



"THE PREHISTORY OF PUBLIC HEALTH - WATER AND WASTE IN THE ANCIENT NEAR EAST"

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Introduction

Techniques of water management and the problems of providing and maintaining sources of clean water for both households and communities have a long history in the Near East. Without the evolution of patterns of behaviour which helped to preserve public health, the widespread sedentarisation which preceded and accompanied the establishment of early farming communities would have been impossible (refs. 1 and 7). The existence of settlements lasting several centuries shows that some of the problems of public health could be met and controlled within tolerable limits, even though there is also evidence from both early villages and early urban centres that originally high standards of hygiene could deteriorate with time, leading to the abandonment of sites or acceptance of lower standards of public health.

Components of traditional domestic water use can be traced back to Neolithic farming villages of 9-10,000 years ago, while fully developed town planning including sophisticated systems of water engineering designed to support urban communities began to appear by 5,000 years ago. However, the difference between village and urban water systems is largely a matter of the scale on which water was diverted, obtained and stored and the size of the labour force which could be mobilised, as the hydrological techniques varied surprisingly little.

Archaeological evidence of public health and patterns of waste disposal and water use can provide case studies of the ability, or even inability, of human communities to provide and maintain water resources over a period of several centuries, as well as illustrating the range of adaptations to local hydrological conditions which is possible using a simple traditional repertoire of skills and tools.

Public health in the early villages of the Near East

Features of traditional water use in the Near East which were developed in the Neolithic villages of c. 10,000-7,000 years ago include digging canals or wells to supply water to settlements and using ceramic containers for domestic water storage.

While canals would have increased crop yields, the economic benefits of irrigation would have been partly offset by the increased incidence of schistosomiasis which is endemic to irrigation projects. Although the earliest direct evidence of schistosomiasis at present comes from Egypt c.1250-1000 BC (ref. 2), it is probable that schistosomiasis has been endemic in human populations exploiting marshy environments from the Pleistocene onwards.

Establishing permanent settlements in the immediate vicinity of permanent water sources would have enabled early sedentary communities to exploit the relatively rich food resources of well-watered environments, but would also have exposed the inhabitants to a greater incidence of water-related diseases. Without careful attention to domestic hygiene and ensuring a good supply of unpolluted drinking water, there could have been a relatively high incidence of gastroenteritis contributing to mortality, especially during summer months when water would be in critically short supply and of poor quality (ref. 3: 103-10). Forms of skeletal pathology attributed to chronic gastroenteritis and malaria have been diagnosed in both adults and infants among early Neolithic farmers of the eastern Mediterranean and western Asia settled near marshes and permanent sources of water (refs. 4 and 5). Although the skeletal sample is probably too small to be of significance, a lower frequency of skeletal pathology was noted in prehistoric groups inhabiting dry environments away from springs and permanent sources of water (ref. 4: 762).

Water-washed diseases, particularly diarrhoeas, are one of the major human health hazards (ref. 6: 12-13). Indirect evidence of a significant part of the household water budget being devoted to domestic hygiene is found in the scrupulously clean plaster floors which are found in early Neolithic houses of the 8th-7th millennia BC at sites such as Jericho and Çatal Hüyük. Rubbish from meals and household activities was swept and washed off the plaster surfaces of these floors, which extended part way up to the base of the walls, facilitating waste water runoff, and frequent cleaning with water could lead to the leaching of the underside of these floor plasters (ref. 7: 335). Such carefully plastered floors are often lacking in later Neolithic households from the second half of the sixth millennium BC on, and were generally replaced by mud floors, although some culturally conservative sites, such as Byblos,

founded in the middle of the 6th millennium BC, continued to plaster house floors. Elsewhere in the Near East at this time there is much greater likelihood of finding domestic refuse caked on mud floors, suggesting that standards of domestic hygiene may have deteriorated, with an accompanying increase in water-washed diseases.

However, the suggestion that standards of domestic hygiene in later Neolithic villages may have deteriorated needs to be qualified, as an important innovation in sites from the 6th millennium BC on is the existence of permanent wells, which enable individual families and separate residential quarters to have access to their own private water supply and avoid depending on surface water sources which are more liable to pollution. Such wells which could provide water in quantity for both drinking and washing are a feature of late 6th millennium BC settlements in Mesopotamia, and contemporary sites in the Levant are often located in areas with easily tapped sources of permanent groundwater where wells were probably also a feature of village subsistence.

Provided the well head is protected from pollution, and sewage is not discharged into the groundwater in the vicinity of the well, high quality water could have been obtained from such wells, and it is possible that trial and error led to the development of ad hoc public health standards. In normally permeable soil, such as the clay of an occupation mound, wells which tap groundwater deeper than 12 m should be free of bacterial pollution (ref. 8: 336). The need for wells to exceed this depth may have been recognised in the late 6th millennium BC at Tepe Gawra and Arpachiyah in northern Iraq where wells 15 m deep have been found.

Another Neolithic innovation of lasting significance for public health was the use of ceramic containers which could hold water beginning around the second half of the 7th millennium BC. In addition to holding drinking water, domestic water jars could also be used to keep an alkaline solution of ashes from the hearth which could be used to wash dishes and laundry, following traditional Near Eastern village customs. However, open containers in households also provided a new breeding ground for the *Aedes aegypti* mosquito, which carries filariasis and yellow and dengue fevers. In the Mediterranean, this mosquito is totally dependent on the man-made environment provided by storage jars and discarded containers (ref. 9: 295), and was probably one of the unintentionally domesticated species produced by the Neolithic revolution.

One answer to the problem of avoiding water-related diseases was to avoid settling at permanent water sources and instead to rely on journeys to springs to obtain drinking water. At the early Neolithic site of Beidha in southern Jordan, for example, the nearest spring is 5 km away, but water for laundry and stock-watering could have been obtained from seasonal pools and shallow wells in nearby valley floors.

Another option was to avoid sedentarisation, and some groups probably chose to remain mobile, either as hunter-gatherers or livestock herders. After 6000 in Palestine and Syria there is a

temporary break in sedentary occupation on many sites which may reflect a widespread reversion to nomadism. Although the boundary between settled and nomadic life has often fluctuated as a result of social and economic choices as well as in response to micro-environmental changes, one factor in the persistence of nomadism in the past which should be taken into account is the existence of groups aware of their lack of resistance to the various water-related diseases endemic to settled populations. A parallel may be drawn with recent Arabian nomads who avoided contact with towns and farms because of the fevers they experienced when camping too near densely populated well-watered areas (ref. 10: 477). Where standards of village hygiene have deteriorated in the past it may be suggested that the option of nomadic life would have proved attractive.

Nomadism enabled encampments of variable but generally modest size to exploit widely dispersed seasonal surface and groundwater catchments where the relatively brief association between humans and water sources would inhibit the transmission of water-related diseases dependent on a permanent reservoir of human carriers such as a village or town could provide. In addition to avoiding some pathogens associated with settled life, poor hygiene and permanently polluted water, nomadic groups were able to exploit efficiently small and quickly exhausted water sources which would otherwise be uneconomical to use.

The sophistication with which these scattered water resources were exploited can be seen in the number of words used to describe wells and groundwater catchments among the early 20th century AD Rwala bedouin of N. Arabia, who distinguished between fourteen different kinds of well and six types of groundwater (ref. 10: 676-84).

Early urban water systems

In the period beginning around 3500 BC, water engineering skills for supplying urban centres with water were developed in the Near East. Systems of diversion dams, canals and reservoirs were constructed to provide water for irrigated fields near settlements and provide intramural water supplies to supplement surface water sources in and near settlements.

One of the best preserved of these early town water systems is found at Byblos (ref. 11), where a centralised water system lasted for almost a millennium, evidence of effective continuity in integrated town planning and public health. Shortly before 3000 BC during the phase of urban development which transformed Byblos from a fishing village into a major Mediterranean trading port, the marshy area near the spring was dug out to create a small reservoir of water, simultaneously providing an improved supply of water and eliminating the marsh which would have been a favourable environment for mosquitos and other carriers of water-related diseases. During the following millennium of urban prosperity at Byblos, the area round the spring was kept free

from burials and domestic construction, and a clear space of c. 30 m diameter around the spring was retained down to c. 2150 BC.

This area was the focus of the town plan, at the intersection of two major streets, with public buildings constructed on the periphery of the clear space around the spring. As the level of the town rose c. 2750-2500 BC, the sides of the spring pool were reinforced with retaining walls and a flight of stairs was constructed to give access to the spring. At the same time a reservoir with a capacity of c. 2500-3000 m³ was put in north of the spring to provide a source of water for laundry, stockwatering and swimming and to keep the spring free of the pollution associated with these activities.

Byblos provides an example of long-term use of water sources created or modified by water engineers which can be maintained and used without special skills once the water system is set up. Similar successful long-term water planning can be identified in the re-use of earlier water systems in a number of first millennium BC Palestinian towns, in the well-built Iron Age and Roman water systems which are still in use today at Jerusalem, Homs, Bosra and elsewhere, in the qanats of the mid-first millennium BC and later, and in the canal systems in the alluvial plains of S. Mesopotamia.

In the case of Mesopotamia, a number of early second millennium BC texts enable us to reconstruct the activities of early water engineers as seen by their contemporaries. Even though the credit for the work usually went to the monarchs who sponsored it, the scale of these works is impressive. In order to provide fresh water for Larsa, Sin-iddinam (1849-1843 BC) dug out a new course for the Tigris (ref. 12: 191-2) and Rim-Sin of Larsa (1822-1763 BC) dug a large canal and reservoir to divert the spring flood of the Tigris and Euphrates with the dual function of irrigation and supplying fresh water to the cities of lower Mesopotamia (ref. 12: 205-6). Some concern for public health may be inferred from the claim by one late 19th century BC ruler of Uruk to have repaired the city rampart which had slumped into the canal by the city and to have faced the canal with burnt brick "so that the water in its ditches would be noisy", i.e. fast-flowing and not stagnant and thereby reducing the infestation of the canal by the snail hosts of schistosomiasis (ref. 12: 233).

One of the best documented water systems in the Near East during the early 2nd millennium BC is that at Mari, where part of the correspondence of Kibri-Dagan, the official in charge of building the canal which was at the basis of the city's prosperity, has been preserved (ref. 13: nos. 1-9). This canal was some 100 km long, and brought water from a diversion dam built on the Khabur 20 km upstream from its confluence with the Euphrates. In an inscription commemorating the building of the canal, the king of Mari states: "I opened canals, I did away with the digging of wells in my country in scorched lands, in an arid place where no king before me had ever built a city, I built a city" named after himself, "Yahdun-lin City" (ref. 12: 244-5).

The obsolescence - or banning? - of wells and their replacement by canals is interesting, and may reflect the differing water exploitation priorities of town planners and rural farmers, as some of the bottom lands used for pasture by shepherds were likely to have been brought under cultivation and lost to them together with the wells located in the bottom land, creating a potential source of conflict, and requiring the resettlement of shepherds with new sources of water and patterns of water use, perhaps in the newly-established urban centre built by Yahdun-lin.

A conflict between nomads and townsmen over water resources and access to stored water is believed to have been one factor implicated in the breakdown of the best-preserved early town water system, that of Jawa, a late 4th millennium BC site in the basalt desert of northern Jordan which provides a unique, if short-lived example of urban water engineering (ref. 14). A system of deflection dams, canals and reservoirs was built to supply a population estimated to be 3000-5000 with water for their fields, flocks and households. As both groundwater and springs are lacking in the region today, if the same conditions prevailed in antiquity, a precondition of human occupation was having the engineering ability to harvest the runoff from episodic and unpredictable winter storms to provide enough water for the coming year.

To design and construct Jawa's water system needed a knowledge of local hydrology, geology and soils to determine the best materials, location and design for the components of the system. Even today specialised engineering skills of a high order would be required (ref. 15: 166).

Although Jawa's water system needed to operate at only 3% efficiency to harvest and store an estimated 50-60,000 m³ of runoff from the 2 x 10⁶ m³/yr available from adjacent catchments, it failed within a few generations of its construction. After a phase when squatters' housing encroached on public land and huts were built next to reservoirs and sluice gates, with the town authorities either unwilling or unable to prevent the spontaneous expansion of the settlement, and an abortive attempt to rebuild the water system without expanding its storage capacity, the site was abandoned (ref. 14: 201-14).

However, the tradition of water engineering represented by Jawa continued, and reservoirs linked to the town plan, although on a smaller scale than at Jawa, are features of the urban landscape in a number of third millennium BC towns of the Levant apart from Byblos, notably Ai and Arad. Arad was laid out inside a small catchment basin whose runoff was channelled by radially oriented streets to a central reservoir which could have stored approximately 2000 m³ (ref. 16). At Ai runoff from inside the town was diverted to a corner of the fortifications which surrounded the site and stored in a 3 m deep pool with a storage capacity of about 1800 m³ which was paved with stone slabs and sealed with naturally water-sorted clay found locally (ref. 17).

Although significant as adaptations of

water engineering principles to local conditions which have been studied by archaeologists in co-operation with water engineers, the importance of these third millennium BC reservoirs should not be exaggerated, as their storage capacity is less than half the capacity of open-air cisterns used in modern villages in Syria and Lebanon to store water for stockwatering and washing (ref. 7). Except in times of siege, most ancient sites would have obtained drinking water from springs or wells within a few kilometres of the site and could have used intramural runoff for laundry and animals.

As emergency stores of drinking water, these reservoirs suffered from grave defects. If precautions were taken to ensure that the water stored in these reservoirs did not receive fresh inputs of human waste, any pathogens brought in with the original storm runoff from inside the town would either be diluted, destroyed by ultraviolet radiation or die after reaching the end of their natural life-cycles without finding a fresh carrier. However, these reservoirs would have inevitably become populated with algae, producing unpalatable drinking water.

Whatever the intentions of the water engineers who designed and installed them, such open reservoirs were hazardous civil defence measures which would be vulnerable to pollution. Even if at the time of their construction awareness of the sort of hygienic behaviour needed to prevent faecal-oral disease transmission was present (Elmendorf, this conference), the odds are good that eventually a conflict or emergency would arise when these reservoirs which had been allowed to become polluted through their convenience for laundry and stockwatering were used to supply drinking water to the town as a whole, with potentially serious risks to public health. A serious epidemic of disease could eventually lead to the site being abandoned and avoided, as most of these early urban sites eventually were.

Conclusion

What relevance does evidence of water use and waste disposal in the past have in planning for the future? One concrete suggestion is that in an arid area such as the Near East, having separate sources of water for drinking and other uses, combined with public health education aimed at individual households, is a formula which has worked well in the past, where both rural and urban water use and water engineering have a much longer history than is often realised. Models derived from and taught in water-rich areas are more likely to be inappropriate in the long run, even if already in operation (Metwally, this conference).

The efficiency of small-scale water exploitation techniques in contributing to the long-term survival of rural communities, and the dangers of poorly maintained, poorly understood, or poorly applied water systems can be observed in action archaeologically. Perhaps study of past techniques of water use in a given area could be of some use in formulating cost-

efficient and lasting public health improvements appropriate to their geographical and cultural setting.

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