

Evolution of urban waste-and storm-waters management through the centuries focusing on Hellenic civilizations

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Outline

Prolegomena

Bronze Age (ca. 3200-1100 BC)

Minoan era

Mycenaean civilization

Historical Times (ca. 490 BC- 330 AD)

Classical and Hellenistic periods

Roman period

Byzantine Times (ca. 330-1453 AD)

Ottoman Period (ca. 1453-1832 AD)

Modern Times (1832 to present times)

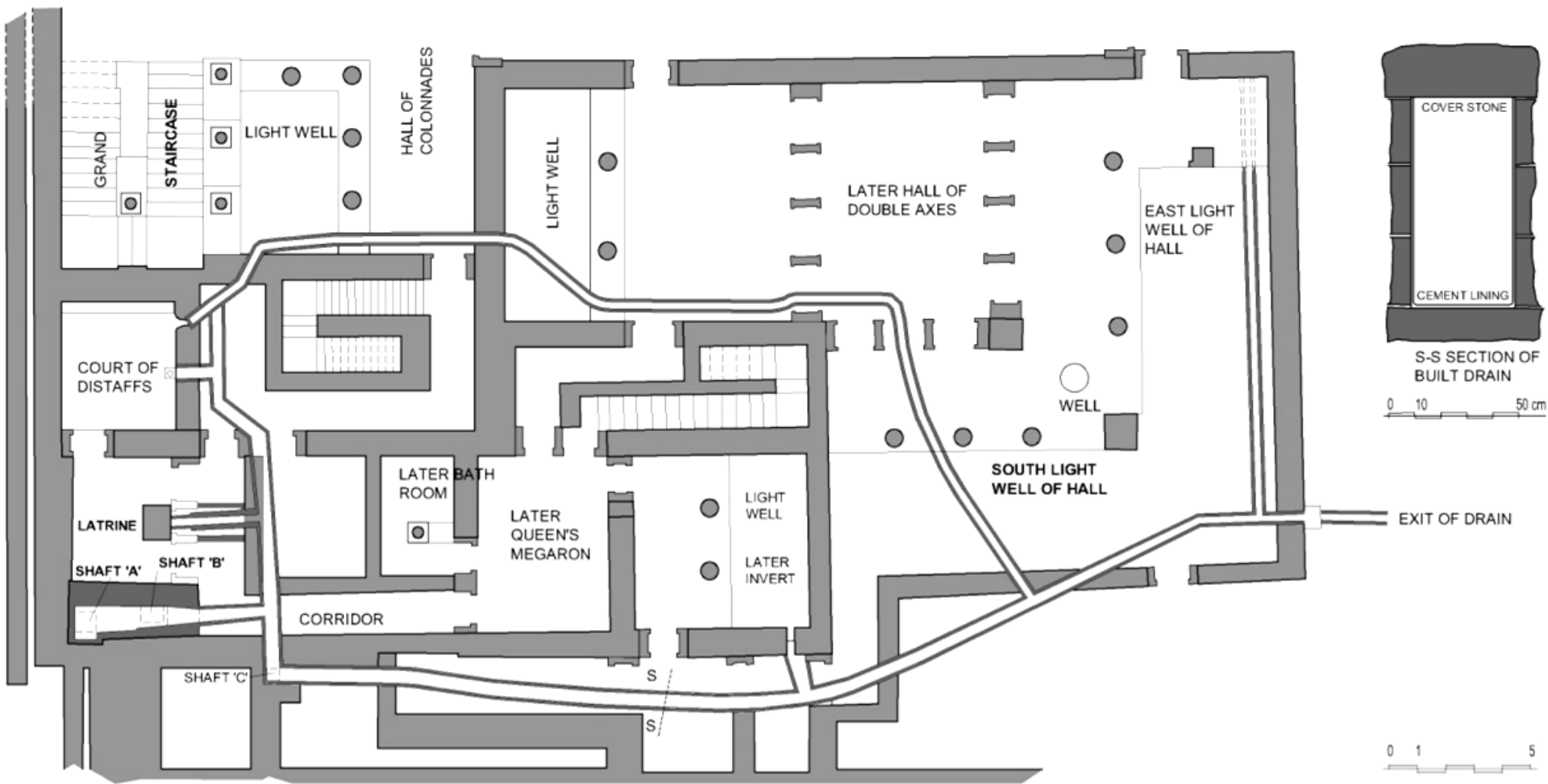
Future Challenges

Epilogue & Conclusions

Bronze Age (ca. 3200-1100 BC)



Minoan sewerage systems: (a) the output of the central system of the Phaistos palace and (b) part of the central system of the villa Hagia Triada.



Part of the sewerage and drainage system in the palace of Knossos

During the Minoan Era nothing was more remarkable and elaborate than the stormwater and sewerage systems

I doubt if any other case of stormwater drainage system that works 4,000 years after its construction.

Mosso (1907).

Each quarter of the palace had its own subsidiary drainage system connected to the central drain. These systems had vertical shafts of ample size which acted both as roof drains and as ventilation ducts, the latter in much the same manner as do the soil stacks in our the modern house. Perhaps we also may permitted to doubt whether our modern sewerage systems will still be functioning after even one thousand years.../

Gray H. (1940). Sewerage in Ancient and Mediaeval Times. Sewage Works J. 12.5: 939-46.

Historical Times (ca. 490 BC- 330 AD)

Classical and Hellenistic periods

Roman period



Kassope is considered one of the best remaining examples of a city built on a rectilinear street grid of a Hippodamian plan in Greece



Theater

Katagogeion
(Hotel)

Prytaneum - Πρυτανείον
Dianery - Town Hall

Stoa - Forum

Altar

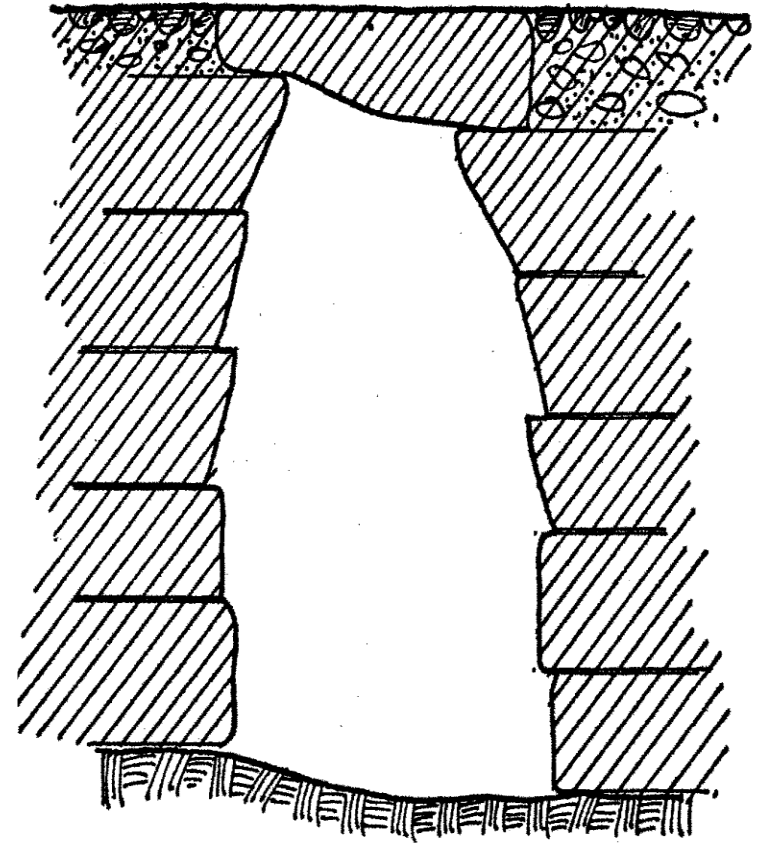
Odeum - Ωδείο



Remnants of sewerage and drainage system in Kassope



***Quadruple sewerage opening at
the fortifications of Amphipolis***



Parts of sewers and drains in Hellenistic period: (a) Sewer covered with prefabricated ceramic well ring sectors in south foothills of Acropolis and (b) Cross section of a bridged section of the Great drain in in Hellenistic Agora in Athens



The Theatre of Dodoni in Epirus: (a) general view and (b) detail of the drainage channel (A. N. Angelakis)



Roman time sewers in Thessaloniki : (a) closed to walls and (b) central sewer covered with stone-build apsis

Byzantine Times (ca. 330-1453 AD)



Stone-build sewers of Byzantine time (6th c.): (a) in Pastier road and (b) in Egnatia road.

Ottoman Period (ca. 1453-1828 AD)

In the medieval Islamic world, hydraulic hygiene facilities were remarkable as a latrine connected to a sewer or cesspits was widely used and was found in the most of the houses. The importance of defecation hygiene etiquette related to religion, should not be excluded as an aspect to the evolution of the toilet.



(a)



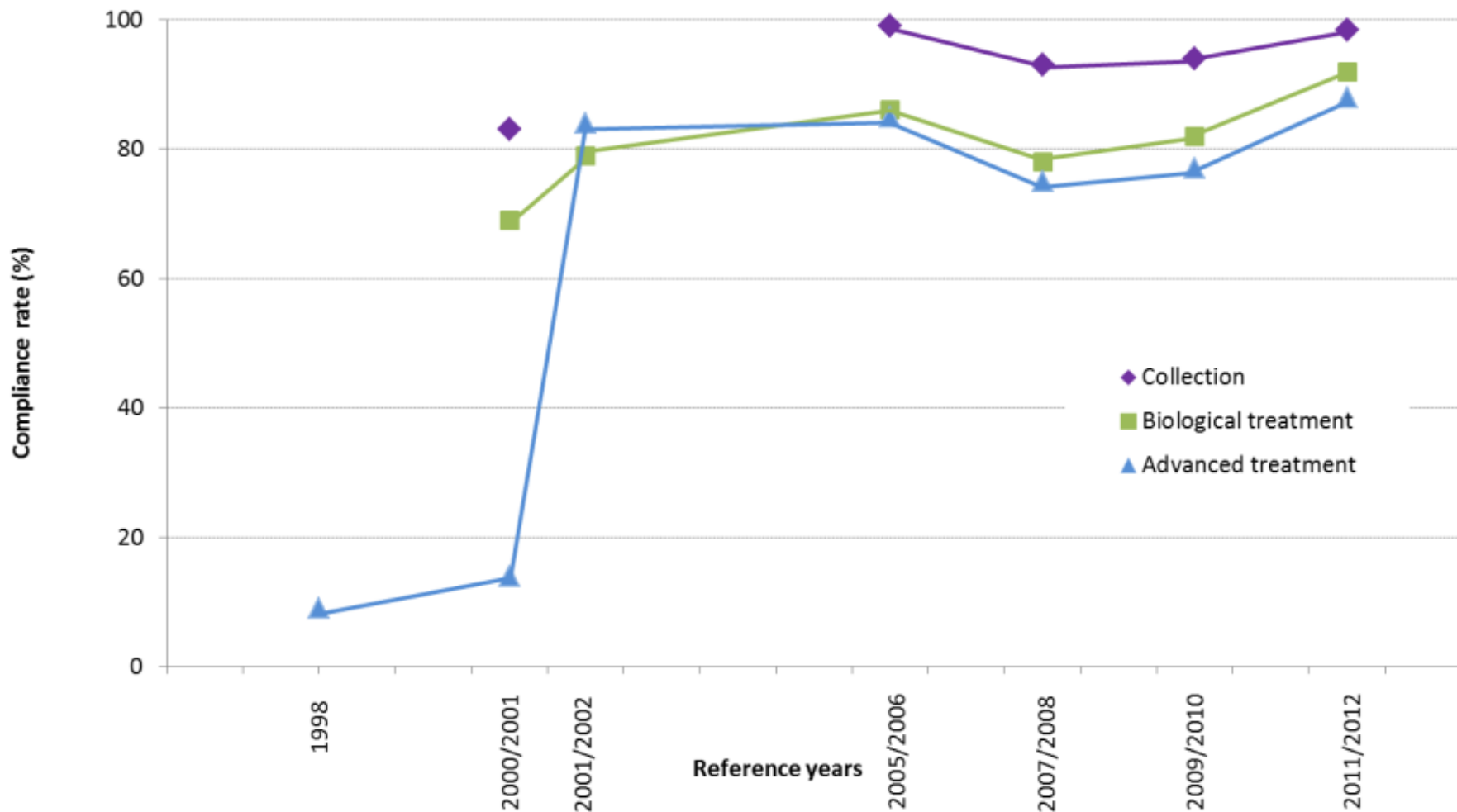
(b)

Ottomann toilets (a) In the women's section, Abid Efendi or Hammam of the Winds, Athens and (b) in Lesvos, Mytilene in Karavangeli hammam (Antonioni et al., 2014).

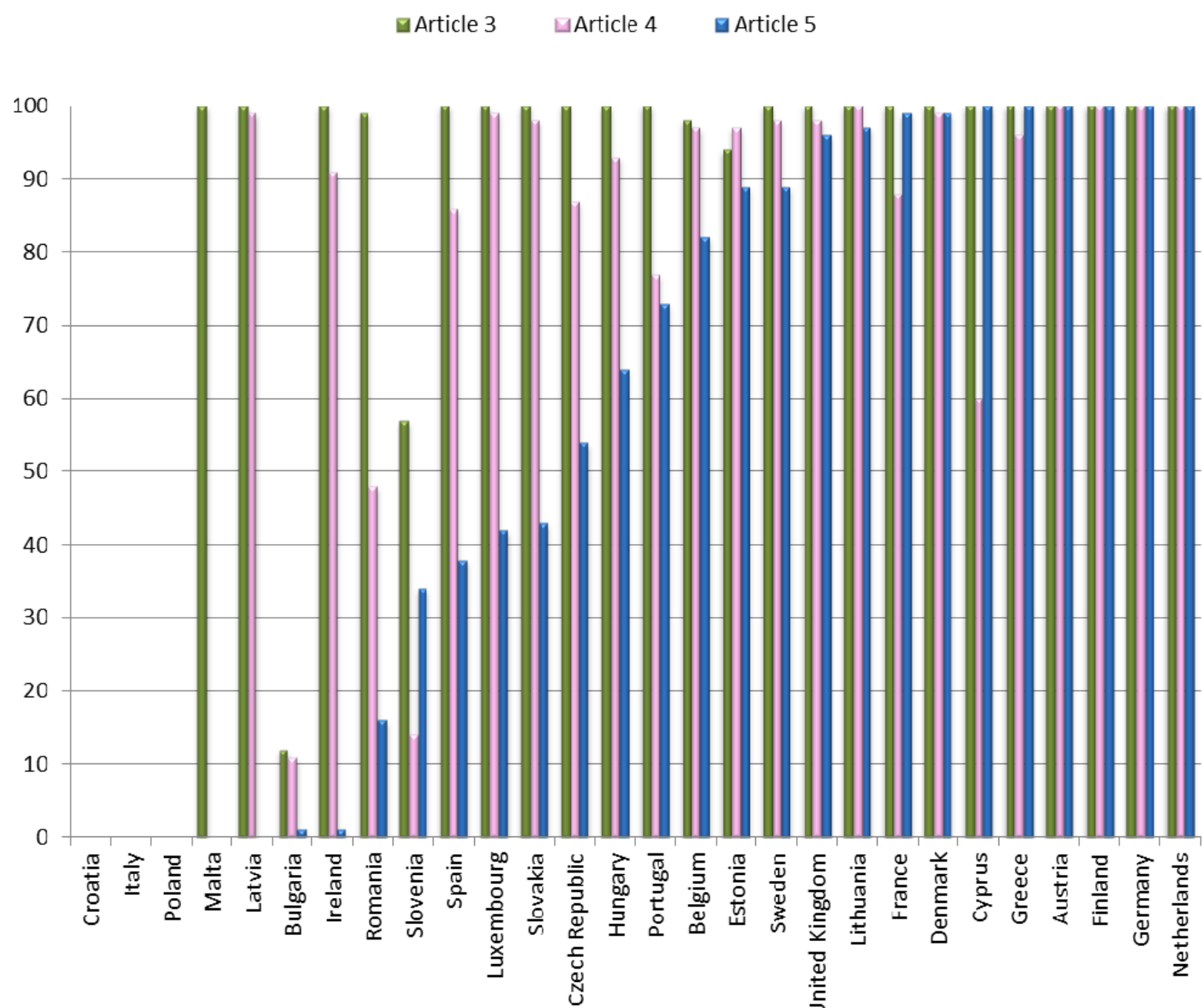
Present Times

1. Since the end of 19th c. all systems were CSS
2. After the World War I, beginning of the 20th century, Greece state was established as it is known today and the modern wastewater technologies started to be developed which were expanded after the World War II
3. Today both SSS and CSS systems are implemented.
4. The total length of sewage system is estimated to be ca. 36,000 km and more than 90 % of the total population is covered with it. Today most of the systems (80 %) are SSS.

Compliance rates over years



Evolution in compliance rates since reference year 1998 (based on incomplete - data sets available) (8th Report EC for Implementation of Council Directive 91/271/EEC, 2016).



Compliance results per Member State for Articles 3 of the UWWTD (collection), 4 (secondary treatment), and 5 (more stringent treatment).

WWTP IN GREECE (2015)

(8th Report EC for Implementation of Council Directive 91/271/EEC, 2016)

Category (p.e.)	No of WWTP	Comments
< 2000	650-750 ^a	Implementation of effective non conventional treatment systems to a large number of projects, serving 20% of the total e.p. of the country.
2,000-10,000	370	With completion of the projects under implementation the e.p. serviced pe with such projects will be 16% of the total.
10,000-15,000	39	
15,000-100,000	72	Still to be implemented 3-4 (Eastern Attica)
100,000-150,000	5	
>150,000	6	
Total	1192	

^aEstimation

Future Trends

- Today both SSS and CSS systems are implemented.
- The total length of sewerage system is estimated to be ca. 36,000 km and almost 100 % of the total population (> 2000 p.e.) is not covered with it.
- Most of the sewerage systems (80 %) are SSS.
- In the future we will mainly deal with > 2000 p.e. communities, which are about 5000 (2.5 mil. population).

Future Challenges

1. *Population Growth*. It is estimated that by 2050 the world population will increase by an additional 2 billion people (e.g. a city of ~145000 inh./d).
2. *Urbanization*. The great majority of these additional people will settle in urban areas further stressing the pollution pressures and health risks in these areas.
3. *Climate Change (variability)*. For sure, it is predicted that the world will experience more extreme climatic conditions (bigger floods and more severe droughts).
4. *Ageing Infrastructure Assets*. Many networks and installations in mature economies are ageing and deteriorating.

Conclusions

1. In Greece, sewerage and drainage systems were of great importance since the prehistoric times.
2. These systems were further improved mainly by increasing their scale during the historical times.
3. The rapid growth and urbanization has increased both the importance of sustainable wastewater management and the complexity of implementation which will have serial impacts to the future wastewater management.
4. Therefore, an expected increase in decentralized self-supporting, small (local) systems will emerge.
5. In the future, water and wastewater management systems based on reapplication of old practices using new equipment and knowledge could be of great significance.



Thank you for listening

General view of toilet in the residential quarter of palace of Minos



Roman time sewers in island of Thassos