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RESEARCH ARTICLE

'Who can tell me what potable water means?' The assessment of water quality in debates over hydraulic infrastructure in nineteenth-century Italy

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Abstract

How water is perceived and represented has an impact on the relationships between a given society and its water infrastructure. Historians have identified a shift in the perception of water during the nineteenth century, which was connected to the development of chemistry. From an understanding based in Hippocratic medicine and natural history that treated it as an infinite variety of substances, water eventually became understood as a simple compound consisting of oxygen and hydrogen. This resulted in the abstraction of water from its social and environmental contexts, with consequences for the way water was managed. This article aims to demonstrate that such a view gives a mistaken intellectual coherence to a fragmented and conflicted process, which involved continuities, an adaptation of old frameworks to new social priorities, and fine changes in scientific thinking and practices. This paper examines the scientific and political debates concerning water infrastructure, surveys and analyses on water quality, medical reports and political measures in nineteenth-century Italy. Ultimately, the reduction of 'waters' to 'water' in Italy was more about determining who had the authority to assess water quality in the process of creating and stabilizing new power relations between the public and the private spheres than about the abstraction of water from its social and environmental contexts.

In 1868, the Venice city council was discussing several projects intended to carry additional water to the lagoon city. Engineer Demetrio Busoni wanted the council to adopt a precise criterion for measuring the quality of the aqueduct's water source, rather than a generic concept of potability, because, as he asked, 'who can tell me what potable water means? When does water stop being drinkable? It is not a well-defined concept to me. Water that is drinkable in Venice may not be drinkable in Rome'.[1] Water quality was perceived as being site-specific in a way that was linked with local habits.

In every society, the perception of water is influenced by general patterns of thinking, beliefs, social dynamics, political institutions, economic interests and material objects. Hence what constitutes good drinking water varies across time, space, societies and cultures, as well as among individuals. Defining the criteria for good water involves multiple

[1] Consiglio Comunale di Venezia, *Discussione sui Vari Progetti d'Acquedotto*, Venice: Tipografia Naratovich, 1868, p. 183.

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questions. What is the best way to transport and store water? Is it necessary to switch water sources and related devices? Do large investments need to be sustained for a switch from one water system to another? Is there a cheaper but equally valid alternative? Should members of a given society pay for access to low-quality water?

In nineteenth-century Italy, different communities perceived water in different ways, making the definition of good drinking water a complex matter which some thought required more precise characterization. This article examines the slow, contested and uneven changes that occurred in the conceptualization of good drinking water; investigates which social groups became authoritative about this issue; and explores the dynamic between the debate about water quality and the search for new water infrastructure in nineteenth-century Italian cities, a process which involved a cluster of complex relationships related to culture, scientific practices and politics.

Some scholars have tried to relate the changes that occurred in water management in the nineteenth and twentieth centuries to a paradigm shift in water conceptualization. For Christopher Hamlin, for example, during the nineteenth century, a shift took place from 'waters', understood in Hippocratic medicine and classical natural history as an infinite variety of substances that had different qualities and effects on health, to 'water', a reductionist view of water as a compound made of hydrogen and oxygen, which could contain a variable degree of external substances.[2] For Jamie Linton, between the nineteenth and twentieth centuries, water became known as H_2O, a monolithic substance and resource, whose components and rules could be translated into mathematical formulae, thus abstracting water from the environmental, social and cultural contexts in which it occurred.[3]

This view captures the trajectory of a process that was consistent in nineteenth-century Western societies, but which gives an intellectual coherence to a process that was fragmented and conflictual, a matter of continuities, adaptation of old frameworks to new social priorities, and fine changes in scientific thinking and practices. Despite an emergent scientific master narrative of precision, abstraction and standardization of the biophysical world, water 'continued to be encountered, manipulated, consumed, and represented in ways that reflected its diverse origins, contexts, and qualities' well into the mid-twentieth century.[4] This is not surprising. Material and intellectual developments regarding water quality were constructed in a dialectic manner amidst discussions and projects for water infrastructure, and, more generally, water management issues, which were deeply rooted in specific social and spatial contexts.

Nineteenth-century Italy is a fascinating case for analysing this topic. Italy had areas where water was abundant and others where it was scarce, because of its varied geography and different climates. This resulted in a diversification in the hydraulic cultures from one area to another, which had practical effects in terms of the adopted infrastructure: spring-fed aqueducts, canals to catch underground aquifers (like the *qanat*, which illustrates the transfer of technologies from North Africa to Europe), groundwater wells, rainwater cisterns and direct catchment from rivers and lakes.[5] While Italy was at the periphery of scientific knowledge production in early nineteenth-century

[2] Christopher Hamlin, '"Waters" or "water": master narratives in water history and their implications for contemporary water policy', *Water Policy* (2000) 2(4–5), pp. 313–25.

[3] Jamie Linton, *What Is Water? The History of a Modern Abstraction*, Toronto and Vancouver: UBC Press, 2010, p. 6.

[4] Giacomo Parrinello, Etienne Benson and Wilko Graf von Hardenberg, 'Estimated truths: water, science, and the politics of approximation', *Journal of Historical Geography* (2020) 68(2), pp. 3–10, 6.

[5] David Gentilcore, 'The cistern-system of early modern Venice: technology, politics and culture in a hydraulic society', *Water History* (2021) 13(3), pp. 375–406; Pietro Todaro, 'Sistemi d'acqua tradizionali siciliani: qanat, ingruttati e pozzi allaccianti nella Piana di Palermo', *Geologia dell'Ambiente* (2014) 22(4), pp. 19–28; Katherine Rinne, *The Waters of Rome: Aqueducts, Fountains, and the Birth of the Baroque City*, New Haven, CT: Yale University

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Europe, its scholars increasingly participated in the latest debates and techniques of scientific inquiry.[6] At the same time, however, Hippocrates' *Airs, Waters, and Places* and the related medical framework for understanding the relationships between water and disease had long been accepted in Italy, dating back to the Renaissance, when this treatise stimulated public debates in Italian cities on the necessity of providing enough quality drinking water to the population.[7] One of the peculiarities of nineteenth-century Italy, in fact, is the way in which tradition and innovation entwined in the pursuit of good water.

The present article is structured in three sections. First, I examine how authoritative claims about water quality were subject to different ways of knowing water, without chemistry playing a dominant role, between the 1830s and 1860s. Second, I scrutinize the rise in popularity of the concept of impurities in water analysis. I look at the practical consequences this had in Italian cities such as Rome, and how this shift was contested and evidence was disputed, revealing the role that water analysis played in shaping and consolidating a certain water policy. Finally, I analyse national surveys on public health and water quality, the practices of national laboratories for water analysis, and the development of state power over local water policies between the mid-1880s and 1900. In this way, I want to show that the reduction of 'waters' to 'water' in Italy was more about reducing who had the authority to assess water quality in the process of creating and stabilizing new power relations between the centre and periphery, as well as in the public and the private spheres, than about the abstraction of water from its specific contexts.

The uncertain nature of water in the early nineteenth century

In Britain, from the first half of the nineteenth century, chemists were in the process of establishing themselves as an authority on the evaluation of water, as a consequence of a combination of the needs of an industrial society to resolve social questions by technical means and aggressive professional promotion.[8] In Germany, the Justus von Liebig school in Giessen provided the profession with a place for practical training and a centre for influencing the production of knowledge: at the time, there was no analogous context or school of chemistry for training in Italy.[9] Hence, if some Italian authors were aware of the new chemistry, this was not a predominant way of perceiving and representing water in the early nineteenth century.[10] Architects, engineers, physicians, city councillors and laymen discussed and debated the meaning of water. Their assessments were based on notions of water derived from classical authors, empirical experience and water's suitability to practical tasks. A good example of this can be found in Rome, where, from the 1820s, ways of building a new aqueduct to provide fresh water to districts of the city not

Press, 2010; Emanuela Ferretti, *Acquedotti e Fontane del Rinascimento in Toscana: Acqua, Architettura e Città al Tempo di Cosimo I dei Medici*, Florence: Olschki, 2010.

6 Maria Pia Donato, 'Science on the fringe of the empire: the Academy of the Linceans in the early nineteenth century', *Nuncius* (2012) 17(1), pp. 10–40; Marco Ciardi, *Reazioni Tricolori: Aspetti della Chimica Italiana nell'età del Risorgimento*, Milan: Franco Angeli, 2010.

7 Nancy G. Siraisi, *History, Medicine, and the Traditions of Renaissance Learning*, Ann Arbor: University of Michigan Press, 2007, pp. 93–6, 177; Sandra Cavallo and Tessa Storey, *Healthy Living in Late Renaissance Italy*, Oxford: Oxford University Press, 2013, p. 220.

8 Christopher Hamlin, *A Science of Impurity: Water Analysis in Nineteenth Century Britain*, Berkeley, Los Angeles and Oxford: University of California Press, 1990, pp. 48–9.

9 Frederic L. Holmes, 'The complementarity of teaching and research in Liebig's laboratory', *Osiris* (1989) 5, pp. 121–64.

10 David Gentilcore, '"La qualità delle acque": Le risorse idriche nel Regno di Napoli all'inizio dell'Ottocento', in Elisabetta Bini, Diego Carnevale and Domenico Cecere (eds.) *L'Acqua: Risorsa e Minaccia: la Gestione delle Risorse Idriche e delle Inondazioni in Europa dal Medioevo all'Età Contemporanea*, Naples: Federico II University Press, 2023, 161–85.

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connected with the late Renaissance aqueducts were discussed.[11] In 1828 Carlo Fea, archaeologist and president of the Capitoline Museum, tried to find some of the local springs that had been in use in imperial Rome.[12] He adopted a process of learning and information organization strategies similar to that of early modern men of learning, which was a mixture of archaeology, the works of Ovid and Titus Livius and notions of hydraulics. In this way, Fea identified the Mercury springs as a 'prodigious water for the ancient Romans, due to its pleasant taste and healthfulness'.[13] He assessed the quality of this water by referring to the works of Vitruvius and Pliny the Elder in combination with the performative properties of water like boiling legumes, dissolving soap, sensorial assessment and physiological experience.[14] In short, the assessment of water was a sophisticated mixture of antiquarian knowledge, direct observation, human physiology and practical suitability.

Around the same time, Pietro Carpi, professor of chemistry at the Seminario Romano, analysed the waters of Rome according to chemical principles.[15] Carpi was aware of the systematic approach developed between 1760 and 1830 by European chemists, citing Torbern Bergman, Richard Kirwan, Jacob Berzelius and Antoine-François de Fourcoy. Hence Carpi focused on 'adventitious substances' in water but continued to relate his findings to the Hippocratic conceptualization of water. In this, his practice was unlike that of his European counterparts, Bergman in particular, who refuted the methods and perceptions of the ancient authors.[16] Carpi referred to Hippocrates' treatise to demonstrate the relevance of good water provision for human societies, but was most influenced by the eighteenth-century Roman physician Giovanni Maria Lancisi, who published a volume in 1711 on the qualities of Rome's environment, including water.[17] Analysing the Lancisiana water (named after the aforementioned physician), an urban spring on the right bank of the Tiber, Carpi discovered it had a large concentration of solid substances, a negative indicator for the chemistry of the time. However, because 'it is digested and passes through urine easily', it had to be considered excellent water.[18] In his report, there were frequent references to people's opinion of waters, for which he usually agreed to relating popular preferences with the levels and types of minerals dissolved in water. Carpi's analytical tools included opinions of past authorities, the human body as the most sophisticated way to evaluate water quality, people's opinions, and chemistry, among others.

However, the true nature of water and its effects on health remained uncertain and approximate. The frequent methodological changes that occurred in European chemistry during the nineteenth century, and the fierce controversies on what method was best to understand water, were an indication of the fact that, despite their assertiveness, chemists struggled to penetrate water's secrets and offer a decontextualized perspective.[19] In 1857, the Neapolitan physician Mariano Semmola, studying the relationship between endemic

[11] Angelo Vescovali, 'Sulla forza motrice idraulica utilizzata in Roma e convenienza del suo accrescimento', *Giornale delle Strade Ferrate* (1858) 15, pp. 234–6.

[12] Carlo Fea, *Storia della Scoperta dell'Antica Acqua di Mercurio*, Rome, 1828.

[13] Carlo Fea, *Storia delle Antiche Acque Sorgenti in Roma*, Rome: Stamperia della Regia Camera Apostolica, 1832, p. 2.

[14] He referred to Giuseppe Benvenuti, *Riflessioni ed Esperienze sulla Natura, Qualità, e Scelta dell'Acqua*, Lucca: Stamperia Jacopo Giusti, 1769, pp. 16–17.

[15] Pietro Carpi, *Esame Fisico-Chimico delle Acque Potabili di Roma*, Rome: Antonio Boulzaler, 1831.

[16] Armel Cornu-Atkins, 'Appraising waters: the assimilation of chemists into the trade of mineral waters in eighteenth-century France', *Circumscribere* (2019) 24, pp. 66–82.

[17] Giovanni Maria Lancisi, *De Nativitis Romani Coeli Qualitatibus*, Rome, 1711.

[18] Carpi, op. cit. (15), p. 43.

[19] Hamlin, op. cit. (8), pp. 22–36.

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goitre and water in the towns near Naples, had to admit that the composition of water 'is hypothetical … and [the chemist] is unable to provide any secure data about the composition of water as it is before being processed'.[20] Contradictions in the chemical analysis of drinking water were also a result of the fact that since the eighteenth century it had been used to provide a rationale for the use of mineral waters in medical therapy. This orientation led chemists to emphasize water's unique properties, rather than stressing the matter of purity.[21] Between the 1830s and 1860s, for Italian chemists, waters were 'earthy', 'sulphuric' (*selenitose*), 'calcareous', 'good and potable' and of other subgroups, rather than pure or impure. Accurate analysis of drinking water consisted of examining the source, looking at organoleptic features of the water and conducting empirical tests, like hand washing and recording the smell it left on the hands, sun exposure and boiling, among more specific tests with chemical reagents.[22] Chemistry's uncertainty and fragile professional organization in Italy paved the way for other professionals to impose their point of view on the set of questions associated with the assessment of water.

Giuseppe Bianco, chief engineer of the municipality of Venice in mid-century, observed that chemical analysis of water required a long, logistically demanding, and expensive process, which was actually unnecessary. He argued that 'we can safely make a sound judgement of water quality even before chemistry shows us its concealed and multifarious composition'.[23] From his perspective, sensorial, performative assessment was a cheap, easy, and reliable way to analyse water. On this basis, between 1858 and 1862, he developed a project to improve Venice's water supply with a set of groundwater wells in Venice Lido. The Venetian professional establishment expressed scepticism regarding the quality of such water because of its proximity to the sea, but Bianco invited them to 'come, taste, and then judge'. Furthermore, 'the good health of people who drink this water, their masculine robustness, and their tolerance of hard labour' proved it was of good quality.[24] Bianco's attitude illustrates the ongoing role played by tradition in the understanding of water even in the mid-nineteenth century in his use of Renaissance medicine variables such as people's lively colour and their physical strength as indicators of water quality.[25]

Given the relationships between the perception of water and water infrastructure, architects and engineers felt well qualified to speak about water quality, and exercised prudent caution in giving chemistry a role in the evaluation of water. For example, in 1862, the architect Felice Francolini discussed the projects for supplying fresh drinking water to Florence.[26] He asserted that 'advancements in science have not changed people's opinions (about good water), which were based on instinct and observation long before chemistry explained the reasons behind their preferences'.[27] He felt that this point granted him the right to challenge the proposal made by a private company for supplying Florence with water from a tributary of the river Arno. The project had been endorsed by

[20] Mariano Semmola, *Studi di Chimica Applicata alla Medicina*, Naples, 1859, p. 25.

[21] Noel G. Coley, 'Physicians, chemists, and the analysis of mineral waters: "the most difficult part of chemistry"', *Medical History* (1990) supplement (10), pp. 56–66; David Gentilcore, 'From "vilest beverage" to "universal medicine": drinking water in vernacular regimens and health guides, 1450–1750', *Social History of Medicine* (2020) 33(3), pp. 683–703.

[22] Analisi e Giudizio delle Acque Artesiane di Venezia della Commissione Istituita dalla Delegazione Provinciale, Venice, 1847.

[23] Giuseppe Bianco, *Sui Modi più Acconci di Provvedere Venezia d'Acqua Potabile*, Venice: Tipografia Naratovich, 1862, pp. 173–4.

[24] Bianco op. cit. (23), p. 109.

[25] Gentilcore, op. cit. (21), p. 686.

[26] Simone Fagioli (ed.), *"L'Acqua Potabile che da Quasi un Secolo è Argomento di Lagni": l'Ingegner Celso Capacci e il Dibattito sull'Acquedotto di Firenze*, Bagno a Ripoli: Opificio Toscano di Economia, Politica e Storia, 2019.

[27] Felice Francolini, *Delle Acque Potabili*, Florence: Tipografia Galileiana, 1862, p. 11.

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Giacchino Taddei, a Tuscan chemist and physician.[28] Taddei observed first that many of Florence's groundwater wells, then the city's main source of water, were full of nitrites, a sign of contamination with human and general waste. However, Taddei did not relate the faecal contamination of water to diseases like cholera and typhoid: from a medical standpoint, his objection was that this water contained a lot of 'earthy' substances, which encumbered digestion, and whose slow but steady accumulation in the human body caused scrofula. This was a very traditional understanding of water-related diseases.[29] Furthermore, he looked at the variety of functions that urban water had to accomplish, arguing that Florence's groundwater was unsuitable for industrial processes like distillation, paint and soap production, cloth dyeing, and so on. River water, on the other hand, was high-quality because it was airy and always flowing. 'Rivers', he argued, 'are the source of drinking water par excellence, better than any other'.[30] Felice Francolini disagreed, noting that good drinking water is always pure, limpid and at a constant temperature, which keeps it fresh in the summer and not icy in the winter, and this was not the case with river water. Moreover,

> It is unlikely that the local population, which has grown up for centuries using groundwater wells, whose water is a bit rough but fresh and clear, and who has all the mechanical tools to use it; would buy river water, which is whitish, hot during the summer, and icy in the winter.

Thus he suggested that the municipality of Florence look for spring water from the Apennine mountains.[31] These conflicting views reveal that the characteristics of the kind of water that was best for particular tasks, and the question of who had the authority to make such assessments, were crucial elements in the decision-making process concerning water infrastructure.

As a means of standardizing water quality measures in mid-nineteenth-century Europe, hardness, or the levels of magnesium and calcium salts dissolved in water, became increasingly popular. This parameter was focused on by Sir Edwin Chadwick in the 1850 report on London's water.[32] According to Christopher Hamlin, Chadwick opted for hardness mainly because it was an unambiguous criterion, and as such useful to standardize water policy in British cities.[33] Other reasons also contributed to the spread of this criterion, at least in the Italian case. Hardness was related to the performative qualities of water. Water too rich in calcium carbonate was unsuitable for industrial and domestic purposes (cooking, washing). Additionally, hardness fitted Hippocratic medical pathology because, as noted, hard water was assumed to generate problems for the digestive system. Finally, the diffusion of hardness as a key criterion of assessment was facilitated by the creation, in 1856, by the French chemists Boutron and Boudet, of a rapid and simple method to measure it using only two burettes and a solution of soap, alcohol and distilled water.[34] This technique was particularly appreciated by Italian engineers as late as the

[28] Gioacchino Taddei, *Idrologia di Firenze*, Florence: Felice Le Monnier, 1858.
[29] Taddei, op. cit. (28), p. 115.
[30] Taddei, op. cit. (28), p. 117.
[31] Francolini, op. cit. (27), p. 24.
[32] Hamlin, op. cit. (8), p. 108.
[33] Hamlin, op. cit. (8), p. 109
[34] Jean-Paul Haghe and Agathe Euzen, 'What water is good enough? The evolution of perceptions about drinking water in Paris from modern to contemporary period', *Water History* (2012) 4(3), pp. 231–44, 236. For a method that encountered the favour of engineers see, for example, Alessandro Bettocchi, *Delle Acque Pubbliche di Roma Moderna, Discorsi Accademici*, Rome: Tipografia Salviucci, 1865, p. 24.

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1870s, since it allowed them to justify their perspective on water quality by reference to scientific methodology.[35]

Conversely, chemists and physicians progressively downplayed the role of hardness in water assessment. For example, in 1870, a private company built a modern aqueduct to carry water in Rome from one of the springs of the ancient water Marcia.[36] The company stressed the fact that such water was praised by Pliny the Elder as 'the most famous of all waters in the whole world for coldness and wholesomeness, the glory of the city of Rome, is the [water] Marcia'.[37] The trouble was that, as Giovanni Campbell, a British chemist, demonstrated through analysis, the water was also very hard. Significantly, in his analysis for the company, he separated the medical properties of the water from its performative qualities, reducing the issue 'to a mere economic disadvantage'.[38] Consumers, however, disagreed, with many people complaining about the hardness of the water Marcia.[39] The prefect of Rome appointed two physicians, Clito Carlucci, former rector of the University of Rome, and Pietro Balestra and Fausto Sestini, a chemist, director of the Royal Agricultural Station of Chemists of Rome, to analyse this water in relation to human health. They concluded that, given the balance of minerals, the lack of ammonia and being free of organic matter, Marcia water was good drinking water and the aqueduct was sufficiently well built to prevent infiltration of external substances. However, from a visual aspect, 'it has a serious defect, which anyone can see, and which informs common people's view … who observes that water pipes are gradually obstructed in two or three years, fears the same would happen in his own body, and therefore he does not drink water Marcia gladly'.[40] However, in their opinions, sensorial perception deceived laymen, who did not understand the 'real' process that made the water unsafe.

Notably, these professionals also did not have a precise understanding of water safety. By switching the focus from hardness to the organic matter dissolved in water as a possible source of disease, they were producing a certain kind of knowledge about water, but this estimation of water qualities was just as partial and uncertain as was the previous conceptualization.[41] The most significant change was the fact that experience and observations were downplayed as a way of understanding water qualities, thus creating a robust boundary between the expert's opinion and that of the layman, interrupting the dialogue that had been a significant part of the previous chemical understanding of water.

A contested shift: sewage contamination as the main indicator of water quality

This section will focus on the controversial rise in popularity of sewage contamination as the primary criterion for assessing water quality between the 1870s and the 1880s and its consequences for the use of groundwater wells in Milan and Rome, which are treated as examples of the impact of the newly adopted criterion on the use of certain infrastructure. It contends, nonetheless, that this criterion was still arbitrary and part of a particular view that slowly permeated the scientific body and water policy.

[35] See, for example, Marco Ceselli, 'Le acque potabili di Roma e loro varie applicazioni agli usi domestici ed industriali', *Il Buonarroti* (April 1873) 8, pp. 102–11.

[36] Francesco Amendolagine, *La Rinascita di un Mito: Acque Sorgenti, Acquedotti e Imprese Finanziarie, Documenti e Storia della Società Acqua Pia Antica Marcia*, Venice: Marsilio, 1997, p. 15.

[37] Thomas Ashby, *The Aqueducts of Ancient Rome*, Oxford: Clarendon Press, 1935, p. 90.

[38] G. Campbell, *Ricerche Analitiche sulle Acque Potabili in Roma. Marcia e Vergine*, Rome: Tipografia Romana Bartoli, 1873.

[39] Clito Carlucci, Pietro Balestra and Fausto Sestini, *Acqua Marcia: Relazione Chimico-Igienica Approvata dal Consiglio Provinciale di Sanità nell'Adunanza del 18 Marzo 1876*, Rocca S. Casciano: Stabilimento Tipografico Federigo Cappelli, 1876.

[40] Carlucci, Balestra and Sestini, op. cit. (39), p. 28.

[41] Parrinello, Benson and von Hardenberg, op. cit. (4), pp. 5–6.

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As the previous section showed, the lack of a specific standard for evaluating water quality rendered disputes on the issue intractable, with various professionals offering differing evaluations. During the International Hygiene Congress in Brussels in 1876, the search for a universally valid standard for water quality was one of the central concerns. Physicians, chemists and state officials, like the Italian Luigi Torelli and the Englishman Sir Edwin Chadwick, discussed the properties that good drinking water must have.[42] Different points of view emerged regarding the most suitable criteria, ranging from the amount of oxygen contained in the water to its ability to support complex forms of life, such as algae and fish; the type of source (springs, rainwater cisterns, groundwater wells, artesian wells); the medical scrutiny of people who drank certain water; the morbidity of (assumed) water-related diseases like goitre and cretinism; mineral composition; and so on.[43] Although a general agreement on the best parameters to appraise water was hard to find, many discussions of water polluted with human and animal droppings, Asiatic cholera and other epidemic diseases were entwined and somewhat related.[44] Without discussing medical aspects, Senator Luigi Torelli, president of the Italian delegation at the congress, simply affirmed that what made water bad was the filtration of organic materials in the soil, noting that water did not just need to be protected from sewage, but also from contact with cemeteries.[45] As a non-scientist, Torelli did not feel it necessary to identify the specific nature of any harm there might be in the water. He had been a prefect and was convinced that the traditional precautionary approach of avoiding any water that might contain organic contamination was sufficient protection.

However, as we shall see, this remained something of an abstract principle since it was not easy to convince people that the water they drank was polluted when their sensory evaluation of it was positive. Here the Italian chemists were able to exert a more robust influence on the water issue. Angelo Pavesi, professor of chemistry at the University of Pavia, analysed the groundwater wells of Milan in 1876. He argued that 'limpidity, no bad taste nor bad smell are not sufficient elements to state some water good'.[46] For him, the most relevant criterion to consider was the presence of 'rotting and decaying matters of animal origins which communicate unhealthy properties to water'.[47] In Pavesi's view, organic matter could actually be innocuous to human health. The chemist's job, therefore, was to try to use the identification of some substances, like ammonia and nitrites, as indicators of the presence of germs, which generated a process of fermentation. This perspective, of course, drew on the work of Justus von Liebig on decay and fermentation in the 1840s, which had a lasting impact on the interpretation of disease in nineteenth-century Europe.[48] Other more traditional criteria, like hardness and the combination of minerals, were also part of Pavesi's analysis.

Pavesi knew, however, that the local population, which drank poor water with minerals, often showed no signs of harm. This conflicted with medical statistics in Italy and more broadly through Europe, which showed a relationship, at that point hard to explain, between improvements in water supply, namely reduction of sewage contamination, and a

42 *Congrès international d'hygiène, de sauvetage, et d'économie sociale*, Paris and Brussels: Germer Baillière & c., 1877.

43 *Congrès international d'hygiène*, op. cit. (42), pp. 266–305. The concept of aquatic life as an indicator of safe water was popularized by the French chemist J.B. Dumas, in a session at the French Academy of Sciences in 1869. See Haghe and Euzen, op. cit. (34), p. 237.

44 *Congrès international d'hygiène*, op. cit. (42), pp. 325–67.

45 *Congrès international d'hygiène*, op. cit. (42), pp. 279–80.

46 Angelo Pavesi and Ermenegildo Rotondi, *Studi Chimico-Idrologici sulle Acque Potabili della Città di Milano*, Milan: Urlico Hoepli, 1876.

47 Pavesi and Rotondi, op. cit. (46), p. 4.

48 Hamlin, op. cit. (8), pp. 129–33.

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decrease in mortality rates of epidemic diseases like cholera and typhoid fever.[49] As a result of Angelo Pavesi's analysis, Milan's groundwater wells were found to be contaminated with sewage at certain locations. His analysis was followed by a public debate about the renewal of Milan's water infrastructure. A physician, Gaetano Pini, noted that when ideas were proposed to bring new water to Milan in previous years, 'the elderly shook their heads … they cited stories and statistics to prove that Milan was even overflowing with water, and with rare exceptions, it was fresh, limpid and healthy'.[50] Pini was able to draw on the work of Angelo Pavesi and others to refute such a viewpoint. As a result of this debate, Milan City Council discussed and, in 1881, approved a project to conduct water to the city from distant mountain springs, which they believed to be free of organic contaminants.[51]

As noted in the previous section, this perspective on analysis was becoming more common among other Italian chemists and physicians. Paolo Emilio Alessandri, professor of food science at the University of Pavia, which was an important centre for Italian chemistry, wrote a handbook on chemical water analysis in 1887. He still spent part of this work in discussing water in relation to bodily functions, in particular the role of water as a medium to wipe off bodily impurities. He also stated that 'water as a beverage has multiple roles for humans … it facilitates swallowing, digestion and related chemical processes; it permits blood, organ, tissue and bone formation'.[52] However, writing in the 1880s, Alessandri was also keenly aware of the international debate on water contamination and of the rising germ theory as a new medical philosophy to explain the relationships between the environment (including water) and diseases. Indeed, the parameters he adopted reflected the overlapping of these two perspectives on water: the levels of carbonic acid, oxygen, nitrogen, sulphates, chloride, silica and calcium and magnesium carbonates were used to assess water quality in relation to human physiology, while the levels of calcium phosphate, ammonia, nitrates and nitrites were used to determine water contamination.[53]

Use of the latter set of parameters had a significant impact on people's use of groundwater wells and water cisterns, which in cities like Milan, Rome, Naples and Venice were subject to stringent inspections and, in some instances, closure by municipal authorities. In September 1884, when an epidemic of cholera was raging in Naples, Rome's assessor for public health forbade the use of water from all groundwater wells in the Italian capital. Many complained about this decision. Some were laymen, like this judicial officer, who described the water from his well as 'very fresh, pure and light', effective in treating his uricemia. Water from the Marcio aqueduct, however, made his condition worse.[54] He pleaded eloquently that since 'the first duty (of man), Oh Sir, is to cure or even better to preserve his own health; I beg you to let me reopen my own well with tears in my eyes for this tormenting inconvenience'.[55] A group of women wrote to King Umberto I claiming that the mayor of Rome had banned all groundwater wells in the city, without distinguishing between those that 'have good drinking water, and so are the most of the wells in this city, which are fed by local water veins … and those in need of some change'.[56] Prominent

[49] Hamlin, op. cit. (8), p. 5.

[50] Gaetano Pini, *Le Acque Potabili a Milano: Le Acque del Brembo. Il Gozzo*, Milan: Civelli, 1881, p. 3.

[51] Teresa Isenburg, 'L'acquedotto di Milano', *Storia Urbana* (2000) 93, pp. 19–29.

[52] Paolo Emilio Alessandri and Leopoldo Maggi, *Acque Potabili Considerate come Bevande dall'Uomo e dai Bruti*, Milan: Fratelli Dumolard, 1887, p. 3.

[53] Alessandri and Maggi, op. cit. (52), pp. 12–13.

[54] Bonaventura Pisani to Rome City Council, complaint about Rome mayor's ban of groundwater wells, Rome, 18 October 1884, Archivio Storico Capitolino (subsequently ASC), Post-unitario, Titolo 46, b. 22, f. 102.

[55] Pisani, op. cit. (54).

[56] Plea to Thy Majesty about Rome mayor's ban of groundwater wells, Rome, 19 October 1884, ASC, Post-unitario, Titolo 46, b. 22, f. 123.

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physicians in Roman hospitals, like Luigi Gualdi, also challenged these decisions. Gualdi argued that while water from wells was not perfectly healthy, it was not impure. Marcia water, on the other hand, whose contested qualities were discussed in the previous section, was even poorer because it made digestion problematic and provided no nourishment to the body.[57] These complaints illustrate significant individual differences in the perception of water quality in groundwater wells, as well as the potential divergence of such public perceptions from the views of the medical and political authorities.

This multiplicity of ways of understanding water, in addition to the transformation of the ban on groundwater wells into a permanent measure, convinced physician Giulio Bastianelli, councillor for public health in Rome, to commission the University of Rome to perform two water analyses, one chemical and the other bacteriological, in order to demonstrate that the ban on water from Rome's wells was well grounded from a scientific perspective.[58] In light of these sequences of events, a political decision first, scientific scrutiny second, we can see that the relationships between the construction of the notion of water purity and the implementation of measures concerning drinking water were related not in terms of cause and effect but as co-producers of a new water policy. Chemical analysis of Rome's groundwater was conducted by Francesco Marino-Zuco in 1885. In his opinion,

> Rome's groundwater wells and local springs would be excellent if organoleptic features were considered much in water analysis. They are limpid, very fresh, and pleasing to the palate … Also, the solid residue is not so important … However, the presence of chloride, nitrates and nitrites, all show that water had been contaminated and, from our tests, we can deduce that Rome's groundwater contains not insignificant amounts of organic matter.[59]

The most relevant feature of these statements is the creation of a boundary between what was perceivable by anyone and what was clear only to the expert, who in this way delimited the space of his social agency and imposed his point of view over less authoritative forms of knowledge.[60] It was curious, however, that Angelo Celli, a bacteriologist and malariologist, in writing the bacteriological report on Rome's groundwater wells, based his knowledge on experience and observation of the field. He considered Rome's underground water impure *a priori*, making the assumption that sewage and animal waste must leak into the soil.[61] In his report, this was essentially the strongest proof of the harmfulness of Rome's groundwater wells. As part of this demonstration, he cultured water bacteria in a solid gelatine-peptone medium, drawing this procedure from the work of Robert Koch. However, he had to acknowledge that bacteriological analysis could only provide a quantitative assessment of germs in a water sample: little could be said about whether they were harmful to health.[62] Nevertheless, he attempted to reiterate the argument made by Francesco Marino-Zuco that Rome's groundwater wells

57 *Bollettino della Regia Accademia Medica di Roma* (1884) 10(8), pp. 319–28.

58 *Bollettino*, op. cit. (57), pp. 312–13.

59 *Relazione sulle Analisi Chimiche delle Acque del Sottosuolo di Roma Eseguite per Incarico del Municipio dal Dott. Francesco Marino-Zuco coll'Aiuto di Guido Fabris nell'Istituto Chimico della R. Università Diretto dal Prof. Stanislao Cannizzaro*, Rome: Tipografia della Reale Accademia dei Lincei, 1885, pp. 24–7.

60 In terms of water science, this was still an ongoing process in the early twentieth century; see Matthew Evenden, 'Debating water purity and expertise: the chlorination controversy in Vancouver during the Second World War', *Journal of Historical Geography* (2019) 65(3), pp. 85–95.

61 Angelo Celli, *Relazione Bacteriologica sulle Acque del Sottosuolo di Roma Eseguita per Incarico del Municipio*, Rome: Tipografia della Reale Accademia dei Lincei, 1886, p. 5.

62 Celli, op. cit. (61), p. 8.

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were demonstrably contaminated by sewage, recommending that they be closed. Celli's experience illustrates the way in which laboratory procedures did not determine the outcome of debates, but were just one element to be taken into consideration, alongside broader epistemological questions and observations of the environmental context from which the water samples had been taken.

In short, in the late 1880s, after decades of conflict over what defined good water, Italian physicians and chemists were opting for very prudent, though strict, criteria of water purity as the framework for their research, but the evidence in support of their view remained contested. This is not to imply that Italian chemists and physicians were backward. In the 1890s, debates over the quality of the waters of British cities and the question whether water analyses were useful or not continued to occupy consumers, politicians and scientists.[63] The precise understanding of harmful components in water and their effects on human health remained controversial, but the focus on sewage contamination and the rationale provided by bacteriology made water analysts prominent figures in debates over water quality and in the contested political decision making about what water could be used. In this context, water analysis provided a discreet way to mediate between individual perceptions of water and the policies that were expanding public authority over health and water. The next section will investigate this issue more closely.

Water analysis and the government of water

The previous section considered the relationship between the intellectual debates on water quality and practices of water analysis, and the political decisions regarding water infrastructure such as groundwater wells. This illustrated an attitude to the governance of water that can be associated with what historians describe as the 'growth of government', a process of expanding the public sphere in various areas of life through the implementation of large technological systems, including, among other things, water infrastructure.[64] The implementation and operation of these systems in turn required the establishment of organizational and regulatory procedures.[65]

Until the point where water analysis was fully incorporated into the political government of water, national surveys and parliamentary inquiries were the primary tools used by the Italian state to drive the renewal of the water system. The survey of the *Drinking Waters of the Kingdom of Italy*, published in 1866, was an example of this.[66] Promoted by Luigi Torelli, later head of the Italian delegation at the 1876 International Hygiene Congress in Brussels, at the time minister of agriculture, industry and commerce, the survey was perceived not only as a mere collection of data but also as a tool that could move water infrastructure renewal to the top of the urban political agenda, as well as a means of setting targets for Italian drinking-water policy. In the preface, Torelli stated that 'people, even those unrefined, know by experience the difference between good and bad water; under this aspect the opinions of both masses and experts are similar', but neither science nor experience, he argued, 'had driven the Italian population to correct nature'.[67] The survey's classification of water quality reflected a way of perceiving water based on observation and experience, while chemical analysis did not appear to be a useful tool. People's perception was key in evaluating water: good water had no taste and was easy to digest,

[63] Hamlin, op. cit. (8), pp. 283–7.
[64] Christopher Otter, *The Victorian Eye: A Political History of Light and Vision in Victorian Britain, 1800–1910*, Chicago and London: University of Chicago Press, 2008, p. 14.
[65] Otter, op. cit. (64), p. 13.
[66] MAIC, *Le Acque Potabili del Regno d'Italia*, Florence: Tipografia Barbera, 1866.
[67] MAIC, op. cit. (66), p. vi.

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but bad water contained defects that were easy to spot, had a bad taste, was unsuitable for cooking legumes, and could not dissolve soap.

If public perception was key in evaluating water, however, a problem arose from the multiple and contradictory opinions held as to the quality of any given source: how could water be governed on this basis? As we saw in the previous section, many people in Milan and Rome still believed that the water from their wells was safe. Torelli and his successors were wary of the bureaucratic and political consequences of the creation of a new structure to control water quality, since it might become the means of promoting a radical change in the way water was accessed and distributed in Italian cities. In contrast, in France, an annual report on the quality of river water (in particular of the Seine, Paris's main source of water) had been issued since 1851, and Edward Frankland had been monitoring the Thames in Britain since 1865.[68] Crucially, though, these reports still did not resolve the issues concerning the harm that was present in the water, and they were accompanied by fierce controversy. They did, however, provide a less arbitrary rationale for political choices concerning water than those used in Italy, as well as demonstrating a sign of the genuine commitment of the public authority to the health of its citizens. The power of these practices was in the discreet control of water management and mediation between various perceptions of water. The plurality of subjects who could speak about water quality was in sharp contrast with attempts at standardizing practices and infrastructure.

The chance for a more decisive shift towards the creation of a professional structure to monitor water came, as we saw, in Rome, with the 1884–93 outbreak of Asiatic cholera in Europe. Koch's identification of pathogenic agents in water in India generated an intense debate on the way water, contaminated with human faeces, contributed to the incidence of epidemic diseases and morbidity.[69] However, the reception of bacteriological theory on the origins of cholera varied from one country to another.[70] In the 1880s, regardless of whether Koch's theory was accepted or rejected, a shift to an almost obsessive representation of water as a medium for epidemic diseases was taking place in medical and political discourses, although its exact role varied according to the medical theory.

In Italy, which hosted the Sixth International Sanitary Conference in 1885, the period was a turning point for the issue of drinking water. The Italian prime minister, Agostino De Pretis, wrote a circular to all the Italian prefects on 9 January 1885, in which he announced his intention to 'compile an inventory of the sanitary conditions of the country', referring to the cholera epidemics of the previous year and the subsequent debate concerning the impact of the hygienic conditions of cities on the spread of this disease.[71] As for drinking water, the survey asked about water quality and quantity; whether the chemical analysis had been done; the type of sources, infrastructure and equipment to fetch water; and whether fountains and wells were in public or private areas.[72]

Only 355 out of more than eight thousand municipalities had done a chemical analysis of their water at the time, though most of the Italian provincial capitals themselves had

[68] Haghe and Euzen, op. cit. (34), p. 236, Hamlin, op. cit. (8), p. 158.

[69] Eugenia Tognotti, *Il Mostro Asiatico: Storia del Colera in Italia*, Rome and Bari: Laterza, 2000, pp. 244–5.

[70] Mariko Ogawa, 'Uneasy bedfellows: science and politics in the refutation of Koch's bacterial theory of cholera', *Bulletin of the History of Medicine* (2000) 74(4), pp. 671–707; Anne Hardy, 'Cholera, quarantine and the English preventive system, 1850–1895', *Medical History* (1993) 37, pp. 250–69; Jean-Pierre Goubert, *La conquete de le'eau: L'avènement de la santé à l'age industriel*, Paris: Laffont, 1986, p. 99; Richard J. Evans, *Death in Hamburg: Society and Politics in the Cholera Years*, Oxford: Clarendon Press, 1987, pp. 262–72.

[71] Direzione Generale della Statistica, *Risultati dell'Inchiesta sulle Condizioni Igieniche e Sanitarie nei Comuni del Regno. Relazione generale*, Rome: Tipografia in San Michele, 1886, pp. 219–20.

[72] Direzione Generale, op. cit. (71), p. 222.

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their water chemically analysed.[73] The others 'based their assessment on the rough evaluation of water's taste, freshness and clarity, so this information should be taken with caution'.[74] However, there was still a significant overlap between chemical analysis and sensory perception in the 1886 survey. This survey revealed that 9,500,000 people drank what it called 'bad water'. In the few cases where that water was chemically analysed, this term was linked to levels of ammonia and nitrites, which were indicators of organic contamination. In all other cases, the term was based on sensory assessment. Commenting on the 1886 survey, the director general of the Ministry of the Interior lamented the fact that Italian municipalities had not prioritized the issue of adequate and reliable water supply,

> Because they do not understand that the rapid spread of epidemic diseases, the fact that mortality rates are higher [in Italy] than in other countries, the low level of body development among the Italian population, and the persistence of sources of miasmas, are directly linked with the lack of good-quality drinking water … This Ministry is seeking ways to provide a strong push to the improvement of public health … starting with the issue of drinking water.[75]

As discussed previously, these statements contained references to the miasma theory, and they tended to highlight the lack of water as the only, or the main, cause of many social issues, which were also linked with a broader context of poverty and social inequality. The pressing question that emerged was how to provide that 'strong push to the improvement of public health' and thus expand state control over municipal matters and private water users in a non-coercive manner.

The National Public Health Laboratories (Laboratori Centrali della Sanità Pubblica) were established in Rome under the 1888 Public Health Act.[76] These laboratories were crucial in assuring centralized and standardized control over water. Some Italian cities, like Rome, Venice and Milan, already had their own offices or cooperated with local universities and scientific institutions to monitor, among other things, water quality. However, the National Public Health Laboratories were not only places for water analysis but institutions for training a new generation of public analysts, for standardizing the criteria and method of water analysis, and for determining the water policy of any Italian town. Municipal authorities had to provide detailed information to the General Board of Health about what they had done in terms of projects and studies to improve the quality of their water supplies. Municipalities rated with bad or poor water in the 1886 survey were required to seek a good, abundant source of water nearby. After that, they had to send a sample of the source of water they intended to use for the supply to the national laboratories for testing.[77] This centralized process of water monitoring sought to rapidly solve controversies over water safety, the best way to distribute it, and the need for new infrastructure.

The work of these laboratories helps clarify their role in mediating between different perceptions of water, and environmental, social and political constraints. For example, Bartolomeo Gosio, director of the National Public Health Laboratories, writing on the

73 Direzione Generale, op. cit. (71), p. 75.

74 Direzione Generale, op. cit. (71), p. 41.

75 Circular to all the prefects of the kingdom on drinking water, Rome, 18 September 1886, Archivio Centrale dello Stato (subsequently ACS), Ministero dell'Interno (subsequently MI), Direzione Generale della Santità Pubblica (subsequently DGSP), versamento (subsequently v.) 1, b. 24.

76 Roberto Cea, *Il Governo della Salute nell'Italia Liberale: Stato, Igiene e Politiche Sanitarie*, Milan: Franco Angeli, 2019, pp. 86–96.

77 Circular to all Italian prefects on the norms for chemical analysis of water, Rome, 6 February 1889, ACS, MI, DGSP, v. 1, b. 24.

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waters of the island of Lampedusa, stated that they would not be good to drink. However, there was no alternative source of water on the island, so 'the levels of minerals in such a water are still tolerable', and thus his advice was 'just to take a better care of the groundwater wells to prevent contamination of the water with organic materials'.[78] Hence, despite narratives of abstraction, locale continued to play a role in the practices of water analysts until the late nineteenth century. The test sample had to be accompanied by a report of the source of water and the local environmental conditions.[79] Additionally, the sensorial qualities of water remained part of the process. Christy Spackman has noted that, in the US between the two world wars, unwanted or offensive tastes and odours posed a constant threat to water workers' (engineers, physicians, chemists) authority over the safety of the water.[80]

A good example of this for the Italian case was the controversy over the safety of an artesian well drilled by a private company for Noale, a town near Venice, in the early 1890s. When the well was drilled, water was sent to the state laboratory, which declared it drinkable.[81] The local population, however, rejected it because of its bad taste and stench 'like rotten eggs'.[82] Noale's town council refused to pay the private entrepreneur for water that the people did not drink. They asked for further investigation, but four chemical analyses determined that the water was pure.[83] As a result, the private entrepreneur sued Noale's town council to obtain payment for the work. The controversy was only resolved when Bartolomeo Gosio himself went to Noale and overturned the conclusions of the previous chemical analyses. In his official report he stated that while a bad odour (sensory experience) would be a good reason to avoid such water, there was also good chemical evidence to support the local population's empirical aversion. In his work, he said, he had found high levels of hydrogen sulphide, which had gone undetected in the previous laboratory studies, because of 'the time span between the taking of the water sample and its analysis'. Therefore he concluded that drinking water from Noale's artesian well was not 'advisable from a hygienic point of view'.[84] The notion of water purity was elastic and open to contextualization.

The political role of water analysts as mediators between different interests came up in multiple cases. For instance, in 1895 a private company built an aqueduct to supply Palermo, but the royal commissioner, who governed Sicily between 1896 and 1897, complained about the fact that

> only a tiny fraction of the population drinks such water, which is indisputedly better than the water of the old aqueducts. I have been told that water from the old aqueducts is polluted and harms the health of the population. I want to know more about this, and if water pollution is confirmed, I will forbid the use of such water … which supplies private houses and public fountains.[85]

[78] Dispatch on Lampedusa's drinking water, Rome, 31 July 1898, ACS, MI, DGSP, v. 1 b. 24.

[79] See, for example, prefect of L'Aquila, circular to the mayors, L'Aquila, 24 September 1893, ACS, MI, DGSP, v. 1, b. 24.

[80] Christy Spackman, 'Just noticeable: erasing place in municipal water treatment in the U.S. during the interwar period', *Journal of Historical Geography* (2020) 67(1), pp. 2–13.

[81] Venice, Prefect of Venice to General Board of Health, report on Noale's artesian well, 16 October 1894, ACS, MI DGSP, v. 1, b. 38.

[82] Venice, Provincial Medical Officer report on Noale's artesian well, Noale, 19 July 1892, ACS, MI, DGSP, v. 1, b. 38.

[83] Bartolomeo Gosio report to Head of the General Board of Health and to the Minister of Interior, Rome, 13 February 1895, ACS, MI, DGSP, v.1, b. 38.

[84] Bartolomeo Gosio report to Head of the General Board of Health and to the Minister of Interior, Rome, 13 February 1895, ACS, MI, DGSP, v.1, b. 38.

[85] Royal Commissioner for Sicily to Ministry of the Interior, Palermo, 11 March 1897, ACS, MI, DGSP, v. 1, b. 33, Palermo.

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As a result, he sent a test sample from two of the springs that fed Palermo's public fountains to the National Public Health Laboratories. It probably came as a surprise that the water was perfectly drinkable from a chemical point of view.[86] However, the possible consequences of a negative evaluation of water quality for what was at the time one of Italy's largest cities shed light on the power of the centralized water-monitoring system. Depending on the analysis, the Ministry of the Interior could dismiss a city council whose water supply needed to be improved if it did not take decisive measures to reach a higher standard.[87] In addition, the local prefect could override municipal resolutions that were perceived as delaying the construction of waterworks.[88]

Such measures proved effective in driving a change. In 1903, the Ministry of the Interior surveyed the drinking water throughout the Kingdom of Italy and between 1889 and 1903 had sought to evaluate the evolution of the water system in each Italian municipality. During this period, 1,850 new aqueducts and forty water cisterns were built, 427 artesian wells were drilled, and 304 groundwater wells were dug.[89] There were 1,979 chemical analyses and 1,429 bacteriological analyses conducted on water sources.[90] The director general of the Ministry of the Interior noted that improvements in water supply had been steady, and he wished to acknowledge the efforts of all the prefects, the provincial health officers, and 'the National Public Health Laboratories, which had conducted numerous water analyses on behalf of municipalities, enabling advances in public health'.[91] The institutionalization of practices of water monitoring in the late nineteenth century had contributed to an intense programme of renewal of the Italian water infrastructure. The role of public water analysts was to mediate between the coercive power of prefects, the administrative practices of municipal authorities, private-sector actor interests, and local perceptions and conditions of the water quality. Although there were still evident epistemological limits in water analysis at the time, the opinions of experts, paraphrasing Torelli, and even more their practices, were powerful means to 'correct' nature, and, more precisely, to govern society.

Conclusion

It took a long time before the identification of water as a compound of hydrogen and oxygen was widely accepted in Italy. Other perceptions, rooted in the relevance of classical culture and pride in ancient infrastructure, remained influential, especially outside the circuit of health officials and public analysts. At the same time, sensorial perception and physiological knowledge of water, and observation of the places which surrounded a body of water, remained crucial to the chemical and bacteriological analyses, despite the search for innovative methodologies. Regarding the limits of these methods, it is worth mentioning the judgement given by Giovanni Bizio, a prominent Venetian chemist, on the European debate on chemical methods to assess water. In 1886, he wrote that 'all these official data enacted in official congresses, from committees, from authority in the field of chemistry, are incongruent with each other, and after a brief review they lose even

86 Palermo's chemical analysis of water, Rome, 7 April 1897, ACS, MI, DGSP, v. 1, b. 33, Palermo.

87 Royal Commissioner for Ateleta to the labs of the General Board of Health, Ateleta, 21 August 1893, ACS, MI, DGSP, v. 1, b. 24.

88 Ministry of the Interior report to the State Council on Avezzano's aqueduct, 5 April 1895, ACS, MI, DGSP, v. 1, b. 24,

89 Ministero dell'Interno, Direzione Generale della Sanità Pubblica, *Inchiesta sulle Acque Potabili del Regno al 31 Dicembre 1903. Relazione Generale Acquedotti*, vol. 3, Rome: Officina Poligrafica Italiana, 1906, pp. 370–1.

90 Ministero dell'Interno, op. cit. (89), pp. 514–15.

91 Ministero dell'Interno, op. cit. (89), p. xv.

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their relative value'.[92] A good chemist had to stay abreast of the new methodologies, but acknowledging their limits, he also had to rely on senses and experience to interpret the water analysis.

So where did the potency of these practices lie? Looking at the social dimension of water analysis, these practices were rooted at the intersection of conflicts regarding water quality between different social groups, and thus they represented a place for power, negotiations and mediation. Water analysis in nineteenth-century Italy was less about understanding the 'truth' of water than about making sense of the daily problems citizens faced regarding the use of water: water infrastructure, water pollution and their unclear relationships to diseases, like Asiatic cholera and typhoid fever, which had replaced kidney stones and less deadly digestive problems as the focus of medical research. More than filtering water from its previous meanings, the analysis of water was a procedure that delimited the field of who could determine legitimate opinions on water quality. In the daily practice of water monitoring, water analysts were more empirical and context-based than they openly admitted. Because of its various forms and almost ubiquitous presence in any social activity, water resisted attempts at standardization and intellectual abstraction. Despite scientific representations as H_2O, the nature of water remained elusive, contingent and deeply rooted in time and space with the human societies of which it is a part.

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[92] Giovanni Bizio, 'Relazione Intorno alla Analisi Chimica dell'Acqua della Sorgente di Sant'Ambrogio nel Comune di Trebaseleghe', in Giunta Municipale di Venezia, *La Nuova Presa d'Acqua per l'Acquedotto di Venezia, Rapporto della Giunta Municipale*, Venice: Tipografia Naratovich, 1889, pp. 7–41, 39.

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