CHAPTER 7

Between Industry and the Environment: Chemical Governance in France, 1770-1830

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Chemistry's visibility in the historiography of the first industrialization remains minimal.[1] The traditional view is that the first industrialization centered on the textile and steel industries, while energy and technological systems driven by steam engines symbolise the "revolution" of productive systems. Even the historiographies that emphasize slow, integrated changes, the intensification of know-how, and the rise of consumption, insisting on an *industrious revolution* rather than an *industrial revolution,* rarely refer to chemistry.[2] This reflects the facts that there were few large chemical companies until the mid-nineteenth century and that chemical processes are often invisible, incomprehensible and dangerous – three traits that explain why chemistry is often ignored. Yet chemistry was (and remains) at the heart of many processing operations and played a vital role in production processes and the encouragement of technical development.[3] More than physics or mechanics, the discipline of chemistry progressed rapidly in the last third of the eighteenth century, accounting for many industrial experiments and advances. While much has been written about a "chemical revolution", embodied particularly by Antoine Lavoisier, his colleagues and protagonists, chemically based activities amongst craftsmen and tradesmen are too often overlooked. Many crafts, however, used chemical substances that were indispensable for production and its "improvement". Organic and mineral acids, chlorine, ammonium chloride, various pigments and sodium hydroxide were all chemicals promoted to improve the manufacturing of consumer goods. Especially from the 1770s

1 For a more detailed presentation of this essay, see Thomas Le Roux, "Chemistry and Industrial and Environmental Governance in France, 1770-1830," *History of Science* 54 (2016): 195-222.

2 Liliane Hilaire-Pérez, *La pièce et le geste. Artisans, marchands et culture technique à Londres au XVIIIe siècle* (Paris: Albin Michel, 2013); On chemistry's importance in the first industrialization: André Guillerme, *La naissance de l'industrie à Paris. Entre sueurs et vapeurs: 1780-1830* (Seyssel: Champ Vallon, 2007).

3 Bernadette Bensaude-Vincent, Isabelle Stengers, *Histoire de la chimie* (Paris: La Découverte, 1992); Sacha Tomic, *Comment la chimie a transformé le monde. Une histoire en 7 tableaux* (Paris: Le Square, 2013).

 | DOI 10.1163/9789004325562_009

chemical manufacturing drastically changed industrial processes. This not only had adverse effects on workers' health, it more broadly altered European societies' relationship with their environment.[4] Revolutionary events amplified this process by freeing the productive sphere from a number of constraints, encouraging all kinds of technical improvements and giving chemists a crucial role in matters of governance.

This essay examines how chemists contributed to the technological reorganization in France at the end of the eighteenth and the beginning of the nineteenth century, how they justified using potentially harmful or polluting processes by stating that this would contribute to national prosperity, and how the idea of improvement helped legally and rhetorically to build a production regime that disqualified traditional precautionary attitudes to certain artisanal and industrial processes. This resulted in a new regime of environmental governance devoted to the advancement of chemistry and industrial production.

The Acids Revolution and Value Shift

In the 1770s in France, a silent revolution took place in the relationship between chemical production and both its environment and medicine. Alain Corbin has shown that this decade was a turning point in medical and olfactory attitudes towards certain products.[5] Broadening this line of enquiry by considering the art of governing populations, it appears that chemistry played a crucial role in social and political representations as well as in governance systems. Previously, faced with the hazards, nuisances and disadvantages involved, regulatory authorities had been wary of laboratory and artisanal chemistry. The police, who traditionally saw to matters of public health and community safety and comfort, particularly resisted the use of aggressive acids. Reflecting this distrust, several trials took place in Paris against craftsmen who made nitric acid, the only strong acid produced on an industrial scale before 1770, known then as aqua fortis. In 1768, for example, Police Superintendent Jean-Baptiste Lemaire, with the backing of the Faculty of Medicine, summoned a nitric acid distiller who operated in the city center before the police court, on a charge

4 Thomas Le Roux, *Le laboratoire des pollutions industrielles, Paris, 1770-1830* (Paris: Albin Michel, 2011).

5 Alain Corbin, *Le miasme et la jonquille. L'odorat et l'imaginaire social, XVII-XIX[e] siècles* (Paris: Aubier, 1982).

of endangering the public's health.[6] Under the continued influence of the miasma theory, police protocol through the end of the *ancien régime* called for keeping close tabs on manufacturers of aqua fortis and acids, viewing them as sources of ill health and pollution.[7] Workshops and factories that offended the senses and contaminated the air and water underwent strict preventive investigations known as *commodo et incommodo*.[8]

The manufacturing of chemicals, and acids in particular, was banned from cities and often carried out in small-scale and home-based production facilities, where hazards were none the less significant, as the case of nitric acid reveals. Before the growth of sulfuric acid, nitric acid was used in most industries, from tanneries to metal works[9]. A key product for industrialization and highly corrosive, it was made in Paris beyond the Porte Saint-Denis in small isolated workshops guarded by the police. Despite their product's fundamental contribution to industrialization, these spaces remained untouched by large capitalist investment and exuded a sort of toxic domesticity. In the 1770s, however, a new way of seeing chemistry was emerging. Of course, even chemists generally recognized nitric acid's corrosive nature. In 1773, describing the art of the aqua fortis distiller in *Description sur l'art du distillateur d'eau forte*, Jacques-François Demachy described its "suffocating fumes" and very dangerous manufacturing processes.[10] The accompanying illustration, however, reveals a purpose quite other than promoting care when working with dangerous substances. A worker is pictured only to show the scale of the place, which is depicted without any chemical substances; the devices shown were to be understood, not experienced, and the heat, hazards and acid-soaked atmosphere were hidden to suggest an idealized vision of technical know-how.[11] There was neither activity nor matter, just production tools, which were the pedagogical focus of this book's representation of work. (See figure 7.1)

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6 Archives Nationales (AN), Y 9471B, report by Superintendant Lemaire, 5 August, 1768; AN, F12 879, *Rapport fait à la Faculté de médecine* [...] *pour examiner le laboratoire du Sieur Charlard, et juger les inconvéniens qui peuvent résulter pour les maisons voisines, de la distillation d'eau-forte*, by Bellot, de la Rivière, des Essartz, de Vallun, 1774, 16-17.

7 Nicolas Des Essarts, *Dictionnaire universel de la police*, 8 vols. (Paris: Moutard, 1786-1790), vol. 6, 1-2.

8 Le Roux, *Le laboratoire*, chapter 1 (see note 4).

9 John Graham Smith, *The Origins and Early Development of the Heavy Chemical Industry in France* (Oxford: Clarendon Press, 1979).

10 Jacques-François Demachy, *L'art du distillateur d'eaux-fortes* (Paris: impr. de Delatour 1773), 37-38.

11 Ibid., Part 2, Plate 1, Figure 2.

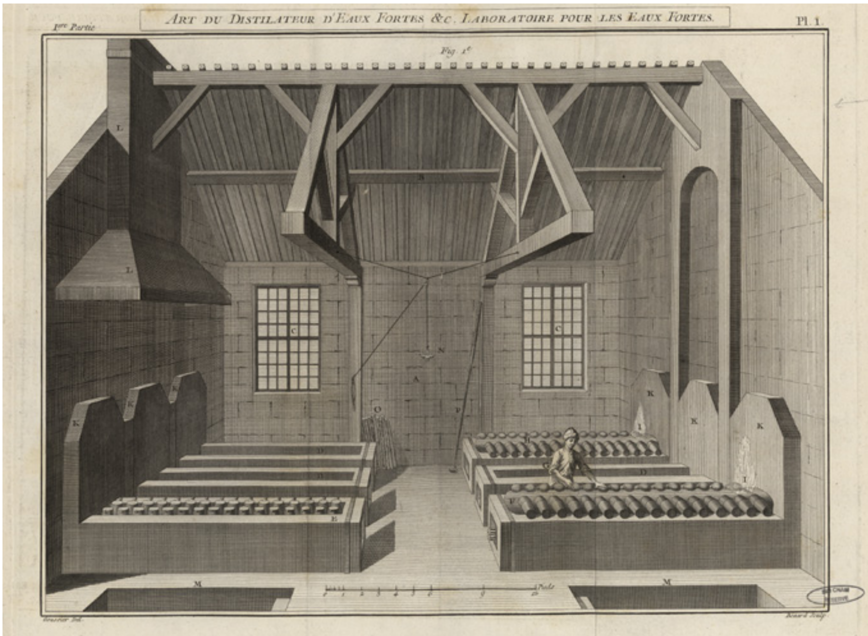

FIGURE 7.1 *Jacques François Demachy, "Art du distillateur d'eaux fortes etc. Laboratoire pour les eaux fortes,"* Description des arts et métiers (*Paris, 1773*), *Part 2, Plate 1, Figure 2.*
ILLUSTRATION COURTESY OF CONSERVATOIRE NATIONAL DES ARTS ET MÉTIERS.

Just like the *Description des arts et métiers* commissioned by the Academy of Science, which included the study of aqua fortis distillers, the *Encyclopédie*'s plates were based on facilities in Paris: their representations of work reflected a technological and universal order that wished to discipline bodies and become free from the constraints of particular locations.[12] This was a world ruled by scientists and technicians, who increasingly imposed their authority on the world of craftsmen and related physical practices. The stakes were all the higher because acids were a key industrial product, and government had begun ardently to promote acid manufacturing.

The main change came with sulfuric acid production. Despite having similar uses to nitric acid, sulfuric acid was only produced in small quantities

12 William Sewell, "Visions of Labour: Illustrations of the mechanical arts before, in and after Diderot's *Encyclopédie*," Steven Kaplan and Cynthia Koepp, eds., *Work in France. Representations, meaning, organization and practice* (Ithaca: Cornell University Press, 1986), 258-286; Georges Friedman, "L'*Encyclopédie* et le travail humain," *Annales, histoire, sciences sociales* 8 (1953): 53-68; Ken Alder, *Engineering the Revolution: Arms and enlightenment in France, 1763-1815* (Princeton: Princeton University Press, 1999).

before the late 1760s, mainly in laboratories where it was condensed in expensive and delicate glass jars during the final production stage. Sulfuric acid was absolutely essential for cotton printing, on which the government had recently lifted its ban in 1759. Simultaneously, in the United Kingdom, John Roebuck broke new ground by using lead chambers to condense sulfuric acid. The room-sized lead-lined chambers allowed sulfuric acid production on an industrial scale, which soon challenged nitric acid's preeminent position. The technology was introduced in France by the Englishman John Holker, a factory inspector employed by the French monarchy, who in 1768 set up a sulfuric acid factory next to his printed cotton factory in a suburb of Rouen.[13] Over a period of some months, the gases discharged by the chambers corroded by the strong acid caused breathing problems for neighbours and damaged surrounding vegetation.[14] According to police jurisprudence, this kind of nuisance was not tolerated near homes and, in 1772, Holker was prosecuted in France's first great industrial pollution trial. After several months of proceedings in the *Parlement de Rouen* (then called *Conseil supérieur*), the accused parties, supported by Jean-Charles Trudaine, the Commerce Director, obtained a hearing at the finance royal council. There Trudaine had to argue against Minister Henri Bertin, a former Paris Lieutenant-General from 1757 to 1759.[15] Economic interest prevailed over Bertin's arguments: in September 1774, the plaintiffs' case was dismissed and henceforth, no one was allowed to trouble or disrupt the factory's operation.[16]

The lead chamber was therefore not only a technological development: it occasioned a shift in the order of industrial and environmental governance. Firstly, it required major investment, which made any production stoppage problematic. Secondly, it was supposed to be a perfect device that replaced multiple operations by the workers with a simple system in which leaks could be better controlled. The same argument was used for both health benefits and economic profits, as any leak was treated as a loss of value.[17] Lastly, it led to a change in the representation of sulfuric acid manufacturing, presented from then on through its technology, such as by a technical drawing or a model showing only the mechanism's external envelope. Devices appeared, in the

13 Smith, *The Origins* (see note 9).

14 L.-G. de la Follie, "Réflexions sur une nouvelle méthode pour extraire en grand l'acide du soufre par l'intermédiaire du nitre, sans incommoder ses voisins," *Observations sur la physique* 4 (1774): 336.

15 AN, F[12] 879, vitriol oil factory in Rouen, letter from Bertin to Trudaine, 11 December 1773.

16 Ibid., order of the royal council, 20 September 1774.

17 de la Follie, "Réflexions," p. 336 (see note 14).

first representations of this kind of factory, like magical boxes where everything took place according to the scientific processes of physics and chemistry. Through representations of the working world and especially of artisanal and industrial chemistry, the last *ancien régime* decades witnessed the inevitable fading out of the proximity of arts and crafts. In its place arose a technical, disembodied order that would celebrate technical drawings during the nineteenth century, the seeds of which were already present in the encyclopaedic initiative and in scientific encouragement.[18]

While chemistry transformed the governance of industry and especially the government's attitude to nuisances, the root causes of this change should be sought in the government's economic policy as well as in the changes chemists were introducing to medical aetiology. The groundwork was laid by the chemist Louis-Bernard Guyton de Morveau from Dijon. In March 1773, he was contacted by the Dijon Cathedral's authorities, who could not get rid of the mephitic stench emanating from the decaying corpses in one of the building's vaults. Applying the theory on the combination of ammonia, whose presence could be deduced from the smell of decay, with an acid to produce a neutral salt, he fumigated the vault with muriatic (hydrochloric) acid and managed to neutralise the smell. In the medical community, among which the miasma theory was predominant, this removal of a smell was considered a victory over putrid infection and the experiment had a huge impact.[19] It was the first time acid fumigation was used in France as a way of controlling fermentation and its smell. The novel procedure broke with traditional conceptions about the corrosive and dangerous nature of acids. Until then, acids had never been thought of as a disinfectant; instead physicians recommended fumigation with odoriferous herbs, the spraying of vinegar or starting of a fire or a powder explosion to disperse and destroy miasmas. The fact that acid fumigation was not widely taken up, at least not immediately, is not important. The significance of these experiments and the publicity surrounding them in 1773 and 1774 was not that they immediately led to routine therapeutic use, but that they profoundly altered the perception of acids, a product that was crucial for industrial development.

18 Nicolas Pierrot, "Les images de l'industrie en France, peintures, dessins, estampes, 1760-1870," (Doctoral dissertation in History, Université Paris I Panthéon-Sorbonne, 3 vols., 2010).

19 Louis-Bernard Guyton de Morveau, "Nouveau moyen de purifier absolument, et en très-peu de temps, une masse d'air infectée," *Journal de physique* 1 (1773): 436 and 3 (1774): 73; Thomas Le Roux, "Du bienfait des acides. Guyton de Morveau et le grand basculement de l'expertise sanitaire et environnementale (1773-1809)," *Annales Historiques de la Révolution française* 383/1 (2016): 153-175; For the further history of Guyton's fumigating machine, see Elena Serrano's essay in this volume.

Because acid promotion was at the heart of a governmental scheme to encourage production in order to boost industrial development, Guyton de Morveau's experiments were a godsend and allowed medicine to progress hand in hand with economic development. In 1774, Vicq d'Azyr prescribed acid fumigation to treat epizootic diseases in the south of France, and the following year, the academicians Etienne Mignot de Montigny and Philibert Trudaine de Montigny also recommended this disinfection method in two separate notices and enquiries.[20] The chemist Antoine Parmentier, senior scientific advisor to the police lieutenant-general, observed that "acid vapours" combined with other elements in the air to "contribute to its cleanliness."[21] He further extolled the virtues of "spirit, acid and corrosive fluids, which could be released to destroy or neutralise the miasma supposed to be dispersed in the air."[22] The link between medicine and chemistry was strengthened specifically during this decade: one after the other, the physicians Claude Berthollet, Antoine Fourcroy and Jean-Antoine Chaptal stopped practising medicine to study chemistry, and all played a predominant role in the development of industrial chemistry, especially in relation to acids. Fourcroy became an expert and regular government advisor, assessing nuisances caused by chemical factories. For instance, he was commissioned by the Royal Society of Medicine in 1783 to write a report on a sulfuric acid factory in Rouen. In this report, he strongly defended the manufacturer, dismissing his opponents as prejudiced and ignorant about chemistry.[23] From then on, the *Bureau du Commerce* (Trade Office) relied on these new ideas to encourage and at times force the establishment of acid factories in close proximity to cities. To override public objections, trade officers used a combination of medical and chemical arguments, claiming that "sulphur vapours, far from being hazardous, are very healthy. They purify unhealthy air. They prevent epidemics."[24] This was a reasonable stance to take, especially as the chemists Macquer and then, from 1784, Berthollet were members of the *Bureau* and greatly contributed to spreading these ideas.

20 Etienne Mignot de Montigny, *Instruction et avis aux habitans des provinces méridionales de la France, sur la maladie putride et pestilentielle qui détruit le bétail* (Paris: Imprimerie Royale, 1775); Philibert Trudaine de Montigny, *Avis aux peuples des provinces, où la contagion sur le bétail a pénétré et à ceux des provinces voisines* (Paris: Imprimerie Royale, 1775).

21 Antoine-Augustin Parmentier, *Dissertation physique, chimique et économique, sur la nature et la salubrité des eaux de la Seine* (Paris: impr. de J.-G. Clousier, 1775), 9-10.

22 Antoine-Augustin Parmentier, *Dissertation sur la nature des eaux de la Seine* (Paris: Buisson, 1787), 104.

23 AN, F^{12} 1507, folder I-1, report by Fourcroy and Thouret, 2 November 1783.

24 AN, F^{12} 1506, folder 5, factory in Javel, department of trade documents, undated [1777-1778].

Chemistry not only contributed to the idea of improvement in arts and crafts, but also in society and the economy. Many chemical substances were used to produce semi-luxury and luxury goods, especially in the non-ferrous metal industry. This was the case, for example, for silver and gold plated products and in the new platinum industry. In a letter to Guyton de Morveau, dated November 1786, Lavoisier mentioned that he was working with the innovative gold and silversmith Jacques Daumy. To treat platinum for craftsmen and manufacturers, they refined, dissolved, precipitated and revived the metal with hydrochloric and nitric acid, ammonium chloride, borax, lead, bismuth, antimony and arsenic.[25] More generally, the integration of new chemistry with luxury goods production occurred through precision metalwork on precious metals, "the artistry of which was perfected through very delicate chemical operations and relatively challenging processes for the workers."[26] The new Paris Mint, built between 1771 and 1775, served as a laboratory, not only for making coins but also mastering the chemistry behind refining, cupellation and alloying assays to make all kinds of gold and silverwork pieces. In this field, with a similar argument as that used for sulfuric acid, the matter of goldbeating was raised before the royal council in 1773. Gold beaters in Lyons were accused by the police of using furnaces within the city, as well as treating gold with antimony and corrosive sublimate (a mercury compound), two dangerous substances. Both activities violated manufacturing and public health laws. The beaters defended themselves by appealing to the king and arguing a number of economic points: to uphold the restrictions and the "broadly prohibitive law" would condemn their industry to decline; and it was only by violating restrictions "contrary to the public interest" that their "art has improved." According to them, violations were "brutal procedures enforced by an uninformed police officer." The king was convinced and agreed to authorize the use of furnaces as well as antimony and mercury for metal refining, "to support the main factories in Lyons," by an order of the Council dated 29 April 1773. The order's preamble stated that the petitioners had "a duty to preserve their industry for the state and to perfect it."[27]

Chemistry thus contributed to transform physicians' and scientists' perception of mineral acids and other chemical substances, which until then had been feared for their corrosive effects. It demonstrated the medical usefulness of these acids, thereby helping to overcome the usual precautions and spurring their industrial use. This reversal had an effect on industrial nuisance policy in

25 Antoine Lavoisier, *Œuvres* (Paris, 1854-1868), vol. 5, 340.

26 AN, K 903, Monnaie, file 108, *Observations sur le projet d'édit de Mr de F*, undated (1770s).

27 Essarts, *Dictionnaire,* vol. 7, p. 434 (see note 7).

the medium-term. During the Revolution, the Consulate and Imperial years, it translated into fundamental reports and regulations, which tied medical expertise, chemistry and industrial development together.

Chemical Governance and the Environment (1789-1810)

In 1791 liberalism, which was already perceptible at the end of the *ancien régime*, inspired several steps to facilitate the setting up of industries whatever their nuisances. While the disruption that occurred in 1789 implicitly resulted in more freedom for industrialists, who took advantage of the dismantling of former regulatory institutions, the new legislation permanently released industry from several controlling regulations.[28] *Commodo et incommodo* investigations were stopped, and the d'Allarde Law of March 1791 abolished arts and crafts guilds and their statutes.[29] In September 1791, the *Bureau* and industry inspectorate were dismantled. In October 1791, letters patent granting exclusive privileges were abolished, which did away with preliminary investigations in use under the *ancien régime*. Consequently, industrialists were free to set up factories wherever they wanted and manufacture products using whichever processes they wished. Legislators ruled that the courts only had jurisdiction to address property damage.

However, the revolutionary period was also characterized by a strengthening of the value shift occurring in the public interest domain. Public interest was no longer concerned first and foremost with safeguarding public health, but was permanently associated with economic development. Chemists became the new official experts on assessing pollution and contributed to the policies of the successive republican governments. Thus in 1791, when the Academy of Science investigated the pollution caused by an ammonium chloride factory established in the middle of a populated neighbourhood near Valenciennes, the report's authors (chemists Louis Cadet, Fourcroy and Berthollet) conceded that pollution had disadvantages, but considered that the smoke could be tolerated in the interest of national industry and general welfare.[30]

28 Alain Plessis, ed., *Naissances des libertés économiques, 1791-fin XIXe siècle* (Paris: Institut d'histoire de l'industrie, 1993).

29 Philippe Minard, "Le métier sans institution: les lois d'Allarde-Le Chapelier de 1791 et leur impact au début du XIXe siècle," Steven Kaplan and Philippe Minard, eds., *La fin des corporations* (Paris: Belin, 2003), 81-95.

30 Archives de l'Académie des Sciences, *Registre des procès-verbaux de l'Académie des sciences*, fol 371-373, 28 June 1791.

Moreover, with the outbreak of war, scientists legitimized exceptional industrialization. Lazare Carnot, Fourcroy, Guyton de Morveau and Pierre-Louis Prieur took an active part in the decisions taken by the *Comité de Salut Public* (Public Safety Committee), including the decision to employ reputed chemists such as Gaspard Monge, Berthollet, Jean Darcet, Bertrand Pelletier and Chaptal in the war effort.[31] This patriotic mobilization led to the idea that national production should be boosted in the context of war and economic competition. Requisitioning and military orders caused the reconversion of factories and the adoption of foreign processes: hatters converted their workshops to make varnished helmets; the need for uniform buttons led to the setting up of workshops for copper treatment and acid gilding; and textile workshops were set up under the supervision of the agency for republican military clothing to make cloth, sheets and military dress.[32] In a more obvious way, the arms industry flourished in the capital, where the *Manufacture de Paris* was set up in the autumn of 1793 as a huge cluster of workshops including a small arms testing and improvement workshop established in April 1794 under the authority of the weapons commission, headed by Guyton de Morveau.

A few flagship products illustrate the involvement of chemists in industry. In addition to armaments manufacturing, leather, copper and pigments are worth noting. From the autumn of 1793, the revolutionary government was looking for a way to produce leather goods for the troops as fast as possible and entrusted the task to the chemists. The *Comité de salut public* instructed Berthollet "to take charge of tanning improvement," and named Armand Seguin to conduct several experiments. Fourcroy praised Seguin's "revolutionary" tanning method, which involved replacing previously used weak organic acids with a concentrated solution of sulfuric acid, in his report to the Convention, noting that the new process sped up manufacturing considerably.[33] The new method was employed at the state-financed tannery established in late 1794 on the Sèvres Island in the Paris suburbs, with used acid discharged into the Seine.

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31 Patrice Bret, *L'Etat, l'armée, la science. L'invention de la recherche publique en France, 1763-1830* (Rennes: Presses Universitaires de Rennes, 2002); Charles C. Gillispie, *Science and Polity in France. The revolutionnary and Napoleonic years* (Princeton, NJ: Princeton University Press, 2004); Nicole Dhombres and Jean Dhombres, *Naissance d'un nouveau pouvoir: sciences et savants en France, 1793-1824* (Paris: Payot, 1989).

32 Jean-François Belhoste and Denis Woronoff, "Ateliers et manufactures: une réévaluation nécessaire," Françoise Monnier, ed., *A Paris sous la Révolution, nouvelles approches de la ville* (Paris: Publications de la Sorbonne, 2008), 79-91.

33 Antoine-François Fourcroy, *Rapport, au nom du Comité de Salut Public, sur les arts qui ont servi à la défense de la République, et sur le nouveau procédé de tannage découvert par le citoyen Armand Seguin* (Paris: impr. Nationale, 1795).

A similar mindset was applied to copper production. From 1791, the government requested gold and silversmith Daumy to melt and refine bronze bells to make coins, and then cannons, in a new factory on the Île de la Cité using chemical processes requiring large amounts of nitric, sulfuric and muriatic acid.[34] Here too, toxic remains were discharged into the river.

The example of minium, a lead-based pigment used to make porcelain, shows how chemists used pollution charges to promote industrial innovation. Neighbours alleged that the lead oxide discharged from a minium factory in the Parisian neighbourhood of Bercy in June 1793 polluted the area. Simultaneous to Bercy's council banning the factory, the government entrusted an expert report to the chemists Pelletier and Petit, who argued that the problem could be reduced by improving manufacturing processes. Guyton led a second inspection, with the understanding that minium production was "valuable for the Republic" and "useful for arts workshops." Fourcroy, then a National Convention member, advocated that the owner should be "protected in his factory given that minium could no longer be procured in Britain or Holland."[35] Confirming that there was a public health issue, Guyton's report resulted in an order to demolish the factory, but the owner was encouraged to improve his manufacturing processes with the help of well-placed chemists and physicians, who also lobbied successfully for generous government compensation to rebuild the factory.[36] This case exemplifies what became a pattern of technical improvement under the guise of chemical scientific expertise, initially only seen with sulfuric acid factories, now fixed by Guyton de Morveau and Fourcroy.[37] From the Napoleonic regime, members of the *Conseil de salubrité* would take it upon themselves to make this the core of environmental regulation. Two important considerations emerged from chemists' involvement: public interest was equated with economic development and technical solutions were proffered as the best way to reduce nuisances from craft production. It thereby became possible to divest the traditional police of its prerogative powers and to bypass the judicial reasoning of the *ancien régime*.

After peace returned in 1795, France's economic expansion was driven by its chemical industry. In Paris alone, dozens of factories were working inside the city walls and suburbs. Growth was especially embodied in four flagship plants

34 Bibliothèque Historique de la Ville de Paris, Ms 929, Manufacture Daumy.

35 *Procès-verbaux du comité d'instruction publique de la Convention nationale* (Paris: Impr. Nationale, 1891-1907), vol. 2, 792; *Archives parlementaires* (Paris: CNRS, 1980-), vol. 79, 153-154.

36 AN, F^{12} 1509, Comité agriculture, folder Ollivier, 1794.

37 On this case, Le Roux, *Le laboratoire*, pp. 204-212 (see note 4).

that were largely established between 1795-99 by chemists who were (or became) academicians. The factory owned by Chaptal in Ternes was a particular focus of public attention and began raising protests while it was being built. However, having become Interior Minister, Chaptal rejected all complaints year after year and generally became the key agent for unifying science and administration. Before the Revolution, he was a chemical entrepreneur in Montpellier, producing especially sulfuric acid, and in 1790 was sued for pollution by local residents. Berthollet recruited him to be involved in the republican administration, and he headed the gunpowder factory of Grenelle, when it exploded, killing 550 workers.[38] Prior to becoming Interior Minister in 1800, Chaptal built his famous sulfuric acid factory in Ternes and wrote *Essai sur le perfectionnement des arts chimiques* [Essay on the Means of Perfecting Chemical Arts], both a treatise on applying the latest chemical discoveries to industry and a guide for entrepreneurial leadership.[39] As Minister, academician, chemist, entrepreneur and member of the *Conseil d'Etat*, he embodied the conjunction of scientific expertise, entrepreneurial experience and emerging administrative standards through which industrialism and liberalism became associated.[40]

Between 1802 and 1804, Chaptal worked to build a coherent framework to serve industry. He began by founding the *Conseil de salubrité* in 1802, an institution with scientific expertise – mainly chemists with a soft spot for industry – to advise the Parisian authorities. In agreement with the owners of the factories and workshops, members often denied that industrial fumes were noxious or deleterious to plaintiffs' health. In the case of chemical factories, they pointed out that the waste gases were "valuable" and that it was in the interest of the manufacturer to prevent them from escaping. Pollution, thus, was construed as the result of unintended accidents rather than daily practice.[41] Meanwhile, economic affairs were entrusted to new or reorganized institutions, such as the Mint, which became a veritable laboratory for testing the

38 Thomas Le Roux, "Accidents industriels et régulation des risques: l'explosion de la poudrerie de Grenelle en 1794," *Revue d'Histoire Moderne et Contemporaine* 58/3 (2011): 34-62; Claire Barillé, Thomas Le Roux and Marie Thébaud-Sorger, "Grenelle, 1794. Secourir, indemniser et soigner les victimes d'une catastrophe industrielle à l'heure révolutionnaire," *Le Mouvement Social* 249/4 (2014): 41-71.

39 Jean-Antoine Chaptal, *Essai sur le perfectionnement des arts chimiques en France* (Paris: Déterville, undated [1799]).

40 Jeff Horn, *The Path Not Taken. French industrialization in the age of revolution, 1750-1830* (London; Cambridge, MA: MIT Press, 2006).

41 Le Roux, *Le laboratoire*, chapters 7 to 9 (see note 4).

science/administration alliance.[42] Inside the *Société d'encouragement pour l'industrie nationale* (SEIN, Society for the Encouragement of National Industry) founded in 1801 by Chaptal, Guyton chaired the committee for chemical arts. There, he regularly saw Berthollet, Fourcroy, Nicolas Vauquelin, Parmentier, Darcet and Deyeux, under the general chairmanship of Chaptal – that is, all the academician chemists of the time, all supporters of industrial development and almost all editors of the leading journal *Annales de chimie*. During these years, the state apparatus particularly supported acid chemistry. The Directory had already recognized its considerable value, emphasizing in 1798 that acids "are like a reservoir of very powerful forces, which nature has made available to man to produce effects that would be impossible to obtain using mechanical force."[43] Under the Consulate, acid promotion increased.

However, everywhere in France as in Paris, trials against owners of chemical factories accused of pollution threatened to disrupt the steady industrial production. After Chaptal was replaced by Jean-Baptiste de Champagny as the Interior Minister in August 1804, the authorities contemplated a national response to this recurring issue. In November 1804, the new Minister asked the French institute "about factories exhaling an obnoxious smell and the risk that they posed for public health"; the institute entrusted the report to Guyton de Morveau and Chaptal.[44] A second report followed in 1809.[45] Together they provided the basis for the law of 1810 on polluting industries.[46] The 1804 report argued against the necessary validity of complaints by claiming a distinction between industries with processes based on organic putrefaction, which released "smells that were disturbing or toxic fumes," and those with processes

42 Patrice Bret, "Des essais de la Monnaie à la recherche et à la certification des métaux: un laboratoire modèle au service de la guerre et de l'industrie (1775-1830)," *Annales Historiques de la Révolution Française* 320/2 (2000): 137-148.

43 AN, F^{12} 2234, information provided to the Conseil des Cinq-Cents by the Directory, 31 January, 1798.

44 "Rapport […] sur la question de savoir si les manufactures qui exhalent une odeur désagréable peuvent être nuisibles à la santé," 17 December 1804, *Procès-verbaux des séances de l'Académie des sciences* (Hendaye: Impr. de l'Observatoire d'Abbadia, 1910-1922), vol. 3, 165-168.

45 "Rapport sur les manufactures de produits chimiques qui peuvent être dangereuses," 30 October 1809, *Procès-verbaux* vol. 4, pp. 268-273 (see note 44); Subsequent citations not referenced in the notes are from these reports.

46 For details, Geneviève Massard-Guilbaud, *Histoire de la pollution industrielle, France 1789-1914* (Paris: Editions de l'EHESS, 2010), 34-45; Le Roux, *Le laboratoire,* pp. 255-261 and 274-283 (see note 4); Jean-Baptiste Fressoz, *L'apocalypse joyeuse. Une histoire du risque technologique* (Paris: Le Seuil, 2012), 150-165.

based on fire, which emitted vapours or gases that were uncomfortable to breathe, but usually only inconvenient. In particular, factories that were well run, might release an obnoxious, but certainly not a harmful smell. As a matter of fact, they wrote, the smell released by sulfuric acid factories "was not dangerous in the least for the workers who breathed the smell daily, and no neighbours' complaint could be deemed well founded." As for nitric and hydrochloric acid factories, their characteristic smell could not affect human breathing; the men "who work there every day were not at all inconvenienced and it would be very wrong of the neighbours to complain."[47] Another hydrochloric acid expert, the industrialist Robert O'Reilly, contradicted their assertions. In his *Essai sur le blanchiment* [Essay on Bleaching], O'Reilly reported witnessing "in a very large plant near Paris, the cruel suffering endured by [the] wretched [workers] because of the suffocating fumes. I saw them writhe on the floor in pain; often these first effects of oxy-muriatic acid can cause even serious illnesses."[48] In fact, Chaptal knew that occupational health was at stake in the workplace. In 1798, in his *Essay*, he argued that "the various tasks in a workshop are not all equally easy or pleasant; and since young men are too often minded to refuse difficult or repulsive tasks, a coercive force is needed to compel them to carry out these tasks and this force can only be found in the ties that bind them to the workshop and keep them at the disposal of their superiors."[49] Politics and productivity won the day in his view.

The 1804 report's fundamental stance was that the central government needed to protect France's chemical industries. Obstructions "would be at once unfair, persecutory, harmful to the advancement of the arts and would not address the harm caused by the operation." Chaptal and Guyton thereby turned the Minister's question on its head, moving away from a public health issue to a concern of political economy by defining an entirely new program. "[P]rosperity of the crafts absolutely requires that boundaries are set to put an end to arbitrary decisions by magistrates by drawing a circle around industrialists, inside which they will be able to ply their trade freely and securely."[50] The 1809 report followed similar reasoning, but the context had changed. On the one hand, since its foundation in 1802 and its specialization in industrial affairs in 1806 (with chemists Deyeux and Cadet de Gassincourt as its authorized experts), the Paris *Conseil de salubrité* had acquired an undeniable legitimacy.

47 Quotations from "Rapport" (1804) (see note 44).

48 Robert O'Reilly, *Essai sur le blanchiment* (Paris: Bureau des Annales des arts et manufactures, 1801), 99.

49 Chaptal, *Essai*, pp. 9-10 (see note 39).

50 Quotations from "Rapport" (1804) (see note 44).

On the other hand, for several months, an ongoing problem had been caused by sodium hydroxide factories, in which sea salt was broken down by sulfuric acid using the Leblanc process, discharging large quantities of muriatic acid. Several soda plants, managed by distinguished chemists who would become members of the *Conseil de salubrité* or were very close to them, were built, in the Parisian suburbs after 1800. The irreversible damage caused by acid vapours and the utter destruction of crops and orchards around these factories was obvious. Faced with a fresh spate of pollution cases in 1809, the Minister was forced to commission a second report from the institute. The new committee membership had a similar "industrialist" flavor: alongside Chaptal and Guyton de Morveau, the entrepreneurs Fourcroy and Vauquelin also owned a sizeable chemical factory in the center of Paris, while the chemist Deyeux made no bones about his industry bias in the *Conseil de salubrité.*

The Minister urged its authors to strike a balance between the interests of industrialists and those of neighbouring property owners. No longer simply cast as victims, industrialists were required to choose factory locations carefully. The report's conclusion thus called for a consensus, proposing to group industries into three classes according to their degree of nuisance. The chemists suggested introducing specific administrative enquiries for the purpose of authorizing factories in each group, to pre-empt most pollution problems. However, the spirit of Guyton's 1793 report on minium was not forgotten; on the contrary, the report promoted technical improvement for the chemical industry as a means of moving from one class to another to lighten constraints and government control. These conclusions were included in the law of October 1810 on insalubrious industries.

Pollution and Governance through Chemistry

The decree of 1810 aimed to establish a regulatory framework by separating industries into three categories depending on their level of noxiousness. A great deal was at stake in how a factory was categorized; being moved from the first meant that the factory was no longer considered noxious and could avoid the *Conseil d'Etat*'s long and strict authorisation procedure. The decree was therefore supposed to promote innovation and the *perfection* (a word very often used) of processes.[51] *Conseil de salubrité* members, who completely sup-

51 Thomas Le Roux, "La chimie, support du développement de l'industrie perfectionnée sous la Révolution et l'Empire," Natacha Coquery, ed., *Les progrès de l'industrie perfectionnée* (Toulouse: Presses Universitaires du Midi, 2017), 26-35.

ported their founder's industrialism, were soon convinced by the principle of process improvement as a way of avoiding production restrictions. From 1811, the *Conseil de salubrité* linked industrial improvement and public health.

In the years after the decree was first implemented, *Conseil de salubrité* members expressly encouraged the building of chemical plants in Paris, as shown by numerous reports supporting the four flagship factories mentioned above. These factories belonged to the first class according to the decree, but had been set up prior to it. Their assessment by the *Conseil de salubrité* was spurred by complaints from neighbours. Impressed by these magnificent factories for which substantial capital had been raised, the *Conseil* systematically ruled in their favor. Complainants were discredited as reflecting the much-admired entrepreneurs' reverse image, their complaints deemed even less reasonable because at each inspection, improvements were observed. To explain why complaints persisted, the *Conseil* blamed exuded fumes on accidents, themselves considered rare and due to worker negligence, an increasingly standard response from the nineteenth century. Hopes about further improvement rested on the wager that scientific theorizing and laboratory tests could and would be confirmed on an industrial scale. Despite multiple protests, none of the main factories were threatened with closure.

Instead, the chemical industry became a pillar for industrial governance, with chemists and other scientists given a crucial role. On one hand, they were granted authority through claims of how they stimulated further industrial innovations. On the other hand, they were asked to exercise that authority as arbiters of the governmentally sponsored drive for national prosperity and perfection of the arts while attending to matters of public health. Like Achilles' spear, chemistry was thus poised to "cure the wound it had inflicted."[52] In calling for grouping insalubrious industries together in certain areas, for example, the *Conseil de salubrité* member Parent-Duchâtelet showed the way:

> [A] special government official will be able to supervise them *effectively* and implement the conditions required to ensure public health. We stress the importance of the latter point, to show that large manufacturing centres will not become, as we might have feared, sites of infection by expelling their poisonous atmosphere far away, but will contribute to the

52 Victor de Moléon, ed., *Rapports généraux sur les travaux du Conseil de salubrité de la ville de Paris et du département de Seine. Années 1802-1839* (Paris: Bureau du Recueil industriel, 1828-1841), vol. 1, 207-208.

> advancement and sanitizing of factories, and perhaps also to the improvement of the arts.[53]

This sanitizing by chemistry was carried out in several ways, depending on the industry, through disinfection, smoke consumption or condensation. In industries using putrescible matter, “disinfection” was one of the preferred means of applying the recommended procedures. The first large-scale trials were carried out in Parisian gut factories using chlorinated products, in a decisive battle against putrid infection. In 1820, the *Société d’encouragement pour l’industrie nationale* created an award for manufacturers who could dress guts without prolonged maceration or noxious smells. The model gut factory in Clichy near Paris became a site for testing disinfection, using the new method of the pharmacist Antoine Germain Labarraque. The guts were steeped in a soda chloride bath, which removed the smell straight away. Though expensive, the method was quicker than the old one and succeeded in sanitizing the factory. In October 1822, Labarraque was awarded the prize and the *Conseil de salubrité* recommended the method to every new gut factory, assuming that it would also be adopted in older factories in a few years.[54] The “disinfecting” properties of acids were also put to use, thanks to their powers of decomposition. Darcet tested the use of sulfuric acid himself for melting tallow in the new Parisian slaughterhouses after 1818. In the 1820s, the acid was also used to purify oils in many Parisian workshops, distilleries and potato starch factories, where it immediately turned starch to syrup, and in beet sugar refineries, where it prevented decay. Darcet began to use muriatic acid in 1815 to extract gelatine from bones, and encouraged strong glue manufacturers to adopt his method.[55] With regard to smoke consumption in furnaces, he was once more at the heart of technological change to cut down the amount of industrial smoke. To reduce the incidence of industrial smoke increasingly criticized by city dwellers, especially as the use of fossil coal had begun to spread in Parisian industries, the *Conseil d’Etat* strove to recommend the construction of smokeless furnaces. Having witnessed the first lasting attempt to build a smokeless furnace at the mint in 1808, Darcet continuously encouraged the adoption of this kind

53 Alexandre Parent-Duchâtelet, *Hygiène publique* (Paris: Baillière, 1836), vol. 2, 326.

54 Moléon, *Rapports*, vol. 1, pp. 141-142, 163 and 319-322 (see note 52).

55 Jean-Pierre Darcet, Antoine Germain Labarraque, Jean-Baptiste Huzard, and Henri-François Gaultier de Claubry, “Rapport sur l’examen comparatif de la fonte des suifs à feu nu, et par l’intermédiaire de l’acide sulfurique,” *Annales d’hygiène publique et de médecine légale* 24 (1840): 54-78; “Mémoire sur divers emplois de la gélatine extraite des os, par le procédé de M. d’Arcet,” *Annales de l’industrie nationale et étrangère* 7 (1822): 276-285.

of smoke "burning" furnace with improved combustion and perfected the technology.

Finally, the expansion of the chemical industry in the Paris region forced manufacturers to take technical measures to preserve the surrounding areas. Condensing, absorbing, dissolving and closed-system production were all complementary methods implemented to "coerce" or retain the vapours produced by the manufacturing or use of chemicals by industry. In the 1820s, the *Conseil de salubrité*'s efforts to condense acid vapours increased. Whenever possible, closed-system production was encouraged in acid factories. Woulfe's apparatus, in which gases were forced to pass through a series of tubes and vessels filled with water or liquid absorbents, was recommended in nitric acid workshops.[56] Other condensation devices were proposed for various industries that implemented chemicals and acids in particular. This was the case for precious metal refining, for instance. Gold and silver refining, no longer restricted by a Directory government monopoly and performed subsequently with less expensive methods using sulfuric acid instead of nitric acid, was carried out in several Parisian workshops after 1815. Having observed various technical processes at the mint, Darcet set out to prove their harmlessness provided a number of steps were followed to ensure gas condensation. Therefore, industry's presence within cities hinged on the manufacturers' ability to prevent the discharge of acid gases. In 1827, Darcet himself designed a model refining workshop and its furnishings. In the refining furnace, five closed platinum vessels allowed acid gases to discharge through a lead pipe and flow into a single pipe under the workshop towards three refrigerated lead boxes, where the sulfuric acid fumes condensed. Uncondensed sulfuric vapours remaining in the gas were then removed by directing the gas into a box filled with hydrated lime, which rotated on itself when operated by a crank and a gear system. This mixed the lime and improved contact with and absorption of the sulfuric acid. Finally, a pipe discharged any remaining vapours from the box into the main workshop stack.[57]

The same reasoning was applied to recycling. In the 1820s, the chemists Charles Derosne and Anselme Payen embarked on producing depurative

56 Moléon, *Rapports*, vol. 1, p. 160 (see note 52).

57 Jean-Pierre Darcet, *Instruction relative à l'art de l'affinage* (Paris: impr. de Huzard-Courcier, 1827); Jean-Pierre Darcet, *Seconde instruction relative à l'art de l'affinage* (Paris: Bachelier, 1828); Thomas Le Roux, "Déclinaisons du 'conflit'. Autour des atteintes environnementales de l'affinage des métaux précieux, Paris, années 1820," Thomas Le Roux and Michel Letté, eds., *Débordements industriels dans la cité et leurs conflits, XVIII-XXIe siècles* (Rennes: Presses Universitaires de Rennes, 2013), 179-198.

organic compounds (bone-black and animalized carbon) from animal residue. Recovered animal waste was made into chemicals with sanitizing properties, for example to clarify and purify beet sugar, while partly addressing the problem of refuse disposal. Against charges of polluting the neighbourhood, the *Conseil de Salubrité* praised Derosne's operation for recycling wastes, boosting production and sanitizing the environment:

> This animal matter [livestock blood], which used to be wasted and often spoiled the air as it decayed, is now carefully collected to be used in numerous sugar refineries [...] and will be turned into a worthwhile export industry; the fortuitous benefit of an industry in operation, which extracts a useful product out of a worthless substance and turns an unhealthy cause into a new source of wealth.[58]

Like Derosne, Payen was involved in the chemistry of recycling animal waste, which he distilled in his Grenelle plant to make ammonium chloride.[59] By 1820, the factory had become a huge industrial complex, also manufacturing soda chloride, lime chloride, animalized carbon, sugar, and so forth. While pollution from recycling on such a large scale was frequent and at times permanent, the *Conseil de Salubrité* found a convenient answer in proposing to recycle the recycling plant's main waste, empyreumatic oil, which they offered to gas factories. These could distil the oil into lighting gas, in exchange for which the soda chloride factory could then treat the ammoniated waste that they produced.[60] Therefore, most of the time, sanitizing processes combined waste recycling and its profitable reclamation.

This insistence on promoting technical improvement explains why chemists became so fond of engraved technical drawings, which were soon adopted by the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*. From the first issue published in 1802, the *Bulletin* included copper-engraved plates as inserts, showing the emerging graphical art form that was developing around the *Conservatoire des arts et métiers*.[61] Unlike representations by artists, who had distanced themselves from production sites during the revolutionary decades, technical drawing was a political undertaking in itself. As a tool for

58 Moléon, *Rapports*, vol. 1, p. 286 (see note 52).

59 Sabine Barles, *L'invention des déchets urbains: France, 1790-1970* (Seyssel: Champ Vallon, 2005), 38-39.

60 Moléon, *Rapports*, vol. 2, pp. 15-17 (see note 52).

61 Yves Deforges, *Le graphisme technique. Son histoire et son enseignement* (Seyssel: Champ Vallon, 1981).

rationalization, it introduced a new symbolic order that established technology as superior to work places and physical movements.[62]

Chemistry was at the heart of the combination of technical devices and law: environmental governance simply conformed to the necessities of competitive industrial production. In March 1815, to explain the shift to local prefects, the government tried to clarify the new approach and the spirit that should guide their decisions on implementing the 1810 law: "Before, the existence of chemical factories was precarious in some respects [...] In reviewing authorisation applications [the local authorities] will most certainly rise above petty interests; and driven only by reasons of public interest, they will give opinions based on considerations of a higher order."[63] Sulfuric acid production improved continuously as greater numbers of lead chambers appeared; they symbolized the analogy between economic growth, political economy, chemistry and technical and environmental devices. Increasingly effective lead chambers were one of the advanced industries that could better prevent acid vapours, and was typical of scientists' discourses. According to Chaptal, in 1819, this technology had "reached perfection, as not one sulphur atom was lost in the operation as proven by the analysis carried out on the acid produced."[64] Without any loss of acid, and therefore, no loss of value for the manufacturer, virtuous profit was combined with environmental protection, Chaptal claimed.

Conclusion

Thus, linked to industrial production and scientific improvement, chemistry contributed to change environmental perceptions of the industrial world by the turn of the nineteenth century. The mistrust widely shared by local authorities, social observers and citizens regarding factory and workshop emissions was replaced by a new definition of harmfulness and harmlessness as industrialization imposed its pace, in order to adapt to the claimed imperative of

62 Ken Alder, "Innovation and Amnesia: Engineering rationality and the fate of interchangeable parts manufacturing in France," *Technology and Culture* 38 (1997): 273-311; Eda Kranakis, *Constructing a Bridge: An exploration of engineering culture, design and research in nineteenth-century France and America* (Cambridge, MA: MIT Press, 1997); Olivier Lavoisy and Dominique Vinck, "Le dessin comme objet intermédiaire de l'industrie," Pierre Delcambre, ed., *Communications organisationnelles. Objets, pratiques et dispositifs* (Rennes: Presses Universitaires de Rennes, 2000), 47-63.

63 Archives de la Préfecture de police, DB 134, instruction by the Director-General for Agriculture, Commerce, Crafts and Industry to the department prefect, 4 March 1815.

64 Jean-Antoine Chaptal, *De l'industrie française* (Paris: Renouard, 1819), vol. 2, 65.

economic growth. While this shift was perceptible from the 1770s with the first regulatory exceptions for strategic products, the 1810 decree – imagined, designed and implemented by chemists – perpetuated chemistry's role as an environmental regulator. Chemistry and its practitioners helped build an industrial world at a time when its arrival was not universally welcomed. After 1815, there was no doubt that industrial advancement had become a value shared by many actors. Through their experiments as well as their discourses and involvement in industrial applications for their discoveries, chemists participated in this expansion more than others. The authorities provided a great deal of support, especially in resolving conflicts about pollution caused by the chemical industry, by conceiving an administered regulatory framework that justified industrialism. In 1816, in a retrospective essay on industrial growth since the Revolution, Chaptal's first assistant Claude-Anthelme Costaz sang the merits of the 1810 decree: "We are not afraid to say that it has been of great benefit to owners and manufacturers [...] [who] [...] are now assured not to be bothered when carrying out their business once it has been authorized by the authorities: which is not inconsequential for the prosperity of chemical factories."[65]

65 Claude-Anthelme Costaz, *Histoire de l'administration, en France, de l'agriculture, des arts utiles, du commerce, des manufactures* (first edition 1816; Paris: Vve Bouchard-Huzard, 1843), 375-376.