URBAN WASTEWATER TREATMENT: PAST, PRESENT AND FUTURE

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Contents

Summary

The chapter traces the history of water and wastewater management, starting from the hunter-gatherer days of human existence. It divides the evolution of water industry into four phases. It describes traditional wastewater treatment technologies developed as the second generation water management option. Crystal ball view of the future of wastewater treatment technologies is also given, highlighting the novel approaches currently in the pipe-line.

1. Water Management Systems: A Brief History

As their intellectual and social capacities advanced over the past hundred thousand years, hunter-gatherers homo-sapiens expanded across the globe, building on a legacy of tool making and exploration. During the last ten thousand years, homo-sapiens became cultivators, thereby allowing a great increase in population to occur. One of the essential factors in this metamorphosis of hunter-gatherers into cultivators was the management of water supply through storage and distribution (Chanan & Simmons, 2002). In essence, unlike hunter-gatherer days, water was brought to the place of occupation rather than the community moving to reliable water supplies. The drive for water security has grown from there and has become a significant component of human endeavor. Table 1 provides a broad pattern of human water access and use.

Time Period years ago	**Type of Community**	**Example of location**	**Pattern**
10,000+	Hunter-gatherer	Worldwide	Community moved to water
10,000-7,000	Agricultural City States	Mesopotamia Indus Valley	Water brought (carried) to the community
7,000-1,500	Agricultural Empires	Greece, Rome	Water brought to the community by engineered structures from remote sources
1,500-200	Agricultural Protected	Medieval Europe	Water collected and stored on site
200-100	Industrial	Europe	Large collection and distribution systems
100-0	Industrial	Worldwide	Development of large dams – centralised systems
0-50	Managerial	Worldwide	Total Water Cycle Management Soft Path for water

Table 1: Broad patterns of community water access and disposal

The earliest civilisations, such as in the Indus Valley which flourished 4,000 years ago, showed a sophisticated appreciation of water-related health needs (Edwards, 2000). Domestic water supply in these ancient civilisations appeared to be obtained from wells and was simply carried to wherever it was needed. In ancient Egypt for instance, the purest water for consumption was obtained from wells, whereas the Nile River provided water for irrigation (P&M Magazine, 1989). Similarly ancient Jerusalem relied upon underground springs, streams, tunnels and cisterns. This was more reliable than rainfall and offered safety from enemy destruction. The first sewerage systems in Japan were built during the Yayoi Period, approximately 2,200 years ago (Japan Sewage Works Association, 2002).

The earliest water management systems were developed to cater for contemporary small settlements, relying on locally suitable water supply sources and were decentralised in nature.

1.1. Greco-Roman Influence on Water Management

The Greek and Roman civilisations (Chanan & Simmons, 2002) achieved the next level of urban water management. Until then, cities and towns were largely constructed adjacent to rivers and streams, to ensure a continuum of water supply and waste transport. The security of the Roman political system, in particular, allowed for the development of water transport systems from remote sources. With the formation of new centres, and the expansion of existing ones, new supplies had to be identified, captured, transported and stored (Landels, 1998; cited in Chanan & Simmons, 2002).

Figure 1 shows an aqueduct built during the Roman Empire at Nimes, France. Similar aqueducts were built across Europe to transport water over long distances.

Water management and technology, however, declined in Europe after the fall of the Roman Empire. Political and military insecurity and insufficient state wealth meant that the building of large-scale water supply and sewerage schemes was not attempted in Europe, and dependence on decentralised options continued until the 18th century.

1.2. Water Supply and the Industrial Revolution

The Industrial Revolution saw significant growth in wealth, population, scientific knowledge and technology; and the size of cities grew rapidly. The large amount of water needed and the sewage generated, as well as the increased stormwater from vast urban areas, needed a new management approach.

Figure 1: Roman Aqueduct, Nimes, France

Technical advancements resulting from the Industrial Revolution removed some barriers to urban water infrastructure development. By the end of the 18^{th} century, all major northern European cities had built, or were building new systems to distribute water and evacuate liquid wastes (Reid, 1991). The realisation that many diseases, such as cholera, were passed on by contaminated water was primarily behind the development of this "big pipe engineering approach" - for bringing drinking water into the city and for removing wastewater and stormwater from the city. Big pipe engineering became the standard water management technique (Newman, 2007).

A metaphor for this stage in water management is the First Generation – it began to formalise water infrastructure, but human and environmental health were still seriously challenged by the waste products of growing cities (Davis, 2008)

1.3. Water Engineering in the 20^{th} Century

According to Chanan & Simmons (2002), the 20^{th} century could best be described as the century of applying big engineering solutions to water management. During this period, extensive networks of canals, dams and reservoirs were designed and constructed worldwide. Since 1950, the number of large dams (15 metres or taller) has grown from 5,000 to about 45,000. More than 85 per cent of those were built in the last

35 years (World Commission on Dams, 2000).

The resulting centralised system that has now been inherited is based on sourcing large quantities of water from one location (often a different catchment), adding a number of nutrients to it during its once-only use, and finally disposing the waste stream at another point location. Such a system not only results in receiving waters becoming more polluted, it also causes water sources to become scarce and nutrients such as nitrogen and phosphorus to be diluted and removed from where they could potentially be reused (Livingstone et al, 2004).

Returning to the generation metaphor – this was the Second Generation of water management. The Second Generation lasted till late 20th century, consequently water and wastewater technologies developed during this phase are predominant throughout the world. These technologies are now commonly referred to as the 'conventional' techniques.

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Biographical Sketches

Mr Chris Davis is a. Chris Davis is UTS's Sustainability Business Development Manager, a role he has been in since July 2007. Before taking up that position, Chris was CEO of the Australian Water Association for 15 years, having had a career in local government, consulting and process contracting for water. Chris has a BSc in Civil Engineering from the University of the Witwatersrand (Johannesburg), a Masters Degree in Civil Engineering from the University of Texas at Austin and an MBA from the University of New England. In addition to his UTS role, Chris serves on several advisory committees, panels and boards, relating to the water industry.

Dr Saravanamthu Vigneswaran has been working on water and wastewater treatment and reuse related research since 1976. During the last twenty years, he has made significant contributions in physico-chemical water treatment related processes such as filtration, flocculation, membrane-filtration and adsorption. His research activities both on new processes development and mathematical modeling are well documented in reputed international journals such as Water Research, American Institute of

Chemical Engineers Journal, Chemical Engineering Science, Journal of American Society of Civil Engineers, and Journal of Membrane Science. He has also been involved in a number of consulting activities in this field in Australia, Indonesia, France, Korea, and Thailand through various national and international agencies. He has authored two books in this field at the invitation of CRC press, USA, and has published more than 230 papers in journals and conference's proceedings. Currently a Professor of the Environmental Engineering Group at the University of Technology, Sydney, he was the founding Head of and the founding Co-ordinator of the University Key Research Strength Program in Water and Waste Management. He is coordinating the Urban Water Cycle and Water and Environmental Management of the newly established Research Institutes on Water and Environmental Resources Management and Nano-scale Technology respectively.

Dr J. Kandasamy is Senior Lecturer in the Faculty of Engineering University of Technology, Sydney, Australia. He obtained his PhD from University of Auckland., New Zealand where is also obtained his Bachelor in Civil Engineering and Masters in Civil Engineering. He has worked in the New South Wales Government as a Senior Engineer for 15 years and has wide industry knowledge.

Mr Amit Chanan is General Manager of Strategic Assets, State Water Corporation. State Water is New South Wales' rural bulk water delivery corporation, annually delivering more than 5,500GL of water to regional NSW. It manages and operates 20 dams and more than 280 weirs and regulators to deliver water for town water supplies, industry, irrigation, stock and domestic use, riparian and environmental flows. Amit is currently a Member of the International Water Association's (IWA) Australian Management Committee. In 2008 Amit was appointed by the NSW Minister for the Environment and Climate Change to the NSW Load Based Licensing Technical Review Panel. The Load-based Licensing Technical Review Panel advises the EPA on the development of site-specific emission factors and related techincal issues. Amit is also a member of the NSW Government's Science Agencies Group.