SOCIO-ECONOMIC ASPECTS OF WASTEWATER TREATMENT AND WATER REUSE

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ABSTRACT

Wastewater treatment is an essential prerequisite for water reclamation and reuse. Proper treatment and disinfection of wastewater is also a public health necessity in human communities. Treatment and distribution of recycled water involves great expenditure of resources, which in many developing countries is either lacking or is devoted to more urgent national priorities. Also, an appropriate valuation of water and its benefits to society is often lacking due to a misperception of abundance and taking water for granted—a gift of nature, to be used at will. This attitude must be changed with proper educational tools if the relatively constant amounts of water now available are to be sufficient for increasing populations of the future.

Water reuse projects face additional impediments. One major impediment is that the agreement of two or more governmental entities are required before a project can be implemented. These institutional barriers are not insurmountable, but they involves lengthy negotiations and much give-and-take on the part of the involved entities. Ideally, a single entity would be managing all matters related to the entire water cycle, but this is rare. Pricing of recycled water is another issue complicating the ability of water managers to pay the costs of implementing water recycling projects. Recycled water is often priced significantly below the price of potable water.

Public attitudes toward reuse of reclaimed water for non-potable applications is generally positive. However, there have been several instances in California and Australia where resistance to indirect potable reuse has derailed a few otherwise excellent projects. Fortunately, public outreach and educational programs have been devised by professionals in the field for early public involvement and prevention of dissemination of misinformation by project opponents. The effects of global warming on future water supplies is not expected to be uniform everywhere, but it will be drastically limiting in certain parts of the arid and semi-arid regions of the world. Already, the continent of Australia is experiencing a ten-year drought, attributed to global warming. This increases the urgency for development of water use efficiency measures, such as water recycling in these regions.

1. INTRODUCTION

Protection of the public health is the prime reason for providing a supplemental source of water supply—recycled water. The entire process of treatment, distribution and final use of recycled water must, therefore, be also highly protective of the public health.

Until the latter part of the 20^{th} Century, decisions about public water supply resources were made strictly by engineers and other experts. There was virtually no consultation with the public at large regarding their preferences, the impacts of such decisions, or the relative merits of various resources considered for development. In recent years, the public has become involved increasingly with water supply decisions and planning for future water resources for the community. The greater involvement of the public in such decisions—at least in the industrialized nations of the world—has exerted an immense impacts on the nature of the decisions, length of time needed to implement a water project, and especially on the use of water reclaimed from wastewater for reuse.

The socio-economic impacts of wastewater treatment and reuse have always been an integral part of wastewater management decisions. In the past, the impacts became felt long after it was too late to go back and make a better decision. Only in recent years have these impacts come to the forefront of decision-making and selecting options for the future.

2. RECOGNIZING THE FULL VALUE OF WATER

At the heart of the public involvement in water matters is an awakening awareness of the real value of water on the part of the general public. While this awareness is not widespread yet, it is spreading. The fact that middle- and lower-class individuals now routinely pay for bottled water over 1,000 times more than the cost of tap water is an indication of their willingness to pay for the higher quality drinking water. This is in spite of the fact that municipal tap water is, in most cases, comparable to any bottled water on the market in microbial and chemical quality. To convince the same public to pay a fair price for municipally provided tap water requires a herculean effort involving service improvement, reliability of continuous water supply at the proper pressure, assurance of high quality and safety of the served water, and trust in the system providing public water service. Obviously, this cannot be accomplished overnight. But, without a conscious effort, it is hard to imagine that it would ever be accomplished on its own accord.

In many developing countries, there is a strong and widespread reluctance to pay for water service, even among those who can afford the relatively low costs involved. Collection of fees for wastewater treatment and proper disposal or reuse is even more difficult, because the service is often not perceived as necessary, beneficial, or resulting in immediate satisfaction of any desire on the part of the rate payers. This results in a vicious cycle of poor service, dissatisfaction with the poor service, and greater lack of desire to pay for that poor service. This cycle of perpetuating degradation of service is graphically illustrated in Figure 1. It explains why so many communities lack a safe potable water service and a proper wastewater management system. The cycle underlies the difficulty of reclaiming the wastewater and treating it to a high enough level that would make it suitable for a variety of beneficial reuse.

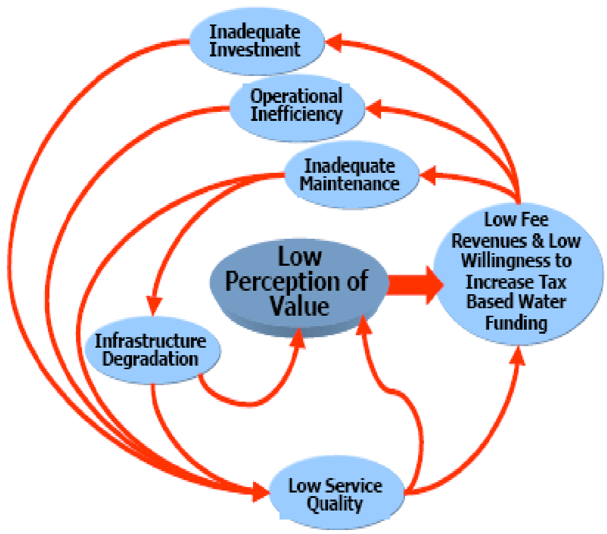

Figure 1. The Vicious Spiral of Low Funding
SOURCE: Pacific Institute

3. PUBLIC PERCEPTIONS OF WATER REUSE

The public generally does not think much—if at all—about the origins of its water supply; however, there is an assumption of purity and virginity associated with potable (drinking) water that defies reality. The reality is that all water is recycled and there is virtually no "new" water created and no naturally occurring water is "pure". With human and animals interacting with water, with urbanization and industrialization, nearly all raw water supplies are contaminated biologically and chemically. This information, plus the capability of technology to take contaminants out of any source of water and return it to a safe and pure status must be communicated to a community on the verge of adopting expensive wastewater treatment and water reuse—as shown in Figure 2, adapted from Asano *et al*[i]. Otherwise, the public's reluctance to pay, their aversion to recycling of water by technological means, and the mistrust of utilities to use public money honestly and efficiently will prevent realization of the water cycle projects.

A graphic depiction of changes of water quality with treatment stages is presented in Figure 2. This depiction is primarily aimed at biological quality of the water, but it can also be used to convey changes in the chemical constituents in water and wastewater as it undergoes use, reuse, treatment, and further treatment.

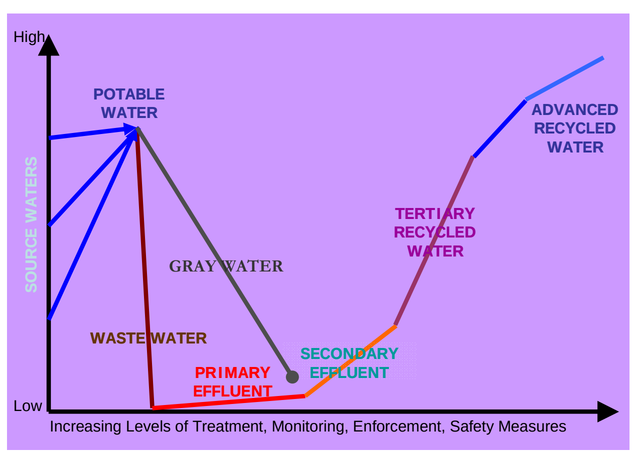

Figure 2. Change in Water Quality with Use and with Treatment Levels
Adapted from Asano *et al*., 2006

Over the coming years, giant strides will have been taken by WateReuse

Association and its research arm, the WateReuse Foundation in solving the difficult problem of overcoming public apprehensions about use of recycled water. Already, several guidebooks and special projects have been completed[ii],[iii],[iv] . Research projects to further delineate public response to wastewater treatment and water reuse have been funded and are "in the pipeline". These projects will bear fruit over the coming decades and result in a much more systematic approach to public education and outreach during the planning process for water recycling projects.

4. PRICING RECYCLED WATER

Recycled water is generally priced below potable water to provide a significant incentive for customers to switch from potable to recycled water. The extent of discount ranges from 15 percent to as high as 100 percent—giving the recycled water free of charge to the users, in cases where the agency desperately needs a reliable disposal venue. This requirement for discounting the price of reclaimed water places one more impediment on implementation of new water reuse projects: inability (or difficulty) to repay the costs of project implementation, operation, and maintenance. Because of the significant benefits of water reuse to society and the environment, incentive subsidies are often provided by regional and central governments to local governments to overcome these fiscal imbalances. This is a means by which the larger society pays for the benefits derived from every water reuse project implemented by local governmental agencies.

The pricing schemes for potable water are generally below the actual cost of operation and maintenance —not to mention the capital costs of constructing the treatment and distribution systems—of the supply systems in many communities. Thus, the even lower price of reclaimed water cannot be expected to cover the normal costs of operating a water reuse system. Subsidies, incentive payments, and transfers from other funds are commonly used to defray the gap between cost and revenue of water reuse systems.

5. INTERAGENCY COLLABORATION AND AGREEMENTS

Several agencies with different authorities and responsibilities must come together and form an agreement before a water reuse project can be initiated in a community.
At the national level, the departments of agriculture, public health, finance, water resources, and the environment are involved and each have a jurisdictional authority over the project. At the local level, the agreement must be reached among water wholesalers, retailers, wastewater managers, and public works officials. These multi-agency agreements are difficult at best and impossible at worst. A strong motivation for the agencies to agree to cooperate must come from one of the following sources of pressure:

- Water scarcity and a public health crisis situation arising from deficiency of water
- Environmental impact of discharge of treated wastewater, loss of threatened and endangered species of plants and/or animals
- Need for increasing the reliability of water supply and independence from imported sources of water

Each of these motivators or a combination of several of them can be strong enough to move the diverse parties to the negotiating table and eventually make it possible to start a water recycling program. Another possible motivation is the anticipated effects of global warming on water supplies—discussed further in Section 6, below.

The greater the number of agencies involved in decision-making regarding a new water reuse project, the longer it takes to accomplish the necessary tasks, reach agreement, and complete the project. In a recent study of over 200 California water recycling projects, an inverse relationship was discovered between the number of "intermediaries" (between the producer and the final customer of recycled water) and the volume of water reclaimed and reused[v]. A similar relationship was also found between the number of intermediaries and the number of successful projects in operation. These relationships are graphically depicted in Figure 3.

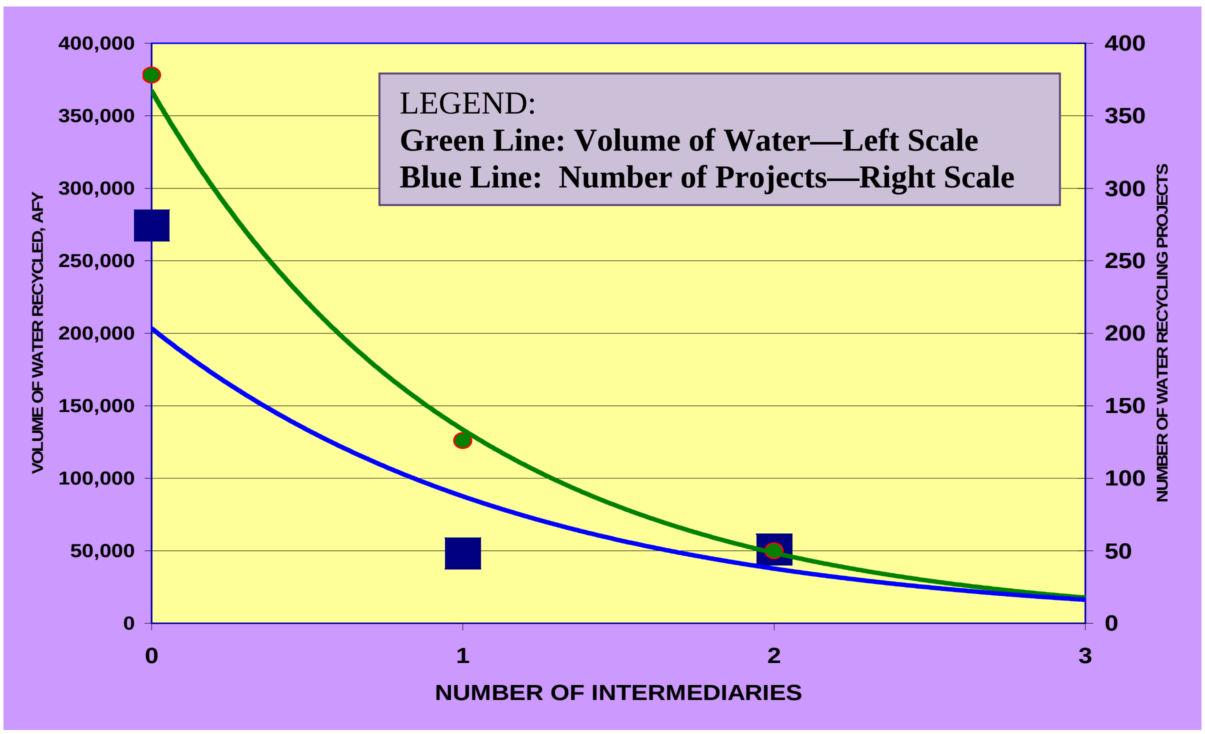

Figure 3. Relationship between Number of Intermediaries and Number of Successfully Implemented Projects, and the Volume of Recycled Water Generated.

6. GLOBAL WARMING

Global warming[1] as affected by human activity since the onset of the industrial revolution is accepted as a phenomenon of grave concern by climate scientists. The phenomenon is questioned by some with a vested interest in the short-term economic and

[1] Climate change is a euphemistic reference to the same phenomenon for those uncomfortable with the massive evidence for global warming or for the role of humans in the accelerated rate of warming of ocean waters, atmosphere, and the gradual melting and disappearance of continental glaciers.

political consequences of decisions that may lead to a reversal of recent (last two centuries) trends in the concentration of carbon dioxide in the earth's atmosphere. However, decisions to reduce carbon emissions are necessary if planet earth is to remain hospitable to human existence for the foreseeable future.

One of the critical (and relatively immediate) effects of global warming is expected to be a major elevation of temperatures throughout the world, resulting in higher evapotranspiration rates, directly leading to increased demand for irrigation water. Irrigation of agricultural lands accounts for over 75 percent of the demand for water in countries in the arid and semi-arid regions of the world. A global-warming induced increase in demand for water—not balanced by an equal increase in supply—would be terribly stressful on available sources of water supply and will likely increase the motivation for implementation of water conservation and recycling programs. After all, recycled water is a local source of water, most readily available to the urban sector, at least for nonpotable applications. Potable applications are on the horizon; Namibia, Singapore, and Australia are leading the way.

7. NEED FOR STORAGE OF RECYCLED WATER

Recycled water is generated at a relatively steady pace and does not require as much storage as does precipitation occurring in only a few months of the year. If used for agricultural irrigation, recycled water receives less treatment than if used for indirect potable use. However, it will need large storage volumes to balance seasonal demand against year-round supply. Figure 4 shows a groundwater recharge basin and pump station for recycled water from the City of Tel Aviv, Israel. The aquifer-stored water is pumped from wells and sent to Negev Desert (50 kilometers away) for unrestricted irrigation of a variety of crops. Israel recycles over 70 percent of its wastewater in planned and managed projects. Unplanned reuse of wastewater and wastewater effluent (by way of withdrawals from local streams dominated with upstream wastewater discharges) is common and sometimes approaches 100 percent of the discharge in some countries. However, this practice is not protective of the public health and is not considered a sustainable water reuse policy.

Figure 4. Groundwater recharge of reclaimed water for treatment, storage, and agricultural irrigation, in Israel

If highly treated recycled water is used for direct potable purposes—rather than for landscape irrigation—the demand will be matched by supply and there will be no need for seasonal storage. Indirect potable reuse, on the other hand, involves augmentation of surface reservoirs or groundwater aquifers. Thus, storage capacity is needed to provide the necessary mixing and detention time.

8. SUSTAINABLE WATER RESOURCES PLANNING

Most water resource planners now recognize the importance of integrated water resources planning, taking into account a variety of sources of water, rather than just one or two traditional sources. It is no longer unusual for an agency to have access to a number of well-defined sources of water supplies from one or more of the following categories:

- Imported water from far away
- Imported water from a neighboring watershed, transfers, and exchanges
- Local surface runoff, stored in surface storage reservoirs
- Local groundwater resources used within a safe-yield management plan
- Local groundwater resources used to extinction—not a sustainable resource, but sometimes an inevitable short-term or interim solution
- Water conservation through a variety of water use efficiency measures
- Water reclamation, recycling, and reuse
- Desalination of brackish water or seawater

Each one of these water supply sources can play a vital role in a given community's integrated water resources plan, managed with full recognition of its limitations, water quality, environmental impact of its utilization, and other services and benefits related to each resource. Bringing recycled water into the supply mix initially may represent a small fraction of the total water demand, or it may be a significant portion of the supply, depending on local circumstances. Either way, its presence in the overall mix will improve dependability of supply of water and will release much needed potable supply from the irrigation sector.

An important attribute of recycled water is that its availability and quantity increases with increasing population—quite the opposite of the trend for other resources, which are either diminishing in quantity, or quality, or both, as a direct function of population increase. Therefore, provisions for inclusion of this sustainable source of water in the community's integrated water resources plan is a wise and visionary step.

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Recycled water used for landscape irrigation, lakes, and golf course fairways, Silver Lake Country Club, California