Signature of the 24th December 2018 eruption of Mt. Etna on the chemical composition of bulk deposition in the Siracusa area (Italy)

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Mt. Etna, in the eastern coast of Sicily (Italy), is one of the most active and most intensely monitored volcanoes of the planet. It is widely recognized as a big source of volcanic gases, such as CO_2, SO_2 and halogens, to the troposphere in the Mediterranean basin, and its gas emissions account for a significant percentage respect to the worldwide average volcanic budget. The SO_2 flux from Mt. Etna's plume has been routinely measured by the INGV since 1987. SO_2 flux ranges between 600 to 25000 Mg/d; fluxes greater than 100000 Mg/d were prevalently measured during eruptive events. During eruptive periods, Etna's emissions can be dispersed over long distances and cover wide areas of the Mediterranean region.
Mt. Etna is also considered a huge source of many trace elements to the atmosphere on regional and global scale.
On the morning of December 24th 2018, a moderate lateral eruption of the Mt. Etna started. This eruption was related to an intrusion of a magmatic dike on the high eastern flank of the volcano, through a 2 kilometres long fracture in the NNW - SSE direction. At the same time, the summit craters produced a continuous strombolian activity generating a very dense ash plume, dispersed by the wind into the S/SE direction.
From June 2018 to June 2019, atmospheric precipitations were collected in the area of Siracusa, a city on the east coast of Sicily, about 80 km SSE of Mt. Etna, and in the area of Milazzo, a city on the northern coast of Sicily. Atmospheric precipitations were monthly collected through a network of 12 pluviometers; the collectors were open during the entire exposure time, receiving both wet and dry deposition (bulk collectors). All the collected water samples were analysed for major ion contents and for a large number of trace elements by ICP-OES and ICP-MS.
During the eruptive period (from 24th to 27th December 2018), the prevailing winds blew from the North direction and there were light rainfalls in the monitored sites (between 0.2 mm in Siracusa and Augusta, and 1.6 mm in Palazzolo Acreide). As a consequence, gases and particles of Etna's plume were carried for long distance from the emission point, and they were deposited as dry and wet deposition also in the area of Siracusa. During the eruption event and in the following days, the plume reached distances of more than 300 km from the emission point (island of Malta).
The samples collected in the study area of Siracusa during the period straddling the eruptive event are characterized by high concentrations of some major ions, such as Fluoride (up to 0.88 mg/l), Chloride (up to 124 mg/l) and Sulphate (23.1 mg/l). These ions derive mainly from the emitted volcanic gases (HF, HCl and SO_2).
The effect of the described eruption is also visible in the high concentrations of some trace elements, such as Aluminium, Thallium and Tellurium. The mean concentrations of the selected trace elements in the samples collected in the area of Siracusa, in the period before the eruptive event, are: 18.2 µg/l for Aluminium, 0.009 µg/l for Thallium, while Tellurium was always under

the detection limit (0.004 µg/l); the concentrations of the same elements in the samples collected during the eruptive event reach 152 µg/l for Aluminium, 0.16 Âg/l for Thallium and 0.025 µg/l for Tellurium, therefore showing a strong enrichment.
While Thallium and Tellurium are highly volatile elements typically enriched in volcanic emissions, Aluminium is a refractory element that was probably released by the dissolution of the related volcanic ashes.
The study area of Milazzo, due to the prevailing winds from the North direction during the period of the eruption, has not been affected by the plume and therefore the signature of the eruption is not visible in the samples collected in that area, as shown by the mean values of the selected trace elements: 24.2 µg/l, 0.026 µg/l and < 0.004 µg/l for Aluminum, Thallium and Tellurium respectively.
In conclusion, close to active volcanic areas, volcanic emissions have to be considered among the major contributors to the chemistry of rainwater, especially during eruptive periods.