

## BRACCIANO' S LAKE WATERS: AN EXPERIMENTAL SURVEY ON THE SURFACE LAYER POLLUTION

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*Summary* - The chemical and trophic conditions of the surface waters of the lake Bracciano, near Roma, have been investigated all through the year 2005. Electrical conductivity, pH, alkalinity, hardness, total nitrogen, phosphorus content, chloride, fluoride and sulphate ions were measured. The results were compared with similar analyses formerly carried out by different authors, to achieve a right evaluation of the actual quality of the surface waters of the lake Bracciano all over the year 2005.

### INTRODUCTION

Everybody knows that water supply represents an ancient and serious emergency all over the industrialized and developing world, both for drinking and farming needs. The lake district of Roma (Bracciano, Albano, and Nemi) constitutes the water reservoir for the city of Roma itself and for the Albano and Sabatino hills belt. Nevertheless first lake is surely more important, because Albano and Nemi lakes refurnish water only for agricultural use, whilst lake Bracciano is the main reservoir for drinking water for Roma<sup>1-3</sup>.

In recent years the authors carried out two analytical campaigns relating to the surface water of the Albano and Nemi volcanic lakes, to evaluate the main chemicals polluting species and to identify the present quality of their waters<sup>4,5</sup>.

Because of the great importance of lake Bracciano, the authors carry on their campaigns of chemical analyses on its surface water layer too. Data showing the trend on time of chemical composition of the waters are practically absent in the current literature, a very strange and worrying consideration, taking into account that Italian legislation (Law 36/94) states that all the public water suppliers (ACEA for Roma) must publish the chemical and biological composition of their waters.

The lake district of Central Italy<sup>6</sup>, including twelve lakes and a total water volume of 14.8 km<sup>3</sup>, is the second in Italy after the Alpine lake district (Lombardia Region). Lake Bracciano (lake area = 57 km<sup>2</sup>, watershed area = 89.7 km<sup>2</sup>, max depth = 165 m, mean depth = 88.6 m, theoretical water renewal time = 165 years, water volume = 5050 10<sup>6</sup> m<sup>3</sup>) represents, with its water volume, the 34% of stored freshwater in the area of Central Italy. The strategic weight of this lake is clear and enlarged by its location and above all by the fact that its water is already used for drinking supply to the city of Roma.

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Despite this, as previously reported, the papers including quantitative information on the water chemistry of this lake are few and defective<sup>7-9</sup> even if a number of biological studies are available<sup>10,11</sup>. Particularly Margaritora F.<sup>11</sup>, in a recent paper (2003), concludes that lake Bracciano, owing the presence of an efficient ring of wastewater treating system, exhibits the best conditions, in comparison with the remaining lake of Central Italy (Albano, Martignano, Nemi and Vico). Nevertheless it must be pointed out that in the stratum water near the lake various pesticides were detected<sup>12</sup>; moreover the presence of fluoride ions was identified both in the lake water and in the surrounding groundwater, probably due to the volcanic origin of the area<sup>7,9</sup>.

## EXPERIMENTALS

During the 2005 year, water sampling was performed on February, May, August and November: the samples were collected 1 meter depth and 5 meters from the shore. The samples were collected almost three days after rainfall during a shiny day at noon. Six sampling sites were chosen: (1) Bracciano (Forestale cottage), (2) Vicarello (near farm house), (3) Trevignano (pier), (4) Anguillara (pier), (5) Vigna di Valle (bathing establishments) and (6) Bracciano (S. Celso shore), see figure 1.

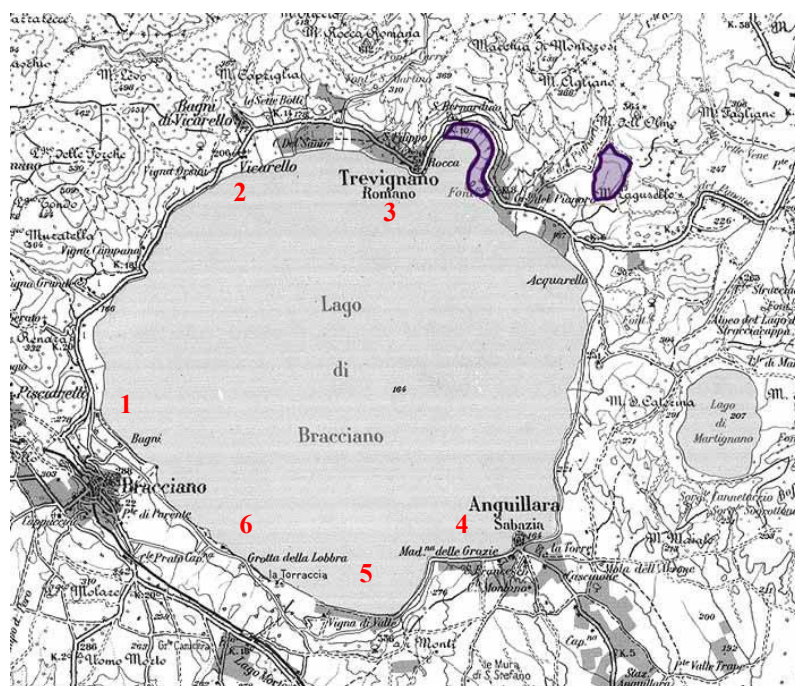


FIGURE 1 - Lake Bracciano, sampling sites.

All the samples were collected following the ASTM standard Method D 3370<sup>13</sup> then stored in the laboratory following the same standard. For the collection, a special glass container was used (to avoid bubbling); a total volume of 6 litres allowed the repetition of each analytical determination.

Electrical conductivity and pH were measured in place with portable instruments (Hanna Instrumets). Total nitrogen content (TKN) was determined by means of the classic Kjeldahl method, after concentration (volume 1:10) by distillation<sup>14</sup>. Total alkalinity (Warder method), total hardness (complexometric titration), total dissolved solids (drying at 110 °C) were also determined.

Phosphorus, as o-phosphate ions, was measured by colorimetry (Hellige Instruments) following ASTM D515 (phospho-molibdate method). Chloride, sulphate and fluoride ions were determined by ion - cromatography (Dionex DX120).

## RESULTS

The average values of pH, electrical conductivity, total dissolved solids and total nitrogen content are depicted in figure 2, 3, 4 and 5 respectively. Different instrumental determinations (pH and conductivity), for the same sample, gave values within the sensitivity of the instrument. In the graphs, the curves differ one another because of the different months of sampling.

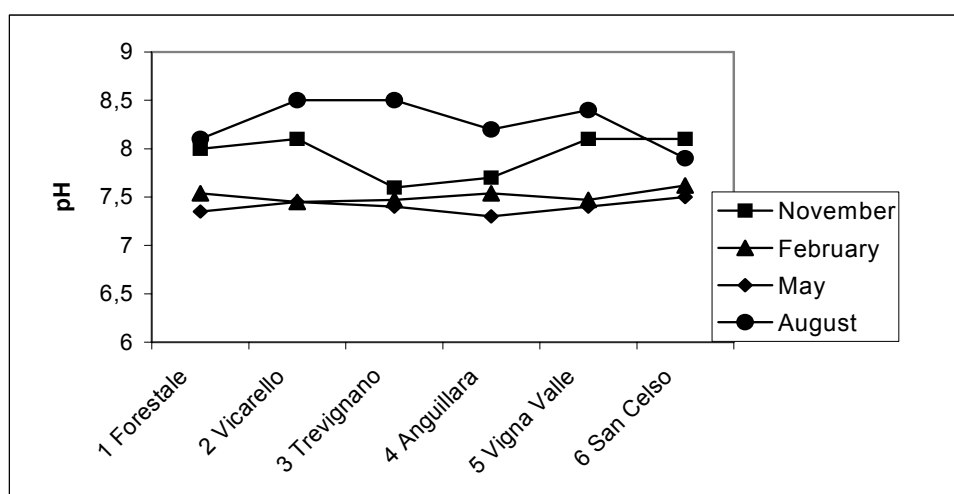


FIGURE 2 - pH as function of the sampling month.

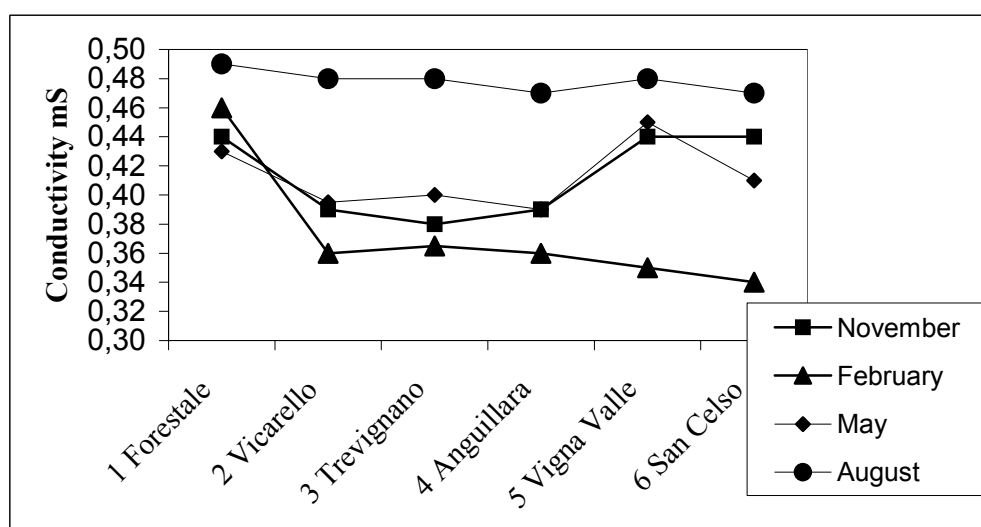


FIGURE 3 - Electrical conductivity as function of the sampling month.

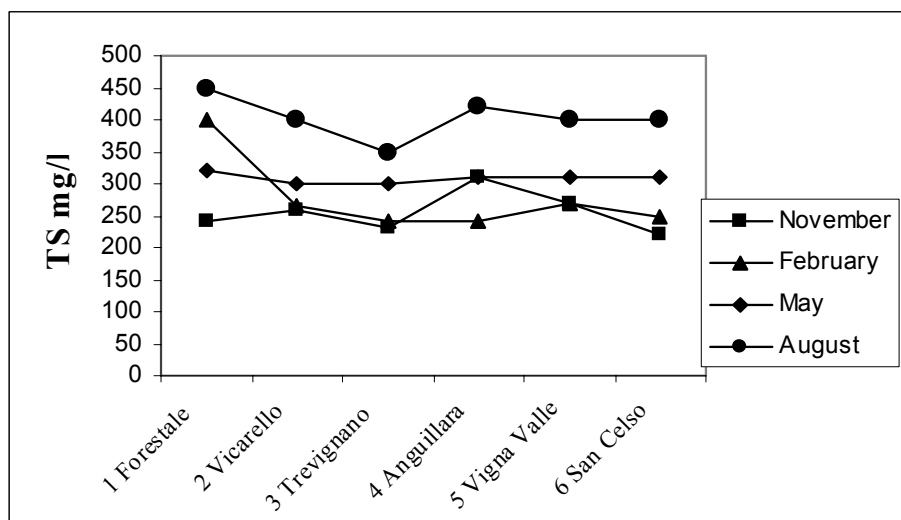


FIGURE 4 - Total Dissolved Solids as function of sampling month.

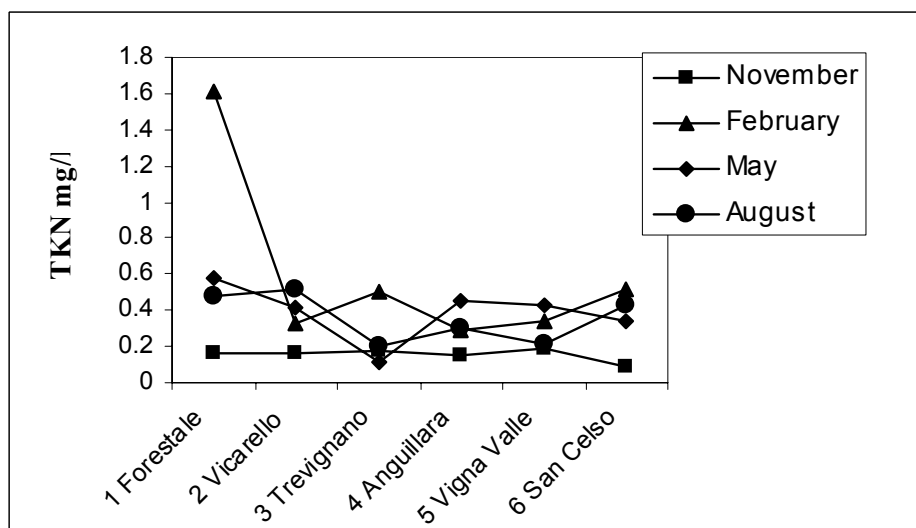


FIGURE 5 - Total Nitrogen Content as function of sampling month.

Table 1 reports the minimum and maximum values measured for the alkalinity, hardness, total nitrogen and o-phosphate ion. Instead table 2 reports the obtained values for chloride, fluoride and sulphate ions; for these ions analytical determinations of the month were carried out on a mixed sample collected from the six sites.

TABLE 1 – Analytical results, in the brackets the site.

	Total Alkalinity mg/l CaCO <sub>3</sub> (± 5)		Total Hardness ° F (± 0.2)		Total Nitrogen mg/l (± 0.05)		O -phosphate ion (as P) mg/l (Ident. limit = 1 mg/l)	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
February	200 (2)	150 (1)	10.5 (5)	9.0 (2)	1.61 (1)	0.24 (4)	25 (1)	< 15 (oth.)
May	205 (3)	165 (5)	11.0 (1)	9.0 (3)	0.58 (1)	0.45 (4)	15 (1)	< 15 (oth.)
August	195 (1)	155 (4)	10.0 (1)	8.0 (3)	0.51 (2)	0.20 (3)	< 15	< 15
November	200 (6)	170 (3)	10.0 (3)	9.0 (2)	0.19 (1)	0.10 (6)	< 15	< 15

TABLE 2 – Analytical results (chromatography): values on the mixed samples for the six sampling sites.

	Sulphate ion mg/l (SO <sub>4</sub> <sup>2-</sup> ) (± 0.1)	Chloride ion mg/l (Cl <sup>-</sup> ) (± 0.1)	Fluoride ions mg/l (F <sup>-</sup> ) (± 0.08)
February	26.5	55.3	1.41
May	33.5	60.1	1.28
August	25.6	35.7	1.37
November	24.6	53.7	1.38

## DISCUSSION OF THE RESULTS

The main experimental results show:

- pH values ranging between 7.3 and 8.5;
- electrical conductivity: 0.34 – 0.49 mS;
- total dissolved solids: 240 – 450 mg/l;
- total hardness: 8.5 – 10 °F;
- total alkalinity: 3.1 and 4.0 meq/l.

The highest values are generally detected on august. The values for hardness, alkalinity and the relative content of some ions (like HCO<sub>3</sub><sup>-</sup> > Ca<sup>+2</sup>, Mg<sup>+2</sup> > Cl<sup>-</sup> > SO<sub>4</sub><sup>2-</sup>) are in good agreement with those recently found (2004) by Mosello R.<sup>6</sup>. In figure 5 are reported the values of total nitrogen content, that exceed those formerly obtained from the literature: the data, summarized as total mean values in table 3, allow the comparison.

TABLE 3 – Total nitrogen and phosphorus concentration: a comparison.

	Total nitrogen (mg/l)	Total phosphorus (µg/l)	Number of samples
Botrè C. 1973, [7]	Not detected	Not detected	13 samples
Pagnotta R. 1986, [8]	0.008	11.5	Not indicated
Ferrara O. 2000, [10]	0.29	9	Not indicated
Medici F. and oth. 2005	0.37	<15	48 samples

On the contrary the total phosphorus content is practically always under the value of 15 mg/l (as P), linking up the results obtained by Margaritora F.<sup>11</sup>; nevertheless, it must be pointed out that, following the Italian regulation (D. Law 152/199, attachment 1, table 11), concerning the protection of the waters, this value of o – phosphate ions could allow the location of the lake in class 2, even if our analyses concern the surface water alone.

The detected yearly increased values of the total nitrogen content all over the coast line suggests some considerations, above all for the sampling site N. 1 (Bracciano, Forestale cottage), where the pollution level can be regarded alarming. In fact there was a peak of concentration (1.61 mg/l) on February, whereas the nitrogen content is always higher in comparison with the remaining sites. The contemporary result for the phosphorus content in the same point and month (25 mg/l) reveals an almost sure fecal contamination in the water layer.

The determination of the total nitrogen in this site (N.1) was repeated four times and this “steady” peak concentration probably is attributable to a continuous wastewater discharge from the Bracciano village.

Another consideration, rising from the ratio 1:10 between the o-phosphate ion and the total nitrogen content (for all the collected samples), distinctive of the water soluble fraction of the ordinary farming fertilizers, is that this “steady” pollution comes from the bordering agricultural activities.

Last, but not least, the fluoride ions content could be considered “dangerous”, even if the lake Bracciano is well – known from the past for its high content of fluoride ions<sup>7,9</sup>; the obtained values allow the location of the water at the border of the category A2, concerning the waters intended for the production of drinking waters (D. Law 152/99, attachment 2, table 1/A).

## CONCLUSIONS

Even if our chemical analyses concerned the surface layer alone of the waters, the lake Bracciano, owing its function of “reservoir” for the city of Roma, in our opinion deserves much more attention: in fact there are strangely too few published results concerning the presence of chemical pollutants.

Our results clearly show an increase in the total nitrogen content all over the surface waters, while the remaining parameters are lining with the previous literature data.

Furthermore, the measured content of fluoride ions reaches 1.41 mg/l (see table 2); and even if fluorides are usually present in water nearby volcanic area, the Italian limiting values for drinking water (D.Law 31/2001) is only 1.5 mg/l, very close to the present measured value.

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