Seawater for non-potable uses

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IN MANY REGIONS of the world people have difficulty in providing enough fresh water to meet increasing demands. In wealthy countries this problem is frequently solved by choosing to desalinate large quantities of seawater or brackish groundwater - at considerable cost. Lower-income countries do not have the resources to do this, and have to manage their existing water resources more carefully. Often, people simply have to use less water.

The importance of proper management of water resources in coastal areas has been highlighted and agreed in Agenda 21. Poor coastal areas of tropical countries are under particular strain, as water presents a major limit to development. Not all water is required to be of a potable standard. Better use of a limited supply of potable freshwater may be achieved by the use of non-potable (lower quality) water in some situations, most notably for toilet flushing and fire fighting. For communities with large coastlines, seawater would be an obvious choice as a medium for conveying sewage.

Despite the fact that several countries successfully operate dual supply systems, many more have indicated that they would be wary of embarking on such projects. For some this is through sound economic reasoning, but for others it is through largely unfounded technical concerns.

The ODA have financed two studies (by staff at WEDC) on this subject and this paper largely reflects the findings of Phase 1, which took place towards the end of 1995.

Phase 1 methodology

Through an extensive literature search, the use of a widely-distributed questionnaire (see Table 1) and collaboration with water utilities and wastewater companies, a detailed picture of the world status on seawater toilet flushing has emerged.

Current use and interest

The survey has revealed that the countries listed in Table 2 already use seawater for non-potable domestic purposes. Many more use seawater for industry. It is also worth noting that ordinary sewerage networks in coastal areas are prone to saline groundwater intrusion. This can result in almost identical conditions to those that would be encountered in a deliberate seawater supply and sewerage scheme.

Table 3 details the level of interest of the respondents in utilising seawater for non-potable uses.

Figure 1 indicates the technical issues that were highlighted as areas of perceived concern by the respondents.

Answering the concerns

Cost of infrastructure

The cost of construction of a dual network, along with any associated increased costs due to special material selection, clearly has to be offset against the benefits that a dual system can bring. It appears that this balance will be affected by the:

Table 1. Questionnaire/letter recipients

Recipients	*Number of questionnaires sent*	*Number completed*	*Per cent response*
Selected WEDC alumni	74	23	31
Selected overseas IAWQ* members	68	19	28
Suitable parties from WEDC database	10	2	20
Other miscellaneous parties	2	2	100
Total	**154**	**46**	**30**

*International Association on Water Quality

Table 2. Locations in which seawater is used for domestic purposes

Country	*Level of treatment*
Cayman Islands	Secondary[1]
Gibraltar	None
Hong Kong	Up to secondary
Kiribati	None
Marshall Islands	None
US Virgin Islands	Primary

[1]Mixed with municipal wastewater

Table 3. Respondents interest in seawater for non-potable uses

Response	*Per cent of responses*
Interested	46
Might be interested	41
Not interested	13

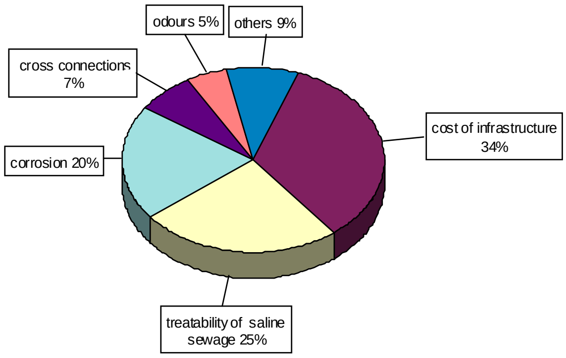

Figure 1. Concerns about a dual supply system

- severity of water shortages;
- whether the site is 'greenfield' or not, plumbing-in a dual system from scratch will be more attractive than re-plumbing an existing site;
- costs and benefits; including environmental impact and socio-economic impact (particularly the effect on tourism).

Regarding costs, only those of labour and materials can easily be quantified. As part of the activities in Phase 2 of this project, a financial analysis will be undertaken to assess the discounted costs of different scenarios in a developing coastal city as a case study. This information, when coupled with an appreciation of the intangible benefits, should provide a measure of the viability of a dual supply system.

A response from the Marshall Islands indicated that their dual system has proven financially worthwhile because of severe limitations in fresh water supply. Use of seawater has alleviated water shortages, and the advantages of saving of a precious resource outweigh simple financial and technical disadvantages of a dual system.

Corrosion

The use of seawater / sewage mixtures in pipes and fittings can cause increased corrosion for two reasons:

- the seawater itself corrodes many construction materials;
- the increased hydrogen sulphide concentrations can, under certain circumstances, lead to the formation of sulphuric acid which corrodes many construction materials.

Fortunately, corrosion can be reduced to satisfactory levels by the use of suitable materials and a network design that minimises pipe residence times. Indeed many of the materials used routinely for water supply and sewerage, such as polyethylene or polyvinyl chloride pipes, are unaffected by both seawater and any sulphuric acid produced by increased sulphate reduction.

In general, however, care would clearly have to be taken at the design stage to ensure that the whole system is capable of withstanding the aggressive environment. Use of some nonstandard pieces of corrosion resistant equipment would undoubtedly lead to increased infrastructure costs.

Treatability of saline sewage

In most coastal locations land treatment of saline wastewater would not be considered a viable alternative to marine treatment (disposal of raw sewage via some sort of outfall). Some places however, would require that wastewater treatment be effected prior to disposal. The latter would tend to be the case where conservation of the marine environment is essential, for example, where the local economy relies heavily on tourism.

The effect of salt concentrations on treatment processes was highlighted as a major concern in the responses to the questionnaires. However, numerous researchers working with activated sludge, percolating filters and rotating biological contactors (RBCs) have found that saline sewage can be treated to a very high degree ('Royal Commission 20 / 30 (BOD / SS) standard') provided the salinity does not vary greatly.

This previous research shows that the activated sludge process can accommodate a constant salinity of 50 g / l (about one and a half times that of seawater) and still produce a high quality effluent (Tokuz *et al.*, 1978). Salinity shocks (sudden changes in salinity), however, severely disrupt all of the biological processes. This is because the micro-organisms present in these systems need time to acclimate to new environmental conditions.

In addition to the activated sludge process being affected by salinity shocks, it is also known that the effect of these shocks is more dramatic above a certain critical organic loading. Li and Guowei (1993) found that, for a two stage activated sludge contact-oxidation process, this critical loading was about 2.8 kg BOD / m^3.d. This is significant because it is likely that any area adopting a seawater sewerage system would, almost by definition, be extremely short of water. This would give rise to very strong wastewaters and hence high organic loading.

There has been little work on physical-chemical treatment, as this form of treatment tends to be more technically demanding and expensive. However, in the case of seawater toilet flushing, it may have certain advantages. The main advantage is that physical-chemical processes are not subject to salinity shock effects, and Kessick and Manchen (1976) found that the addition of alum or lime gave rise to effective coagulation. At the time of publication of their paper, the authors seemed unaware that the lime would also serve to increase the pH of the wastewater, and hence keep the majority of any hydrogen sulphide present in its ionised form, thus reducing odour and corrosion effects. If it could be shown that the salinity of the sludge produced was low enough not to inhibit crop growth, it would be an extremely valuable soil conditioner for the generally acid soils of the tropics (Mara, pers. comm., 1994), although its value would have to be offset against the cost of the lime.

Conclusions

It has been suggested that dual fresh / sea water supply and sewerage systems can significantly reduce the demand on potable water resources in many coastal regions of the world. The appeal of such schemes depends principally on the severity of the potable water shortages.

Concerns about corrosion effects and saline wastewater treatment, though highly pertinent, have been allayed and work will be undertaken in Phase 2 of the project to address financial concerns.

A dual fresh / sea water system is technically feasible, and, although at present most systems are in small island or tourism areas, it may become an increasingly viable option for large urban areas in coastal zones as urban migration continues to grow.

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Acknowledgement

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