Exploiting The Recycled Water Potential: Do's & Don'ts

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Introduction

The optimization hierarchy for cost-effectively reducing consumption of water resources involves reducing demands, then meeting demands efficiently, and finally greening the supply of any residual, reduced demand. Greening the supply can be achieved by tapping alternate water sources. LEED (Leadership in Energy & Environmental Design) recognizes two alternate water sources: rainwater collection and wastewater recovery.

Rainwater collection involves collecting and holding on-site rainfall in cisterns, underground tanks or ponds during rainfall. This water can then be used by the irrigation system during dry periods. However, the requirement of large capacity storage cisterns is a major drawback. Moreover, such an arrangement is extremely inefficient for providing water in summers (when the demand is maximum) as the time lag between the monsoons and the summer is nearly a year, and it is also economically unfeasible to provide that much storage capacity.

Meanwhile, treated wastewater is being used in many countries throughout the world as a reliable source of water which can fulfill the gap between supply and demand in the water sector. Advancements in the effectiveness and reliability of wastewater treatment technologies have improved the capacity to produce recycled water that can serve as an alternative water source, in addition to meeting water quality protection and abatement requirements.

Effluent (a mix of domestic and industrial wastewater or industrial wastewater in itself) reuse has in fact been indirectly practiced for many years and covers the reclamation of wastewater for residential, agricultural and industrial purposes. However, the most widespread application of effluent reuse is from sewage treatment works back to watercourses and rivers, improving river flows and allowing re-abstraction downstream.

The principal forms of reuse include: agriculture, aquifer recharge, industrial reuse, potable reuse and concrete mixing. Wastewater recovery can be achieved either on site or at the municipal scale. On-site systems capture gray water (which does not contain human or food processing waste) from the building for irrigation/horticulture use. Several ways to accomplish the same include: capturing condensate from the mechanical system and storing it in an underground tank for irrigation, and making use of municipally supplied treated wastewater for irrigation, wherein, non-potable water is supplied as needed via a municipal supply.

Advantages Of Using Recycled Waters

Most industrial units have realized that alternate sources of water resource such as treated effluent within their jurisdiction (which may be from their own wastewater recycling plant) have a lower unit cost (present value $/ML supplied or saved) and assured availability compared to fresh, raw water/ municipal supply side options.

Apart from the very obvious advantage of availability of additional water resource, there are specific advantages of using recycled water. Erfani et al. (2001) showed in a research that utilization of treated municipal wastewater caused an increase in the production of tomatoes as compared to irrigation with the well water. Similar benefits on usual landscape flora can be expected.

These methods are most efficient when wastewater is available near the areas where the demand is greatest, thus eliminating the high economic, environmental, and energy costs of diverting untapped surface water and transporting it over long distances.

Moreover, recycled water proves to be a more reliable source of water as the amount available does not vary greatly from year to year.

Precautions To Be Taken

Although recycled wastewater is considered an attractive option for horticulture and other non potable uses, several precautions/ safeguards need to be kept in mind to achieve a win-win situation. The issues related to health and environmental risk pertaining to reuse of treated wastewater cannot be ignored. Reuse of treated wastewater requires effective treatment to protect public health and the environment at an affordable cost.

This is especially true of conventional wastewater treatment plants which produce secondary treated effluent and don't remove total dissolved solids during the treatment processes, hence, the recycled wastewater contains high concentrations of salts. When applied on land for irrigation, this quality threatens the environment, human health and sustainability of planned flora. Such effluent is likely to contain some pathogens and its chlorination or bromination may generate harmful compounds. Prolonged use of effluent of this quality in irrigation induces soil salinity and alkalinity, which is harmful for the soil as well as for plant growth. Erfani et al. (2001) showed that microbial contamination of products is more likely in the case of using treated wastewater in comparison with the ordinary condition.

Another important parameter to be considered when using wastewater for agricultural purposes is the amount of heavy elements entering the soil and their accumulation in the product. Apart from this, owing to chances of contamination by pathogenic bacteria, adequate measures need to be planned to suitably protect the health of agricultural workers when sewage irrigation without proper disinfection is used. It has been reported in India that hookworm and other enteric infections are much more common among workers on fields/landscapes where treated wastewater without adequate disinfection is being applied. The local custom of walking barefoot on grass cover which is also advocated by several naturopaths for improving eyesight may increase the risk of such diseases.

Reasonable standards of personal hygiene appear to be effective in protecting the health of workers/people using the landscaped area for recreational purposes in such wastewater utilization projects. Personal hygiene for workers should include the following: avoiding exposure to recycled water where possible, the use of protective garments, changing of clothes at the end of the work period, care in hand washing and bathing following exposure, and prior to eating food.
Recycled Water Quality & Associated Cost Concerns

Determining Permissible End Uses

Not every category of treated water can be used for horticulture. Each use demands a certain degree of treatment (for example, WateReuse Association, California has framed the criteria for deciding allowed Recycled Water Uses). A report by EPA [stating Environmental Guidelines for the use of Reclaimed Water; EPA Victoria (2003)] has defined four microbiological classes that determine the permissible end uses (for irrigation/ agriculture/horticulture,) which are as follows:

- Class A: <10 thermo tolerant coliforms per 100mL (median value). Suitable for high contact end uses e.g. residential garden watering.
- Class B: <100 thermo tolerant coliforms per 100mL (median value). Suitable for medium contact uses e.g. irrigation of pasture for dairy animals.

Quality	Problem
Microbiological Quality	Risk to health of workers and the public
Chemical Quality (e.g. ammonia, calcium, magnesium, silica, iron)	Corrosion of pipes and machinery, scale formation, foaming etc.
Physical Quality (e.g. suspended solids)	Solids deposition, fouling, blockages
Nutrients (e.g. phosphorus and nitrogen)	Slime formation, microbial growth

Table 1: Potential Quality Concerns For Industrial Use

- Class C: <1000 thermo tolerant coliforms per 100mL (median value). Suitable for low contact uses e.g. irrigation of open spaces with public access controls.
- Class D: <10,000 thermo tolerant coliforms per 100mL (median value). Suitable for nonhuman food chain uses e.g. cotton growing.

Certain concerns that have been reported by EPA, void their guidelines for using recycled water for industries (table 1). However, no such criteria have been formulated for developing nations like India, despite increasing stress on adopting water conservation measures.

The Water Quality Cascade

Although it may appear to be desirable to use the highest degree of treatment for recycled water before use, the financial side warrants the maximum possible implementation of a water quality cascade. A study by White and Turner (2003) has described the evolutionary progress of urban water reuse from agricultural reuse, to large scale industrial reuse, and then to dual reticulation for urban developments. It has argued that the next step in this progression is to more fully implement the principles of the water quality cascade, and to use the benefits associated with reducing sewage and water transport costs to trade off increased costs associated with distributed treatment and reuse systems.

The principle of the water quality cascade involves matching the end use of water with the quality of the water source, and utilizing all water sources to meet water service needs. For example when potable water is brought into a typical household, instead of using the high grade water only once, in the traditional linear approach, higher quality wastewater discharged from end uses such as bathroom and laundry should be treated to an appropriate level within the household, and reused for garden irrigation and/or toilet flushing.

In case of agricultural reuse, the effluent reused often requires a lower standard of treatment and supplies a significant demand, thus reducing the unit cost. In the case of large scale industrial reuse, despite the need for high levels of treatment, the demand is large, thereby reducing the unit cost, although not to the level attained for agricultural reuse (this depends on the piping distances required). Dual reticulation systems generally have a higher unit cost because of the high treatment level required, the duplication of reticulation infrastructure (without an offsetting reduction in sewage transport infrastructure) and the lower demand of potential end uses such as outdoor water use and toilet use.

Specific Operational Requirements

Users of recycled water must also evaluate a second set of criteria concerning the quality of recycled water as it relates to their own operational requirements, as some of the chemical constituents present may cause problems for specific operations. Some examples include: mineral scaling from calcium phosphate and other products; corrosion, pitting, and stress cracking damage to metal heat transfer surfaces and to structural metal surfaces (e.g. damage to copper, copper alloys, and other 'yellow metals' from ammonia); and biofouling of heat transfer surfaces and excessive biological growth on cooling tower fill material surfaces from BOD, phosphate, and ammonia.

One such example is of The Public Service Enterprise Group (PSEG). PSEG had made arrangements with the nearby Linden/Roselle Sewage Authority (LRSA) to receive 8,100 gallons per minute (gpm) of recycled water. One unintended impact of using recycled water in the Linden station was that corrosion problems developed with the Type 316 stainless steel condenser tubes from chlorides and other components in the recycled water. According to a report, the Linden plant and another nearby PSEG plant needed to replace their relatively new stainless steel tubes with titanium tubes.

Specific additional treatment processes can be used to treat the recycled water to the required operational quality level. However, a detailed cost/benefit analysis of the proposed options needs to be undertaken prior to the implementation of these treatment processes as most of the specific technologies available for treatment are more expensive than the general tertiary/polishing treatment options.

For example, recycled water needs to be treated at the municipal wastewater treatment plant, to at least secondary treatment standards to utilize the same for cooling water make-up. In most applications, if the recycled water is not already treated beyond secondary standards, the power plant/ HVAC facility using the water for cooling will either need to treat it at the power plant site/HVAC facility or pay the wastewater treatment utility to provide additional treatment.

There are several examples of applying upgraded treatment before using recycled water for power plant cooling. Several such successful case studies have been documented. The starting level of treatment ranges from secondary to tertiary. The additional treatment steps include chemical addition, clarification, disinfection, pH adjustment, and biological treatment. One such example is that of the Clear Lake Sanitation District (CLSD) wastewater treatment plant in Clear Lake, Iowa, which expanded its capacity from 2.2 MGD to 8.2 MGD in 2002.

CLSD has been providing recycled water to a nearby Alliant power plant since December 2003. The recycled water is piped about 6 miles to the power plant, where 60–80% of the water is evaporated in cooling towers. Blowdown from the towers is piped back to the CLSD wastewater treatment plant, dechlorinated, and then discharged to Beaver Dam Creek. As part of the agreement, CLSD added tertiary filtration and disinfection steps. Alliant paid for this supplemental upgrade, which included a 150,000-gallon, post-secondary equalization basin, a new tertiary treatment building that houses three six-disk cloth media filters, and an ultraviolet disinfection system. The plant uses a sequencing batch reactor system for secondary treatment. Treated effluent flows by gravity to the equalization basin and is then pumped into one of the three cloth media filters. Finally, the flow passes through an ultraviolet disinfection system prior to being sent to a storage tank at the Alliant Energy power plant site. Liquid chlorination was installed to provide a residual that would protect against any biological growth in the pipe during periods when the power plant is shut down.

A capable team and early involvement of local code officials are critical components for the successful design and implementation of using recycled water for non-potable —especially industrial water supply systems. Also special consideration needs to be given to the impact of such use on the life of the piping system. In addition, some alternatives such as dual-plumbing lines for non-potable water supply within the building are fairly easy to plan during initial stages, but much more difficult to retrofit later.

Water Efficiency Vs. Expoiting Recycled Water

It has been stated that there is a logical order of investment in methods of sustainable urban water management, both in terms of unit cost and energy intensity; starting with improved efficiency of water use. Improved water efficiency options have been reported to generally have the lowest unit cost, with typical leveled costs of $0.1-0.7/kL. Their benefits further cascade down in terms of reduction of energy use from hot water savings and reduced pumping and treatment. High level reuse can cost between less than $1/kL for large scale industrial reuse, to over $3/kL for dual reticulation schemes. The energy intensity of high level reuse can be as high as 4,000 kWh/ML.

The implications are clear. Water efficiency options focused on reducing demand for fresh/potable water must be invested in first, and to the maximum extent possible. The relative, unit costs and energy intensity, of all potential measures needs to be considered while prioritizing investment. Actual unit costs will vary according to context and location, but will generally be in this order: *Efficiency Measures < Existing Sources < Source Substitution and Reuse*

Summary & Conclusion

Increasing emphasis is being placed on exploiting the recycled water potential to address increasing stress on fresh water reserves. The use of recycled effluent in the urban context has tended to follow an evolutionary path such as the following:

- Reuse for agricultural or recreational areas (e.g. playing fields, golf courses), where the primary objective has been effluent disposal, rather than using the effluent to displace potable demand.
- Large scale industrial reuse, including power stations and heavy industry reuse such as steel works.
- Dual reticulation for residential and commercial use, or so called 'third pipe' systems, in which recycled effluent is

reticulated back to customers via a duplicated water supply system often from an existing 'regional scale' sewage treatment plant.

Unfortunately, the development of these options has often been intended to meet the objective of reducing effluent disposal, rather than reducing demand for water from potable water supply schemes. It is clear there are a number of related issues to be addressed if we are to move toward a more sustainable urban water system.

Since an evident overlap/inter-linkage exists between the various possible options to achieve sustainable systems, first, we need to apply the principles of integrated resource planning to our consideration of what options to invest in; otherwise we will ignore the importance of investing in water efficiency. For example, rushing straight to effluent reuse will ultimately waste the valuable water resource if demand reduction and water efficiency are not taken into account.

Secondly, we need to recognize the most sustainable and cost-effective solution. For example, in a particular case, a valuable form of effluent reuse could be that which offsets potable demand and reduces the costs of infrastructure, by shifting costs from transport of water and sewage towards treatment. While considering compliance with various identified water efficiency credits, an out-of-the-box and holistic approach needs to be taken.

At municipal level, new urban developments provide a useful opportunity for transitioning from the present system of centralized once-through water carriage, to a more sustainable and efficient configuration of decentralized systems, with local treatment and reuse at the 'lot' or 'estate' scale. Both green-field and infill developments provide this opportunity, as the full consequences of augmenting existing water, wastewater and stormwater systems can be economically feasible, while inclusive benefits of using a more sustainable approach can be understood. It will be necessary to consider the current management of assets, calculation of safety factors required within each system, methods of calculation of capital and operating costs, health regulations, transfer of costs and benefits between individuals, and the levels of service required, to look at these issues with a more holistic and consistent approach.

Specific guidelines need to be in place to safeguard against the likely associated health and environmental risks. Several countries have listed regulatory requirements that must be met by companies that use recycled water. The state regulations or guidelines often include restrictions on the quality of the recycled water that can be used for non-potable uses such as cooling. These generally focus on the protection of public health and the environment. In some cases, state regulations also specify filtration and additional disinfection requirements.

There are currently no established health standards relating to exposure of workers in developing nations like India. However, treatment standards for health purposes might cover oxidation, coagulation, filtration and effective disinfection; such treatment is required where recycled water is available for non-restricted recreational use by the public. Where there is any exposure at all, the lowest degree of treatment would probably be secondary treatment, followed by an intermediate degree of disinfection. Where the possibility of exposure to aerosols exists, as in the case of cooling towers, a high degree of treatment and disinfection maybe necessary to ensure the protection of the neighborhood as well as plant employees.

Adequate consideration to the factors discussed above can effectively enhance the exploitation of recycled water potential and give it the much needed acceptability in the social realm.

About The Author

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