26th WEDC Conference Dhaka, Bangladesh, 2000

WATER, SANITATION AND HYGIENE: CHALLENGES OF THE MILLENNIUM

Green areas and gardens for arid regions

Cáceres L., Contreras R., Rojas J., Monardez, V. and Rodríguez V., Chile

Administrative Regions I and II in the North of Chile are 185 145 Km^2 of desert land with a population of 760 000 dispersed in 6 cities and several isolated villages. Given the complete absence of rainfall, most of the water supplies are transported from distant places in the high mountains. Furthermore, quality water is affected by high concentration of dissolved solids including boron, sodium, sulfate and arsenic among other ions. Under this situation green areas and gardens are severely restricted. Accordingly, in this paper, development of the FONDEF (Chilean agency promoting research and development) funded project "Ornamental plant production for desert areas irrigated with residual waters" with the involvement of local universities and industrial companies in the Chilean administrative Region II. is described.

The objectives of this project are:

Develop new strategies for green areas and gardens expansion in arid places.
Ornamental plant selection and evaluation for its use in arid places.
Ornamental business promotion.

The participants in this project are: Executers: 3 local Universities; supporters and beneficiaries: a) One mining company b).- Two Municipalities c).- Two Ornamental companies and d).- One Construction company.

Problem identification and strategies

Methodology and activities were devised by considering a critical factor -innovation scheme as summarized in table 1.

Since the beginning (30 out of 36 months) most of the results, above indicated have been satisfactorily achieved.

Project activities and results

Organization

All parties composed by agronomists, engineers, and architects are organized in three units namely Arica, Iquique and Antofagasta. In each one an ornamental demonstrative unit were built with a design recommended by architects. In Figure 1 Antofagasta´s ornamental unit is shown. It is composed by a wastewater treatment plant based on 2000 m^2 stabilization ponds and a 3000 m^2 park having a central

Table 1. Critical factors affecting green areas and gardens in arid environments. Particular case: North of Chile

Item	Factors	Restrictions	Innovations	Expected results
1	Water costs	High cost of potable water	Saline and treated wastewater use for green areas.	A significant decrease in potable water use
2	Wastewater treatment process selection	Local characteristics Cost of treatment Bacteriological standards of water	Use natural treatment when possible If land is not available use modular activated sludge process.	Availability of low-cost water for irrigation
3	Water quality and irrigation system	High salt concentration High boron or copper concentration	Use of boron and salt tolerant ornamental plant Fitting selection for dripping systems	Waste water treatment reuse in green areas and gardens
4	Ornamental plant selection.	Poor water and soil quality Unknown ornamental quality Unknown reproduction procedures	Use of plants adapted to desert conditions Research of plant reproduction and ornamental value	Promote demand for low water consumption plants. New business generation.
5	Economic feasibility for new ornamental arrangements	Direct relationship between water quality and cost. High water demand requirements by ornamental plants in current use. Public acceptance of new plants	Potable water replacement or supplement by treated wastewater. Implement ornamental demonstrative units open to the general public in different locations. Professional designer involvement in the project.	Lower costs for green areas and gardens. Promote the idea of "green areas and garden for deserts"
6	Environmental impact	Sewage disposal	Land disposal of sludge to improve soil quality	Desert plant preservation under extinction.

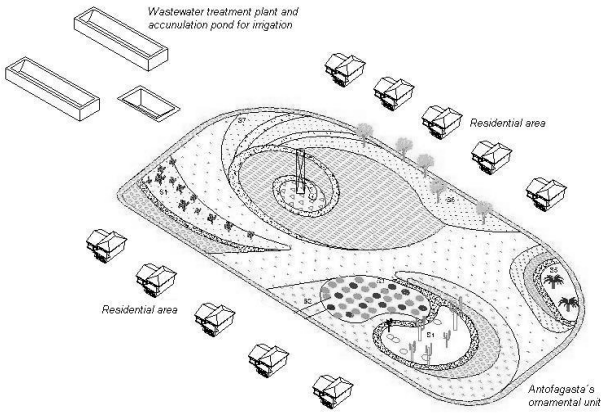

Figure 1. General arrangement of Antofagasta´s ornamental unit composed by stabilization ponds to treat water from residential area, and a demonstrative park

pond and spiral arms filled by ornamental plants. The design is supposed to be harmonic with hilly surroundings. Antofagasta´s soil and water analyses are shown in Table 2.

Ornamental plant selection

A number of selected plants, most of them native, where studied from the point of view of its ornamental value and resistance for conditions of high salinity and shortage of water. *Nolana peruviana, Nolana aplocaryiodes* and *Tetragonia ovata* are specific examples of native plants (Teiller et al, 1998; Nolana´s web site). These plants are adapted to survive with water supplied either from inland or marine coastal fog. Sampled water precipitated from inland and marine fog exhibited maxi-

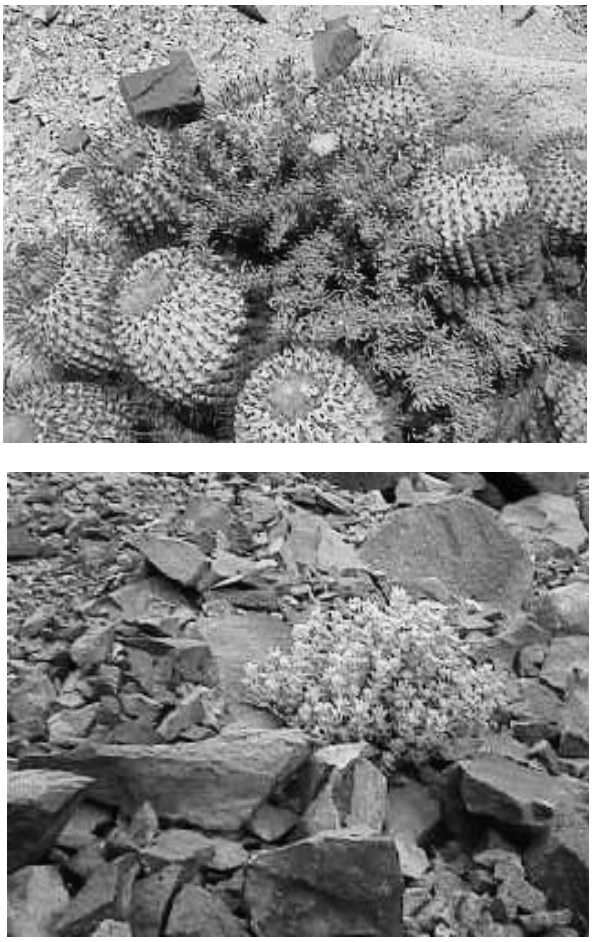

Figure 2. Examples of ornamental arrangements, Top: Cactus (*Copiapoa sp*) and nolana. Bottom: nolana and rocks.

TABLE 2. Minera Michilla and Antofagasta´s raw wastewater characteristics. Michilla´s treated wastewater characteristics. (1999)

Variable	Units	Raw wastewater Minera Michilla	Raw wastewater of Antofagasta	Treated wastewater Minera Michilla	Soil (saturated extract)
Suspended solids	mg/l	340	370.0	155	
Electric conductivity	mS/cm	0.5	3.3	0.6	65.8
BOD	mg/l	277.0	196.0	23	
Amonia	mg/l	10.2	83.2	17.4	
Copper	mg/l	5.6	<<0.1	0.3	
Sulfate	mg/l	22.0	180.0	———	
Sodium	mg/l	67.0	489.0	181.0	16,2 00.0
SAR	mg/l				77.7
Boron	mg/l	<< 0.2	5.4	<< 0.2	54.8
Total fecal coliforms	#/100ml	$4.5 . 10^6$	1.1×10^7	2.0×10^4	

mum values of 0.1 and 0.3 g/l as Na respectively. This low Na concentration value indicates that in the coastal fog, the presence of sea water spray formed by the mechanical action of heavy waves is not significant. Sampled soil from different locations was very saline. (Table 2). Under these natural conditions these native plants exhibit a partially dried foliage with slow growth rate, making them unattractive for ornamental use. After collecting and propagating some natives plant species in a nursery by using simple techniques, they exhibited a fast growth with homogeneous green foliage under an irrigation rate of 1 l/day/plant. Water and soil quality (Table 2) did not produce any deleterious sign in both, plant color and growth rate. For its use in green areas and gardens several arrangements have been considered, for example, ornamental combination between *Nolana peruviana* and native cactus, or between *Nolana peruviana* and rock arrangement, as seen in figure 2. Other native plants with ornamental value for gardens are *Calandrinia cachinalensis, Calandrinia longiscapa* and *Skytanthus acutus*. They produce exotic and durable flowers. It is interesting to note that ornamental plants in current use in the North of Chile-imported from other places- although tolerant in some degree to the conditions given in table I, most of them are not able to resist a shortage of water as native plants do.

Wastewater treatment and irrigation

The apparent trends within wastewater treatment for irrigation is toward the extremes, either small low-tech treatment or large conventional treatment plants (Henze M, 1997). Notorious emphasis on the green accounting and on the health aspects is detected in various institutions as a result of recent advent of environmental legislation (Conama, 1994). Our experience is in agreement with claims of low cost and simplicity reported for waste stabilization ponds found in the literature. For irrigation a standard controlled system were used. Occasional clogging problem in drippers experienced because of the presence of microalgae and/or debris was eliminated by once a month manual cleaning

Project diffusion and public acceptance

To attract users toward a widespread use of native plants in green areas and gardens (Municipalities, mining companies, general public, etc.) the issues of water costs, native plant characteristics and a sense of regional identity have been addressed in seminars, articles in newspapers and other

media. The inability to detect ornamental preferences by users and/or response is considered to be a weakness of the project. Activities of computer assisted design and the detection of user preferences have been abandoned as a result of its associated high costs.

Future plan

An unexpected outcome has been a public demand for large amounts of plants. Unfortunately we were not able to satisfy it. The next step is setting up a definite plan for business. A joint venture between a local investors and INDES is under way.

References

Conama, Corporación Nacional del Medioambiente, Chilean Environmental law 19.300, 1995.

Henze M., Trends in advanced wastewater treatment, *Water. Sci. and Tech*., Vol 35(10), 1-4, 1997.

Mara D.D., Cogman C.A. and Simbins P., Performance of the Burwarton Estate Waste Stabilization Ponds, *Wat. and Env. Manag*., Vol 12(4), 260-264, 1998.

Teiller A., Zepeda H. And García P., Flores del Desierto de Chile (Flowers from Chilean Desert), CONAF, Ed. Marisa Cuneo, 1998.

Nolana web site, **Error! Bookmark not defined.**, Checklist of the Vascular Flora of the Peruvian & Atacama Deserts.

CÁCERES L., CONTRERAS R., ROJAS J., MONARDEZ, V. and RODRÍGUEZ V., Instituto del Desierto, Universidad de Antofagasta, Avenida Angamos 601, Antofagasta, Chile