Water and sanitation: lessons learned from the past to a sustainable future

José M. P. Vieira
WATER AND SANITATION: FROM ANTIQUITY TO THE XXI CENTURY

URBAN WATER: DRINKING WATER - THE MAIN CONCERN
POOR SANITATION SYSTEMS: A THREAT FOR PUBLIC HEALTH

WATER AND SANITATION: TOWARD TO A SUSTAINABLE FUTURE?

WATER AND SANITATION: CURRENT SITUATION
DEMOGRAPHY, URBANISATION AND CLIMATE CHANGE
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PUBLIC HEALTH: THE COMPLEX CHALLENGES OF THE CONTEMPORARY WORLD
Qanat system (1.000 BC - Persia)
Aqueducts in the Helenistic period (323-146 BC)
The Roman water supply system (aqueduct)
The Roman water supply system (aqueducts in Imperial Rome)

<table>
<thead>
<tr>
<th>Aqueduct</th>
<th>Construction date</th>
<th>Length (km)</th>
<th>Flow (m³/d)</th>
<th>Flow (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqua Appia</td>
<td>312 B.C.</td>
<td>17</td>
<td>75.737</td>
<td>876</td>
</tr>
<tr>
<td>Anio vetus</td>
<td>270 B.C.</td>
<td>64</td>
<td>182.517</td>
<td>2.111</td>
</tr>
<tr>
<td>Aqua Marcia</td>
<td>144 B.C.</td>
<td>91</td>
<td>180.068</td>
<td>2.083</td>
</tr>
<tr>
<td>Aqua Tepula</td>
<td>125 B.C.</td>
<td>18</td>
<td>68.516</td>
<td>793</td>
</tr>
<tr>
<td>Aqua Iulia</td>
<td>33 B.C.</td>
<td>23</td>
<td>68.516</td>
<td>793</td>
</tr>
<tr>
<td>Aqua Virgo</td>
<td>19 B.C.</td>
<td>20</td>
<td>103.916</td>
<td>1.202</td>
</tr>
<tr>
<td>Aqua Alsietina</td>
<td>2 B.C.</td>
<td>33</td>
<td>16.257</td>
<td>188</td>
</tr>
<tr>
<td>Aqua Claudia</td>
<td>38 A.D.</td>
<td>68</td>
<td>191.190</td>
<td>2.211</td>
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<tr>
<td>Anio Novus</td>
<td>38 A.D.</td>
<td>87</td>
<td>196.627</td>
<td>2.274</td>
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<tr>
<td>Aqua Traiana</td>
<td>109 A.D.</td>
<td>57</td>
<td>118.000</td>
<td>1.367</td>
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<tr>
<td>Aqua Alexandrina</td>
<td>226 A.D.</td>
<td>22</td>
<td>21.632</td>
<td>250</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>499</strong></td>
<td><strong>1.222.976</strong></td>
<td><strong>14.147</strong></td>
</tr>
</tbody>
</table>
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The Roman water supply system (cistern and castellum divisorium)
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The Roman water supply system (distribution lead pipe)
The Roman water supply system (fountains and public baths)
The Roman wastewater collection system (domestic toilet)

▼ A reconstruction of a typical private toilet at Herculaneum and Pompeii. It was flushed out with waste water from the kitchen.

△ A sponge stick, the ancient equivalent of toilet paper, well known from literary sources.
The Roman wastewater collection system (domestic sewage discharge)
The Roman wastewater collection system (public toilet - latrine)
The Roman wastewater collection system (sewer overflow to river Tiber – cloaca maxima)
Middle Ages (476-1453) (no drinking water and sanitation for 1000 years)
Middle Ages (476-1453) (no drinking water and sanitation for 1000 years)
The Renaissance (XV-XVIII Century) (monumental fountains in Rome)
Modern history (Industrial Revolution XIX Century)
Modern history (XX Century)
Contemporary age (1945 - ) (personal privacy)
Waterborne diseases (pathogenic microorganisms) in Antiquity

- 3180 BC: Epidemics in Egypt
- 1190 BC: Epidemics in Greece
- 790 BC, 710 BC, 640 BC: Epidemics in Rome
- 430 BC – 426 BC: Epidemics in Athens (30,000 people dead)

Pathogens causing epidemics

- Multiple pathogens were the cause of epidemics with typhoid being the principal disease associated with sewage contamination of drinking water
Waterborne diseases (pathogenic microorganisms) in Middle Ages

Bubonic plague in Florence, 1348 (illustration of Marcello)
Waterborne diseases (pathogenic microorganisms) in XIX century
Waterborne diseases in XIX century (scientific milestones)

- **John Snow (1854)**
  Showed that water contaminated by sewage was the cause of cholera (took the handle off the Broad Street pump)

- **Louis Pasteur (1863)**
  Studied and identified microorganisms

- **Robert Koch (1884)**
  Isolated a pure culture of *Vibrio cholerae*
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- Learning with History when looking at the future
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PUBLIC HEALTH: THE COMPLEX CHALLENGES OF THE CONTEMPORARY WORLD
The UN General Assembly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realisation of all human rights.

Resolution of the UN General Assembly, 28th July 2010

663 million people without access to an improved drinking water source

2,4 billion people without access to improved sanitation
Disparities between developed and developing countries
Disparities between developed and developing countries
Proportion of the population using improved drinking water sources in 2015

Source: UNICEF / WHO – 2015 update and MDG assessment
Proportion of the population using improved sanitation facilities in 2015

Source: UNICEF / WHO – 2015 update and MDG assessment
World population

Source: UN World Urbanisation Prospects, 2015
- World’s urban and rural populations

Source: UN World Urbanisation Prospects, 2015
Distribution of the world’s urban population by size of urban settlement

Source: UN World Urbanisation Prospects, 2015
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DEMOGRAPHY, URBANISATION AND CLIMATE CHANGE

Population pressures on urban water
Population pressures on urban water
Population pressures on urban water
Climatic extremes and denser urban environments
Climatic extremes and denser urban environments
Unsafe water sources due to industrial wastewater discharges
Unsafe water sources due to sewage discharges
Unsafe water sources due to chemical (toxic) substances (uncontrolled) discharges
Emergent biological threats

- Well known diseases that may emerge
- “New” diseases due to advanced detection laboratorial methods
- True new diseases
- Changes in diseases behaviour
- Changes in environmental conditions
- Diseases appearing in unexpected environments
- Other aquatic microorganisms that can emerge
Emergent chemical threats

- Pharmaceutical residues
- Endocrine disrupting compounds (DC)
- Pesticides
- Biocides
- Algal toxines algais / cyanobacteria
- Personal hygiene products
- ...
What technological solutions for the future?
The blue planet

Is the development *still* sustainable?