ROLE OF WATER REUSE IN MANAGEMENT OF URBAN WATER RESOURCES

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Summary

The inexorable expansion of urban areas world-wide is placing increased pressure on the availability of water resources. A greater appreciation of the hydrologic cycle is required. Making greater use of recycled water as an additional water resource can offset some of the limitations to existing supplies. Waters from sewage, storm water or saline sources including the sea are increasingly being recycled. There is a wide range of safe and productive uses including, with appropriate treatment and management, for drinking. Recycling can be conducted at several scales and with a range of alternative technologies whose choice will depend on ensuring the fitness of the water for the purpose to which it is to be put. Effectiveness will be determined by the availability of waters for treatment, the potential markets for recycled water, the location of and choice of treatment in relation to the market, the energy required, the safe disposal of by-products from treatment, the successful matching of supply and demand together with the cost of any associated storages, an appropriate pricing strategy, the ability to ensure

safe use through an effective regulatory environment and community acceptance of recycled water through trust in its suppliers.

1. Introduction

The UN's Second World Water Development Report in 2006 recognized that major demographic changes are seriously affecting the quality and quantity of available freshwater on the planet. While the more developed countries enjoy relatively stable populations, the less developed regions of the world are generally experiencing rapid growth and population shifts, particularly into towns, small cities and megacities. In many rapidly growing urban areas, it is proving impossible to build the infrastructure necessary to deliver water supply and sanitation facilities to service the population, leading to poor health, low quality of life and, in many cases, to social unrest. To the urban demands for water must be added the increasing demands on water for food production, energy creation and industrial uses. Greater emphasis is being given to the provision of water services for metropolitan areas. However, much of the world's water resources, both surface catchments and groundwater, are now over-allocated. Water resources available for cities are dwindling. The problem is being exacerbated by the realization that global warming will reduce rainfall in many areas, and that there will be an even greater proportionate reduction in run-off to rivers, lakes, reservoirs and groundwater basins. There are numerous examples where unplanned re-use of water has occurred (Figure 1).

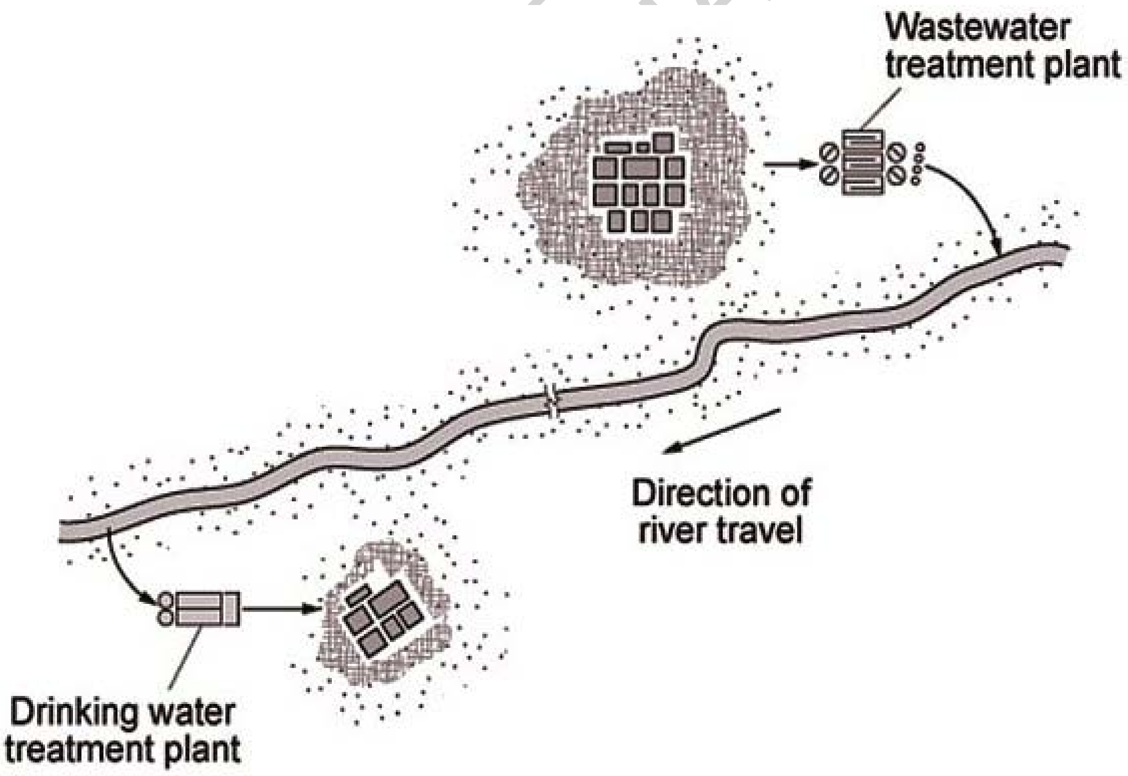

Figure 1. Diagram showing unplanned indirect potable recycling (T. Asano *et al.* 2007)

Attention is increasingly turning to the planned re-use of water as a significant resource option that must be considered. This approach recognizes that many uses do not require drinking standard water and there are opportunities to substitute recycled water of an appropriate quality. Furthermore, the availability of new technologies allows previously used water to be remediated to drinking water standards if required. These various forms of recycled water are increasingly price-competitive with traditional sources but their production and use require skilled oversight and competent monitoring.

All water is ultimately recycled as is illustrated by the hydrologic cycle. The hydrologic cycle refers to the continuous transport of water in the environment, involving evaporation from the surfaces of biota, land and water bodies to form clouds, its movement through the climate system and its subsequent precipitation as rain or snow. Man has learned to intervene in this cycle by developing water storages, and reticulation systems to facilitate the use of water, its subsequent treatment for reuse and/or discharge back into the environment. The components of the hydrological cycle are shown in figure 2.

Figure 2. The Hydrologic Cycle (T. Asano and A Levine 1995)

A variety of sources can be used to produce water that is reclaimed for human use. These sources encompass the treatment and reclamation of water from wastewater / sewage treatment plants, the harvesting of storm water from hard surfaces in urban areas such as from roofs, roads and hard stand areas, the recycling of drainage flows from agriculture and the re-use of brackish or sea water by desalination. The stream of recycled water may be comprised of any or all of these waters, and where used in combination, must be managed in an integrated way. Ultimately, the water must be fit for the purpose for which it is to be used.

2. Uses for recycled water in the Urban Environment

Recycled waters in the urban environment have a range of uses including

- Agricultural irrigation in adjacent farm land
- Landscape irrigation of amenities including ovals, recreation grounds, parks and

gardens

- Industrial use (substituting for drinking water as a water resource conservation measure)
- Recreational uses such as in urban lakes and other water features
- Substitution for environmental flows following up-stream water harvesting
- Groundwater recharge
- Non-potable urban household uses (substitution for drinking water)
- Potable (drinking) water

A range of issues must be considered in producing, managing and using recycled water in the urban environment.

3. Production of Recycled water

3.1 The Extent of the Available Resource

Any proposals for water recycling should take into account long term planning that accounts for the total water demands of the urban community, the quality of water required, the diversity of sources available for access, the potential for changes in availability of those sources and the economic merits of the alternative options. It is becoming increasingly unlikely that an urban area can operate on only one form and source of water supply.

The resources available for recycling can generally be divided into household greywater, industrial wastewaters, domestic sewage, storm water and seawater (see *Unconventional Sources of Water Supply*).

Household greywater from washing machines, showers, baths and basins can be used for limited purposes such as home garden irrigation. It should not normally be stored for more than 24 hours before use, although small domestic treatment plants are becoming available. Industrial plants using high volumes of water for purposes such as car washing are able to make specific installations to recycle a high proportion of the water used, with processing being matched to the use pattern and quality needed. However, there are three major sources of recycled water. That from a Waste Water Treatment Plant (WWTP), sometimes called a Sewage Treatment Plant (STP), will provide a relatively uniform daily volume and composition over time, though it should be noted that if water restrictions are imposed on a community, particularly for household use, a concomitant reduction of wastewater available for recycling must be anticipated. Storm water will be quite variable in availability and quality depending on annual climatic cycles and the frequency, duration and intensity of specific rain events. Seawater is available in quantities that can be considered as effectively unlimited.

3.2. The Scale of Production

Recycled water can be produced at a several different scales, *viz*

- Area scale
- Locational scale

- Site scale

Recycled water can be generated at the **area scale** by collecting sewage (or municipal wastewater) via the sewerage system for appropriate treatment in a WWTP where the solids (sludge) and liquids (effluent) are separated, and biodegradable organics are stabilized and removed. Storm water can be similarly collected at the outlets of major storm water drains for treatment and remediation.

The quality of the water required from the processing will be determined by its ultimate disposition, namely whether it is immediately returned to the environment, in which case environmental standards will need to be met, or if it is to be recycled, the purposes for which it is to be used. Often this involves adding a further water reclamation module to the treatment train to improve the quality of the treated wastewater or storm water so that it is ‘fit for purpose’.

The location of WWTPs at the urban area scale has traditionally been influenced by maximizing ease of access to the effluent flow, the sought elevation of the site (to maximize the use of gravity flows to the plant), the scope for discharge of the effluent (location close to a river, estuary or the ocean has been common), access to power sources, and community acceptance. Large centralized plants have often been favored over smaller decentralized facilities. Usually, supply of recycled water requires pumping to a higher elevation to reach customers, and pumping costs may be a major operational cost. Recycled water can also be obtained at a **locational scale.** This may involve small treatment plants treating waste waters from the immediate vicinity, often driven by limitations of access to distribution facilities to more distant locations, or the need for additional water for non potable use at the location. This can involve a process of **Sewer Mining**, whereby the sewage flow in a main trunk sewer is accessed, and the sewage effluent separated and treated to provide recycled water, with the solids returned to the sewer main for further treatment at the end-point WWTP. Similarly, storm water may be collected and treated at a locational scale. These plants can be termed satellite water reclamation plants.

Recycled water can also be produced at the **site scale**. Packaged units are available for use on high-rise office buildings and apartments. These can be managed by contract service organizations. Installations have also been developed for use at the scale of the urban house-block containing a single-family dwelling. However, there are limits in the use of on-site treatment systems. House-owners have a poor record in achieving effective maintenance, and the average domestic building block is generally regarded as too small for their use where discharge of most of the recycled water is for garden use.

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Biographical Sketch

Dr. John Radcliffe AM PhD FTSE FAIAST FASP is an Honorary Research Fellow in CSIRO Australia and was a Commissioner of Australia’s National Water Commission from 2005 to 2008. He is a member of the Council of the University of Adelaide and the Board of Earthwatch Australia.

Dr. Radcliffe is a Fellow of the Australian Academy of Technological Sciences and Engineering and in 2004, wrote the review “Water Recycling in Australia” for the Academy.

Until retirement in 1999, Dr. Radcliffe was a Deputy Chief Executive of CSIRO. Previously, he was Director-General of Agriculture in South Australia from 1985 to 1992, during which time he was Murray Darling Basin Commissioner.

He has an agricultural science degree from the University of Adelaide and a PhD from Oregon State University.