	21.63352	40.55776	17.9	2.5	7.6	528	23.5	256	ND	6	59	ND	19	0.4	ND	25	4.9	56	23	0.05	0.23
GM4	21.57216	40.53806	18.2	3	7.7	338	15.2	183	ND	11	20	ND	3	0.14	ND	16	4.6	36	15	0.1	0.17
GM5	21.502	40.54722	18.4	-10	7.9	261	11.7	159	ND	3	10	ND	ND	ND	ND	12	5.8	33	9	0.1	0.19
GM6	21.50569	40.54276	17.6	-8	7.9	250	11.1	146	ND	3	11	ND	3	ND	ND	14	4.8	30	9	ND	0.17
GM7	21.56853	40.52827	18.3	87	7.4	769	37.0	268	ND	15	135	ND	45.0	0.24	ND	25	1.3	97	31	ND	0.35
GM8	21.5125	40.54014	18.6	2.2	7.9	388	20	244	ND	4	20	ND	ND	0.2	ND	30	4.2	38	21	ND	0.2

Table 2.6 Chemical analysis from Mouriki basin for the period September 2021.

Sample	X	Y	NH_4 (mg/L)	Sb (μg/L)	Se (μg/L)	As (μg/L)	Cd (μg/L)	Cr(VI) (μg/L)	Cr (μg/L)	Cu (μg/L)	Fe (μg/L)	Pb (μg/L)	Mn (μg/L)	Ni (μg/L)	Co (μg/L)	Mo (μg/L)	Zn (μg/L)	Hg (μg/L)	SiO_2 (mg/L)	B (mg/L)	T.O.C. (mg/L)
GM1	21.5244	40.50202	ND	ND	ND	ND	ND	ND	ND	ND	154	ND	ND	ND	ND	4.3	30	ND	26	ND	ND
GM2	21.59678	40.52301	ND	ND	ND	ND	ND	7	7	ND	114	ND	30	ND	ND	ND	130	ND	35	ND	ND
GM3	21.63352	40.55776	0.05	ND	ND	ND	ND	6	6	ND	175	ND	80	0.05	ND	12	ND	ND	25	ND	ND
GM4	21.57216	40.53806	0.1	ND	ND	ND	ND	ND	ND	ND	181	ND	40	0.1	ND	3.1	ND	ND	21	ND	ND
GM5	21.502	40.54722	0.1	ND	ND	ND	ND	ND	ND	ND	215	ND	20	0.1	ND	2.4	70	ND	17	ND	ND
GM6	21.50569	40.54276	ND	ND	ND	ND	ND	ND	ND	ND	218	ND	40	ND	ND	ND	550	ND	18	0.19	ND
GM7	21.56853	40.52827	ND	ND	ND	ND	ND	ND	ND	ND	177	ND	40	ND	ND	2.4	480	ND	34	0.30	ND
GM8	21.5125	40.54014	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	25	ND	ND

Table 2.7 Chemical analysis from Mouriki basin for the period June 2022.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm)	Total hardness (oF)	HCO_3 (mg/L)	CO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)
GM1	21.5244	40.50202	17.6	7	7.2	419	21.1	233	ND	8	19	ND	ND	0.06	ND	17	5.1	42	23	ND	0.19
GM2	21.59678	40.52301	18.1	9	6.8	426	16.4	159	ND	21	21	ND	32	0.08	ND	19	4.7	37	17	ND	0.22
GM3	21.63352	40.55776	17.7	5	7.3	512	22.4	248	ND	8	63	ND	20	0.6	ND	20	5.2	60	20	ND	0.23
GM4	21.57216	40.53806	17.5	11	7.3	354	14.8	177	ND	13	19	ND	6	0.11	ND	16	4.5	37	14	ND	0.18
GM5	21.50200	40.54722	18	14	7.3	269	11.5	159	ND	3	9	ND	ND	0.030	ND	12	6.7	32	8	ND	0.22
GM6	21.50569	40.54276	17.3	12	7.9	254	11.2	140	ND	4	10	ND	3	0.020	ND	7	5.3	31	9	ND	0.18
GM7	21.56853	40.52827	17.8	99	7.5	773	35.4	247	ND	10	109	ND	49	0.020	ND	12	1.8	51	26	ND	0.31
GM8	21.5125	40.54014	18.2	4	8.0	391	18.0	232	ND	7	11	ND	2.6	0.04	ND	13	5.0	46	16	ND	0.18

Table 2.8 Chemical analysis from Mouriki basin for the period June 2022.

Sample	X	Y	NH_4 (mg/L)	Sb (μg/L)	Se (μg/L)	As (μg/L)	Cd (μg/L)	Cr(VI) (μg/L)	Cr (μg/L)	Cu (μg/L)	Fe (μg/L)	Pb (μg/L)	Mn (μg/L)	Ni (μg/L)	Co (μg/L)	Mo (μg/L)	Zn (μg/L)	Hg (μg/L)	SiO_2 (mg/L)	B (mg/L)	T.O.C. (mg/L)
GM1	21.5244	40.50202	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GM2	21.59678	40.52301	ND	ND	ND	ND	ND	8	9	ND	ND	ND	ND	ND	ND	ND	32	ND	31	0.10	ND
GM3	21.63352	40.55776	ND	ND	ND	ND	ND	6	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	18	ND	ND
GM4	21.57216	40.53806	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND
GM5	21.50200	40.54722	ND	ND	ND	ND	ND	ND	ND	ND	79	ND	ND	ND	ND	ND	ND	ND	18	0.06	ND
GM6	21.50569	40.54276	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	0.07	ND
GM7	21.56853	40.52827	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	ND	ND
GM8	21.5125	40.54014	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20	ND	ND

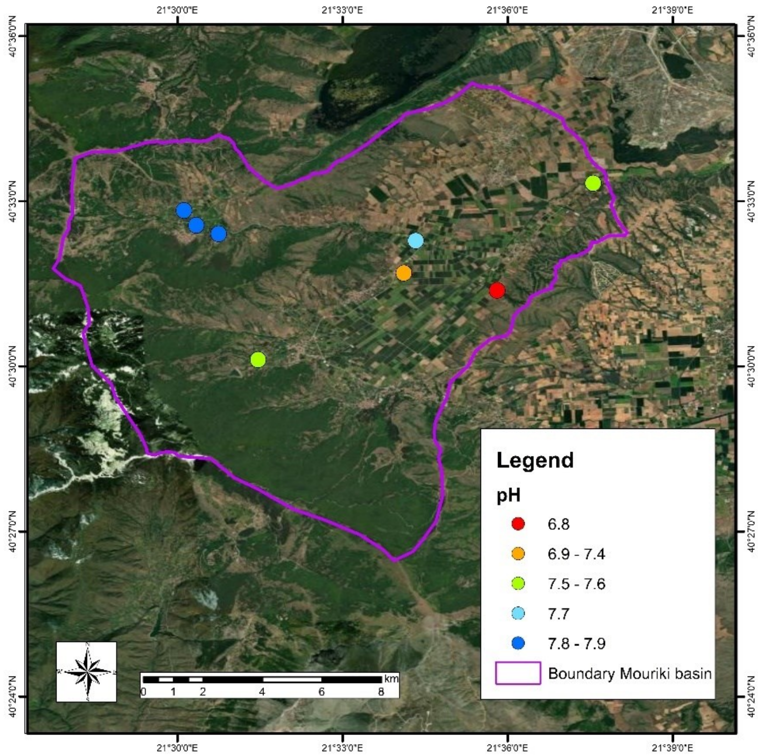

Figure 2.15 Distribution of pH in Mouriki basin for the period September 2021.

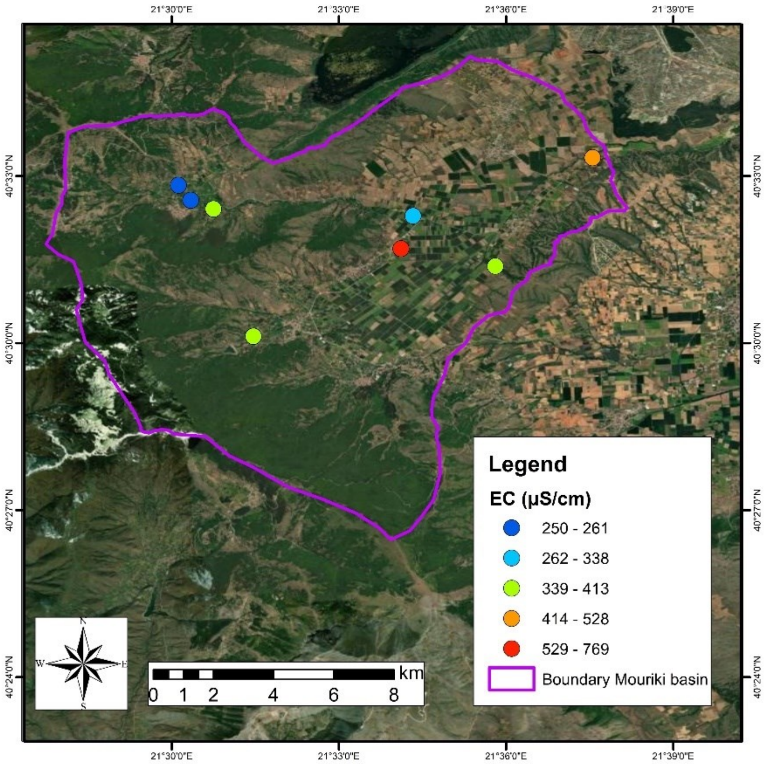

Figure 2.16 Distribution of EC in Mouriki basin for the period September 2021.

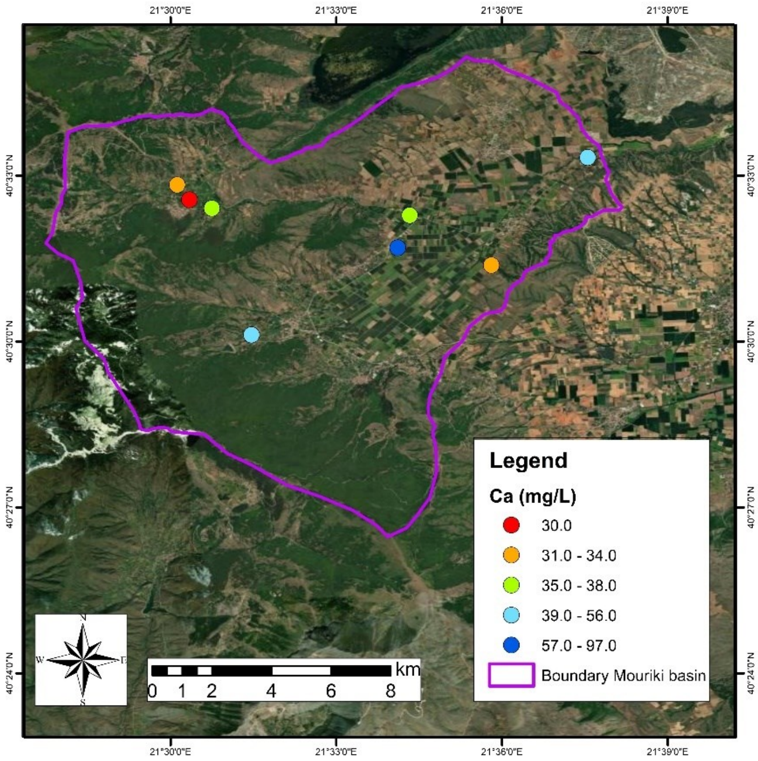

Figure 2.17 Distribution of Ca in Mouriki basin for the period September 2021.

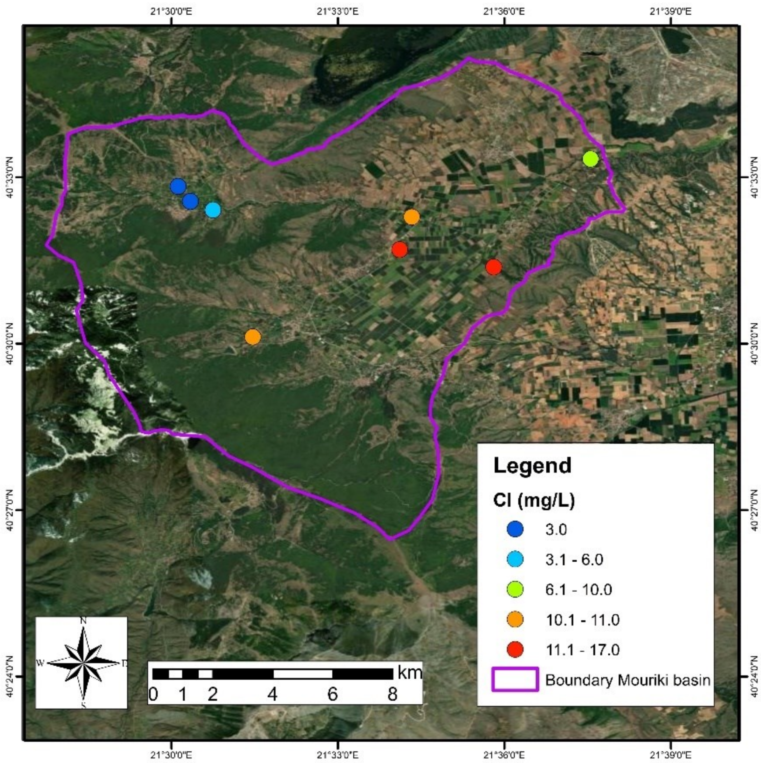

Figure 2.18 Distribution of Cl in Mouriki basin for the period September 2021.

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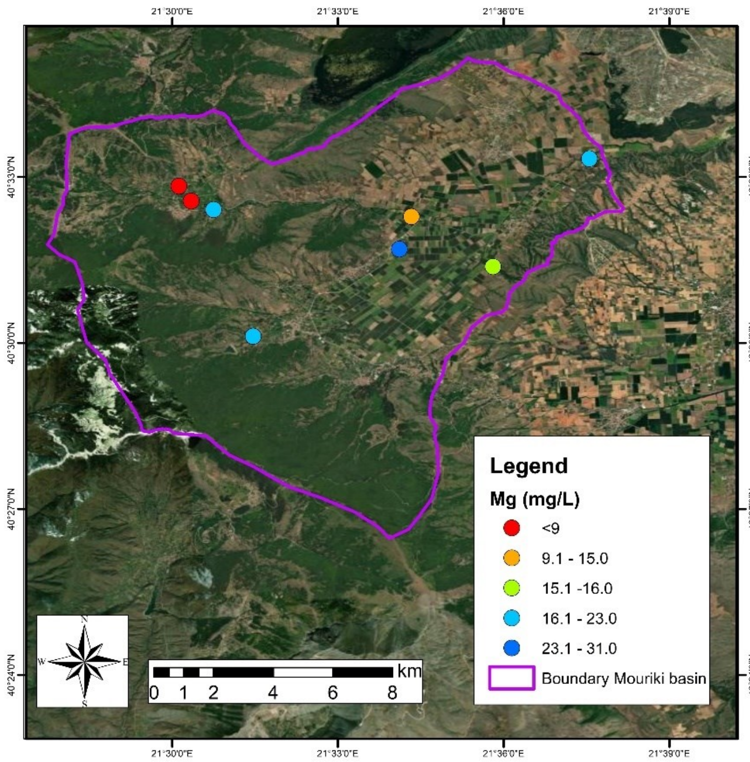

Figure 2.19 Distribution of Mg in Mouriki basin for the period September 2021.

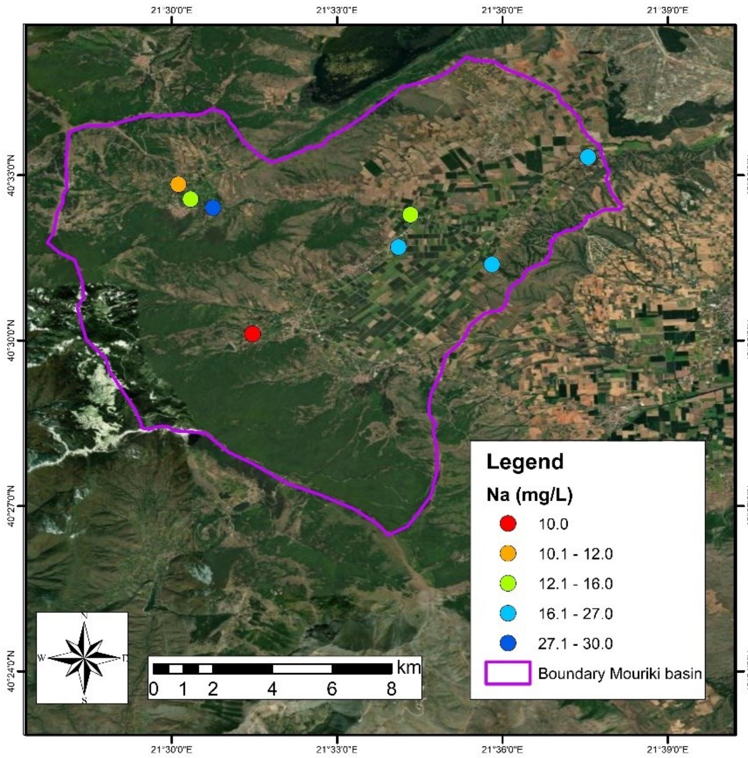

Figure 2.20 Distribution of Na in Mouriki basin for the period September 2021.

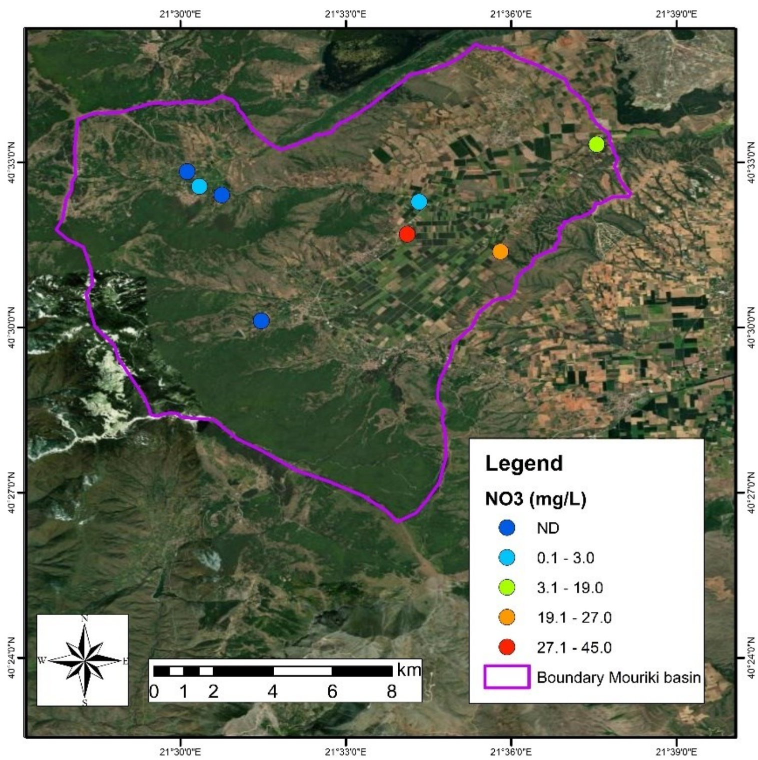

Figure 2.21 Distribution of NO_3 in Mouriki basin for the period September 2021.

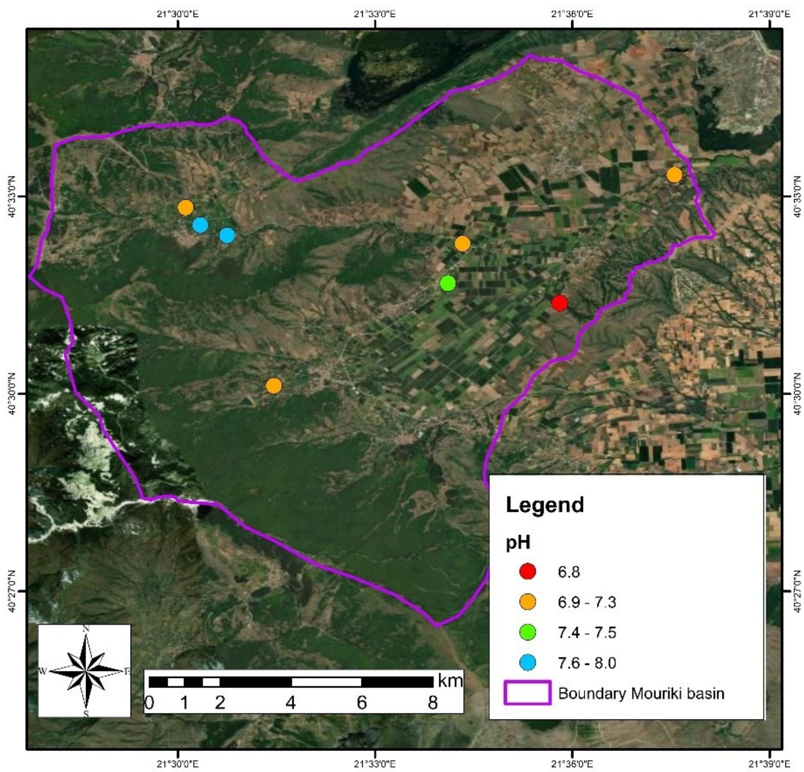

Figure 2.22 Distribution of pH in Mouriki basin for the period May 2022.

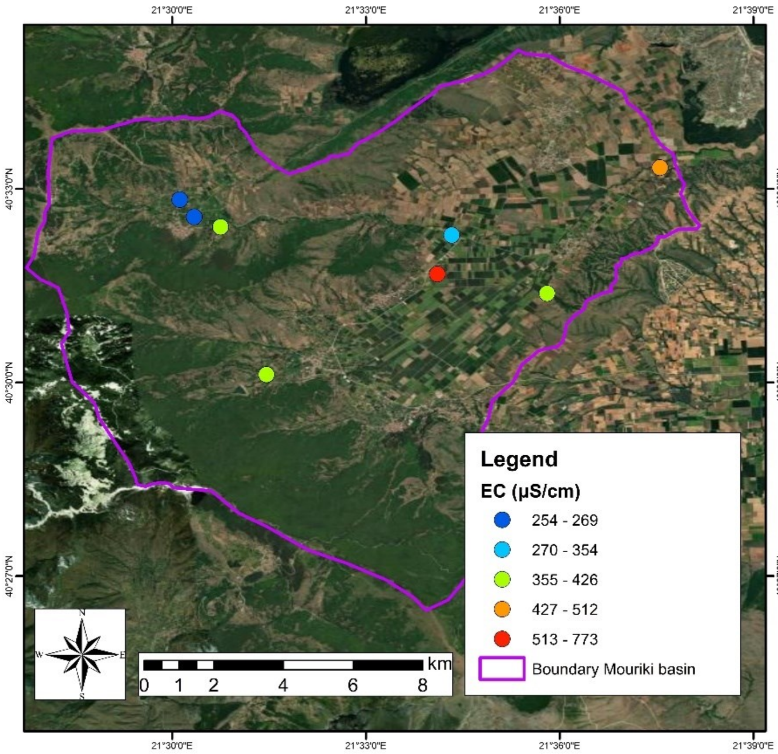

Figure 2.23 Distribution of EC in Mouriki basin for the period May 2022.

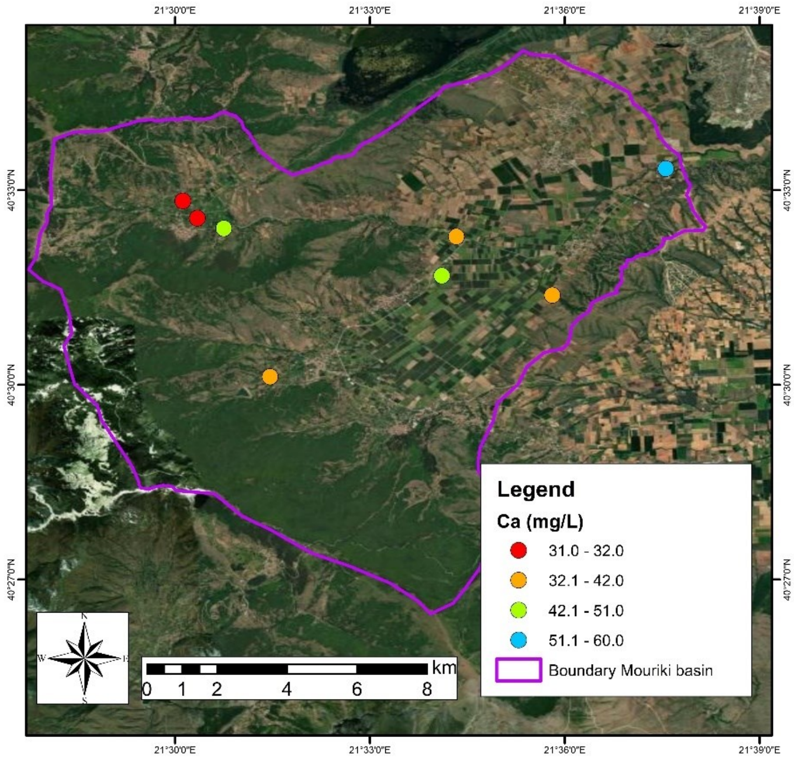

Figure 2.24 Distribution of Ca in Mouriki basin for the period May 2022.

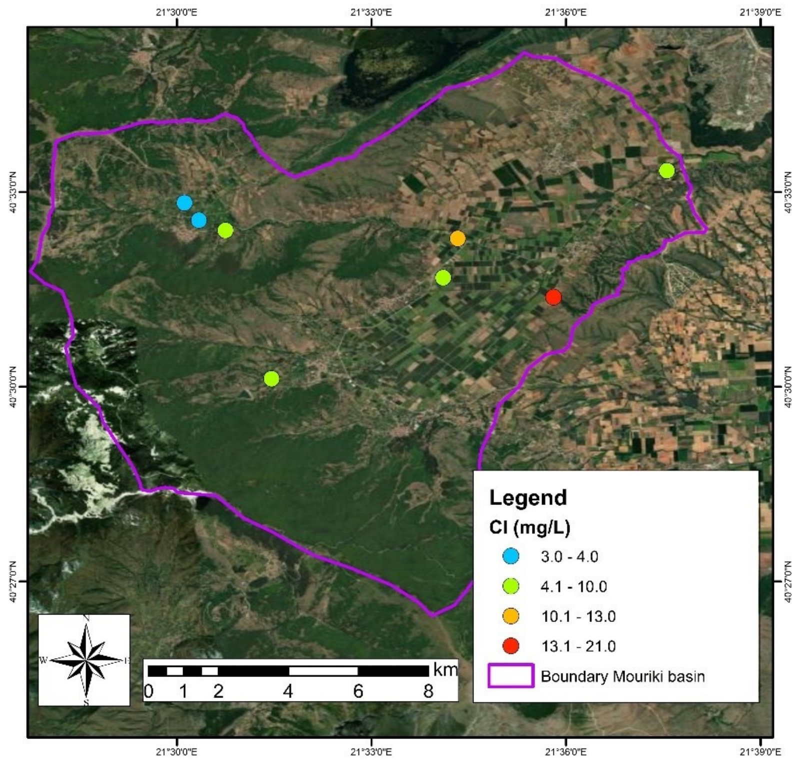

Figure 2.25 Distribution of Cl in Mouriki basin for the period May 2022.

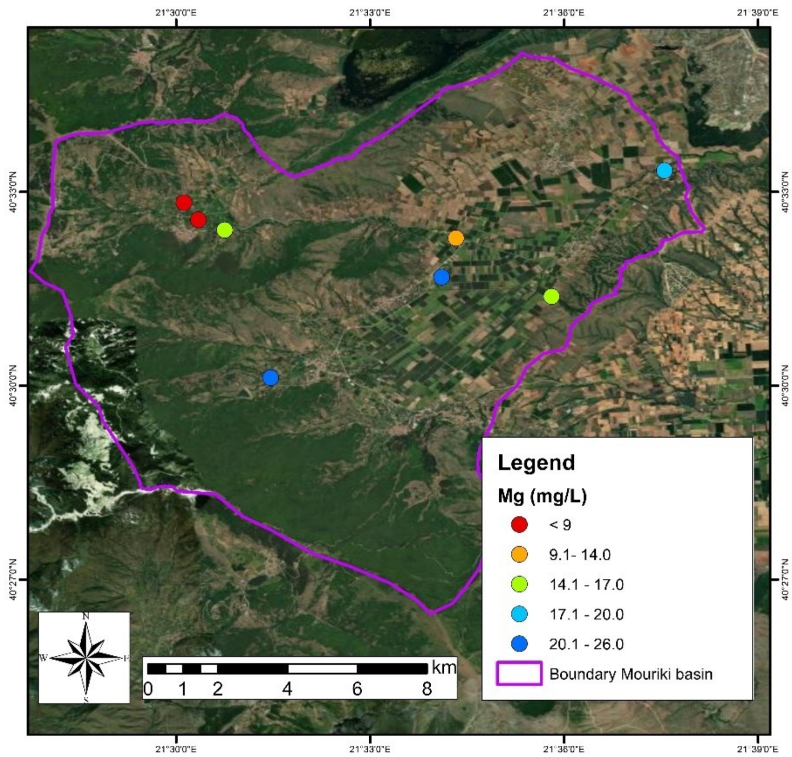

Figure 2.26 Distribution of Mg in Mouriki basin for the period May 2022.

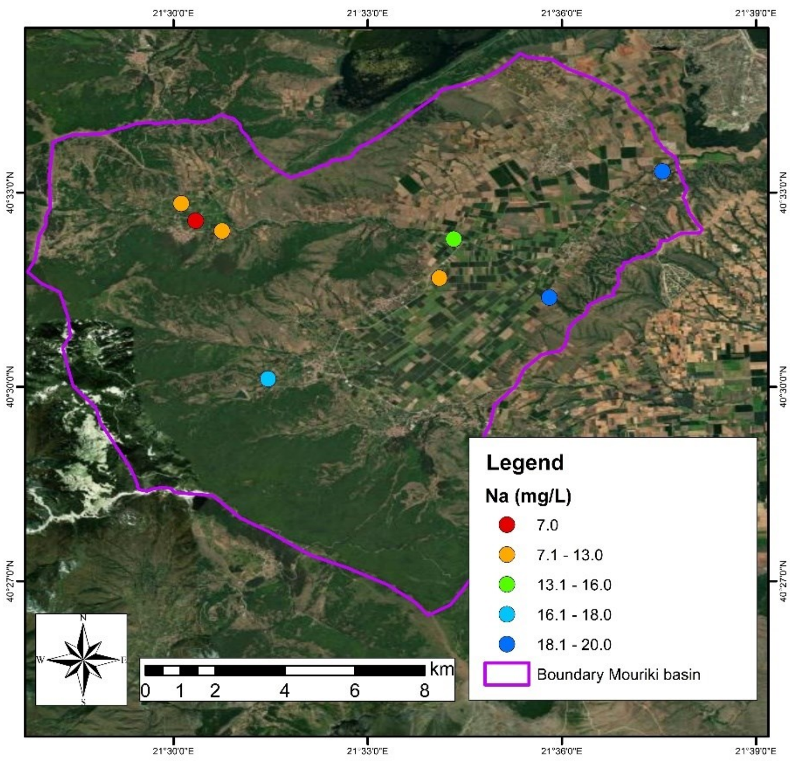

Figure 2.27 Distribution of Na in Mouriki basin for the period May 2022.

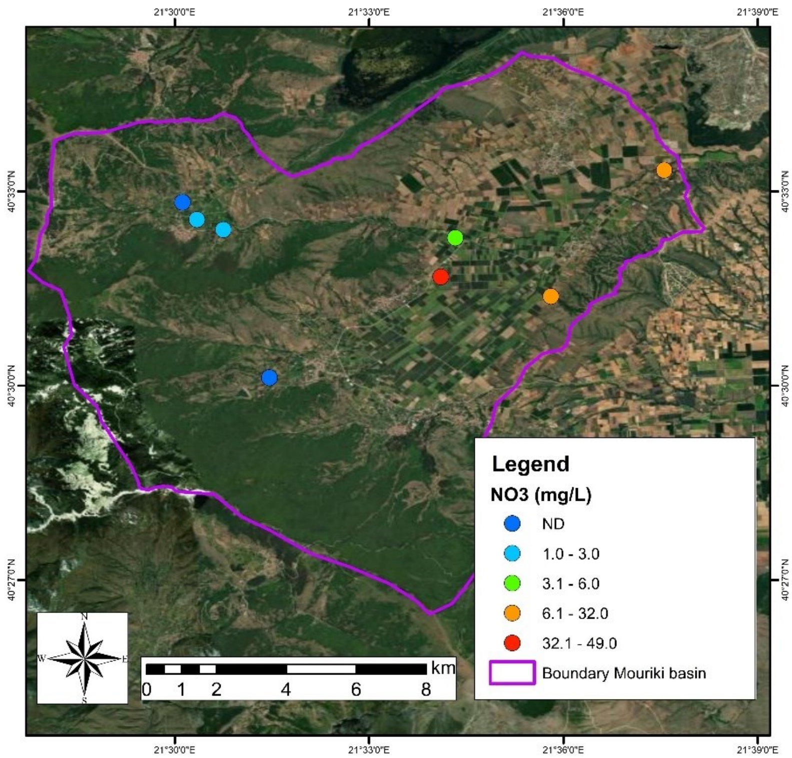

Figure 2.28 Distribution of NO_3 in Mouriki basin for the period May 2022.

2.3 Marathonas basin

The results of the Marathonas basin are presented in the following tables and thematic maps. In Marathonas basin, nitrate pollution and salinization of the coastal aquifer constitute the main qualitative issue of groundwater. Nitrate concentrations are above of the drinking permition limit of 50 mg/L only in the majority of the boreholes. The mean concentration is 94 mg/L, the highest concentration is 257 mg/L, while the lowest concentration is 23 mg/L. The electrical conductivity, chloride and sodium concentrations are very high depicting the salinization issue in the site. The highest value of electrical conductivity is 4880 μS/cm, while the highest concentration of chloride is 1195 mg/L in borehole GA4. Trace and potential toxic elements have also low concentrations.

Table 2.9 Chemical analysis from Marathonas basin for the period September 2021.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm	l hardness	CO$_3$ (mg/L	CO$_3$ (mg/L)	Cl (mg/L)	SO$_4$ (mg/L	NO$_2$ (mg/L	NO$_3$ (mg/L	PO$_4$ (mg/L)	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)
GA1	497644.9	4218820	18	120	7.2	3707	104.7	421	ND	781	200	0.04	230	ND	ND	360	7.5	315	63	ND	1.46
GA2	498270.4	4219554	18.5	36	7.3	2199	56.4	372	ND	452	115	0.025	58	ND	ND	246	8.0	176	30	ND	0.52
GA3	498891	4219878	19	14	7.2	2635	68.5	390	ND	565	167	0.018	85	ND	ND	305	8.9	208	40	ND	0.72
GA4	499635	4220505	17	5	7.1	4692	129.0	384	ND	1150	340	0.043	87	ND	ND	487	7.5	450	40	ND	1.36
GA5	500276	4220320	19	111	7.2	3828	121.6	281	ND	970	172	0.022	135	ND	ND	304	7.4	325	98	ND	1.14
GA6	499605.3	4221653	19	68	7.2	3519	84.3	445	ND	822	212	0.030	69	0.030	ND	435	9.6	232	64	0.03	0.82
GA7	499965.3	4223737	18.5	23	7.3	1060	42.0	372	ND	106	37	0.008	58	ND	ND	54	2.1	130	23	ND	0.26
GA8	498639.4	4221550	17.9	16	7.3	1879	53.4	378	ND	372	76	0.007	44	0.02	ND	188	5.7	138	46	ND	0.4
GA9	497617.1	4220950	17.7	9	7.3	1544	47.0	329	ND	285	67	0.022	34	0.03	ND	135	6.8	146	26	ND	0.42
GA10	495450	4219135	18.1	22	7.2	1718	65.7	305	ND	285	95	0.015	150	ND	ND	96	5.0	224	24	ND	0.86

Table 2.10 Chemical analysis from Marathonas basin for the period September 2021.

Sample	X	Y	NH$_4$ (mg/L)	Sb (μg/L)	Se (μg/L)	As (μg/L)	Cd (μg/L)	Cr(VI) (μg/L)	Cr (μg/L)	Cu (μg/L)	Fe (μg/L)	Pb (μg/L)	Mn (μg/L)	Ni (μg/L)	Co (μg/L)	Mo (μg/L)	Zn (μg/L)	Hg (μg/L)	SiO$_2$ (mg/L	B (mg/L)	T.O.C. (mg/L)
GA1	497644.9	4218820	0.3	ND	ND	ND	ND	1.5	3.5	ND	ND	ND	40	1.7	ND	6.2	30	ND	15	0.23	1.80
GA2	498270.4	4219554	0.15	ND	ND	3.2	ND	4	6	ND	ND	ND	ND	ND	ND	3.7	ND	ND	10	ND	1.20
GA3	498891	4219878	0.15	ND	ND	ND	ND	5	8	ND	ND	ND	ND	ND	ND	3	ND	ND	12	ND	2.50
GA4	499635	4220505	0.15	ND	2.1	ND	ND	4	4	ND	ND	ND	ND	ND	ND	2.9	ND	ND	11	0.28	1.10
GA5	500276	4220320	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	0.43	0.60
GA6	499605.3	4221653	0.08	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	0.50	0.70
GA7	499965.3	4223737	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	205	ND	8	ND	ND
GA8	498639.4	4221550	0.05	ND	ND	2.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.48	ND
GA9	497617.1	4220950	0.05	ND	ND	2.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	ND	0.90
GA10	495450	4219135	0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.4	ND	ND	ND	ND	16	0.25	0.60

Table 2.11 Chemical analysis from Marathonas basin for the period May 2022.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm	l hardness	CO$_3$ (mg/L	CO$_3$ (mg/L)	Cl (mg/L)	SO$_4$ (mg/L	NO$_2$ (mg/L	NO$_3$ (mg/L	PO$_4$ (mg/L)	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)
GA1	497644.9	4218820	17.8	126	7.2	4257	121.4	400	ND	890	248	0.03	257	ND	ND	379	5.4	362	75	ND	1.76
GA2	498270.4	4219554	18	30	7.3	2234	60.3	384	ND	440	114	ND	65	0.02	ND	229	7.4	187	33	ND	0.5
GA3	498891	4219878	18.6	12	7.3	2660	74.9	403	ND	540	167	ND	92	0.02	ND	269	8.1	225	45	ND	0.68
GA4	499635	4220505	17.1	8	7.2	4879	137.3	415	ND	1195	350	0.09	80	0.03	ND	493	6.2	480	42	ND	1.34
GA5	500276	4220320	18.6	94	7.4	3948	110.6	293	ND	959	115	0.550	100	ND	ND	312	7.5	337	64	0.02	1.1
GA6	499605.3	4221653	18.9	62	7.3	3526	90.4	445	ND	810	192	0.020	59	ND	ND	435	384	8.9	230	80	ND
GA7	499965.3	4223737	18.4	20	7.3	1046	39.5	378	ND	107	37	ND	40	0.03	ND	60	2.1	123	21	ND	0.28
GA8	498639.4	4221550	17.2	19	7.5	1696	47.2	403	ND	288	85	ND	37	0.22	ND	175	6.0	118	43	ND	0.4
GA9	497617.1	4220950	17.6	11	7.6	1318	37.5	336	ND	210	61	0.015	23	0.06	ND	122	5.9	118	20	ND	0.38
GA10	495450	4219135	18	26	7.4	1794	65.9	323	ND	287	55	ND	176	ND	ND	98	2.3	224	24	ND	0.9

Table 2.12 Chemical analysis from Marathonas basin for the period May 2022.

Sample	X	Y	NH_4 (mg/L)	Sb (μg/L)	Se (μg/L)	As (μg/L)	Cd (μg/L)	Cr(VI) (μg/L)	Cr (μg/L)	Cu (μg/L)	Fe (μg/L)	Pb (μg/L)	Mn (μg/L)	Ni (μg/L)	Co (μg/L)	Mo (μg/L)	Zn (μg/L)	Hg (μg/L)	SiO_2 (mg/L)	B (mg/L)	T.O.C. (mg/L)
GA1	497644.9	4218820	0.1	ND	ND	ND	ND	2.5	2.5	ND	61	ND	ND	1.1	ND	ND	28	ND	17	0.20	0.82
GA2	498270.4	4219554	0.1	ND	ND	2.6	ND	7	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	0.12	ND
GA3	498891	4219878	0.1	ND	ND	ND	ND	5	5	ND	62	ND	ND	ND	ND	ND	ND	ND	15	0.12	ND
GA4	499635	4220505	0.1	ND	2.2	ND	ND	2	2	ND	89	ND	ND	ND	ND	ND	28	ND	15	0.14	1.01
GA5	500276	4220320	0.3	ND	ND	ND	ND	ND	ND	ND	76	ND	ND	ND	ND	ND	22	ND	16	0.07	0.64
GA6	499605.3	4221653	0.76	ND	ND	ND	ND	ND	ND	ND	71	ND	ND	ND	ND	ND	ND	ND	13	0.12	ND
GA7	499965.3	4223737	ND	ND	ND	1.3	ND	ND	ND	ND	63	ND	ND	ND	ND	ND	334	ND	13	0.08	ND
GA8	498639.4	4221550	7	ND	ND	2.2	ND	ND	ND	ND	60	ND	ND	ND	ND	ND	30	ND	12	0.13	ND
GA9	497617.1	4220950	ND	ND	ND	2.6	ND	ND	ND	ND	69	ND	ND	ND	ND	ND	ND	ND	11	0.06	0.63
GA10	495450	4219135	0.1	ND	ND	ND	ND	ND	ND	ND	75	ND	ND	ND	ND	ND	ND	ND	18	0.08	ND

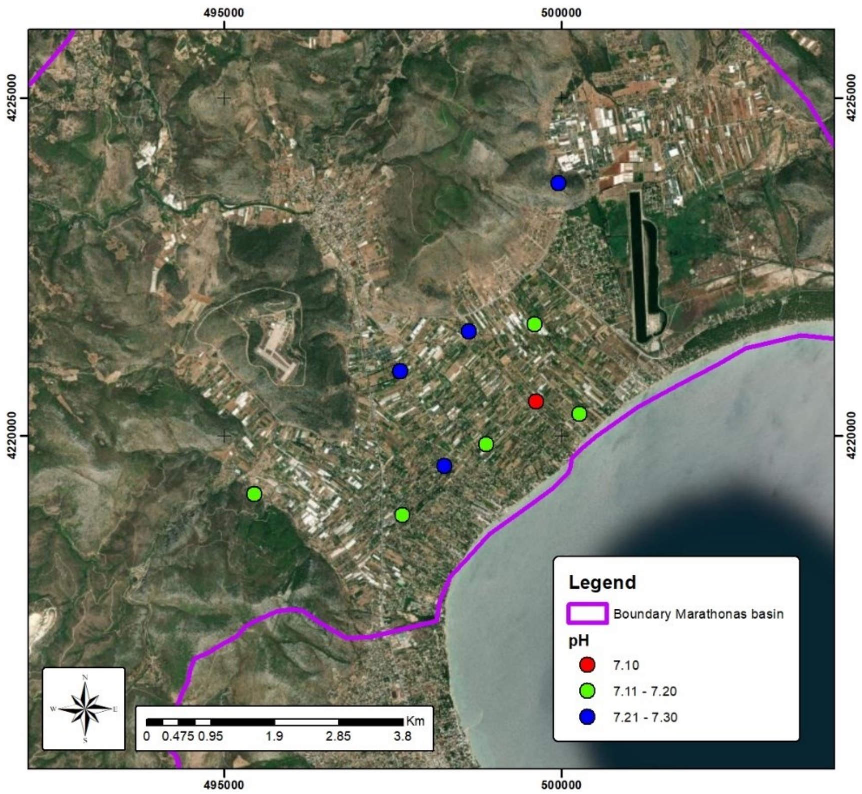

Figure 2.29 Distribution of pH in Marathonas basin for the period September 2021.

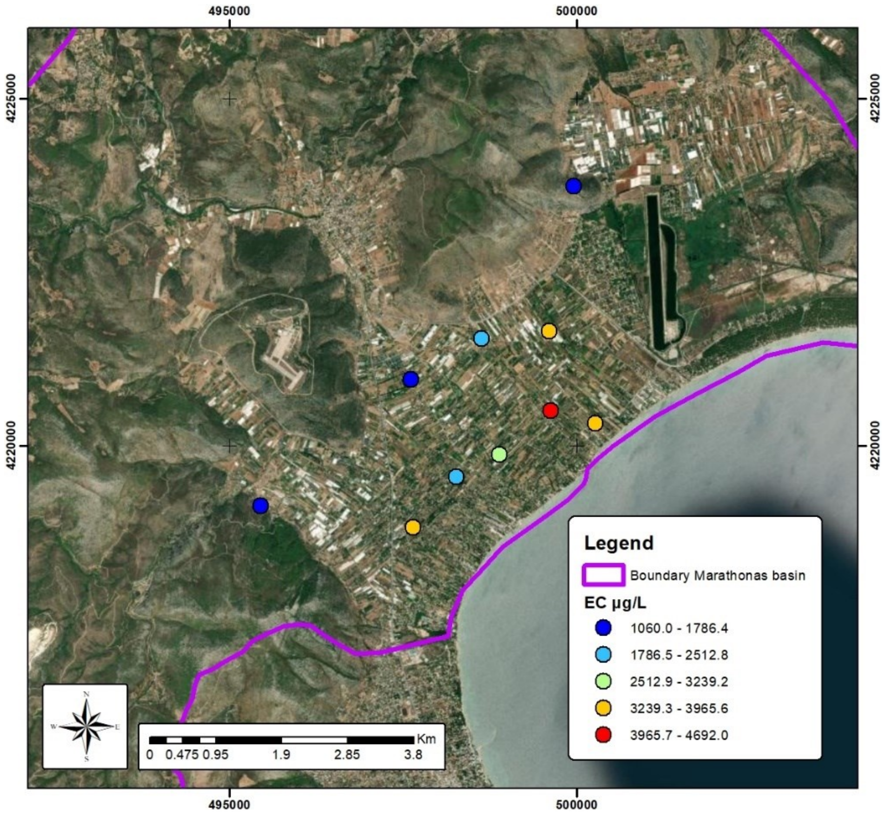

Figure 2.30 Distribution of EC in Marathonas basin for the period September 2021.

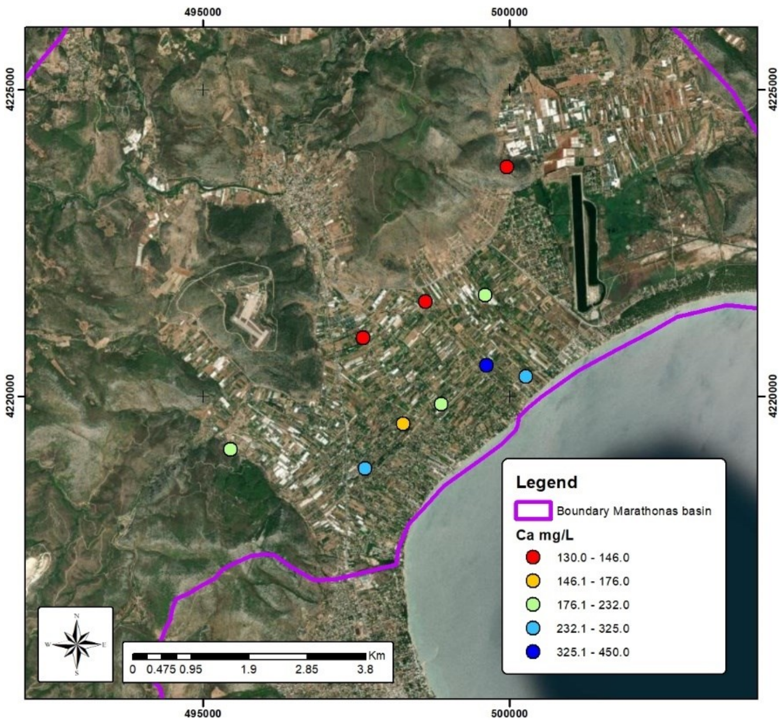

Figure 2.31 Distribution of Ca in Marathonas basin for the period September 2021.

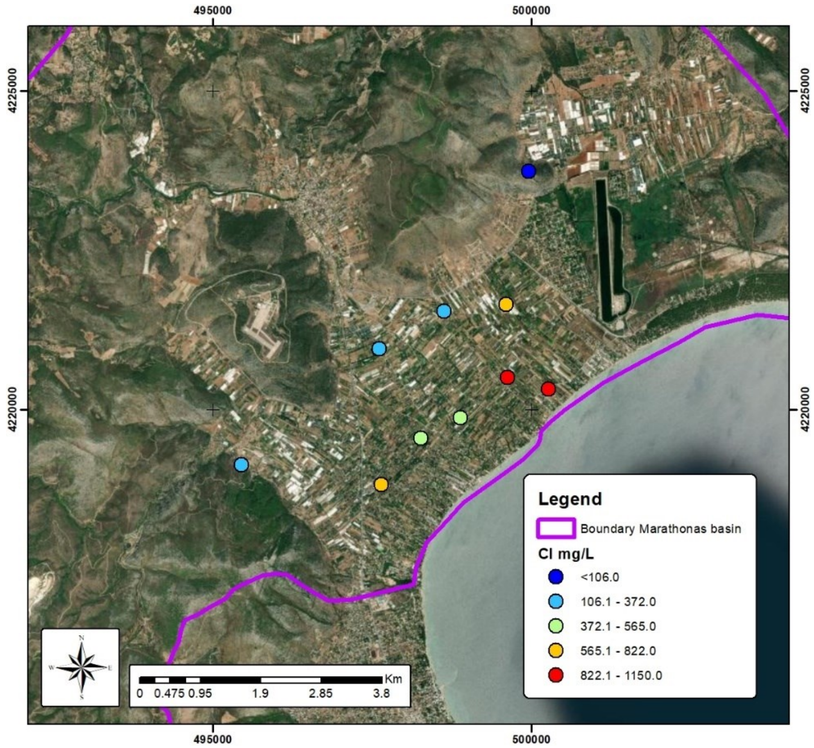

Figure 2.32 Distribution of Cl in Marathonas basin for the period September 2021.

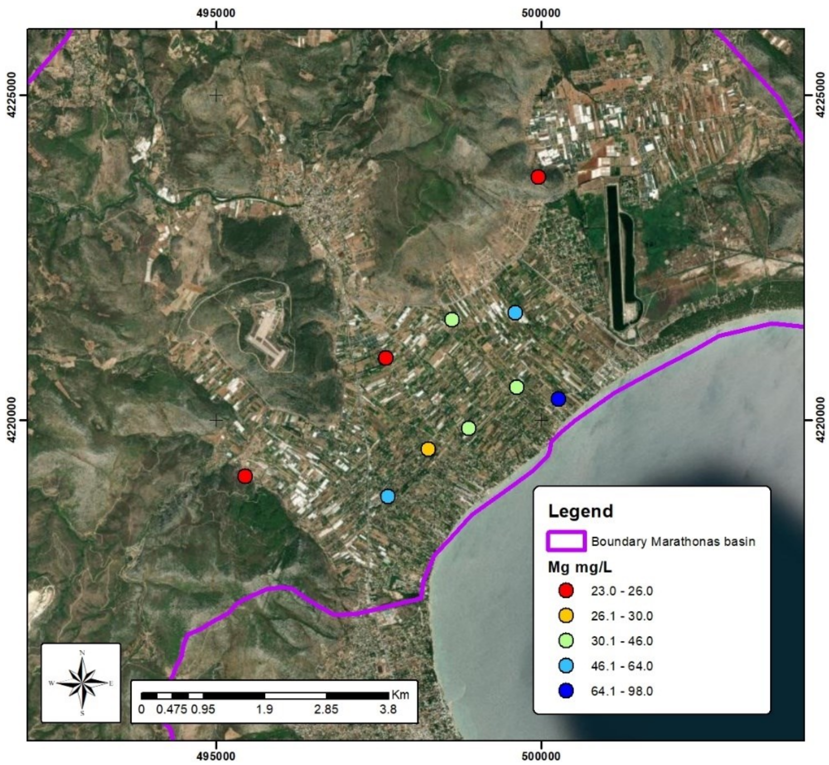

Figure 2.33 Distribution of Mg in Marathonas basin for the period September 2021.

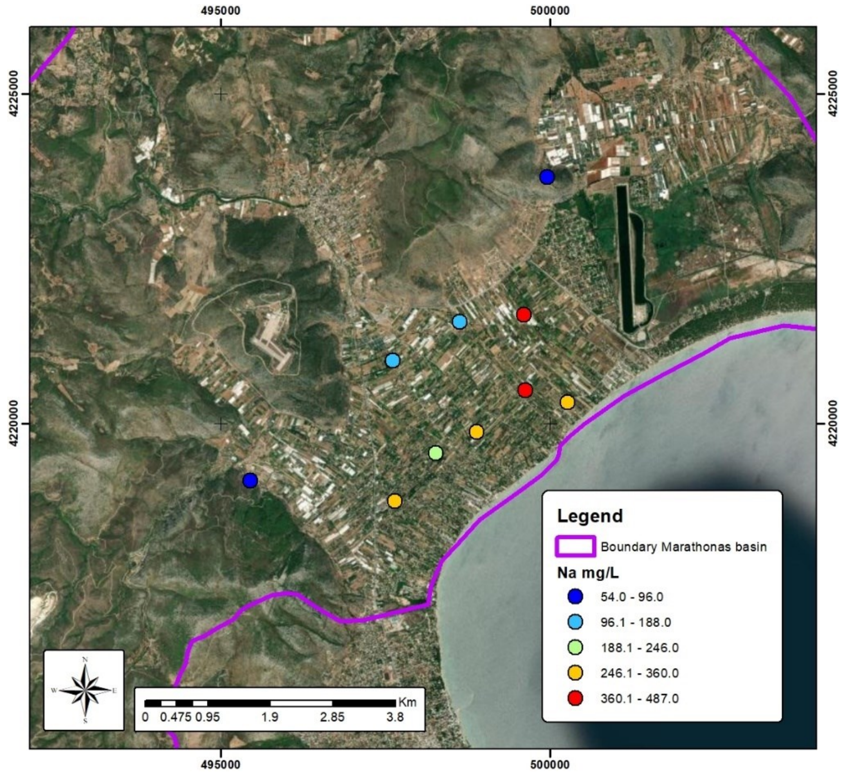

Figure 2.34 Distribution of Na in Marathonas basin for the period September 2021.

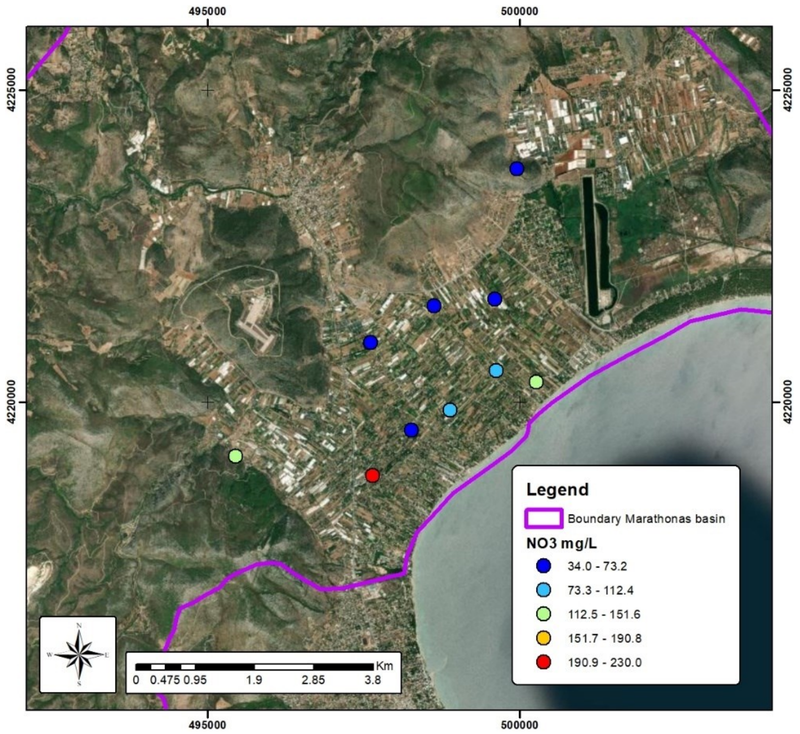

Figure 2.35 Distribution of NO_3 in Marathonas basin for the period September 2021.

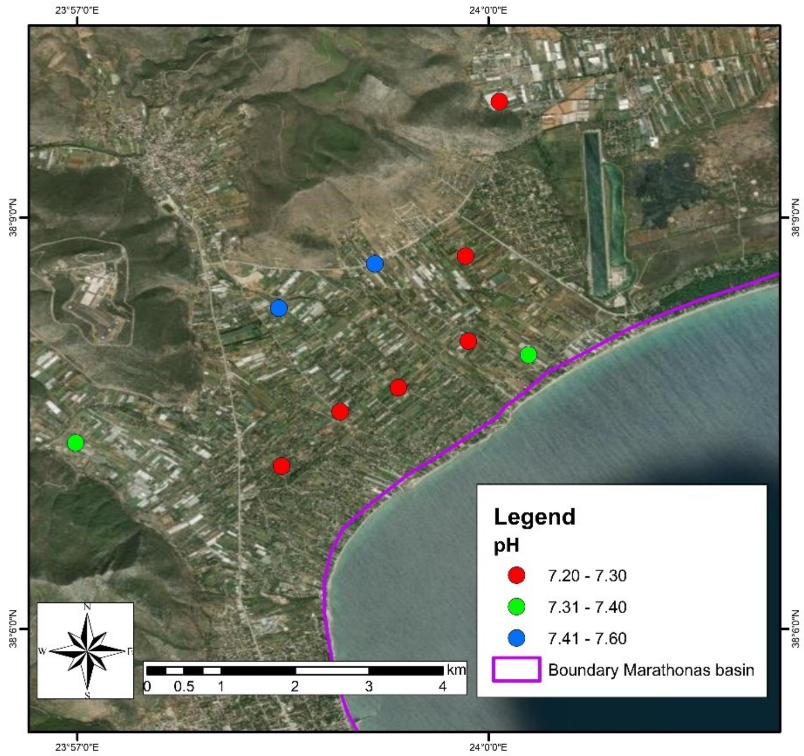

Figure 2.36 Distribution of pH in Marathonas basin for the period May 2022.

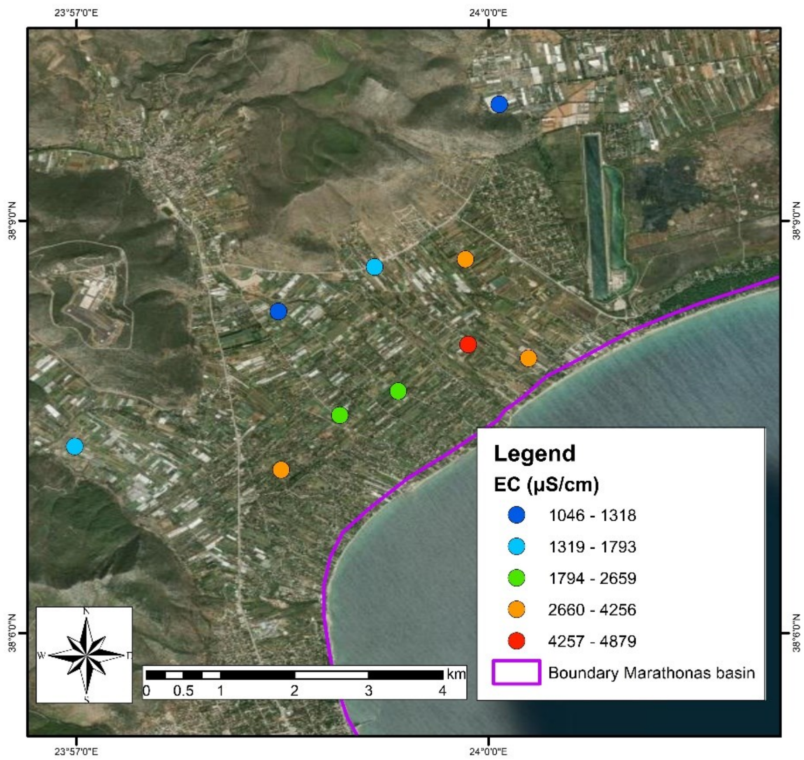

Figure 2.37 Distribution of EC in Marathonas basin for the period May 2022.

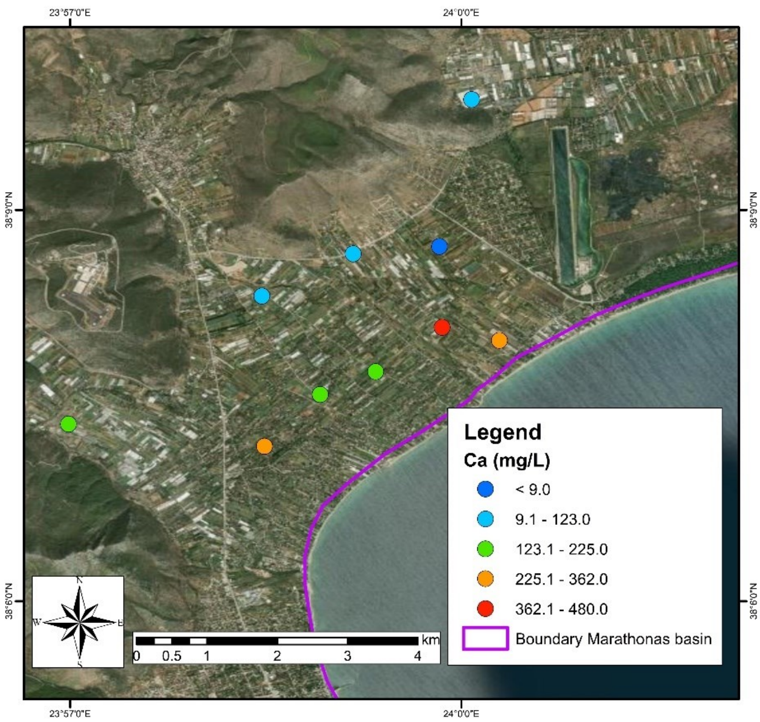

Figure 2.38 Distribution of Ca in Marathonas basin for the period May 2022.

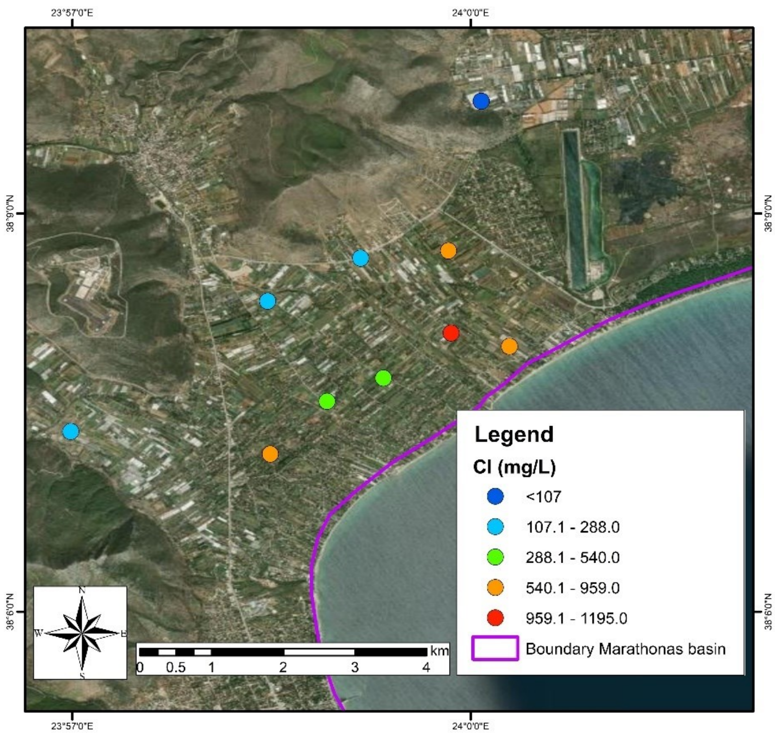

Figure 2.39 Distribution of Cl in Marathonas basin for the period May 2022.

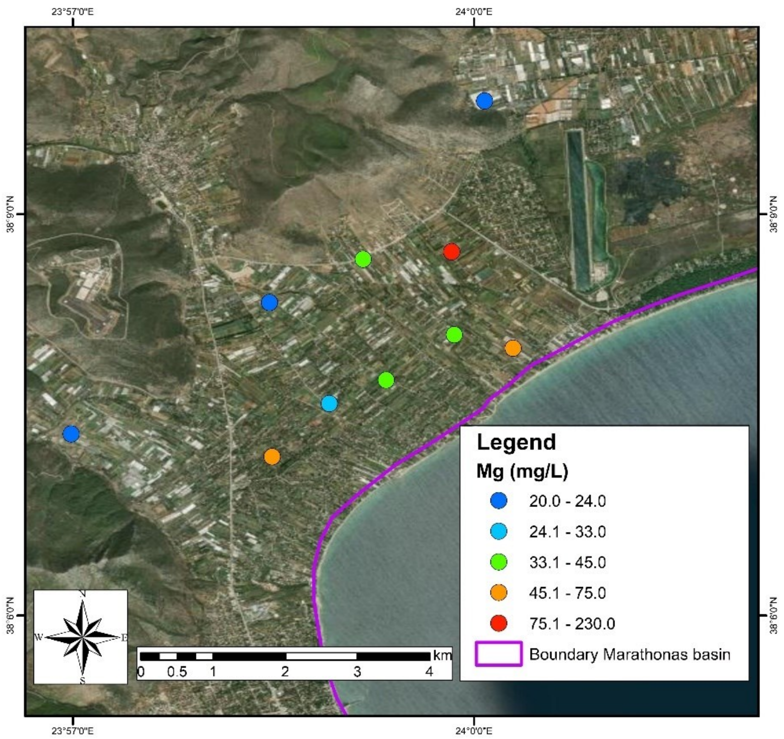

Figure 2.40 Distribution of Mg in Marathonas basin for the period May 2022.

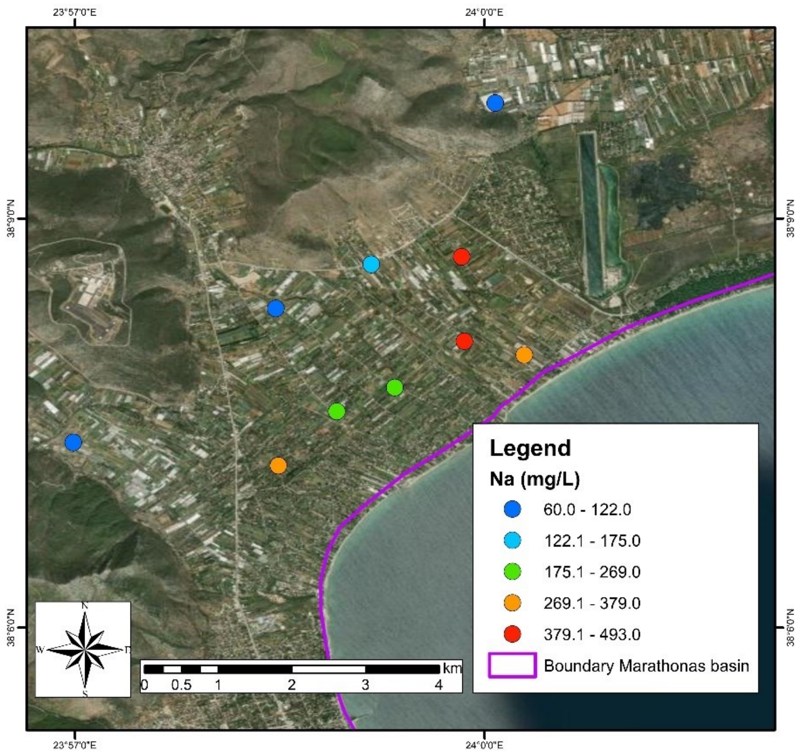

Figure 2.41 Distribution of Na in Marathonas basin for the period May 2022.

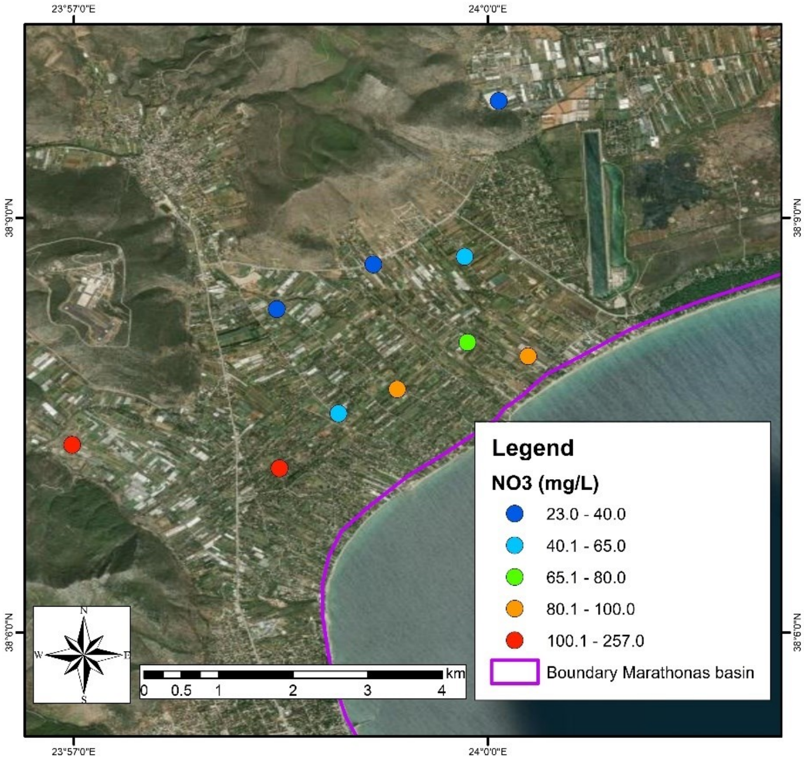

Figure 2.42 Distribution of NO_3 in Marathonas basin for the period May 2022.

2.4 Campania basin

The results of the Campania basin are presented in the following tables and thematic maps. In Campania region the lowest value of pH is 5.92, while the mean value is 6.8. Nitrate concentrations vary from below detection limit to 128 mg/L (V14), while in 4 boreholes the concentration was more than 50 mg/L. Parameters such as electric conductivity, chloride and sodium which are related with seawater intrusion have relative low concentrations. Trace and potential toxic elements have also low concentrations. The main issue of the site is nitrate pollution.

Table 2.13 Chemical analysis from Campania basin for the period September 2021.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm)	HCO_3 (mg/L)	Cl (mg/L)	NO_3 (mg/L)	SO_4 (mg/L)	Na (mg/L)	K (mg/L)	Mg (mg/L)	Ca (mg/L)	F (mg/L)	Li (mg/L)
V1	14.403	41.151	15.4	-15	6.71	396	245.0	21.1	9.6	11.8	28.4	12.4	10.3	63.0	0.7	4.5
V2	14.175	41.400	15.2	25	6.45	914	768.0	7.0	5.6	3.9	4.4	0.7	30.3	213.0	0.2	ND
V3	14.266	41.140	14.8	38	6.62	1166	895.0	38.3	4.1	9.9	23.0	6.9	49.7	209.0	0.3	17.5
V4	14.352	41.225	18.1	57	6.57	245	107.4	21.5	21.3	19.8	20.4	14.0	4.1	28.1	0.2	ND
V5	14.540	41.265	17.4	20	6.91	1032	464.0	37.3	14.0	42.1	31.1	5.6	13.4	142.3	0.4	12.4
V6	14.524	41.222	15.1	-10	6.07	1187	1011.1	48.2	0.0	12.0	27.3	2.5	36.1	288.7	2.5	150.5
V7	14.339	41.331	26.8	36	7	833	436.2	13.5	33.2	16.1	8.8	3.4	44.1	98.7	0.1	0.7
V8	14.430	41.263	21.3	30	7.93	389	251.6	15.9	25.7	16.4	18.1	13.3	3.7	81.1	0.3	1.9
V9	14.082	41.334	16.6	37	6.32	382	78.1	22.5	50.7	10.9	20.6	14.4	6.6	21.1	0.2	4.8
V10	14.189	41.291	18.4	22	6.2	561	259.3	22.9	30.9	4.5	25.8	18.6	10.0	53.5	0.3	0.01
V11	13.994	41.325	14.6	15	5.94	326	184.1	9.2	1.0	2.2	14.4	25.6	7.3	23.4	0.2	3.5
V12	14.255	41.109	19.5	30	7.4	836	347.7	36.1	48.3	29.3	23.1	15.2	25.0	105.0	0.5	3.2
V13	14.329	41.167	12.8	16	7.24	251	195.3	2.9	2.5	1.4	3.5	4.7	4.1	49.3	0.2	1.0
V14	14.386	41.326	17.9	110	7.04	808	526.8	28.4	128.0	15.4	11.8	2.6	46.8	129.5	0.1	ND
V15	14.295	41.334	16	22	7.6	545	357.5	10.1	19.2	10.3	6.7	2.3	25.6	91.3	0.1	1.6
V16	14.492	41.231	27.8	45	7.14	595	237.9	37.3	15.9	39.0	20.5	9.2	5.4	81.8	0.8	12.6
V17	14.414	41.262	24.4	37	7.06	450	328.1	21.4	35.6	11.5	15.2	9.6	3.8	103.9	0.7	3.7
V18	14.121	41.335	19.2	12	7.52	488	171.4	15.2	51.4	22.5	14.5	11.1	4.4	62.0	0.2	0.01
V19	14.193	41.335	16.7	5.6	6.65	438	103.6	12.7	4.3	4.4	11.3	11.1	5.0	25.9	0.6	16.0
V20	14.063	41.295	16.4	-8	5.92	492	241.0	13.9	6.5	4.1	30.1	43.4	9.2	22.3	0.4	17.4
V21	14.413	41.125	16.1	4.8	6.33	402	104.8	22.6	33.5	87.5	25.4	17.5	9.9	40.2	0.2	1.7
V22	14.275	41.173	17.1	9	7.02	565	246.5	25.4	53.8	60.9	21.3	14.3	12.0	84.7	0.7	3.8

Table 2.14 Chemical analysis from Campania basin for the period September 2021.

Sample	X	Y	B (μg/L)	Al (μg/L)	V(μg/L)	Mn (μg/L)	Fe (mg/L)	Ni (μg/L)	Cu (μg/L)	Zn (μg/L)	As (μg/L)	Rb (μg/L)	Sr (μg/L)	Ba (μg/L)	U (μg/L)
V1	14.403	41.151	24.2	267.6	6.9	3.1	79.8	0.8	2.0	6.3	0.0	17.2	295.2	53.3	1.9
V2	14.175	41.400	8.7	1.5	2.3	ND	3.0	4.6	ND	ND	ND	2.8	125.5	8.6	ND
V3	14.266	41.140	209.3	ND	4.4	ND	ND	6.1	ND	ND	ND	16.9	316.3	20.4	2.0
V4	14.352	41.225	42.3	3.6	2.7	1.4	3.5	1.2	4.8	32.3	1.4	42.9	162.2	4.1	ND
V5	14.540	41.265	246.8	1.6	1.2	17.8	16.8	2.2	8.3	25.7	1.3	12.8	556.9	99.7	2.1
V6	14.524	41.222	797.9	ND	0.5	0.4	0.5	ND	ND	ND	ND	19.5	496.4	23.8	ND
V7	14.339	41.331	15.6	4.3	2.3	0.9	0.3	ND	8.2	11.2	ND	6.7	160.4	16.8	ND
V8	14.430	41.263	16.5	ND	6.1	0.4	ND	ND	ND	3.2	2.4	39.5	323.1	2.2	ND
V9	14.082	41.334	30.5	ND	1.0	ND	ND	ND	ND	8.1	ND	32.8	272.7	ND	ND
V10	14.189	41.291	22.2	0.7	ND	ND	ND	ND	ND	20.4	ND	60.1	393.1	19.3	1.6
V11	13.994	41.325	17.9	ND	14.0	ND	ND	ND	ND	4.6	ND	8.3	386.2	8.3	ND
V12	14.255	41.109	87.2	ND	10.3	ND	ND	ND	1.5	14.4	4.2	63.6	341.9	ND	8.5
V13	14.329	41.167	4.8	84.1	4.2	ND	7.0	1.1	4.9	68.1	0.0	7.1	55.3	14.9	1.0
V14	14.386	41.326	81.0	ND	0.9	1.8	5.1	2.0	2.2	3.9	ND	3.6	193.4	45.4	1.7
V15	14.295	41.334	85.4	ND	3.6	ND	5.3	ND	5.1	28.5	ND	13.5	132.1	16.3	1.2
V16	14.492	41.231	41.4	2.2	7.6	1.0	0.8	ND	21.6	20.1	1.6	26.7	694.8	31.2	ND
V17	14.414	41.262	24.9	21.8	8.0	1.4	ND	ND	4.2	4.9	2.2	31.8	352.7	36.1	ND
V18	14.121	41.335	19.1	ND	0.3	ND	ND	ND	ND	ND	ND	32.4	198.4	ND	0.4
V19	14.193	41.335	65.0	ND	17.4	ND	ND	ND	ND	810.4	ND	3.2	189.1	9.6	ND
V20	14.063	41.295	64.7	16.5	18.2	3.0	21.8	ND	0.8	11.6	3.2	68.1	133.8	2.1	1.5
V21	14.413	41.125	20.1	23.5	2.8	0.1	3.3	ND	0.2	4.9	ND	43.4	251.8	38.0	0.5
V22	14.275	41.173	40.9	8.5	2.2	127.4	4.6	11.4	5.5	4554.0	ND	64.3	289.0	7.1	3.6

Table 2.15 Chemical analysis from Campania basin for the period June 2022.

Sample	X	Y	T (°C)	Eh (mV)	pH	EC (μS/cm)	HCO_3 (mg/L)	Cl (mg/L)	NO_3 (mg/L)	SO_4 (mg/L)	Na (mg/L)	K (mg/L)	Mg (mg/L)	Ca (mg/L)	F (mg/L)	Li (mg/L)
V2	14.175	41.400	14.8	20	6.4	922	810.0	5.6	7.0	4.1	6.0	1.2	27.5	220.0	0.4	ND
V4	14.352	41.225	16.5	60	5.43	256	110.7	20.2	23.6	20.0	19.8	16.6	5.6	30.5	0.4	ND
V9	14.082	41.334	15.6	32	6.12	390	80.2	21.1	62.7	11.2	20.1	15.3	8.1	28.4	0.4	ND
V10	14.189	41.291	17.9	18	6.25	557	260.0	21.6	33.4	5.6	22.7	19.4	11.7	60.2	0.6	ND
V11	13.994	41.325	15.4	20	6	321	188.4	10.3	5.2	3.7	16.3	16.4	8.0	25.9	0.5	ND
V18	14.121	41.335	17.6	14	7.48	490	176.7	16.7	55.7	23.0	15.7	12.2	5.1	68.1	0.5	ND
V19	14.193	41.335	16.3	4.3	6.8	442	110.4	13.4	5.9	5.0	12.3	12.6	5.7	27.0	0.7	11.2

Table 2.16 Chemical analysis from Campania basin for the period June 2022.

Sample	X	Y	B (μg/L)	Al (μg/L)	V(μg/L)	Mn (μg/L)	Fe (mg/L)	Ni (μg/L)	Cu (μg/L)	Zn (μg/L)	As (μg/L)	Rb (μg/L)	Sr (μg/L)	Ba (μg/L)	U (μg/L)
V2	14.175	41.400	6.0	ND	2.6	ND	3.5	1.2	ND	ND	ND	2.3	110.4	7.1	ND
V4	14.352	41.225	23.7	2.2	3.0	1.6	7.0	ND	ND	22.0	ND	38.6	150.1	ND	ND
V9	14.082	41.334	15.8	ND	1.2	ND	ND	ND	ND	5.4	ND	30.4	200.0	ND	ND
V10	14.189	41.291	13.5	ND	ND	ND	ND	ND	ND	11.2	ND	57.9	316.0	8.9	ND
V11	13.994	41.325	16.8	ND	10.0	ND	ND	ND	ND	2.3	ND	7.7	276.8	ND	ND
V18	14.121	41.335	12.1	ND	ND	ND	ND	ND	ND	ND	ND	29.8	123.5	ND	ND
V19	14.193	41.335	33.0	ND	12.7	ND	ND	ND	ND	125.0	ND	1.6	112.7	ND	ND

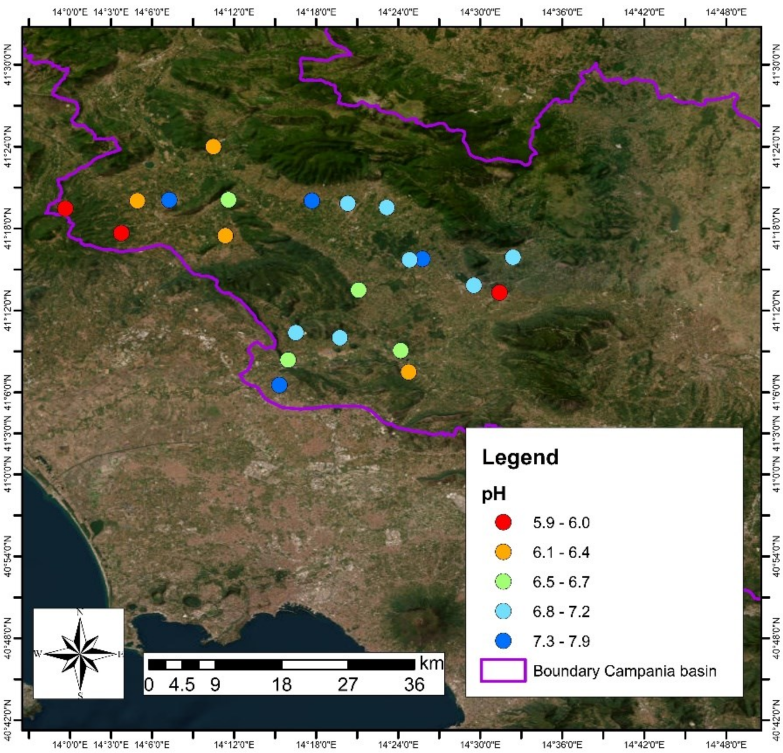

Figure 2.43 Distribution of pH in Campania basin for the period September 2021.

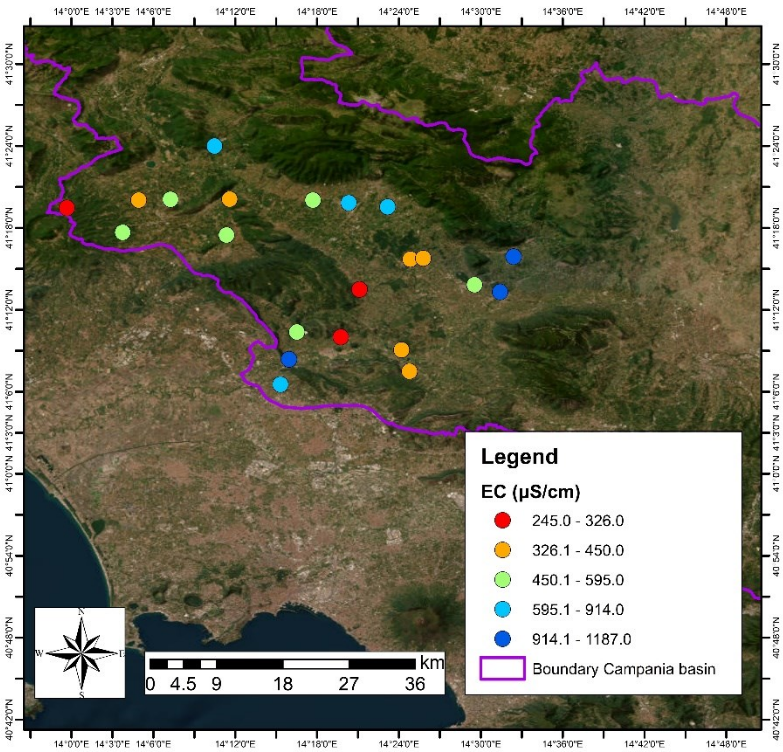

Figure 2.44 Distribution of EC in Campania basin for the period September 2021.

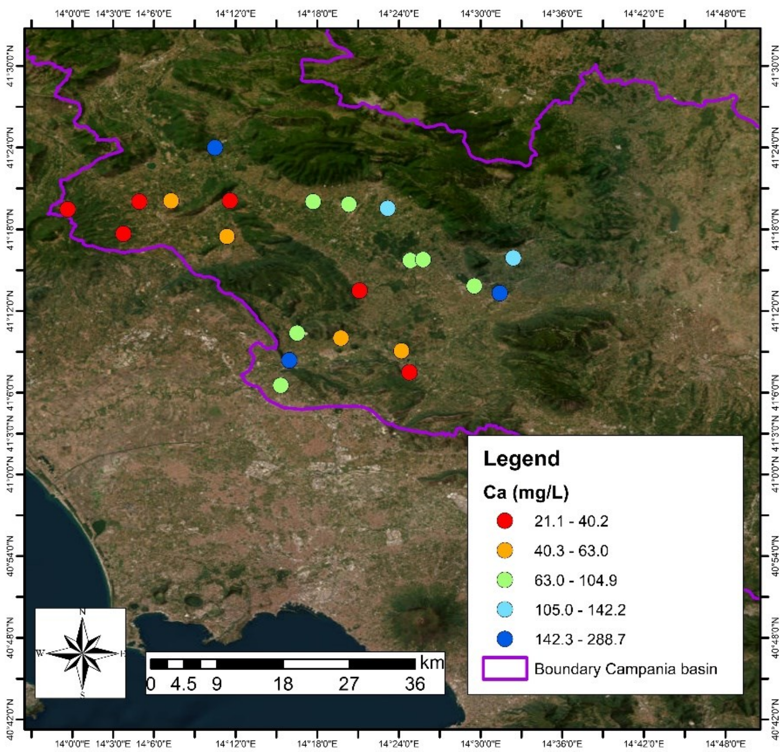

Figure 2.45 Distribution of Ca in Campania basin for the period September 2021.

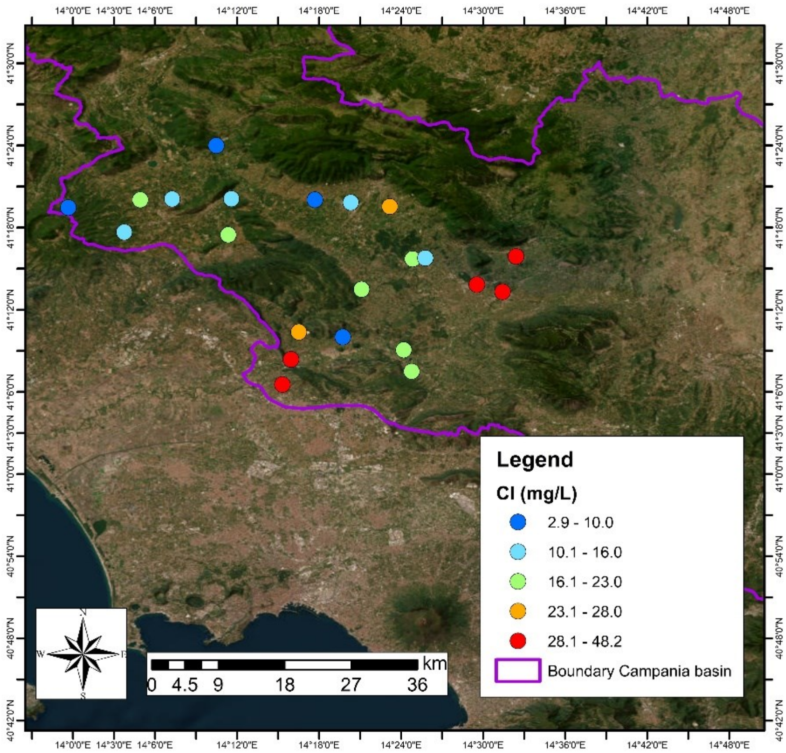

Figure 2.46 Distribution of Cl in Campania basin for the period September 2021.

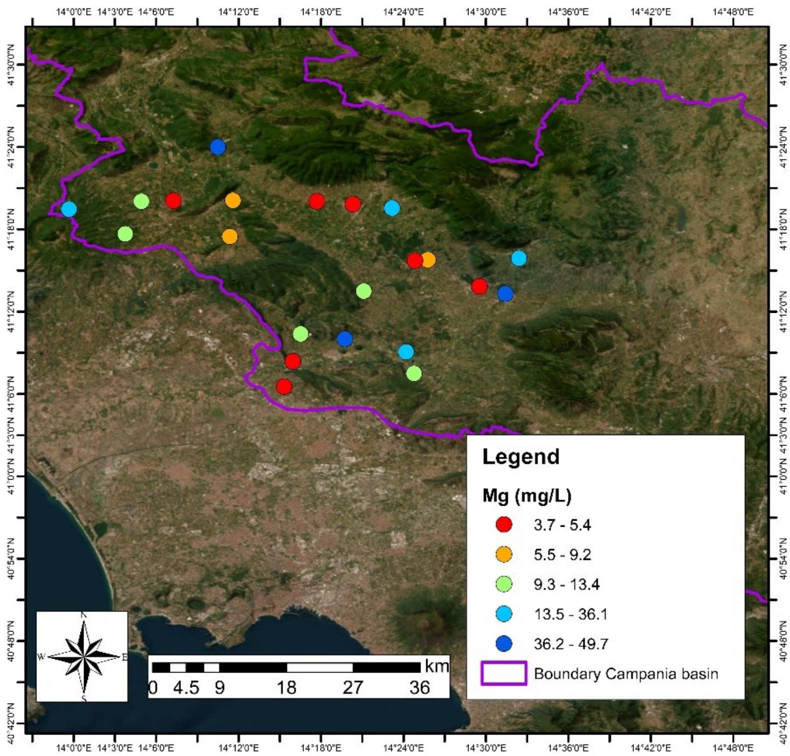

Figure 2.47 Distribution of Mg in Campania basin for the period September 2021.

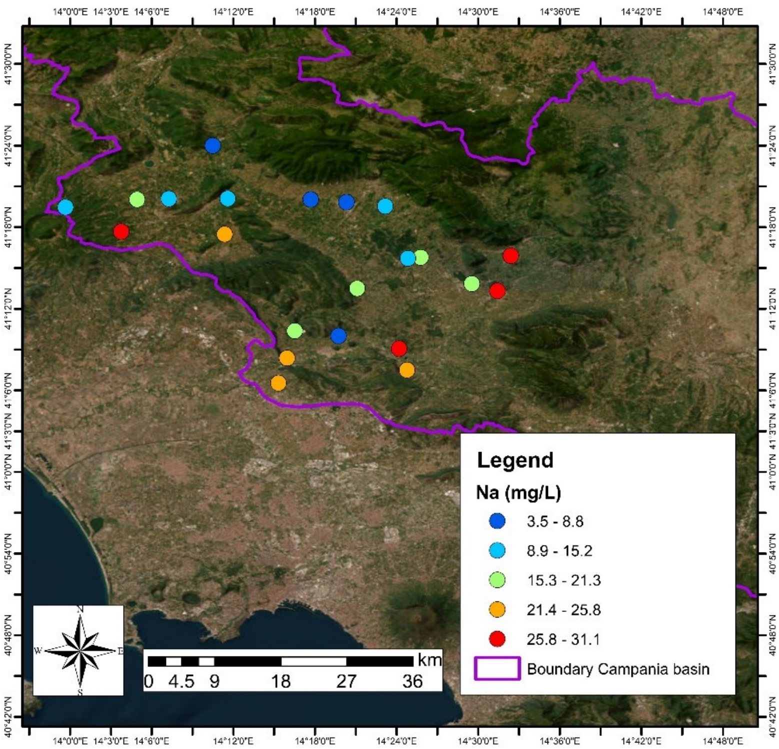

Figure 2.48 Distribution of Na in Campania basin for the period September 2021.

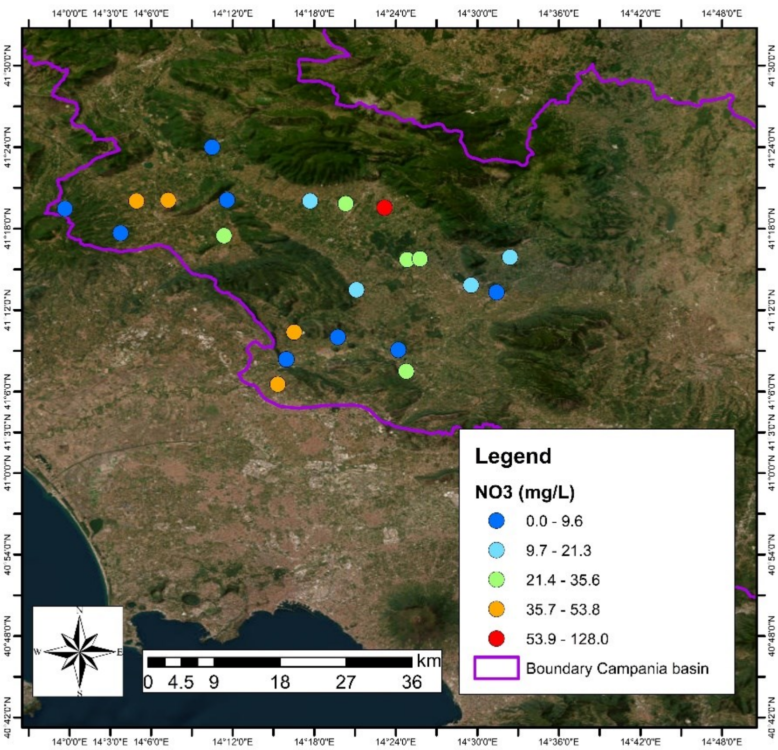

Figure 2.49 Distribution of NO_3 in Campania basin for the period September 2021.

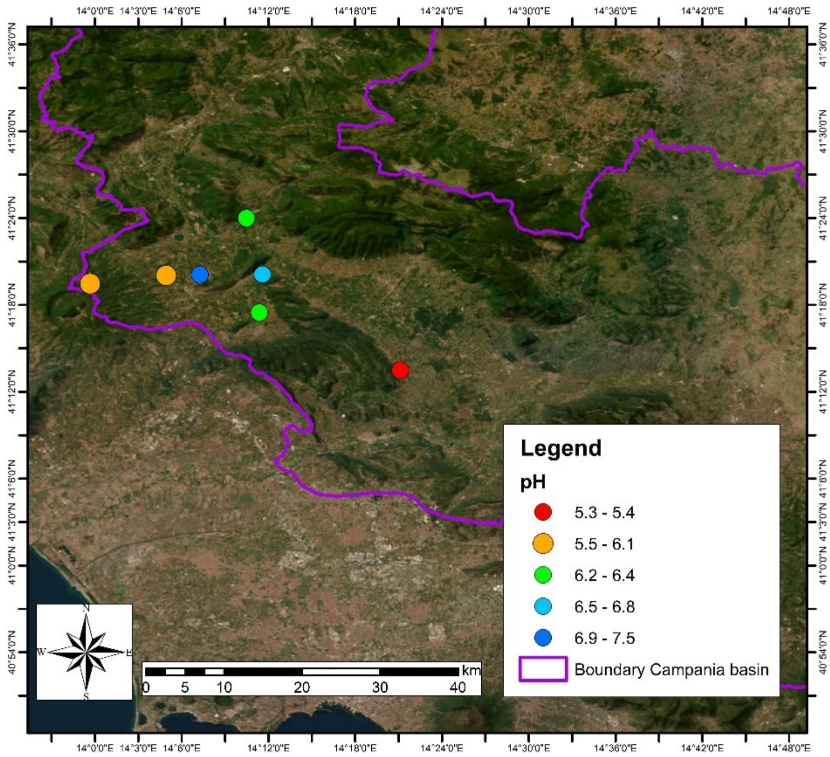

Figure 2.50 Distribution of pH in Campania basin for the period May 2022.

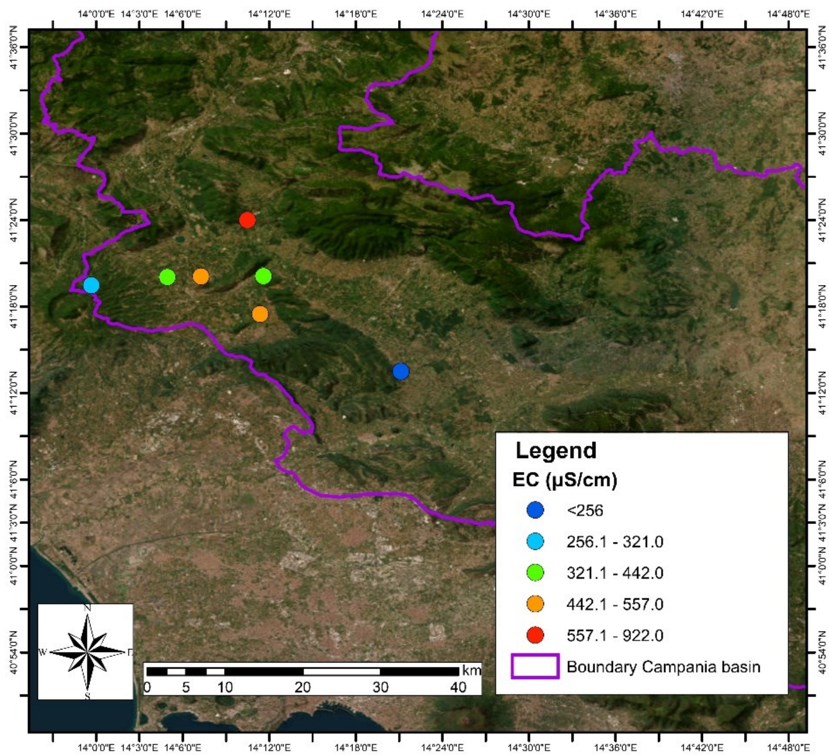

Figure 2.51 Distribution of EC in Campania basin for the period May 2022.

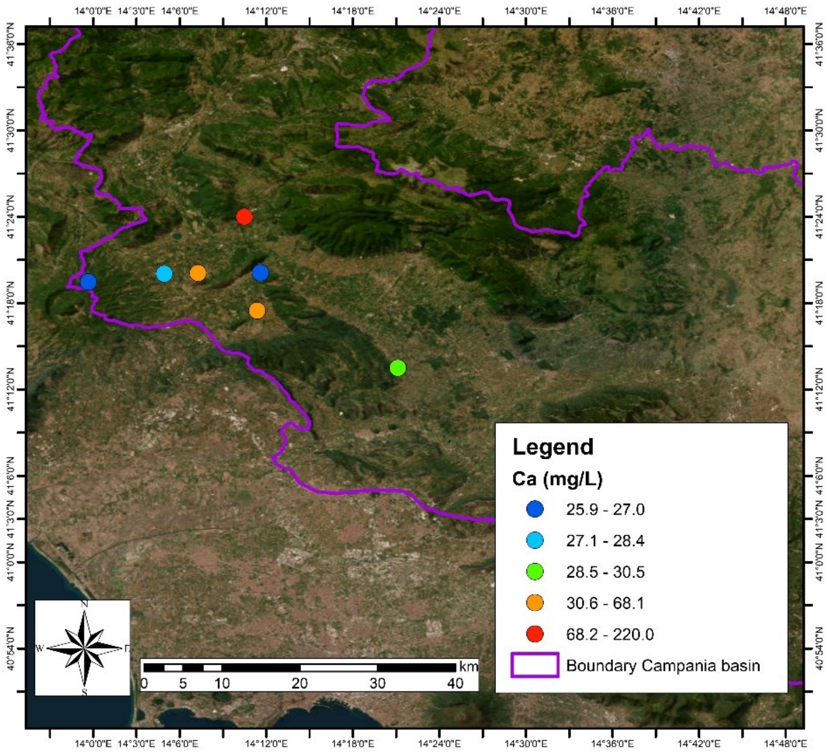

Figure 2.52 Distribution of Ca in Campania basin for the period May 2022.

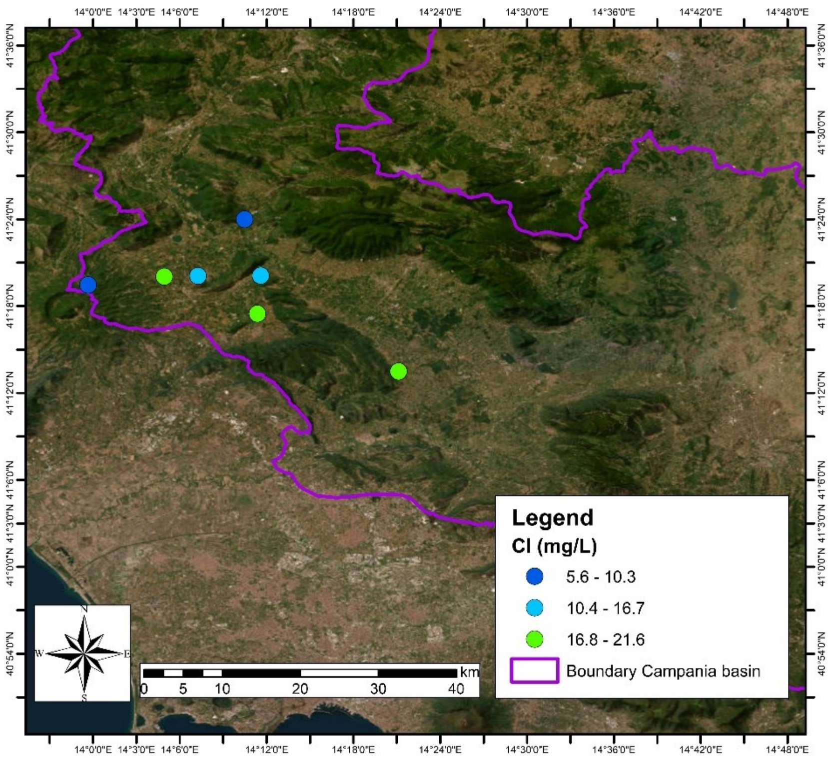

Figure 2.53 Distribution of Cl in Campania basin for the period May 2022.

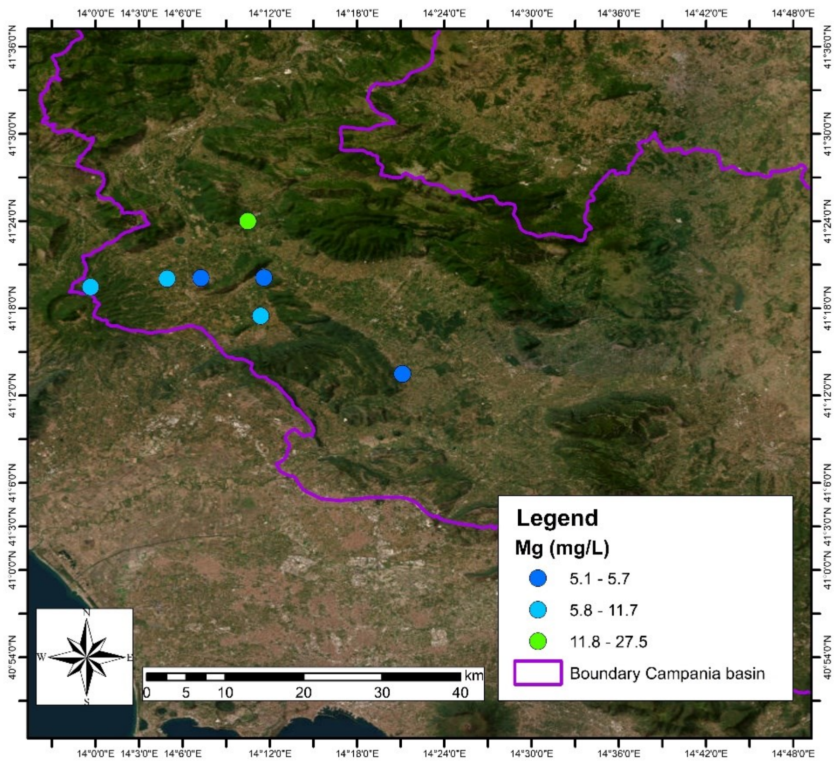

Figure 2.54 Distribution of Mg in Campania basin for the period May 2022.

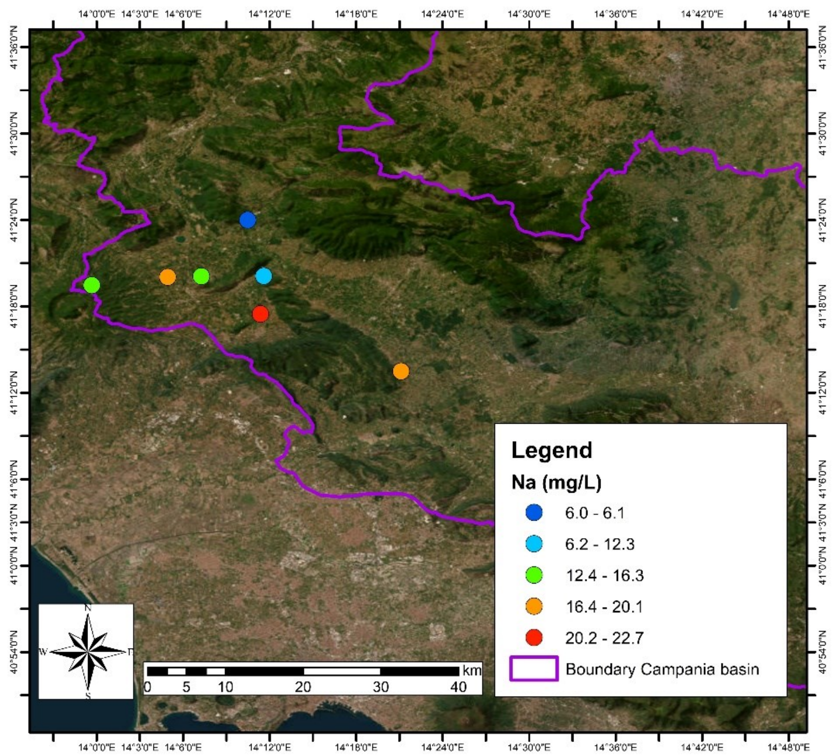

Figure 2.55 Distribution of Na in Campania basin for the period May 2022.

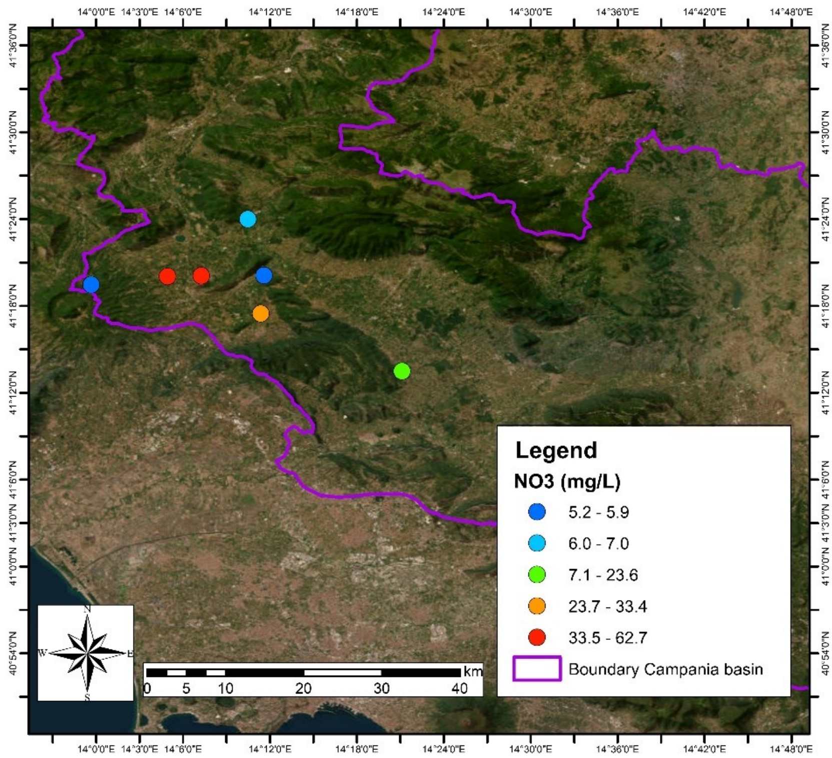

Figure 2.56 Distribution of NO_3 in Campania basin for the period May 2022.

2.5 DAM water quality

The analysis of the dam water quality is presented in the following tables. The main conclusion from the analysis of dam water quality is that the water is suitable for MAR application. The analysis of the data is presented within the corresponding article.

Table 2.17 Analysis of Dam water quality in the period of September 2021.

Sep-21	Sample	pH	EC (μS/cm)	Total hardness (oF)	HCO_3 (mg/L)	CO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)
Anth_1 - Thermi dam	SG1	7.8	683	17.0	189	ND	120	22	ND	ND	ND
Anth_2 - Triadi dam	SG2	8.6	505	25.5	256	516	18	51	ND	ND	ND
Anth_3 - Vasilika dam	SG3	8.0	363	16.0	186	ND	15	22	ND	ND	ND
Anth_4 - Kato Scholari dam	SG4	8.5	584	17.6	232	510	65	20	ND	ND	ND
Anth_5 - Lakoma dam	SG5	8.7	1031	30.5	305	522	152	49	ND	ND	ND
Mouriki	SG6	7.8	190	10.1	107	ND	20	10	ND	ND	ND
Marathonas-Rapentosa dam	GA	7.9	349	15.1	165	ND	19	20	0.018	ND	ND
Campania	CA	8.8	1044	16.7	294	ND	12	31	ND	ND	ND

Table 2.18 Analysis of Dam water quality in the period of September 2021.

Sep-21	Sample	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)	NH_4 (mg/L	Sb (μg/L)	Se (μg/L)
Anth_1 - Thermi dam	SG1	ND	76	6.6	35	20	ND	0.21	0.55	ND	ND
Anth_2 - Triadi dam	SG2	ND	16	2.0	35	41	ND	0.13	0.15	ND	ND
Anth_3 - Vasilika dam	SG3	ND	15	3.2	36	17	ND	0.1	0.4	ND	ND
Anth_4 - Kato Scholari dam	SG4	ND	53	6.5	40	19	0.03	0.29	0.4	ND	ND
Anth_5 - Lakoma dam	SG5	ND	97	4.5	43	48	ND	0.33	0.4	ND	ND
Mouriki	SG6	ND	10	2.6	24	10	ND	0.1	ND	ND	ND
Marathonas-Rapentosa dam	GA	ND	16	1.7	48	8	ND	0.24	0.1	ND	ND
Campania	CA	ND	79	6.9	72	55	ND	0.18	ND	ND	ND

Table 2.19 Analysis of Dam water quality in the period of September 2021.

Sep-21	Sample	As (μg/L)	Cd (μg/L)	Cr(VI) (μg/L)	Cr (μg/L)	Cu (μg/L)	Fe (μg/L)	Pb (μg/L)	Mn (μg/L)	Ni (μg/L)	Co (μg/L)
Anth_1 - Thermi dam	SG1	4.5	ND	ND	ND	ND	235	ND	50	2.4	ND
Anth_2 - Triadi dam	SG2	2.3	ND	ND	ND	ND	193	ND	50	1.1	ND
Anth_3 - Vasilika dam	SG3	2.4	ND	ND	ND	ND	286	ND	20	1.2	ND
Anth_4 - Kato Scholari dam	SG4	8.5	ND	ND	ND	ND	234	ND	30	1.4	ND
Anth_5 - Lakoma dam	SG5	3.9	ND	ND	ND	ND	168	ND	50	1.8	ND
Mouriki	SG6	ND	ND	ND	ND	ND	491	ND	40	ND	ND
Marathonas-Rapentosa dam	GA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Campania	CA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 2.20 Analysis of Dam water quality in the period of September 2021.

Sep-21	Sample	Mo (μg/L)	Zn (μg/L)	Hg (μg/L)	SiO_2 (mg/L)	B (mg/L)	T.O.C. (mg/L)
Anth_1 - Thermi dam	SG1	ND	ND	ND	12	0.54	8.30
Anth_2 - Triadi dam	SG2	ND	ND	ND	9	ND	7.90
Anth_3 - Vasilika dam	SG3	ND	ND	ND	7	0.52	10.90
Anth_4 - Kato Scholari dam	SG4	ND	70	ND	9	1.30	11.30
Anth_5 - Lakoma dam	SG5	ND	ND	ND	6	ND	13.00
Mouriki	SG6	ND	ND	ND	10	ND	2.40
Marathonas-Rapentosa dam	GA	ND	ND	ND	ND	ND	2.10
Campania	CA	ND	ND	ND	ND	ND	4.6

Table 2.21 Analysis of Dam water quality in the period of May 2022.

May-22	Sample	pH	EC (μS/cm)	Total hardness (oF)	HCO_3 (mg/L)	CO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	PO_4 (mg/L)
Anth_1 - Thermi dam	SG1	8.9	678	30.3	244	534	78	36	0.01	ND	0.16
Anth_2 - Triadi dam	SG2	8.3	485	25.1	250	498	17	38	0.07	ND	ND
Anth_3 - Vasilika dam	SG3	8.5	459	21.3	201	507	24	41	ND	3.4	ND
Anth_4 - Kato Scholari dam	SG4	8.7	418	17.6	153	522	58	19	ND	ND	ND
Anth_5 - Lakoma dam	SG5	8.6	1029	33.6	329	516	143	50	ND	ND	ND
Mouriki	SG6	7.7	126	5.3	67	ND	3	10	0.035	ND	ND
Marathonas-Rapentosa dam	GA	8.1	417	17.5	171	ND	33	26	0.020	ND	ND
Campania	CA	8.6	1050	24.3	277	ND	19	48	ND	ND	ND

Table 2.22 Analysis of Dam water quality in the period of May 2022.

May-22	Sample	F (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Li (mg/L)	Sr (mg/L)	NH_4 (mg/L	Sb (μg/L)	Se (μg/L)
Anth_1 - Thermi dam	SG1	ND	40	3.2	70	31	ND	0.36	ND	ND	ND
Anth_2 - Triadi dam	SG2	ND	14	1.1	41	36	ND	0.14	0.1	ND	ND
Anth_3 - Vasilika dam	SG3	ND	18	0.9	45	25	ND	0.18	0.15	ND	ND
Anth_4 - Kato Scholari dam	SG4	ND	30	0.5	39	19	ND	0.28	0.08	ND	ND
Anth_5 - Lakoma dam	SG5	ND	95	4.4	49	52	ND	0.44	0.17	ND	ND
Mouriki	SG6	ND	8	1.7	11	6	ND	0.1	ND	ND	ND
Marathonas-Rapentosa dam	GA	ND	21	1.8	55	9	ND	0.26	0.1	ND	ND
Campania	CA	ND	44	5.1	89	67	ND	0.2	ND	ND	ND

Table 2.23 Analysis of Dam water quality in the period of May 2022.

May-22	Sample	As (μg/L)	Cd (μg/L)	Cr(VI) (μg/L)	Cr (μg/L)	Cu (μg/L)	Fe (μg/L)	Pb (μg/L)	Mn (μg/L)	Ni (μg/L)	Co (μg/L)
Anth_1 - Thermi dam	SG1	3.7	ND	ND	ND	ND	ND	ND	ND	2.4	ND
Anth_2 - Triadi dam	SG2	1.8	ND	ND	ND	ND	ND	ND	ND	2.3	ND
Anth_3 - Vasilika dam	SG3	ND	ND	ND	ND	ND	ND	ND	30	2	ND
Anth_4 - Kato Scholari dam	SG4	5.4	ND	ND	ND	ND	79	ND	ND	1.5	ND
Anth_5 - Lakoma dam	SG5	2.7	ND	ND	ND	ND	ND	ND	ND	2.7	ND
Mouriki	SG6	ND	ND	ND	ND	ND	59	ND	ND	ND	ND
Marathonas-Rapentosa dam	GA	1.2	ND	ND	ND	ND	57	ND	ND	ND	ND
Campania	CA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 2.24 Analysis of Dam water quality in the period of May 2022.

May-22	Sample	Mo (μg/L)	Zn (μg/L)	Hg (μg/L)	SiO_2 (mg/L)	B (mg/L)	T.O.C. (mg/L)
Anth_1 - Thermi dam	SG1	ND	ND	ND	2	0.08	2.35
Anth_2 - Triadi dam	SG2	ND	ND	ND	9	0.08	6.60
Anth_3 - Vasilika dam	SG3	ND	ND	ND	5	ND	5.34
Anth_4 - Kato Scholari dam	SG4	ND	ND	ND	4	0.32	3.80
Anth_5 - Lakoma dam	SG5	ND	ND	ND	4	ND	5.80
Mouriki	SG6	ND	ND	ND	13	ND	1.18
Marathonas-Rapentosa dam	GA	ND	ND	ND	5	0.08	1.43
Campania	CA	ND	ND	ND	ND	ND	3.4

3 Isotopic analysis

From each study site was chosen for isotopic analysis five (5) samples. The results are presented below. Additionally, are presented isotopes measurements in Precipitation in two stations in the study site of Thessaloniki, while for Marathonas basin evaluated the data from the GNIP station ATHENS-THISSION. The data from the station ATHENS-THISSION are available in the site of IAEA. The main conclusion from the tritium analysis is that in all sites the water is relatively new (<50 years), while from the stable isotopes concluded that the recharge water is from precipitation. From the vadose zone it was not feasible to collect the required water to obtain the required isotopic analysis mainly due to the hydrogeological characteristics (e.g. clay material) of the vadose zone and the low precipitation. Nevertheless, this issue didn't provide a problem to the project due to application of the other methods.

3.1 Eastern Chalkidiki and Anthemountas basin

In the following tables are shown the results of the isotopic analysis in the Eastern Chalkidiki and Anthemountas basin.

Table 3.1 Isotopic analysis from Eastern Chalkidiki and Anthemountas basin for the period September 2021.

September 2021	**d^{18}O *vs* SMOW**	**d^{2}H *vs* SMOW**	**3H**
Sample	**at ± 0,1 ‰**	**at ± 1 ‰**	**TU**
GD1	-7.48	-48.40	0.6
GD3	-7.31	-46.10	2.2
GD7	-7.65	-48.50	1.5
GD9	-7.45	-45.90	2.1
GD14	-7.20	-47.20	1.6

Table 3.2 Isotopic analysis from Eastern Chalkidiki and Anthemountas basin for the period May 2022.

May 2022	**d^{18}O *vs* SMOW**	**d^{2}H *vs* SMOW**	**3H**
Sample	**at ± 0,1 ‰**	**at ± 1 ‰**	**TU**
GD1	-7.38	-48.60	0.7
GD3	-7.22	-46.30	2.1
GD7	-7.50	-48.60	1.6
GD9	-7.25	-46.10	2.1
GD14	-7.31	-47.40	1.6

Table 3.3 Measurements in N. Rysio/Trilofos Station

Date	δ2H, in ‰	δ18O, in ‰
15/01/2022	-43.15	-7.026
15/02/2022	-48.98	-7.968
15/03/2022	-45.32	-7.476
15/04/2022	-48.65	-7.215
15/05/2022	-17.58	-2.975
15/06/2022	-22.44	-3.589
15/07/2022	-19.06	-2.435
15/08/2022	-1.91	1.455
15/09/2022	-5.25	-0.503
15/10/2022	-23.04	-3.772
15/11/2022	-43.93	-6.446
15/12/2022	-43.63	-6.425

Table 3.4 Measurements in Thessaloniki station from GNIP network.

Date	δ2H, in ‰	δ18O, in ‰
15/09/2016	-23.56	-4.006
15/10/2016	-28.89	-5.587
15/11/2016	-42.27	-6.705
15/12/2016	-20.97	-4.471
15/02/2017	-74.35	-10.498
15/03/2017	-52.11	-6.806
15/04/2017	5.64	1.486
15/05/2017	-45.01	-6.714
15/06/2017	-27.08	-3.914
15/07/2017	-32.54	-5.623
15/08/2017	-14.96	-0.428
15/09/2017	-23.53	-1.594
15/10/2017	-35.11	-4.832
15/11/2017	-47.17	-7.173
15/12/2017	-40.76	-5.712
15/01/2018	-29.27	-4.872
15/02/2018	-62.1	-9.194
15/03/2018	-30.26	-5.051
15/04/2018	-19.51	-2.39
15/05/2018	-31.18	-5.161
15/06/2018	-36.5	-5.76
15/07/2018	-23.07	-3.292
15/08/2018	-20.28	-1.605
15/09/2018	-7.34	-0.899
15/10/2018	-10.93	-1.286
15/11/2018	-50.81	-7.783
15/12/2018	-58.57	-8.812

15/01/2019	-71.53	-10.471
15/02/2019	-115.69	-15.131
15/03/2019	-55.17	-7.802
15/04/2019	-61.17	-8.161
15/05/2019	-36.21	-5.571
15/06/2019	-15.72	-2.199
15/07/2019	-16.79	-2.973
15/08/2019	-22.72	-2.852
15/09/2019	-20.1	-4.268
15/10/2019	-27.51	-4.731
15/11/2019	-60.82	-8.497
15/12/2019	-53.67	-8.059
15/01/2020	-50	-6.683
15/02/2020	-47.22	-7.047
15/03/2020	-41.19	-6.244
15/04/2020	-61.17	-9.014
15/05/2020	-26.09	-3.873
15/06/2020	-20.67	-2.546
15/07/2020	0.94	2.374
15/08/2020	3.57	2.848
15/09/2020	20.61	9.955
15/01/2021	-67.16	-9.159
15/06/2021	-38.74	-5.721
15/08/2021	-11.12	-1.789
15/09/2021	-42.96	-7.071
15/11/2021	-27.7	-4.878
15/12/2021	-63.32	-7.906
15/01/2022	-67.37	-9.321
15/02/2022	-43.09	-6.941
15/03/2022	-64.06	-9.613
15/04/2022	-54.48	-7.958
15/05/2022	-7.32	-1.749
15/06/2022	-24.57	-3.93
15/07/2022	-25.85	-3.917
15/08/2022	-23.81	-3.796
15/09/2022	-36.81	-6.363
15/10/2022	-13.88	-2.567
15/11/2022	-38.61	-5.708
15/12/2022	-52.62	-7.623

3.2 Mouriki basin

In the following tables are shown the results of the isotopic analysis in the Mouriki basin.

Table 3.5 Isotopic analysis from Mouriki basin for the period September 2021.

September 2021	$d^{18}O$ *vs* SMOW	$d^{2}H$ *vs* SMOW	3H
Sample	at ± 0,1 ‰	at ± 1 ‰	TU
GM1	-7.40	-48.30	0.7
GM3	-7.60	-48.20	≤ 0.5
GM5	-7.60	-47.50	1.2
GM6	-7.50	-48.85	1.1
GM7	-7.30	-48.50	0.8

Table 3.6 Isotopic analysis from Mouriki basin for the period May 2022.

May 2022	$d^{18}O$ *vs* SMOW	$d^{2}H$ *vs* SMOW	3H
Sample	at ± 0,1 ‰	at ± 1 ‰	TU
GM1	-7.45	-48.20	0.65
GM3	-7.55	-48.40	≤ 0.5
GM5	-7.40	-47.30	1.3
GM6	-7.60	-48.70	1.2
GM7	-7.40	-48.30	0.6

3.3 Marathonas basin

In the following tables are shown the results of the isotopic analysis in the Marathonas basin.

Table 3.7 Isotopic analysis from Marathonas basin for the period September 2021.

September 2021	$d^{18}O$ *vs* SMOW	$d^{2}H$ *vs* SMOW	3H
Sample	at ± 0,1 ‰	at ± 1 ‰	TU
GA1	-8.30	-51.30	0.6
GA3	-7.65	-48.50	0.7
GA6	-7.90	-50.20	1.0
GA8	-7.50	-47.10	1.5
GA10	-7.90	-48.65	≤ 0.5

Table 3.8 Isotopic analysis from Marathonas basin for the period May 2022.

May 2022	$d^{18}O$ *vs* SMOW	$d^{2}H$ *vs* SMOW	3H
Sample	at ± 0,1 ‰	at ± 1 ‰	TU
GA1	-8.20	-51.10	0.7
GA3	-7.55	-48.40	0.8
GA6	-7.80	-50.30	1.1
GA8	-7.40	-47.60	1.4
GA10	-7.70	-48.30	≤ 0.5

3.4 Campania basin

In the following tables are shown the results of the isotopic analysis in the Campania basin.

Table 3.9 Isotopic analysis from Marathonas basin for the period September 2021.

September 2021	$d^{18}O$ *vs* SMOW	$d^{2}H$ *vs* SMOW	3H
Sample	at ± 0,1 ‰	at ± 1 ‰	TU
V4	-7.85	-51.50	0.7
V9	-8.50	-58.20	≤ 0.5
V10	-8.30	-51.70	1.5
V11	-8.45	-55.40	≤ 0.5
V18	-7.30	-46.20	1.3

Table 3.10 Isotopic analysis from Marathonas basin for the period May 2022.

May 2022	$d^{18}O$ *vs* SMOW	$d^{2}H$ *vs* SMOW	3H
Sample	at ± 0,1 ‰	at ± 1 ‰	TU
V4	-7.90	-51.60	0.6
V9	-8.40	-58.30	≤ 0.5
V10	-8.20	-51.60	1.4
V11	-8.55	-55.30	≤ 0.5
V18	-7.20	-46.30	1.3

4 Chloride mass balance - CMB

The chloride mass balance has been utilized worldwide as a natural tracer for mass balance estimation of recharge as a low-cost approach (Subyani et al., 2006; Xu et al., 2019). The chloride mass balance (CMB) has been applied in Thermaikos Gulf and Marathonas basin for the recharge estimation according to the following equation:

$$R = P \frac{Cl_P}{Cl_{gw}}$$

Where,

R is the groundwater recharge flux (LT^{-1})

P is the average annual precipitation (LT^{-1})

Cl_p is the average precipitation-weighted chloride concentration (ML^{-3})

Cl_{gw} is the average weighted chloride concentration in the basin groundwater (ML^{-3})

M is representing mass

T is the time

L is the length

Precipitation samples were collected every month for the hydrological year 2021-2022 (October 2021-September 2022). The values of electrical conductivity and pH of rain were measured in the field, while chloride in the laboratory (**Table 4.1, Table 4.2**). The method requires the groundwater to be uninfluenced by external source pollution (e.g. livestock, seawater intrusion). In the area of Chalkidiki and Anthemountas basin the sampling point GD4 was the only uninfluenced and was chosen for the application of the method. In Marathonas basin the method tested in sample GA7 which has the lowest influence from pollution sources.

The results showed that in Eastern Chalkidiki – Anthemountas basin the recharge is 10.91%, while in Marathonas basin is 3.01% (

Table 4.3). In Eastern Chalkidiki – Anthemountas basin the results are in accordance with the other methods, while in Marathonas the recharge is lower than estimated from the other methods. The difference in Marathonas basin is attributed in the influence from other pollution sources. On balance the method didn't provide the expected results due to the influence from seawater intrusion. This conclusion is important in order other researchers to avoid this approach in similar environments.

Table 4.1 Measurements in the region of Eastern Chalkidiki and Anthemountas basin.

Eastern Chalkidiki and Anthemountas basin					
Month	EC (μS/cm)	pH	Cl in Precipitation (mg/L)	Rainfall (mm)	Cl in well GD4 (mg/L)
Oct-21	20	7.26	0.9	213.4	8.7
Nov-21	20	7.21	1.1	40.4	-
Dec-21	25	7.28	1.2	48.8	-
Jan-22	30	7.21	1.1	65.6	-
Feb-22	23	7.18	0.8	56.6	-
Mar-22	30	7.3	1.3	45	-
Apr-22	33	7.34	1	35	-
May-22	52	7.3	1.1	52	11
Jun-22	46	7.2	1.2	76.4	-
Jul-22	30	7.44	1.3	36.2	-
Aug-22	49	7.28	1.1	98.4	-
Sep-22	51	7.31	0.8	46.2	-
AVERAGE	34.08	7.28	1.08	814.00	9.85

Table 4.2 Measurements in Marathonas basin.

Marathonas					
Month	EC (μS/cm)	pH	Cl in Precipitation (mg/L)	Rainfall (mm)	Cl in well GA7 (mg/L)
Oct-21	28	7.4	2	109.6	106
Nov-21	25	7.41	1.5	74.4	-
Dec-21	37	7.55	1	127.8	-
Jan-22	33	7.4	1	95.6	-
Feb-22	30	7.32	1	35	-
Mar-22	34	7.4	2	38.6	-
Apr-22	36	7.55	4	5	-
May-22	60	7.76	3	32	107
Jun-22	57	7.5	5	2.4	-
Jul-22	55	7.7	7	7.6	-
Aug-22	50	7.73	6	29.4	-
Sep-22	58	7.5	5	2	-
AVERAGE	41.92	7.52	3.21	559.40	106.50

Table 4.3 Results of CMB calculations in the study areas.

	Precipitation	**Recharge**	
Study Area	mm/year	mm/year	%
Thermaikos Gulf	814.0	88.84	10.91
Marathonas basin	559.4	16.85	3.01

5 Snow Variability

In this section are presented the snow parameters variability and their mapping. For every year below, 3 types of maps are presented over the regions under study**: (1) the Snow water equivalent (SWE), (2) the Snow Depth (SD) and the (3) Snow density (calculated from the satellite dataset).**

Generally, the snow water equivalent (SWE) represents the amount of water that is contained in a snowpack. Using SI units, it is measured in kg/m^2, which can be considered as the weight of the meltwater per square meter that would result if the snowpack was melted entirely. Given that SWE and snow depth (HS) are derived from the satellite data, the snow density (ρ) is then calculated following the equation:

$$SWE = HS * \rho ,$$

where SWE is in kg/m^2, SD in m, and ρ in kg/m^3

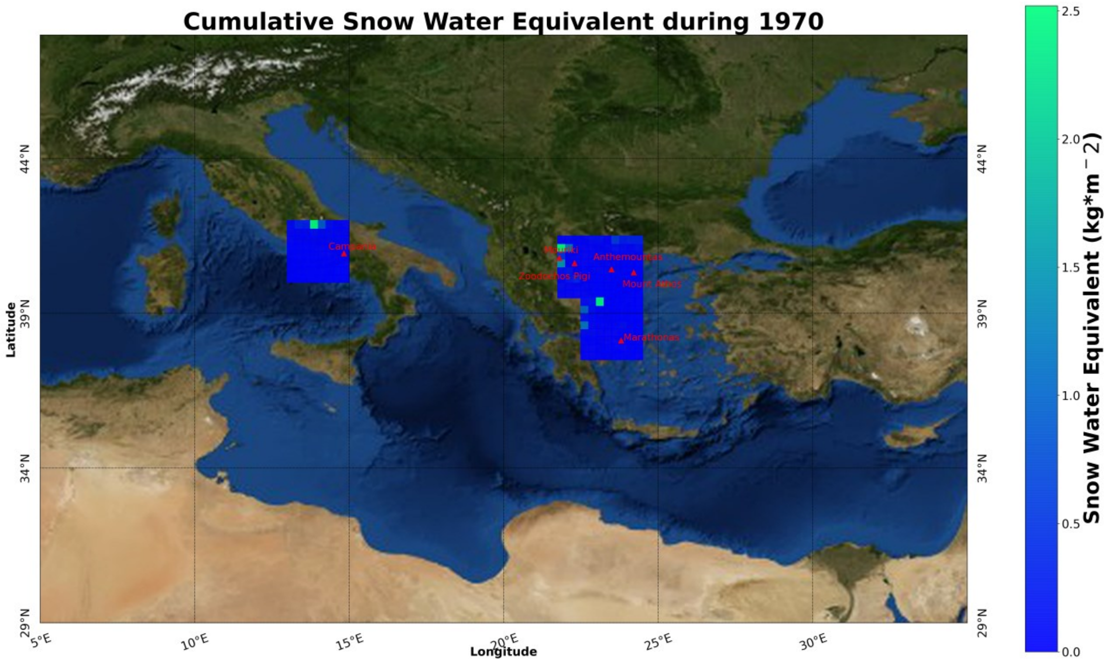

Figure 5.1 Cumulative Snow Water Equivelant for the year 1970

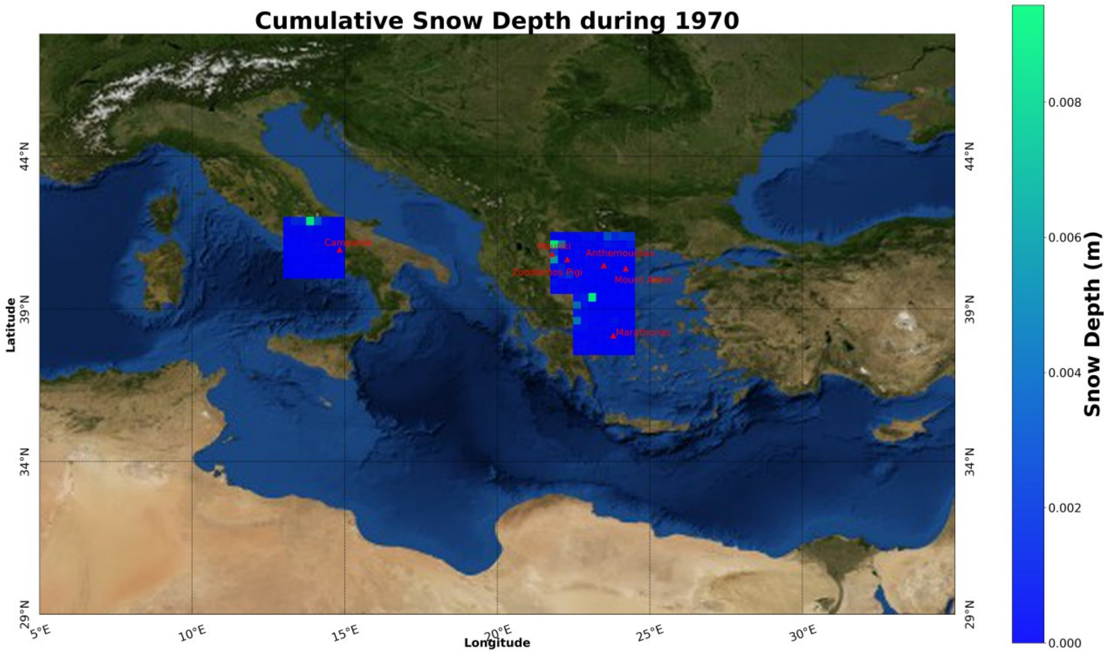

Figure 5.2 Cumulative Snow Depth for the year 1970

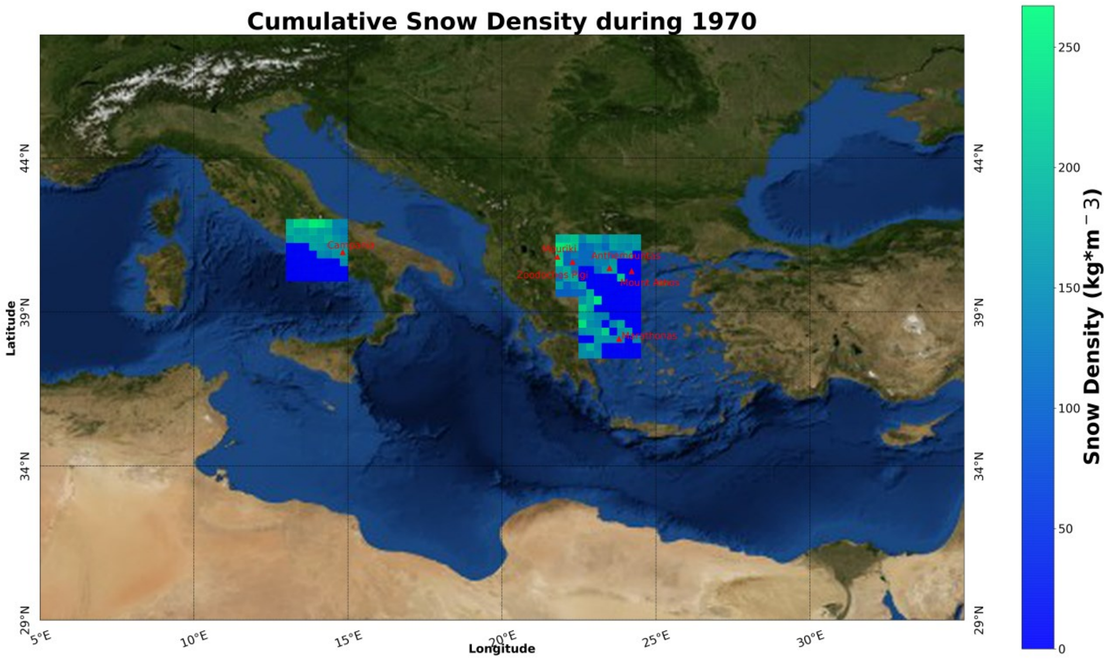

Figure 5.3 Cumulative Snow Density for the year 1970

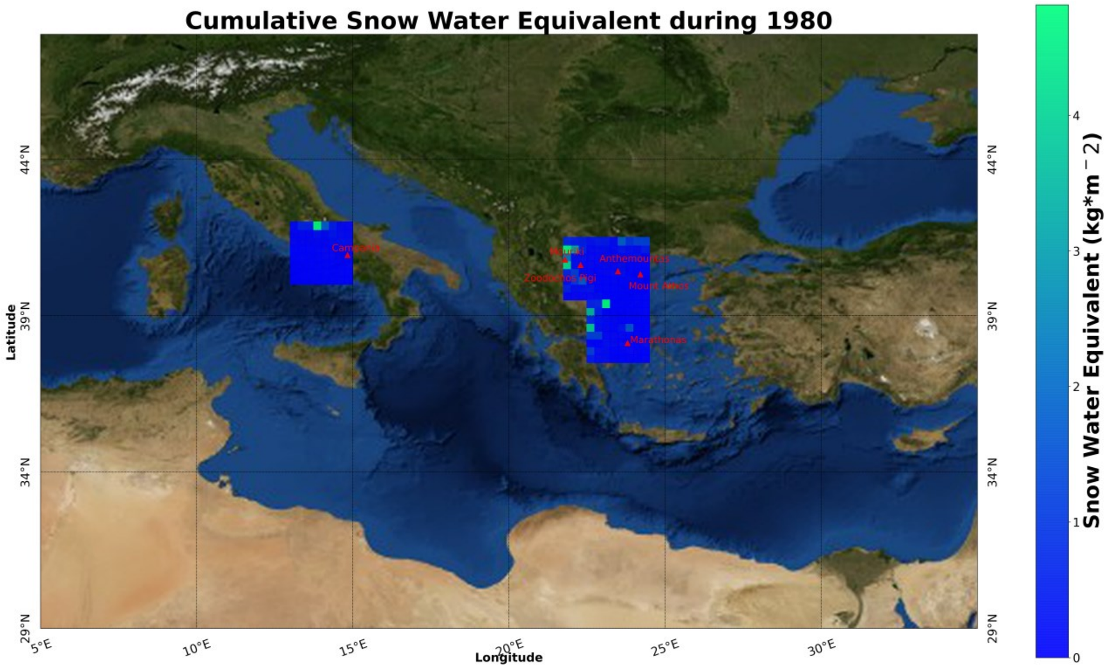

Figure 5.4 Cumulative Snow Water Equivelant for the year 1980

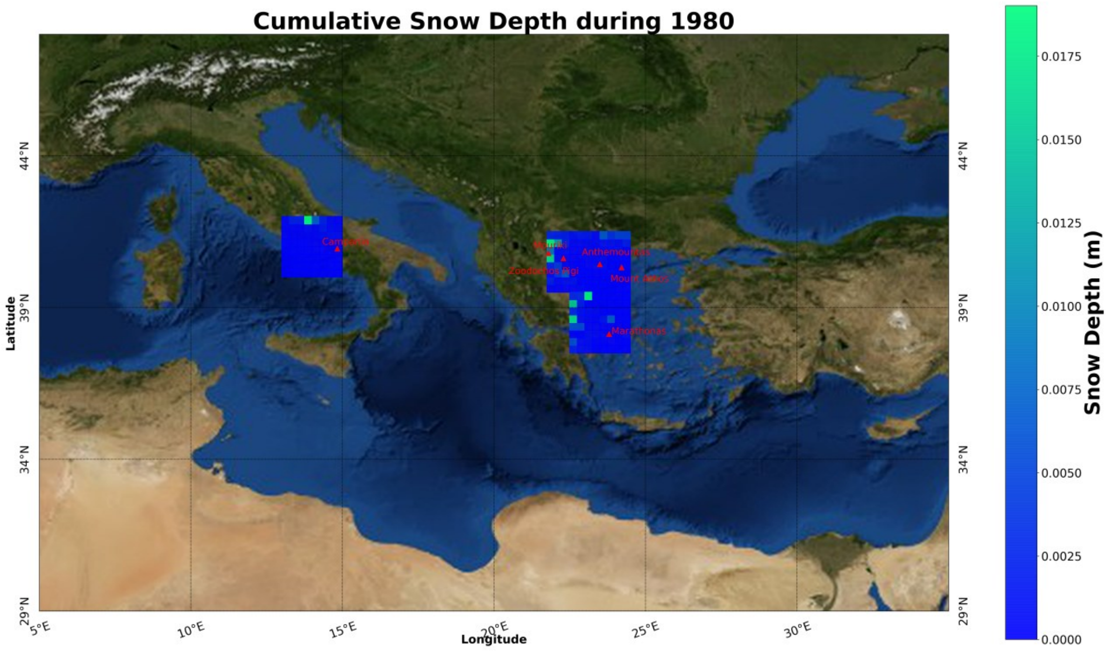

Figure 5.5 Cumulative Snow Depth for the year 1980

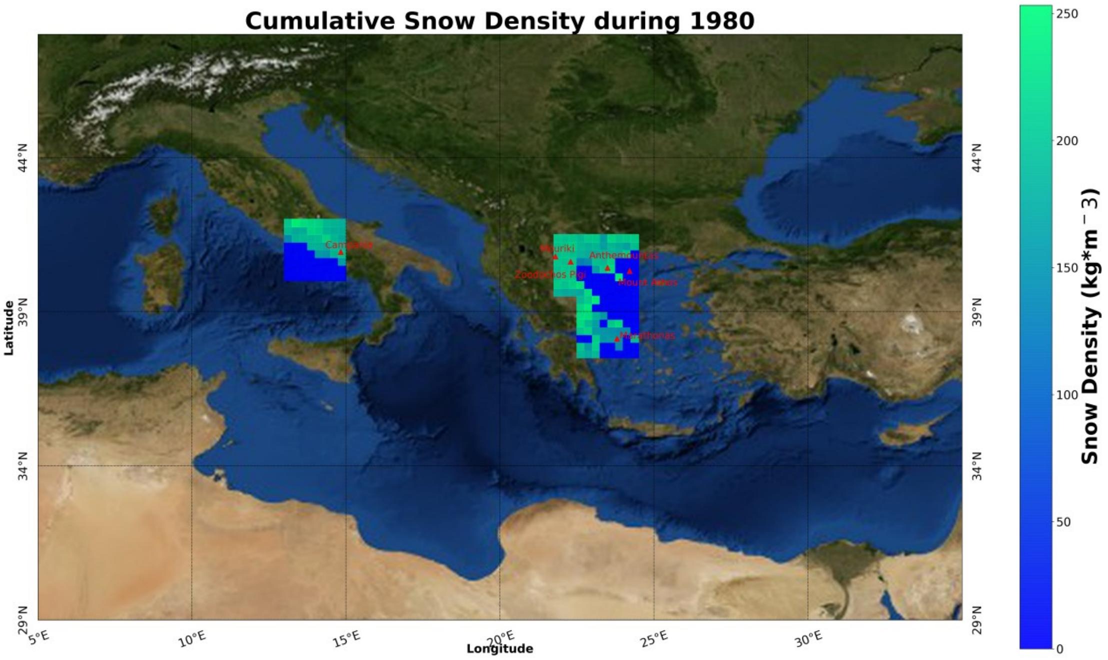

Figure 5.6 Cumulative Snow Density for the year 1980

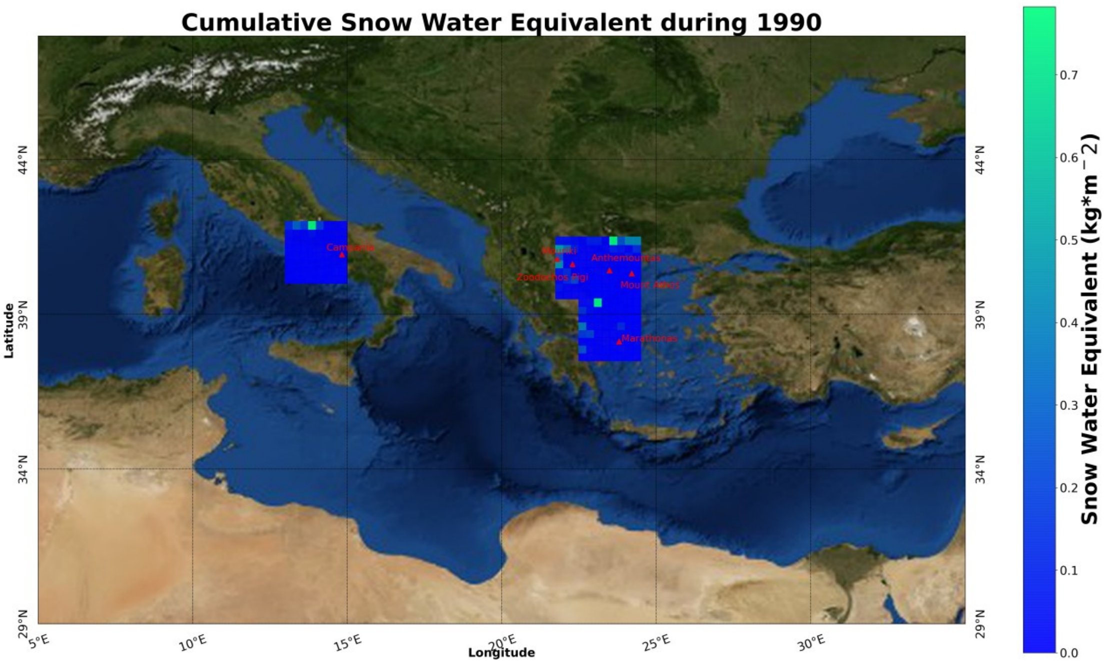

Figure 5.7 Cumulative Snow Water Equivelant for the year 1990

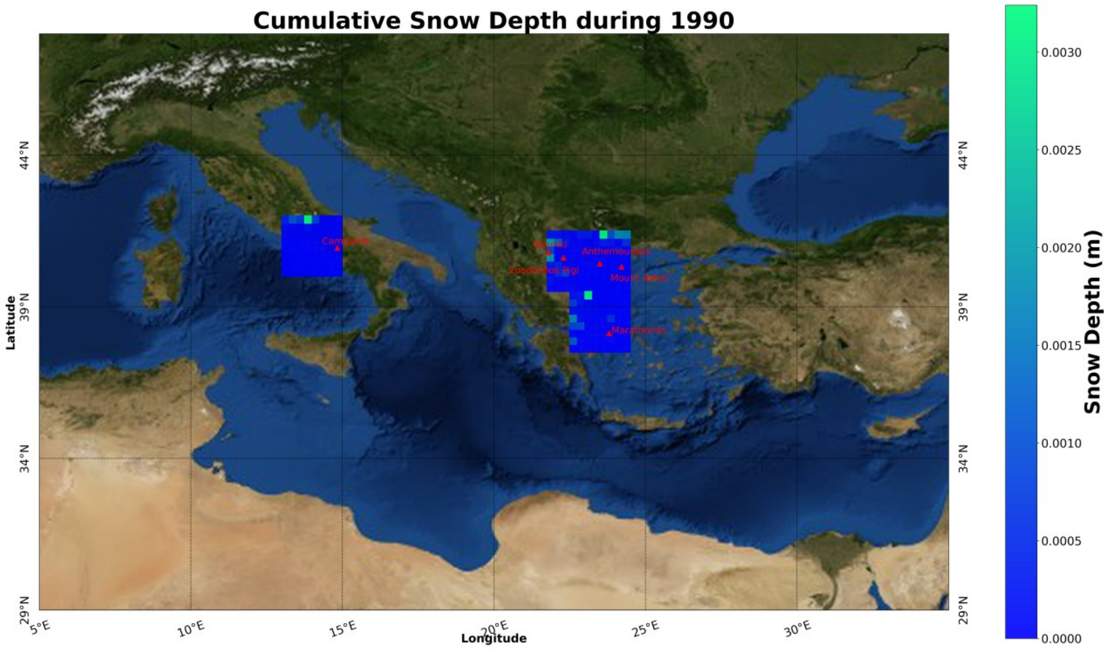

Figure 5.8 Cumulative Snow Depth for the year 1990

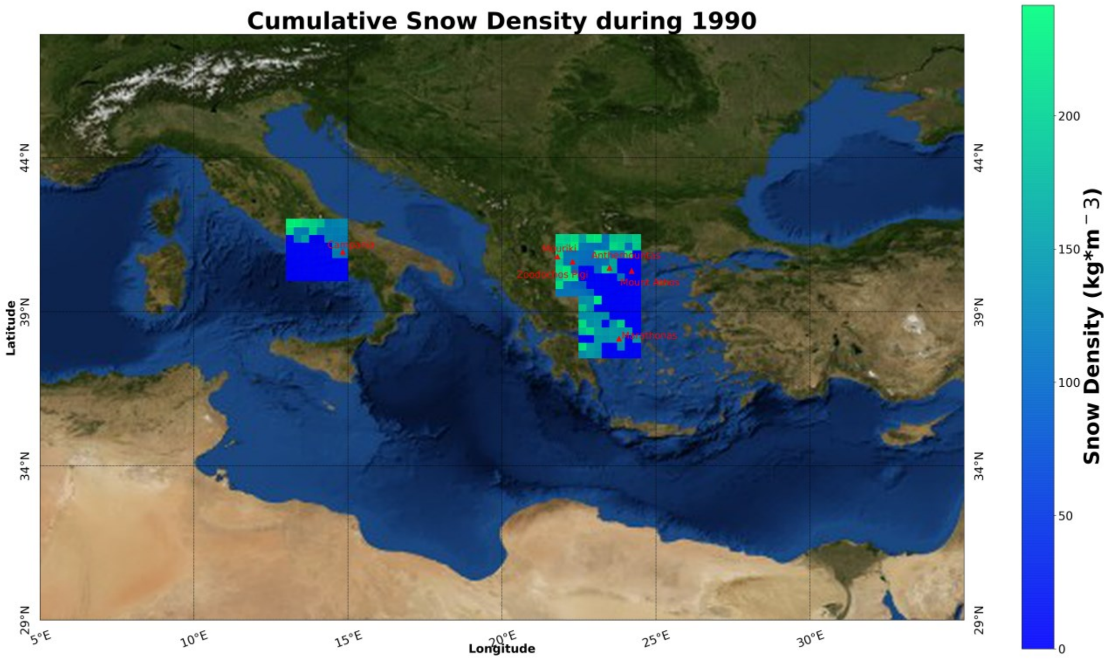

Figure 5.9 Cumulative Snow Density for the year 1990

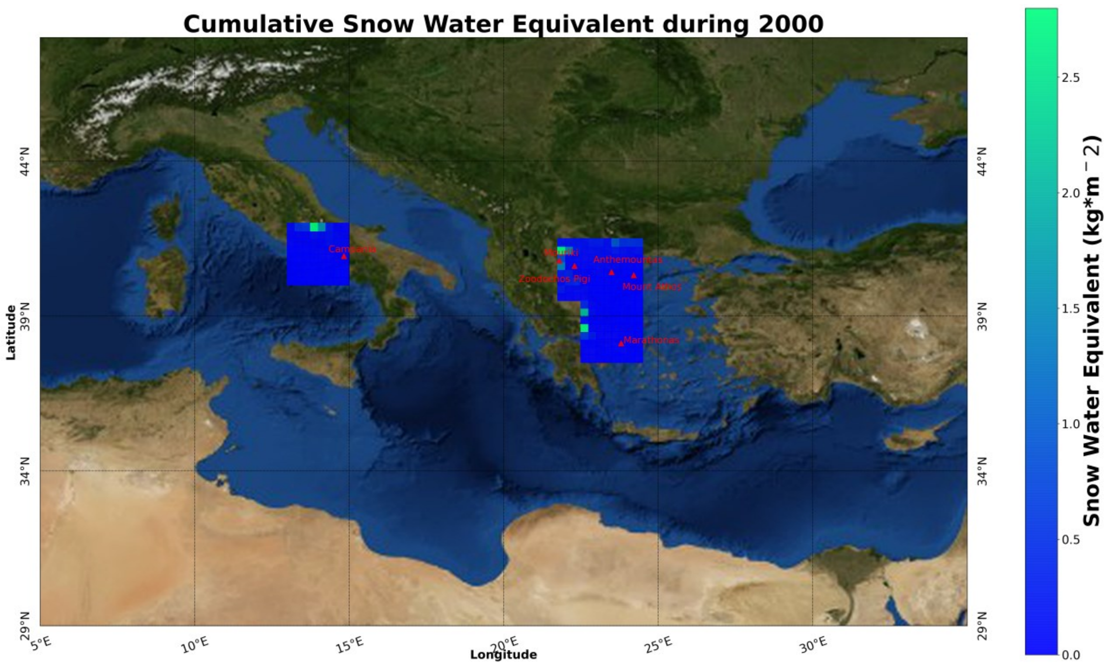

Figure 5.10 Cumulative Snow Water Equivelant for the year 2000

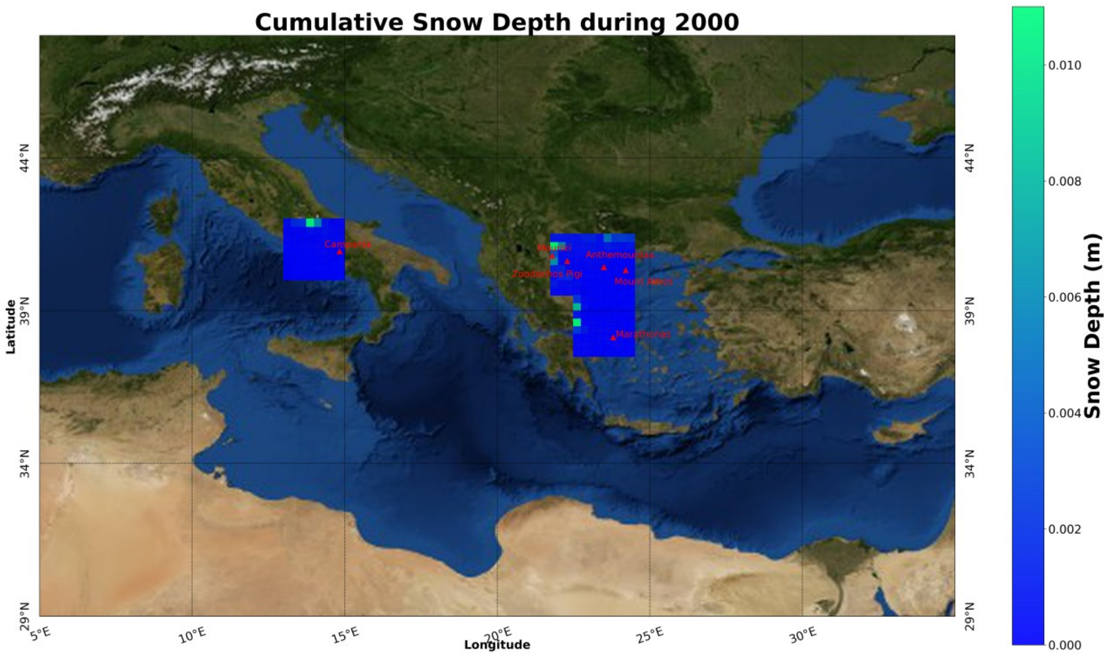

Figure 5.11 Cumulative Snow Depth for the year 2000

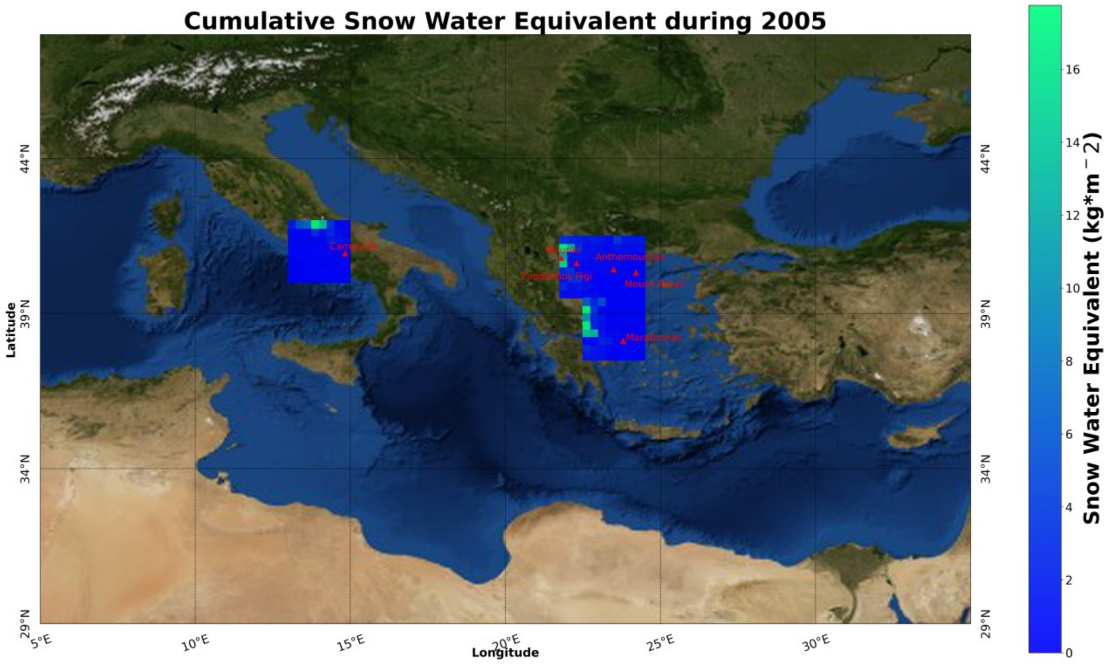

Figure 5.12 Cumulative Snow Water Equivelant for the year 2005

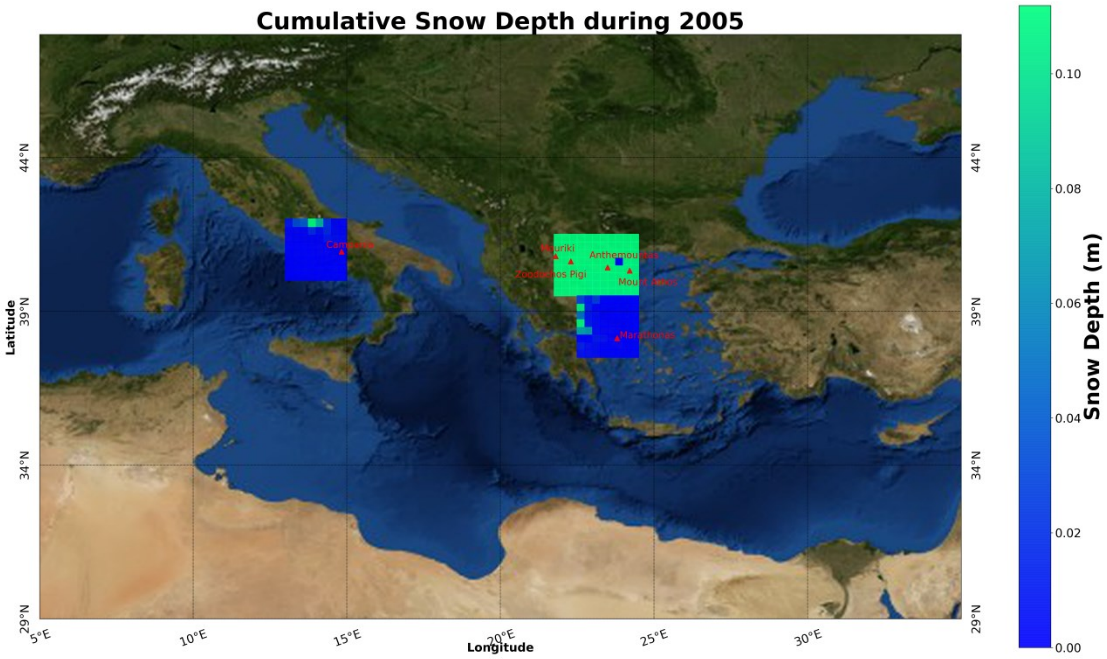

Figure 5.13 Cumulative Snow Depth for the year 2005

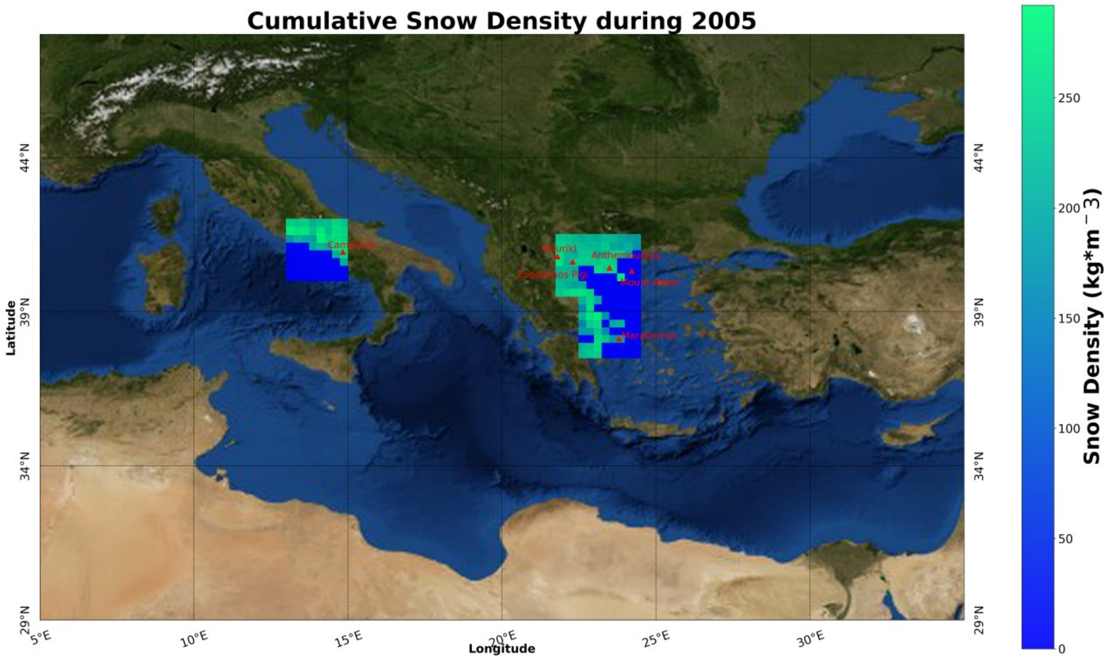

Figure 5.14 Cumulative Snow Density for the year 2005

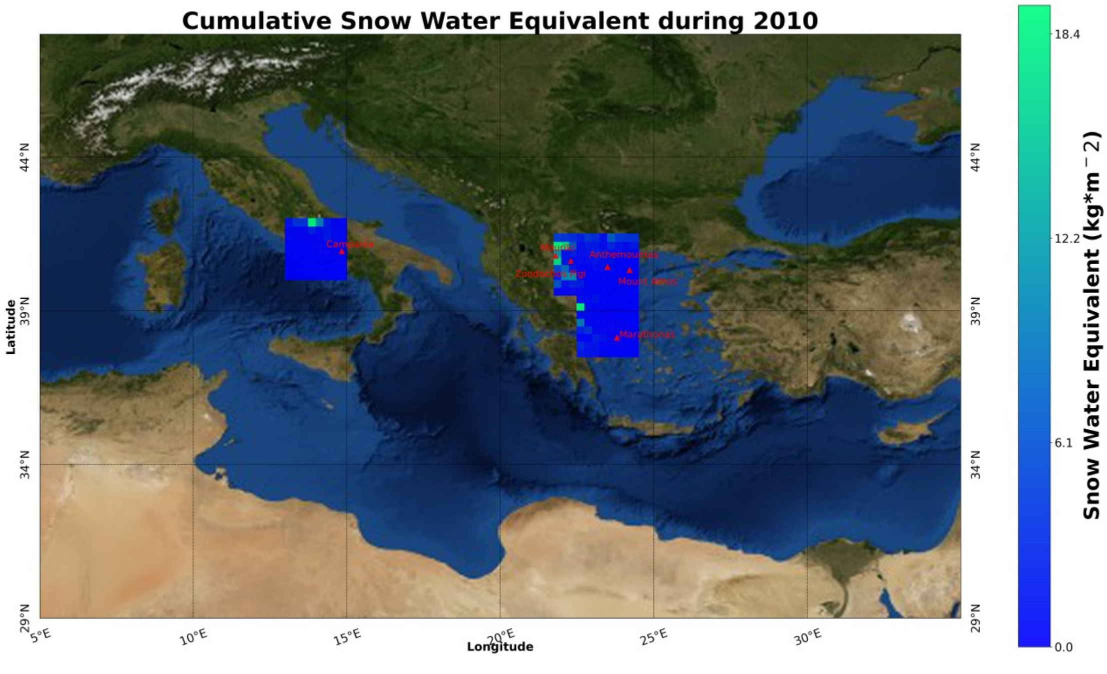

Figure 5.15 Cumulative Snow Water Equivelant for the year 2010

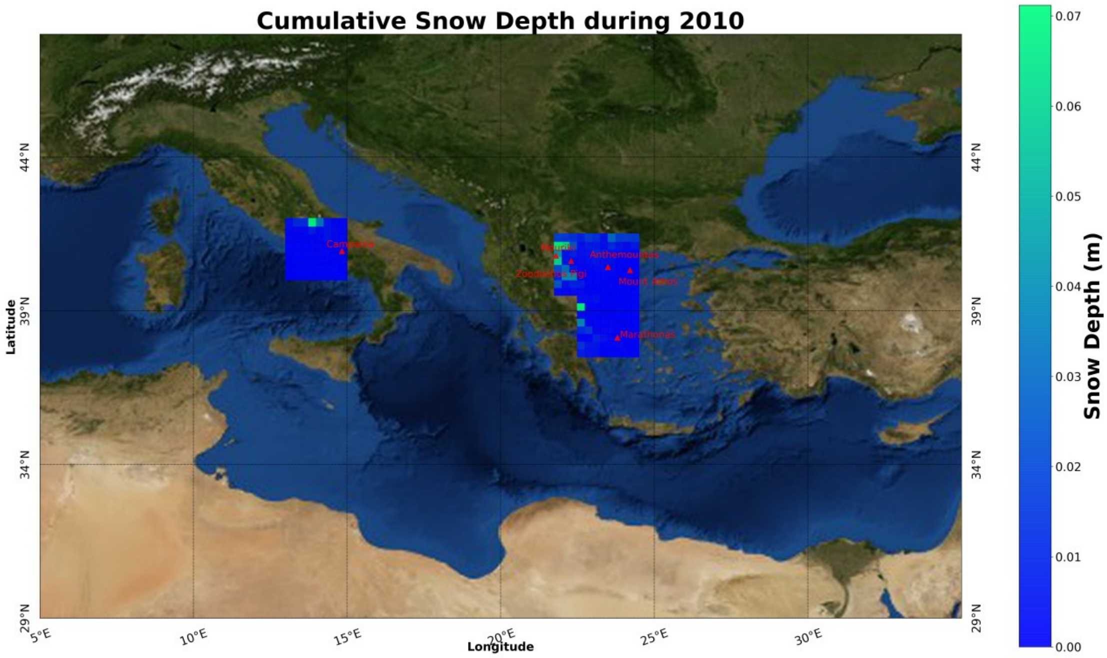

Figure 5.16 Cumulative Snow Depth for the year 2010

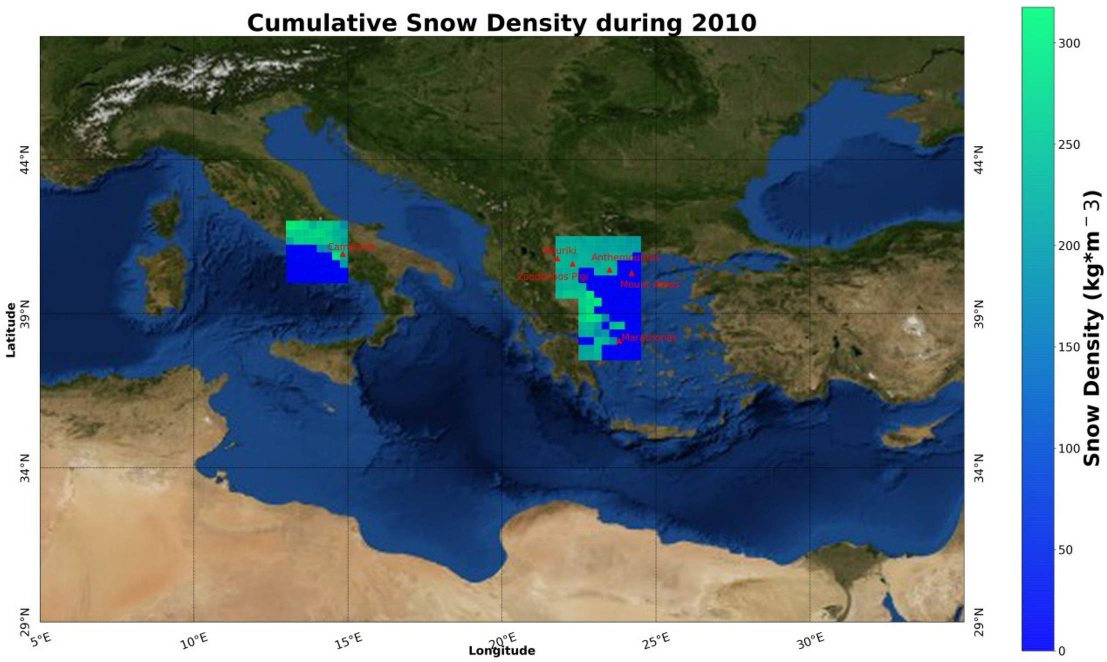

Figure 5.17 Cumulative Snow Density for the year 2010

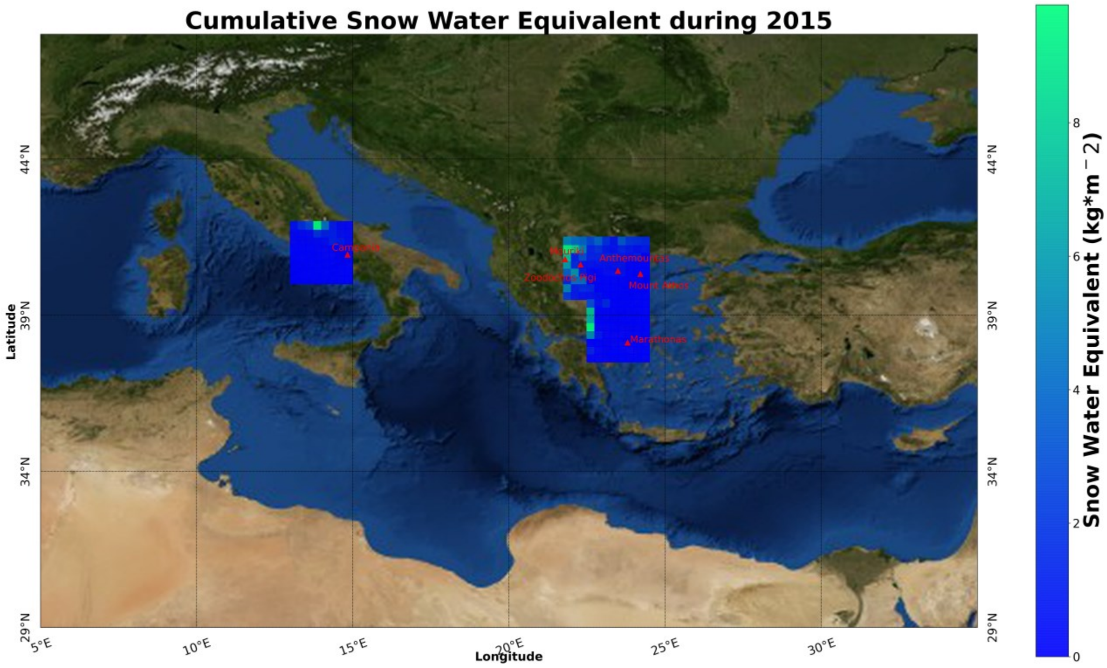

Figure 5.18 Cumulative Snow Water Equivelant for the year 2015

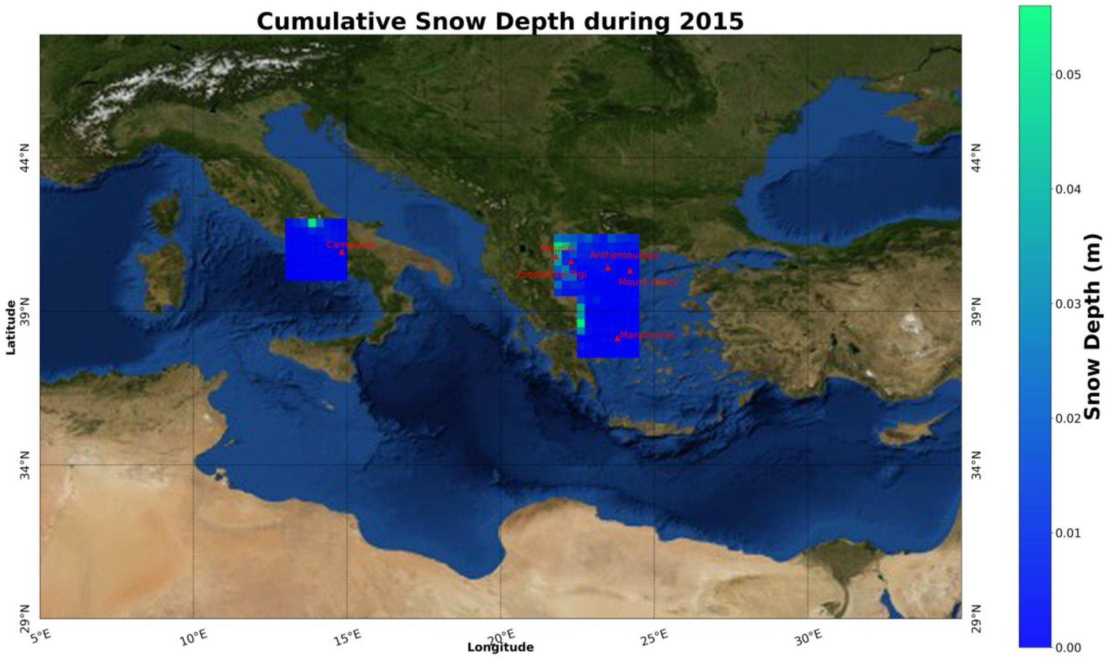

Figure 5.19 Cumulative Snow Depth for the year 2015

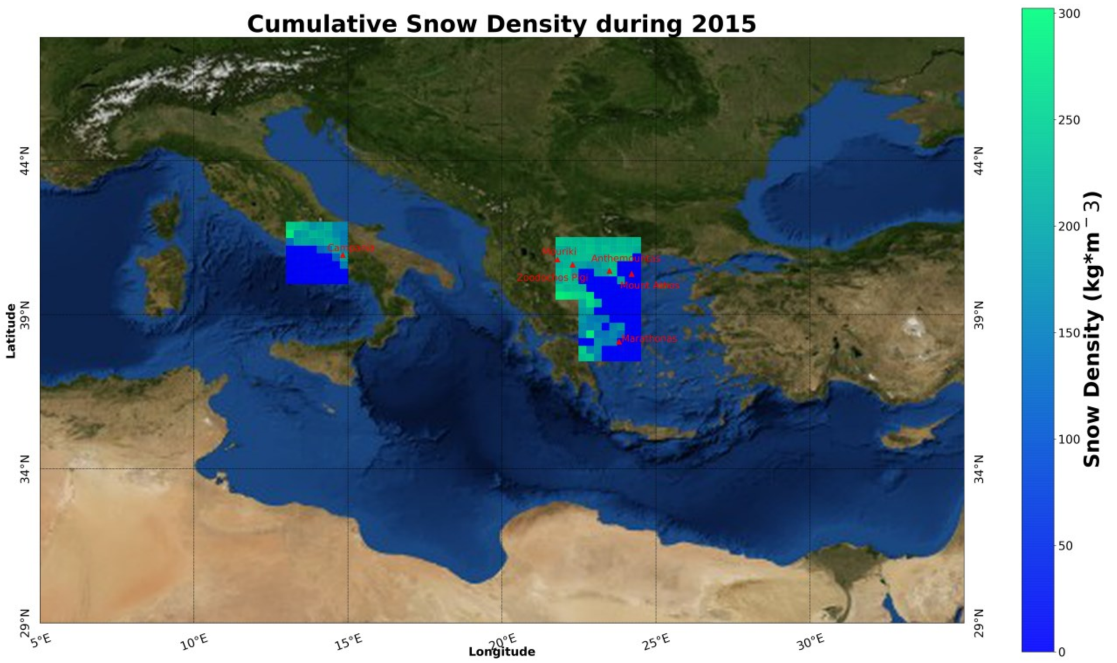

Figure 5.20 Cumulative Snow Density for the year 2015

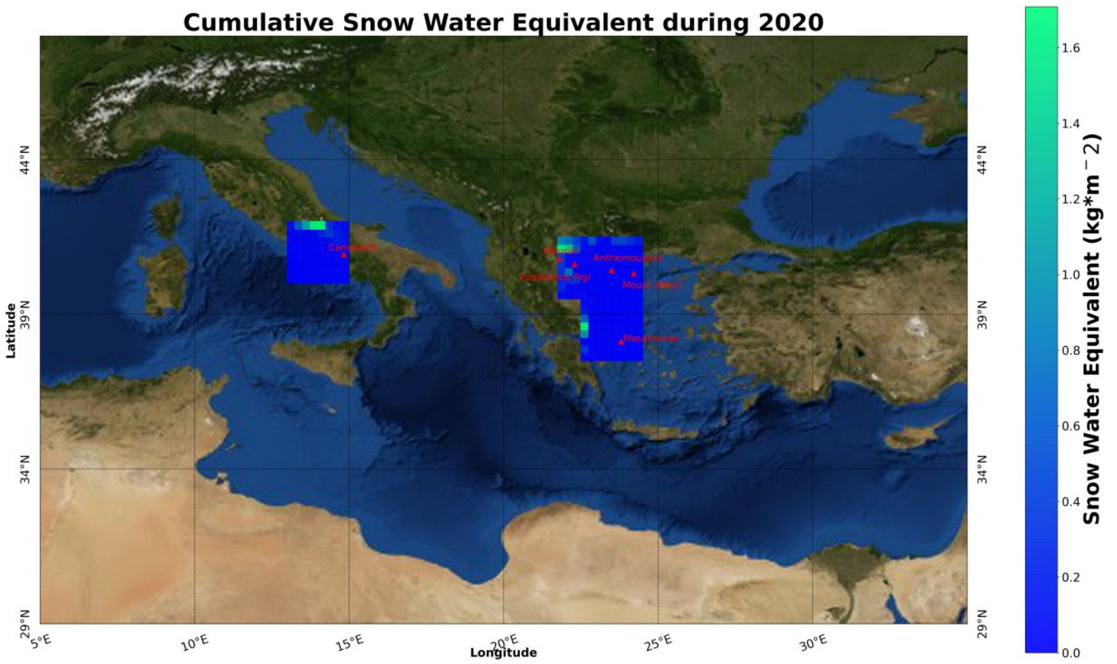

Figure 5.21 Cumulative Snow Water Equivelant for the year 2020

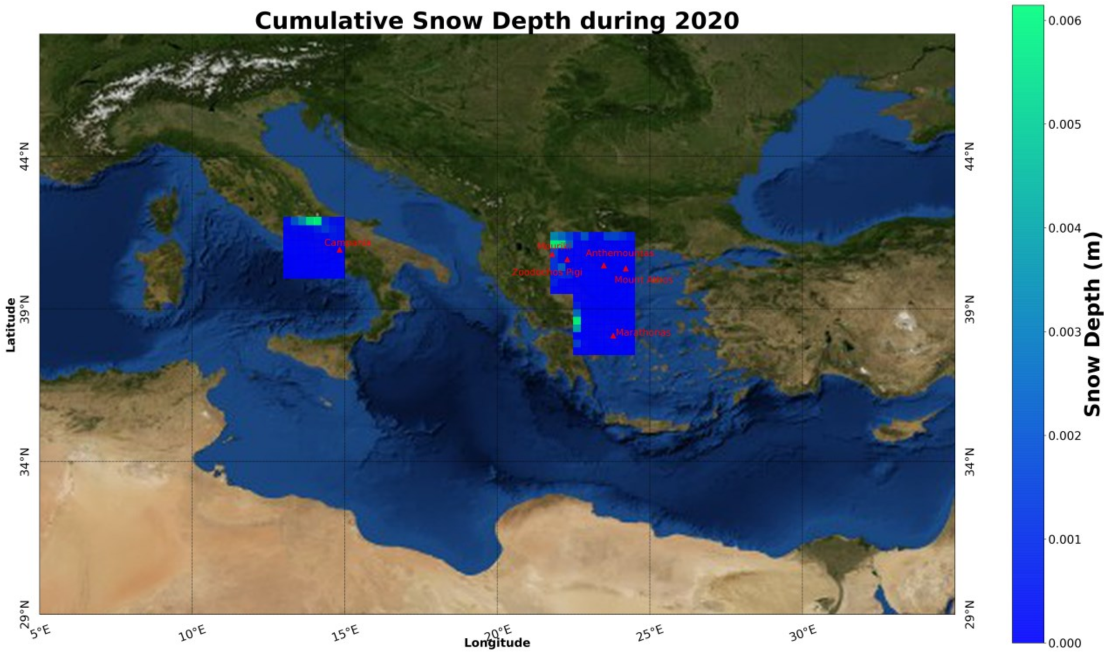

Figure 5.22 Cumulative Snow Depth for the year 2020

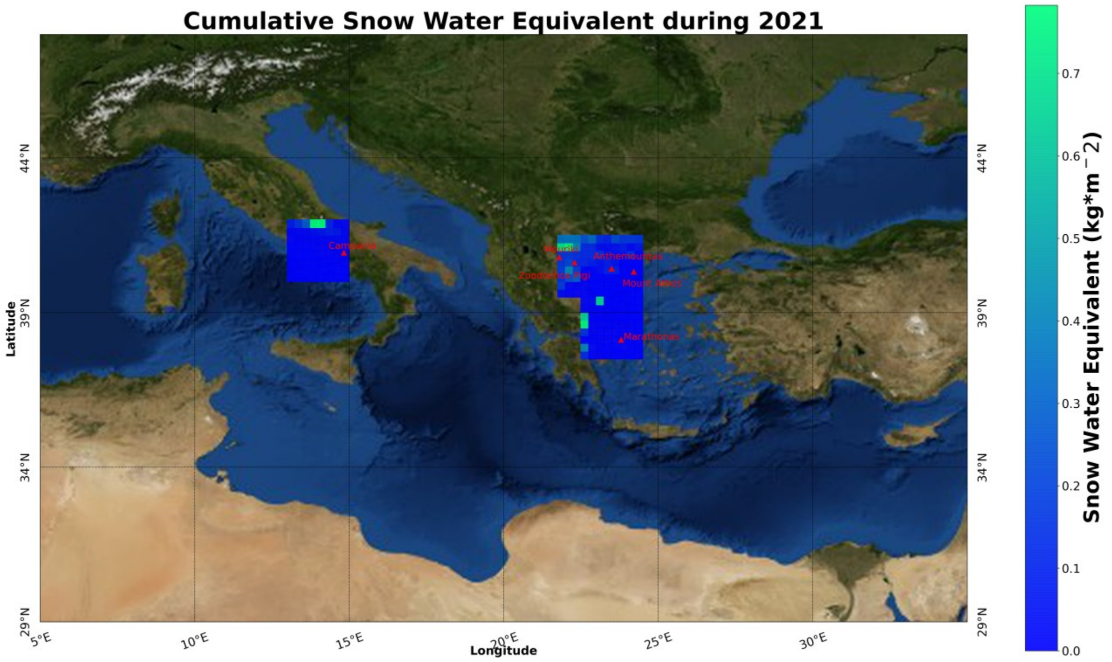

Figure 5.23 Cumulative Snow Water Equivelant for the year 2021

In what follows, the spatiotemporal distribution of the snow parameters over the selected study areas during the last decades is analyzed below on accumulative yearly mean values and an accumulative mean monthly basis. The below presents the temporal distribution of the snow water equivalent over the years 1960–2021 for the three study areas: the Anthemountas basin, the Mouriki basin, and the Upper Volturno-Calore basin.

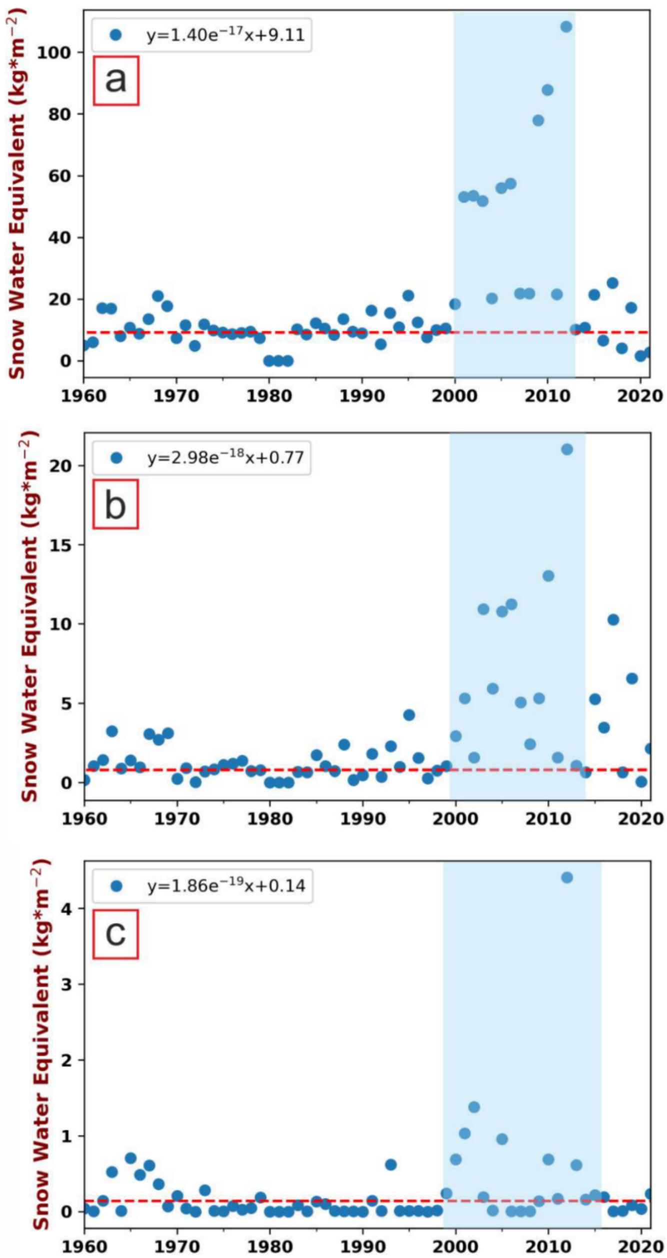

Figure 5.24 Temporal distribution of the snow water equivalent

Moreover, the Table 5.1 below summarizes the accumulative values of the SWE (kg/m2) and the SD (m) and the calculated snow density (kg/m3) for the selected measurement study areas in Greece and Italy, for the period between 1960 and 2021. The retrieved snow density values are within the reported ranges in the literature (100–500 kg/m3), showing no significant deviation for the two Greek and Italian study areas.

Table 5.1 Snow parameters for the studied areas.

Study Area	Anthemountas Basin	Mouriki Basin	Marathonas	Upper Volturno-Calore Basin
Snow water equivalent (kg/m^2)	18.61	2.796	18.9	0.264
Snow depth (m)	0.083	0.0136	0.089	0.0012
Snow density (kg/m^3)	224	206	212	224

5.1 Conclusions – 7th milestone

The variability and mapping of the SWE, SD and the snow density in selected years over the 3 study areas are presented. Similar maps are produced for every year with the automatic algorithm for visualization purposes.

As it can be seen from the plots above, moderate to higher values of the snow statistics were observed, depending on the year and the area. In general, the snow water equivalent and the snow depth are found higher in the Anthemountas basin, whilst the derived snow density ranged between 170 and 230 kg/m^3. Data gaps in the maps represent screened-out pixels due to either cloud or uncalibrated values. The yearly mean snow density values for the Anthemountas basin and the Upper Volturno-Calore basin study areas are found equal to 224 kg/m^3. However, yearly mean snow density values are differentiated for the two Greek study areas. Possible reasons for these insignificant discrepancies could be attributed to their geographical characteristics (e.g., different altitudes).

More detailed information on the algorithm's steps and output can be found in the deliverable D3-3, and the publication "Snowfall Variation in Eastern Mediterranean Catchments" by Voudouri et al., 2023.

Aim of this work is to further use the snow derived parameters in simulation models, by defining the snowfall variability in the groundwater table. Additionally, the snow melting process in conjunction with groundwater dynamics should be studied.

The milestones M4.1 is the snow modeling as described within this report. Hence, the **M4.1 (7th) milestone** have been achieved within the project.

6 Special Issue

One special issue was organized. Initially the plan was to be held it within "Science of the Total Environment", however it was chosen the Journal of Water due to open access policy which help to the dissemination of the project (https://www.mdpi.com/journal/water/special_issues/Groundwater_Depletion). Additionally, the Special Issue was linked with an International Conference (12th International Hydrogeological Conference of Greece and Cyprus) in order to attract more researchers and stimulate the interest for the project.

The selection of open access articles and the organization of a Special Issue in an open access Journal ensures that the Copyrights of the published articles will be available to a wider board.

The title of the Special issues is Groundwater Depletion: Current Trends and Future Challenges to Mitigate the Phenomenon (**Figure 6.1**). The deadline of the special issue was extended until 20 April of 2024 due to the interest of the researchers. Until 8 February of 2024 submitted 18 articles, while 11 was accepted for publication and 2 are still under review. The special issue Viewed by 17714 researchers contributing also in the dissemination of the project.

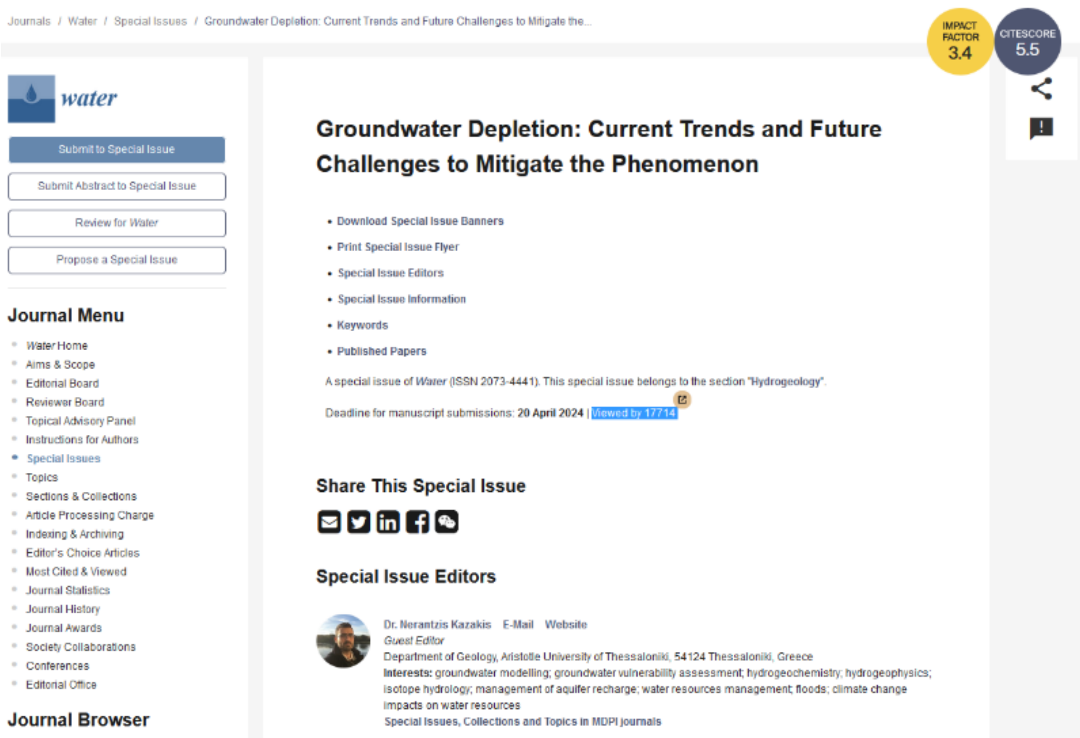

Figure 6.1 Special Issue of the Project in Water Journal.

The published articles within the special issue are the following:

- Nanou et al. 2024 Recharge assessment in Greek karst systems: Methodological considerations and implications
- Liu et al. 2023 Nature-Based Solutions for the Restoration of Groundwater Level and Groundwater-Dependent Ecosystems in a Typical Inland Region in China.
- Kalaitzidou et al. 2023 Water Quality Evaluation of Groundwater and Dam Reservoir Water: Application of the Water Quality Index to Study Sites in Greece.
- Malamataris et al. 2023 Participatory Approach to Explore Nexus Challenges: The Case of Pinios River Basin, Greece.
- Ntona et al. 2023 Application of judgmental sampling approach for the monitoring of groundwater quality and quantity evolution in Mediterranean catchments.
- Karakatsanis et al. 2023 Optimization of dam operation and interaction with groundwater. An overview focusing on Greece.
- Tzampoglou et al. 2023 Hydrogeological Hazards in Open Pit Coal Mines–Investigating Triggering Mechanisms by Validating the European Ground Motion Service Product with Ground Truth Data.
- Louloudis et al. 2022 Repurposing of a Closed Surface Coal Mine in Respect to Pit Lake Development.
- Mehmood et al. 2022 Spatiotemporal analysis of groundwater-storage changes, controlling factors and management options over the Transboundary Indus Basin.
- Gaiolini et al. 2022 Impact of boundary conditions on the groundwater budget in the unconfined aquifers of the Campania region (Italy).
- Papadopoulos et al. 2022 Hybrid fuzzy multi-criteria analysis in selecting of discrete preferable recharge sites for water storage and recovery.

7 Conclusion – 8th milestone

From the hydrochemical analysis concluded that the main issue of groundwater quality is nitrate pollution in all sites. The main pollution source is fertilizers from agricultural activities. In the coastal areas seawater intrusion also constitute a serious issue. The inverse of piezometric head due to overexploitation is the main issue for coastal aquifer salinization. The results of the project highlight that both pollution issues occur. The monitoring of the aquifers should be continued in the site mainly in monthly step regarding nitrate pollution and seawater intrusion. A detailed analysis of the results is included within the corresponding publications.

Within work package 4 fulfilled the 7th and 8th milestones of the project which are the **Snow modeling (M4.1)** and **Special issue (M4.2)**.

The data are available in the web-site of the project. It is necessary the permition of principal investigator if someone want to re-publish this data, while there are not available for commercial reasons.