

1 – Introduction and Geological setting of the studied area

The purpose of the current study is to investigate the groundwater flow and the interaction between continental groundwater and seawater in the fractured and weakly karstified Upper Coralline Limestone (UCL), which extensively outcrops in the northern part of the Island of Malta. Moreover, the study aims to understand the past and the present coastal morphological evolution of the island, which is characterised by frequent deep landslides.

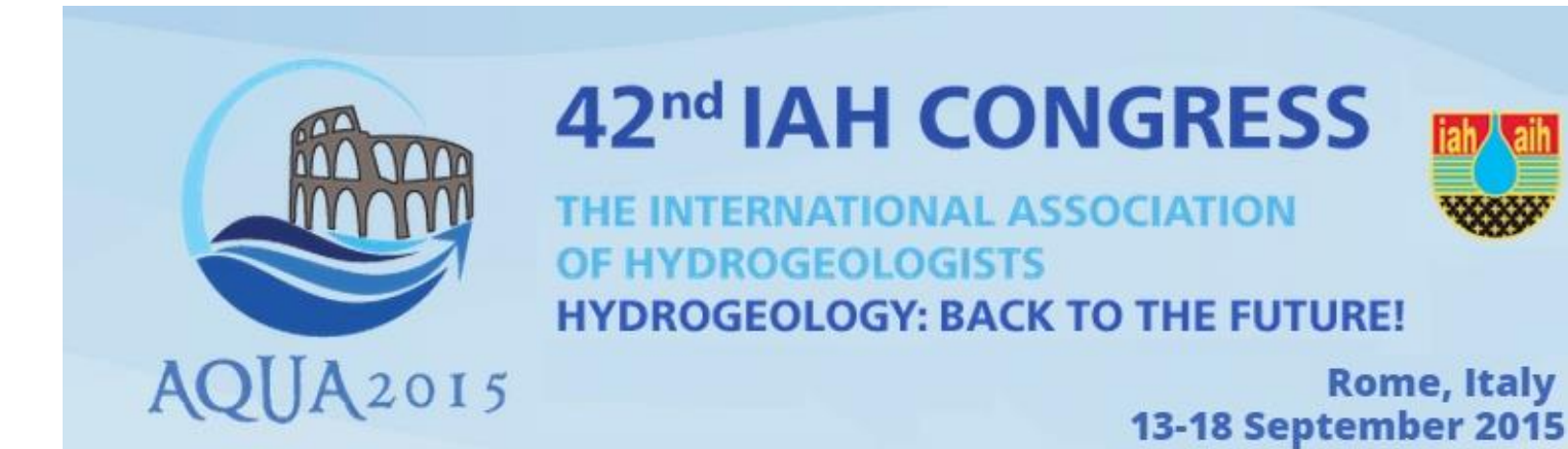
The study has been carried out in an area extending for approximately 0.3 km² at the Latitude between 35°37'÷35°58'North and Longitude between 14°20'÷14°21'East.

The average annual precipitation is less than 600 mm; the months in which rainfall is more abundant are November and December, while the driest months are July and August.

The morphology of the studied area is controlled by a horst–graben geological system; gentle hills are alternated with flat areas. Along the slopes, between the elevations of 20-50 m a.s.l, the UCL formation outcrops and the soil cover is missing. In the flat areas, between the elevations of 0-20 m a.s.l., colluvial deposits outcrop.

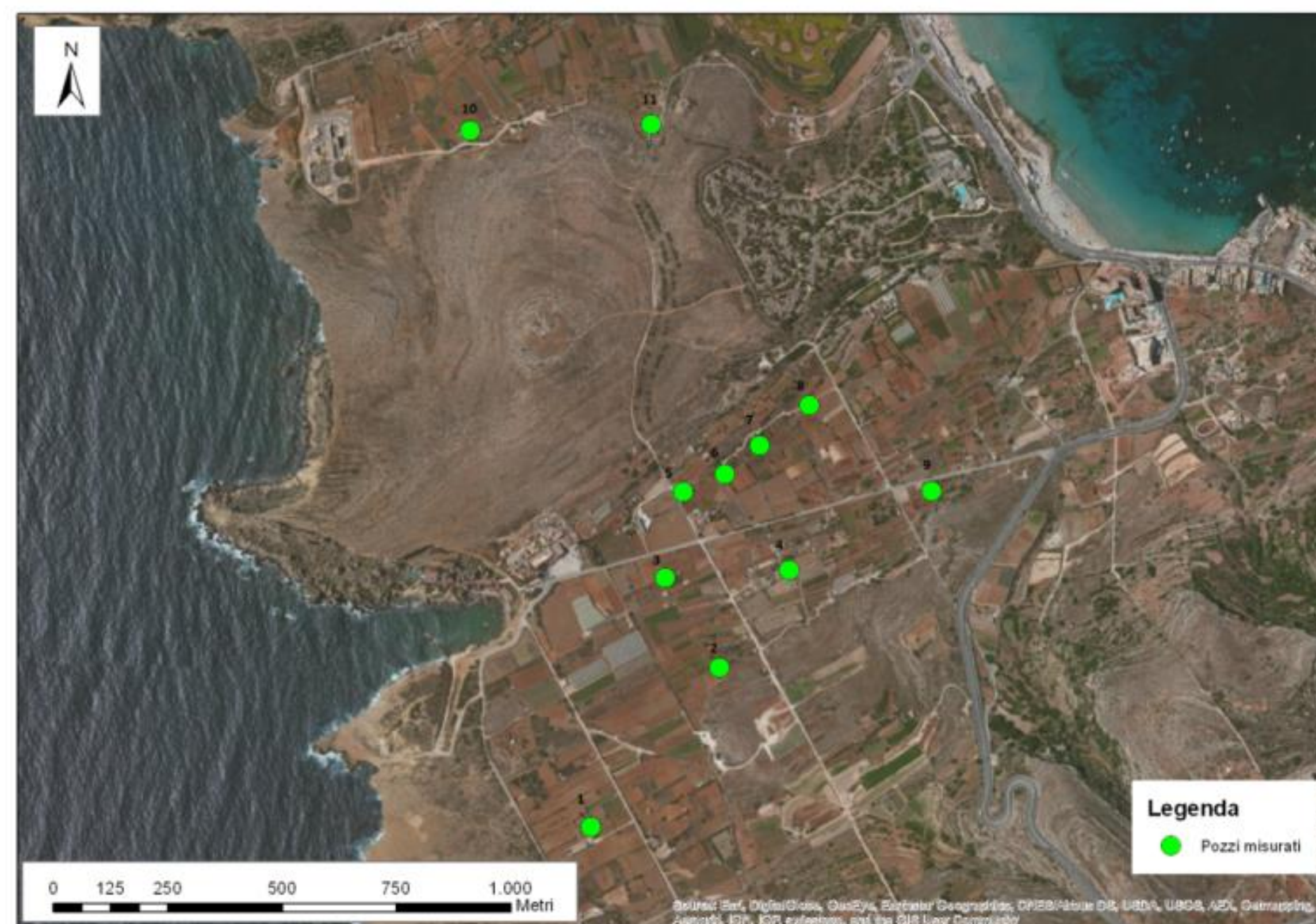
These areas are intensively cultivated, except for some farmhouses, a secondary road and the Popeye Village (tourist attraction).

According to the geological setting of the area, below the UCL, the Blue Clay outcrops.

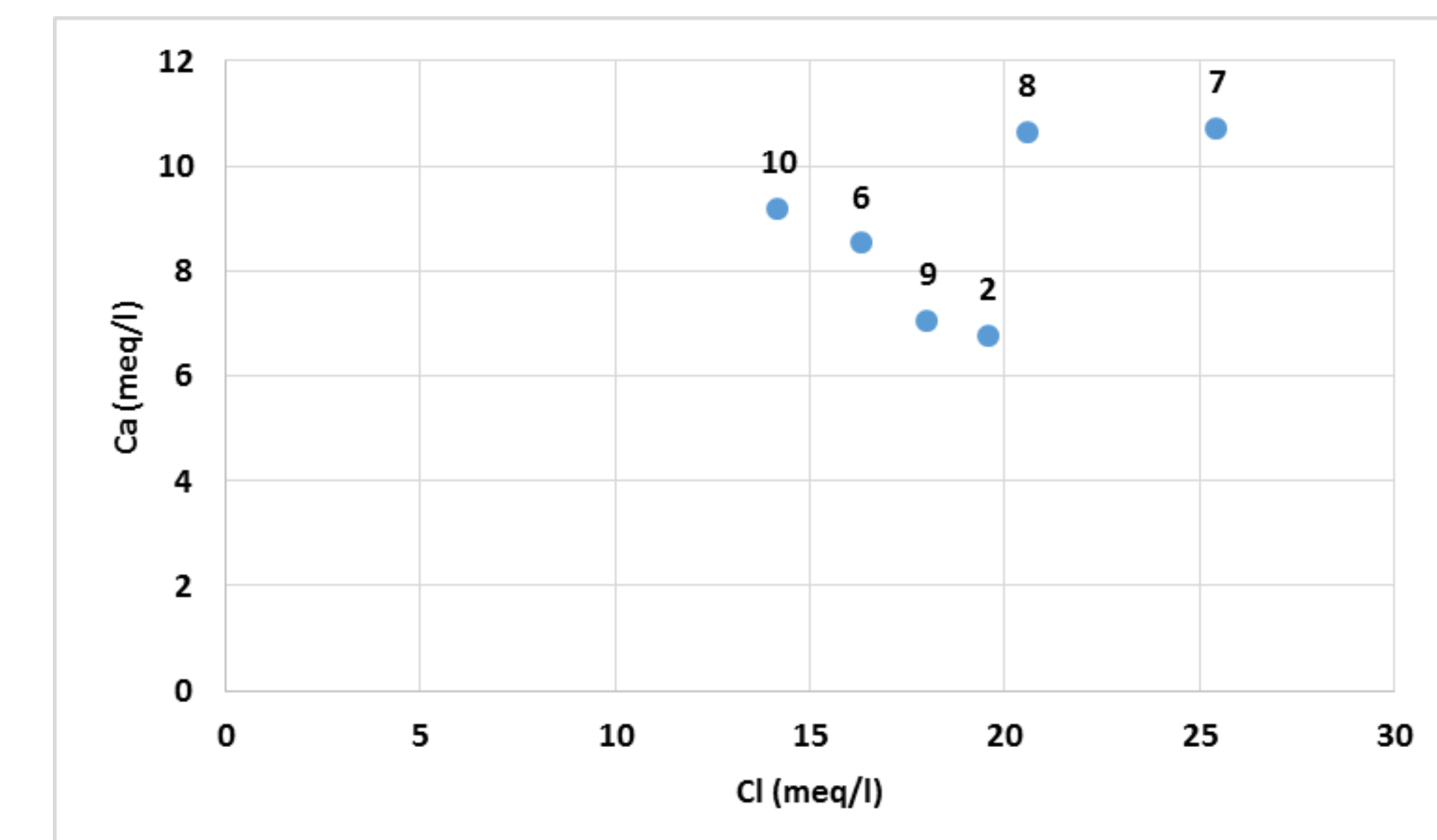
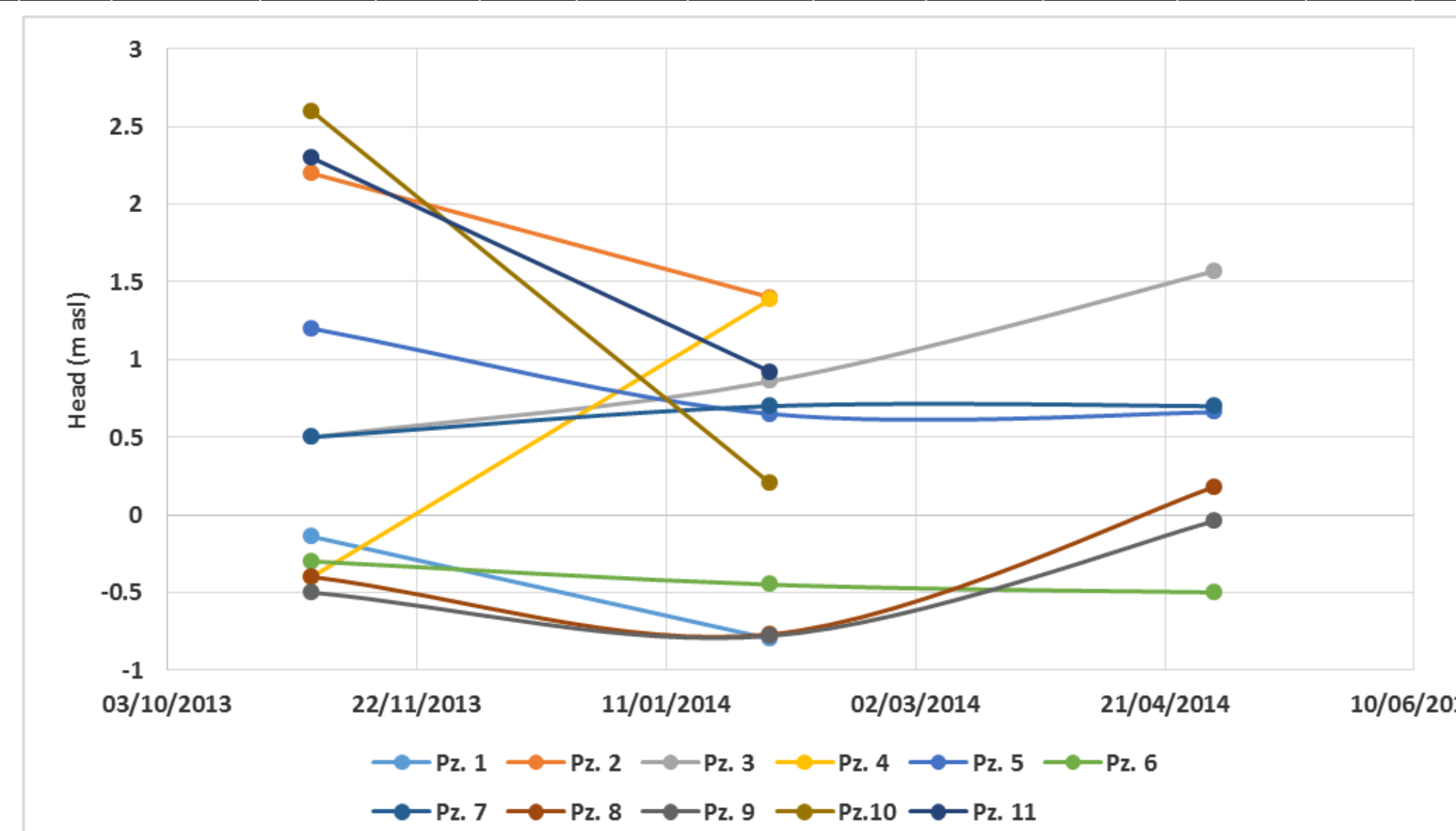
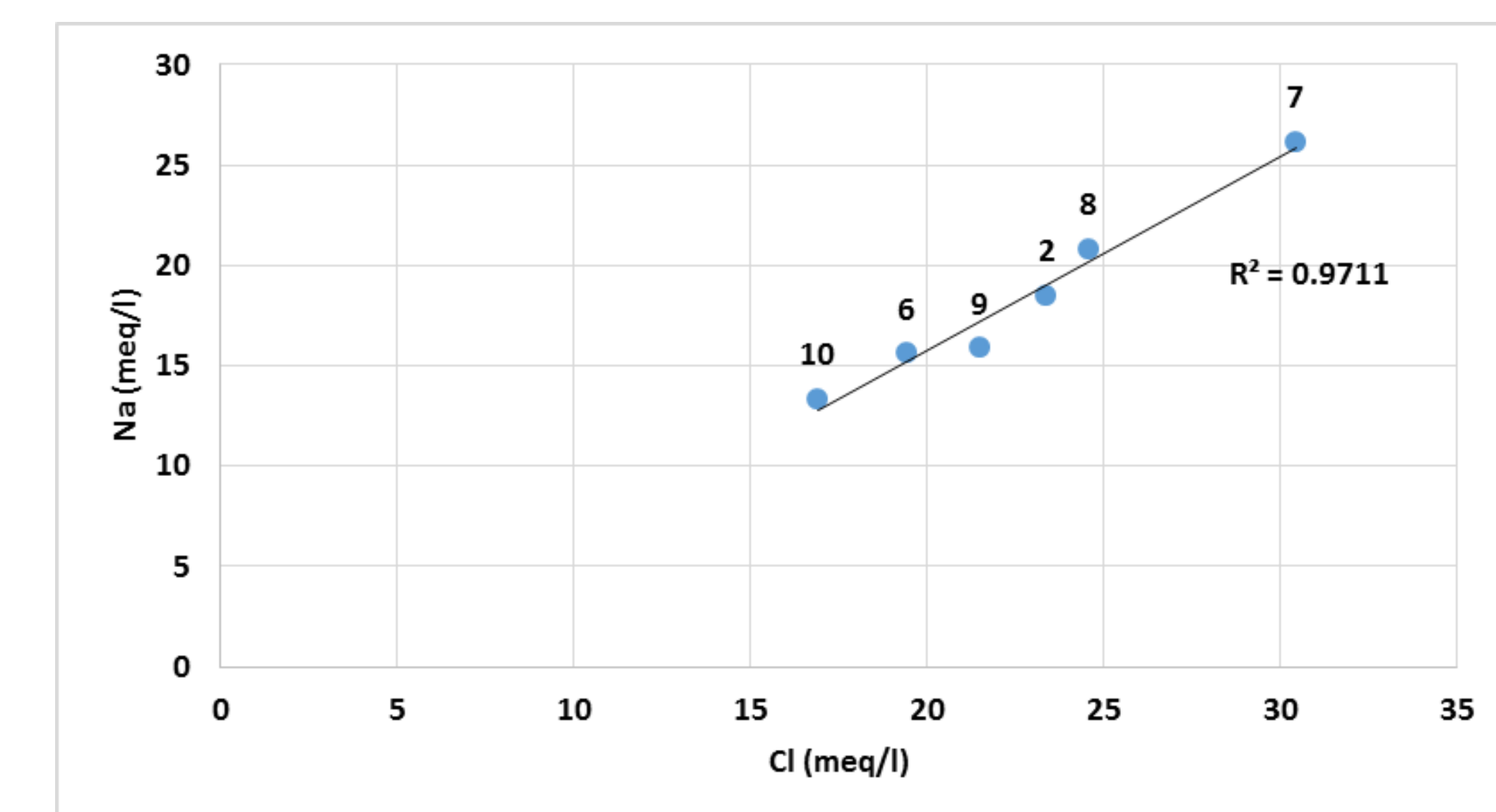


2 – Methods and Results

In November 2013, February 2014 and May 2014, 3 groundwater level (GWL) surveys were carried out in the area. In total 11 groundwater wells have been measured. The depth of the wells is between 5.5 and 37 m. During the surveys, the measured GWL is in the range -0.8÷2.6 m a.s.l. In May 2014, the GW EC, TDS, pH and T parameters were measured in 6 of the 11 wells. At the same time, 6 GW samples were sampled from the same wells. Successively, the samples have been analyzed in laboratory and the ions contents have been estimated.



Well	Date	EC (µS/cm)	TDS (mg/l)	T (°C)	pH	Cl (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Sr (meq/l)	Li (meq/l)	Ca (meq/l)	B (meq/l)
1	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1	may-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	nov-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	may-14	3720	2300	24.1	9.02	19.594	4.408	18.47	0.686	0.01	0.001	6.759	0.264
3	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	may-14	4640	2880	21.1	7.58	ND	3.995	27.483	0.488	0.012	0.001	11.103	0.303
4	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	may-14	ND	ND	ND	ND	32.893	ND	ND	ND	ND	ND	ND	ND
5	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	may-14	ND	ND	ND	ND	2.592	8.913	0.381	0.007	0.001	6.979	0.24	ND
6	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	may-14	2920	1812	21.5	ND	16.316	7.679	15.587	0.418	0.01	0.001	8.525	0.306
7	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	may-14	4320	2720	21.2	7.32	25.444	ND	26.126	0.778	0.013	0.001	10.701	0.422
8	nov-13	ND	ND	ND	7.03	ND	ND	ND	ND	ND	ND	ND	ND
8	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	may-14	3620	2240	23.5	7.05	20.589	4.681	20.817	0.508	0.012	0.0004	10.639	0.434
9	nov-13	ND	ND	ND	7.32	ND	ND	ND	ND	ND	ND	ND	ND
9	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9	may-14	3410	2110	20.3	ND	18.016	4	15.861	0.492	0.009	0.001	7.038	0.306
10	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	may-14	2720	1689	20.3	ND	14.197	3.661	13.335	0.818	0.011	0.001	9.184	0.322
11	nov-13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	feb-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	may-14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND



3 – Discussion and Conclusion

The results of the surveys have highlighted as the groundwater level changes during the year. Groundwater level variation can be linked to the local meteoric recharge.

The elaboration of potentiometric maps shows an overall Groundwater flowing from the most elevated areas to lower ones, and a general flow from the continental to the coastal areas; in the main valleys, the groundwater moves from SW to NE. The TDS is in the range 1.6-2.9 g/l. The chemical analyses show the presence of two groundwater types in the area: one of them is rich in Cl, Na and B content; the other one is depleted in the content of the same ions. Moreover some samples have an ions content that is a mixing between the two groundwater types. The EC and TDS measures and the chemical analysis highlight the presence of a saltwater intrusion in the study area from the NE coast and the presence of isolated and “trapped” saltwater in the bedrock.