The forgotten pollutions of rivers can still lead to risks!

Corinne Castel (CNRS)

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Rivers were not subjected to severe pollution before the industrial era. Nonetheless, they have undergone the long term and sometimes major impacts of human activities. Throughout every era and in every region of the world, pollution has increased with sedentarization, the concentration of populations, increased demography, urban development and that of craft and mining activities.

Diverse forms of pollution already existed in ancient times. They were related to rainwater runoff that washed away animal and human excrements, animal carcasses, and all kinds of refuse and waste from different craft and urban areas to rivers. It became trapped in sediments and contaminated groundwater, especially when shallow, from where it infiltrated into streams. However, pollution may have other sources, as we will see.

In Mesopotamia, in the 3rd and 2nd millenniums BC, the god Enki in Sumerian or Ea in Akkadian, the god of freshwater and groundwater, played a cleansing role and repelled demons responsible for diseases. This explains why it was usual to treat the sick near rivers.

Cylindrical seal from the Akkadian era, 24th century BC,
representing the god Ea (or Enki in Sumerian), with his horned tiara and water gushing from his shoulders (British Museum)
He is the father of a lesser god, Enkimdu, lord of dikes and canals.

Despite the poor soil and aridity in southern Mesopotamia during the same era, vast areas of land were used to grow crops thanks to an irrigation system and constant maintenance works. The extensive agriculture accompanied the establishment of the first cities and governments in history.

Texts and archaeology reveal that specific cultural practices were implemented to protect the region's fragile soils and preserve the fertility of the fields. Thus tablets with cuneiform scripts tell that cultivated earth was left fallow for periods of various lengths, since there was no lack of arable land in the region. Sometimes these fallow periods could last several years. The soil was also regularly leached to remove salt. Furthermore, the Mesopotamians gradually turned from growing wheat to barley, a change revealed by archaeo-botanical data gathered from excavations which seem to indicate that wheat disappeared from lower Mesopotamia from 1700 BC onwards[1]. This choice was undoubtedly linked to the fact that barley is better adapted to dry and salty soil, and droughts. However, large scale irrigation practiced over long periods, combined with poor drainage, sometimes led to considerable salinisation of the soil and the abandoning of land previously dedicated to farming[2]. There is no doubt that such poor land management partially explains why certain towns were abandoned. This issue is controversial[3], but the first evidence of this phenomenon could stretch back to between 2400 and 1700 BC, in the southern part of present day Iraq[4].

Even today, for example, large stretches of the banks of the Euphrates in southern Iraq and the banks of the River Karun in southwest Iran, are bleached by salt. These lands are definitively unusable, despite repeated attempts to wash the salt out of the soil.

Although, strictly speaking, this situation cannot be termed pollution, it has nonetheless been brought about by human activity with little thought given to the consequences of over-exploiting the land surrounding the rivers to the point of no return.

Metal pollution dates back to when men first began mining. Core sampling in the estuary of the Rio Tinto, a small acidic river in southern Spain that drains an area with the most massive sulphide mineralisation in the world, has revealed contaminated soil horizons. The cores contained sands holding sulphur with slag and coal dating back to the European Chalcolithic period, i.e. 2500 BC[5].

When ore extraction came to an end, one might think that it would also have put an end to pollution problems. However, masses of waste rich in metallic sulphides were left on the surface. The rainwater and runoff rich in oxygen reacted with the sulphur to produce acidic water heavily loaded in metals[6]. Thus the drainage of these mines is an old problem that continues to threaten the ecosystems located downstream with pollution and degrade water quality.

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[1] T. Jacobsen and R. M. Adams, 1958, p. 1252.
[2] T. Jacobsen 1982.
[3] A. M. POWELL, 1985.
[4] T. Jacobsen and R. M. Adams, 1958, p. 1252.
[5] Lettre n°11 du Programme International Géosphère Biosphère-Programme Mondial de Recherches sur le Climat (PIGB-PMRC)
[6] http://www.cnrs.fr/cw/dossiers/dosclim1/rechfran/4theme/cycledeleau/transfertmet.html

Although the impact of former mining and metallurgical activities does not appear as serious as that observed in current mining sites, it can still be traced[7]. The areas affected by historic mining activities should therefore be identified and mapped, including in protected sites believed, albeit wrongly, to be free of any anthropic contaminations. Paradoxically, this leads to the question of "natural" and the return to a sustainable and eminently desirable equilibrium. In regions inhabited for centuries, there are hardly any landscapes that could be described as genuinely natural.

The development of cities and densely populated areas along river corridors generates greater quantities of waste that finds its way into the freshwater due to gravity. In the Western world, in the Middle-Ages, the lack of hygiene was general and wastewater stagnated in towns and cities. This public insalubrity favoured the propagation of the Black Death in the middle of the 14th century, which decimated from 30% to 50% of the European population and the Mediterranean basin in five years.

It was not until the 18th and 19th centuries in France, that what was called the "miasmas" or bad air, finally led large cities to build sewer systems[8]. Ancient Rome had its own highly developed sewer system known to all as the *Cloaca Maxima*.

Despite their great age, the activities of bygone eras can have repercussions today, as shown by the example of recent research carried out by a French team from Lyon working on the Tiber and Naples during the ancient Roman period [9].

These studies are based on measures of concentrations and isotopic compositions of lead trapped in piping and in the silted-up ports of ancient Rome. Sediment cores taken from the silt in the ancient port of Ostia in the bay of Naples and samples of antique pipes reveal that the urban water of Rome and Naples was heavily contaminated by lead of anthropic origin. This origin can be attributed to the water distribution system of Roman towns that were supplied by aqueducts, prolonged by networks of pipes made of lead, the *fistulae*.

Lead is now no longer considered as the main culprit behind the decadence of Roman civilisation and there was no question of saturnism at this time, although its presence in the ancient water distribution system is still considered as a major public health problem. Centuries of contaminations have left a lasting impact on river sediments. Indeed, modern river developments such as dams and dikes whose construction started at the end of the 18th century, doubtless combined with hydro-climatic changes, have led to modifications of river morphology.

[7] E. Camizuli *et al*. 2014.
[8] A. Corbin, 1982.
[9] *Cf.* notamment Delille H. 2014 et 2016 et Delille H. *et al.* 2016.

Thus, due to vertical (incision) and lateral erosion, the Tiber of today is capable of releasing pollution stored in its alluvial plains and delta for hundreds and even thousands of years. The bed load of the Tiber now contains pollution more than 2000 years old, but we have only recently become aware of it.

This type of study, both multidisciplinary and diachronic, can be transposed to other contexts. Thus members of the same team are currently working on the Rhone by exploring what the sediment archives of the river's old meanders can tell us about the history of human activities by way of their pollution. Mention can also be made of another concrete example concerning the possible interactions between the management of current habitats and past pollution and the restoration of the oxbows and backwaters of the Rhone. These sedimentary environments are known to have stored heavy metals in the past during their clogging phase. The current policy of restoring these features of the river necessarily leads to the question of the fate of these metal trace elements on the scale of the river hydro-system. More generally, questions must be asked now and in the years to come about how these heavy metals disturbed by restoration works will be managed.

History and archaeology place events in perspective and reveal records of episodes of pollution that have been forgotten, despite the sometimes serious consequences they had and can still have on human health. They provide us with experiences capable of enriching our thinking, allowing us to first understand them and then avoid them or at least limit their impacts.

The long-term view also shows that certain pollution processes can be reversed, something that should make us feel more optimistic. Still more interesting, it teaches us the thresholds of irreversibility beyond which we cannot go, making it possible to avoid situations such as those of certain regions of Lower Mesopotamia, henceforth unsuitable for farming, or that of the Rio Tinto of Andalusia. Concretely, all river development projects should include a section on the history of the landscapes involved and past interactions between populations and their environments. Multidisciplinary and diachronic studies of paleo-pollutions provide one tool among others for considering tomorrow's rivers.

A few references

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