Spring waters and the birth of a civilization, Sacred Waters of Roman Forum, physical chemical analysis of the sources in the III Millennium, a training study

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Introduction

Lot of ancient cities have born "around" a water spring, as Jerusalem[1], Costantinople, Athens and Rome that must be considered one of the richest city of spring sources. Starting from 1000 b.C., thank to the presence of Tiber, Romans have had a great availability of water sources [2]. The increase of citizens (someone talk about more then 1 million in the golden age) led to the need of more and more water; so, in 312 b.C. the first Roman's Aqueducts was constructed, because natural water springs were not enough anymore. When the Forum became the cultural and government centre of Rome the water sources inside it, as Juturnae, Tullianum, Lacus Curtius, became sacred, visited by a lot of pilgrims. During the medieval period, some of these springs started to be used again, but only for a short period, while today just few of them are still accessible.

In order to compare different spring-waters emerging in the area of the Roman Forum (Rome, Italy), a series of measurements "in situ" and "in lab" campaigns started some years ago [3]. A chemical-physical characterization of height sources and two standpipes (see the background map and relative legend) have been performed.

Here we are presenting results obtained in the two last measurement campaigns (March and August 2017). Temperature, pH, Conductivity, Cations, Anions and UV-Visible spectra are reported.

Legend:

Green dots: measured outcropping: 1) balneae of Palazzo Valentini 2), well recently excavated on Traiane temple, 3) basilica Ulpia (P. Funtinalis?), 4) Tullianum, 5) Lapis Niger, 6 -7) wells inside and outside Divo Romolo Temple,) 8) Juturnae

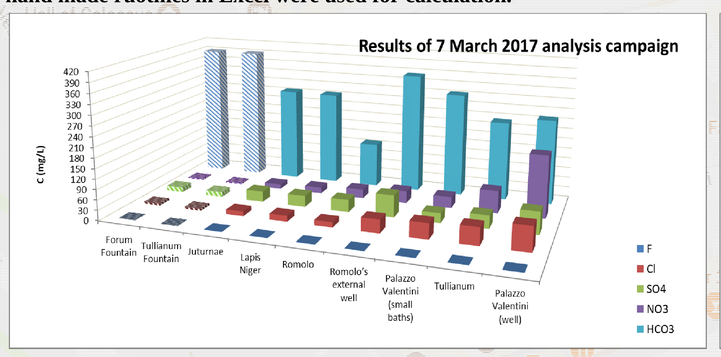
Blue dots: A) and B) standpipes (tap water)

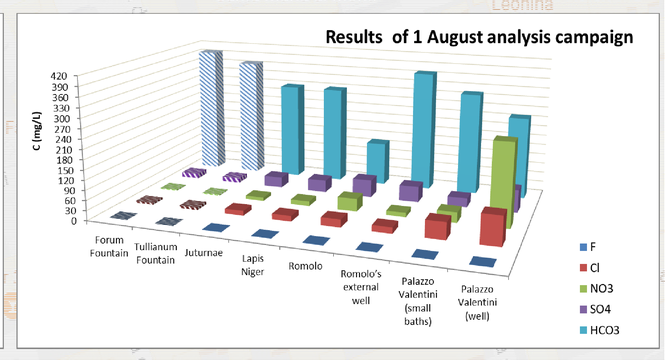
Orange dots: estimated position of Romans era sources currently not accessible W) Acque Fontinalis (del Grillo?), X) Cisterns of Vittoriano, Y) Meta Sudans, Z) Lupercale

Anions analysis

All the anions, except for bicarbonate, were identified and quantified by ion cromatography [4]. A Metrohm 761 Compact IC was used; it was equipped with Dionex AS14 column while the mobile phase was a mixture of Na2CO3 2.3 mM + NaHCO3 2.2 mM + CH3OH 1%.

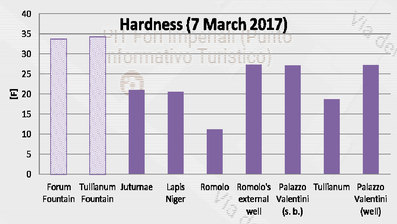
Bicarbonates were determined by a titration performed with an Amel Instruments Digital Burette Model 233 and was followed by an Amel pHmeter 338, equipped with Crison 12-02 pH electrode, using a HCl 0.1M Normex as titrant. In addition to Metrohm software, Kaleidagraph and hand made ruotines in Excel were used for calculation.

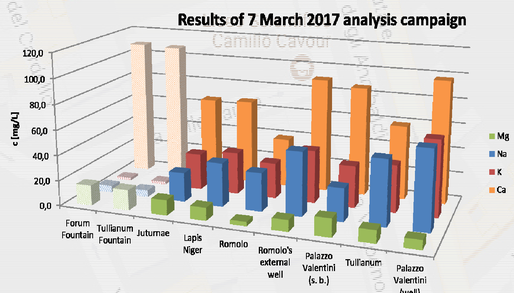


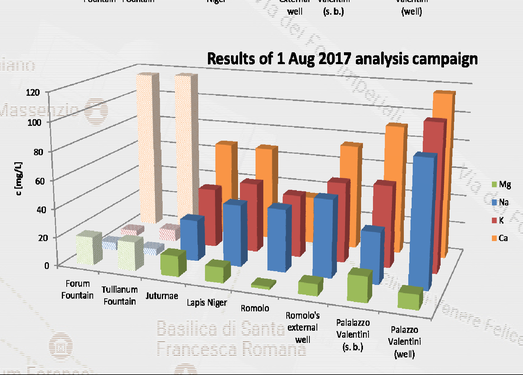


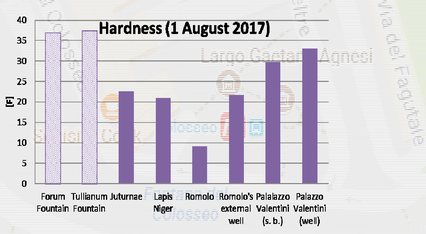
Cations analysis

Cations have been quantified by ion cromatography [5]. Instrumental equipment consisted into a Metrohm IC 761 provided with Metrosep C2-250 and their Guard column. Mobile phases used were a mixture of 2.5 mM HNO_3 + 0.5 mM Oxalic Acid + Acetone 1% for the first analysis campaign, Tartaric Acid 4.0 mM + Dipicolinc Acid 0.75 mM + CH_3CN 1% for the second one.



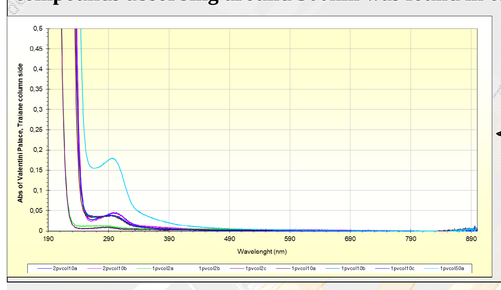


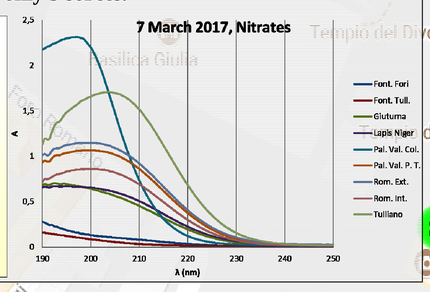




UV-Visible spectra

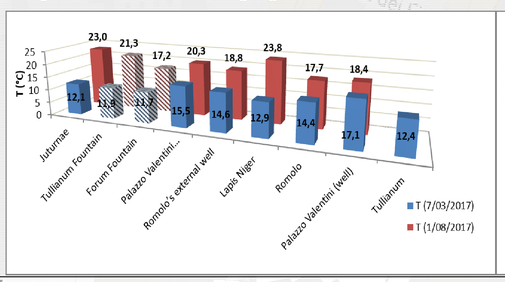
The presence of nitrates and organic compounds has been evaluated using a Lambda 16 Perkin Elmr UV-Vis spectrophotometer equipped with 2 mm, 10 mm and 50 mm cuvettes (Helma). Nitrate presence was evidenced in all the samples (left graph) while organic compounds absorbing around 300nm was found in only 3 sorces.

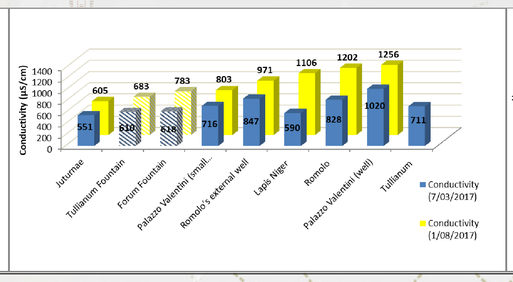


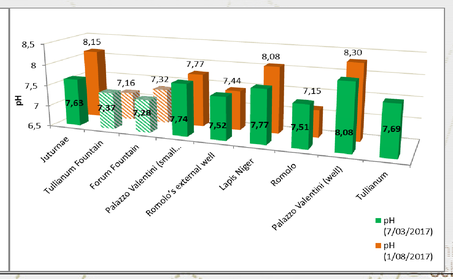


In situ measure

Temperature Conductivity and pH, measured "in situ" by portable instruments (Hanna Instruments) in the two campaigns on all the sources, are compared in the following figures.







Conclusions

The main conclusions useful for the classification of the springs are:

• In all sources no color, that is one of the first requisite for drink water, were evidenced from the Visible spectra, Organic compounds, probably humic acids, absorbing around 300nm were detected so needing deepest investigation;

• Springs inside the Roman Forum show the lowest cations/anions total content in agreement with data from previous campaigns [3];

• A significant mixing with public water supply can be excluded due to the different "fingerprint" imparted by cations/anions chromatograms and Hardness values.

A plausible hypothesis could be that all the spring waters come from the same stratum and their different composition is due to the different kind of ground that they cross before emerging.

A better classification, after some other campaigns already preventivate, will be obtained by a Chemometric data treatment, using knowhow of this research group.

Geological and microbiological data should be added for a better classification and, may be, to estimate if these spring waters were drinkable in the ancient Roman period.

References

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