RECYCLING RUN-OFF WATER

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We began thinking about pollutants in water about 5 years ago. In 1971 we initiated a series of experiments designed to investigate the efficiency of nitrogen utilization and nitrogen in the environment. As the California State Water Quality Control Board became more particular about pollutants in drainage waters, we decided to install a water re-cycling and treatment plant on our new 26-acre parcel. This facility is designed to collect all of the run-off water from the property and treat it for re-cycling at about 250 gpm. The anticipated date of operation is November 1974. (see Figure 1.)

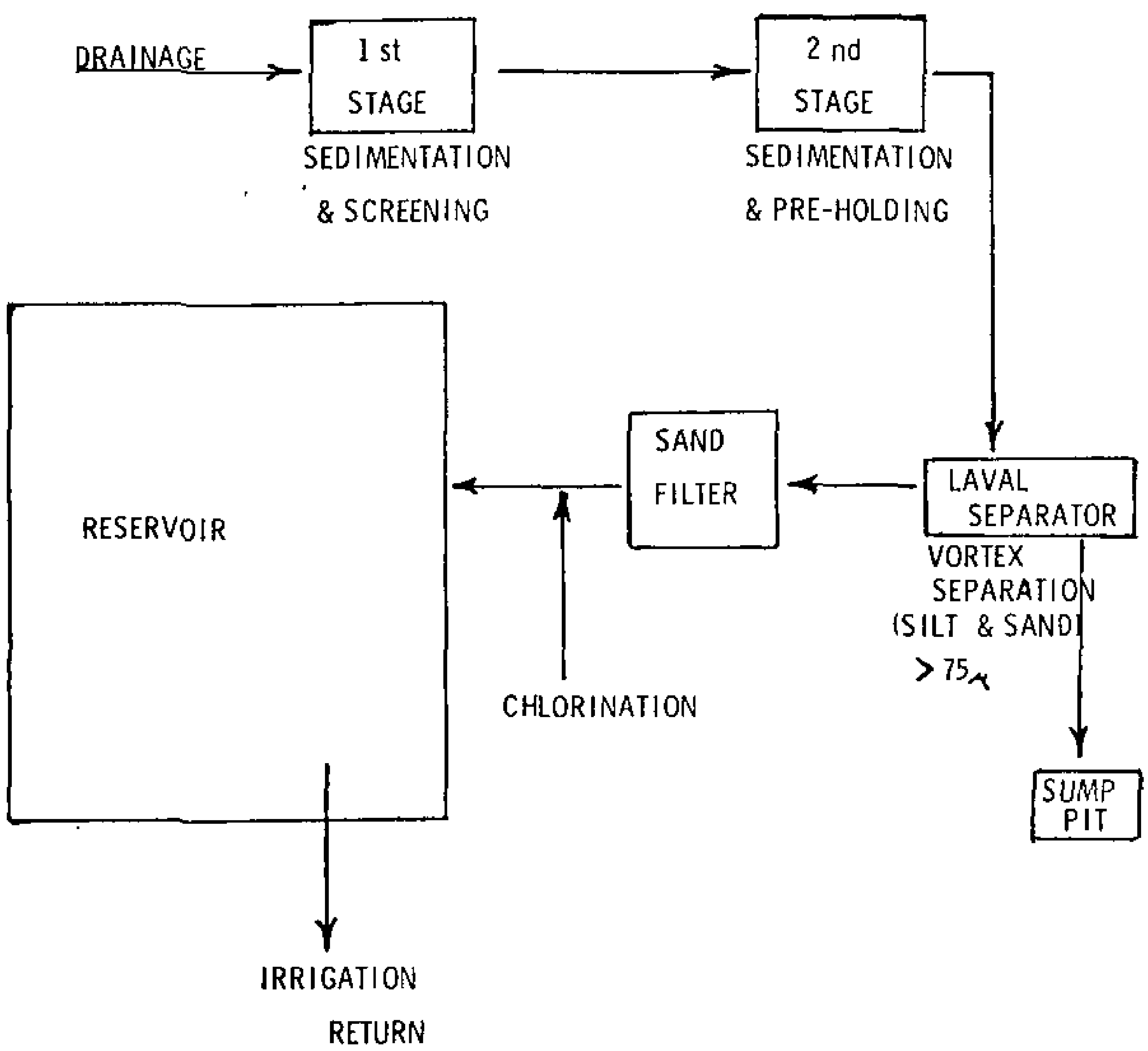

Figure 1. Outline of Monrovia Nursery's re-cycled water treatment plant

KINDS OF POLLUTANTS

The pollutants the Water Quality Control Board is concerned about are nitrogen (N), suspended solids (SS), biological oxygen demand (BOD), and total dissolved solids (TDS). A nurseryman will be confronted with all of these and, in addition, there may be other pollutants peculiar to a particular nursery, e.g., P, pesticides, and certain heavy metals such as zinc, lead and cadmium. We have no heavy metals in our water because we do not use amendments such as sewage sludge. If you're using sludge be aware of this.

Nitrogen is by far the greatest pollutant, since nitrates are considered a health hazard to infants less than 3 months of age. Nitrogen also moves wherever the water goes, adding to the problem. The Water Resources Board places a limit of 45 ppm. nitrates (10 ppm N) in run-off water reaching surface waters (which includes flood control channels).

To show how impossible a standard this 10 ppm N is to meet:

1. Most nurseries using constant fertilization are using between 100 and 200 ppm N in their irrigation water. Systems utilizing slow-release N materials only have not proven completely satisfactory. Even if slow-release materials were satisfactory, the leachate from containers would probably need to exceed 10 ppm N not to encounter N deficiency or a reduction in plant growth.
2. EPA's own tests in northern California indicated many samples of drain waters from *virgin* land exceeded 10 ppm N.

WHAT CAN BE DONE?

There are really only three alternatives:

1. Pump the water into a sewer (there are limits for pollutants even for this).
2. Denitrify the water before you discharge it.
3. Re-cycle the water.

PROBLEMS THAT WILL BE ENCOUNTERED

Sewer Discharge

1. If you pump discharge water into a sewer, you will be limited to 1200 ppm TDS in most cases. (If you're feeding at 200 ppm N and say ½ of that is K, you're at about 950 to 1300 ppm TDS, depending upon the quality of your fresh water). You will also have to pay the Sanitary District a certain amount for every million gallons discharged (regardless of purity). In Los Angeles County this is $104/million gallons. In addition, you will have to pay a certain amount for each 1000 lbs. of suspended matter, and COD. In addition, in L.A. County, there is a charge of $18.75/gal./min. for flows exceeding the peak.

2. You may be restricted in discharging water at certain peak periods, which means the water will have to be impounded for later or gradual discharge. If you have to build an impoundment reservoir, the structure will have to meet certain building codes which are now very restrictive; e.g., earthquake proofing, earth compaction, grade, etc.
3. You may also be required to measure and monitor the flow by some metering device so that the Sanitation District knows what to charge you. You may also be required to monitor the salinity.
4. You may have to install special lines to handle the flow.

Denitrification

1. A special structure is required.
2. Retention time for water dictates the size of holding pond.
3. You would be required to "clean-up" the water of pollutants (besides N) before discharging; e.g., suspended solids, other elements, salinity (by dilution).

Re-Cycling

1. The water has to be cleaned-up of suspended matter; especially clay particles. You can not irrigate plants with overhead sprinklers with "dirty" water. You can't sell a "dirty" plant. Overhead irrigation with water containing clay will result in a coating on the plants which cannot be completely washed off. The clay dirties the plant and the coating on the leaves restricts light and consequently photosynthesis and growth.
2. Diseases and nematodes may have to be cleaned-up by chlorination of the water. In our last experiment which we conducted with nematode traps, there seemed to be no problem with nematodes even though some of the run-off flowed over old citrus land; nor were there other disease problems "out-of-the-ordinary". Dr. Radewald of UCR checked our plant traps and run-off water and could not detect any pathogenic nematodes with the few limited tests conducted. However, we are planning the chlorination of the re-cycled water for our pilot 26-acre experiment.
3. You may not be able to grow certain ornamentals in re-cycled water. Some examples are gardenias and azaleas. Some segregation of the species will have to be done so that these plants get non-recycled water.

WHAT WILL IT COST?

Our re-cycling plant for the 26-acre parcel will cost about $120,000 for initial installation. In addition, there will be an estimated $8,000 maintenance cost per year.

A cost analysis is as follows:

10-year amortization of filtration plant:	$ 3760.00
30-year amortization of reservoir:	2710.00
Yearly maintenance and operating cost:	8000.00
Total yearly cost:	14470.00
Saving in re-cycled fertilizer[1]fl	−5595.00
Balance	8875.00
Saving in re-cycled water[1]fl	−1618.00
Net cost/year:	$ 7257.00

Re-cycling is going to cost more than the water and fertilizer cost without re-cycling. Table 1 shows the relative cost of re-cycled water.

Table 1. Typical Relative Costs for Water

Type of Water	Percent Relative Cost[1]
Non-cycled, fortified,[2] domestic water:	100
Re-cycled, fortified, filtered, diluted 50/50 water[3]fl	150
Re-cycled, filtered, (fortified) water:	200

1. Based on 1974 fertilizer and local domestic City water purchased in quantity.
2. Based on typical fortification of water in a constant fertilization system.
3. Based on 50% re-cycled treated water and 50% makeup water from domestic sources (50% of the applied water was considered lost due to evaporation, transpiration and absorption).

You can get by re-cycling *dirty* water, provided you don't irrigate overhead and provided you strain it (straining does not remove clay). But even with capillary tube systems, clays will tend to coat the tubes and restrict flow.

[1]Based on 50% of the applied water being re-cycled. Cost of fertilizer & water may vary from area to area and on the quantity purchased.

CHANGES IN WATER CONSTITUENTS

There are changes in the constituents of water as it is re-cycled. The greatest change appears to happen with calcium and magnesium. This is reasonable since the original water has low levels of each of these elements and the fortified water tends to act as an extractant and displaces the adsorbed calcium and magnesium. The water pH changes on re-cycling to about 0.1 unit less. Figure 2 indicates the percent relative change in the constituents of re-cycled water under our conditions.

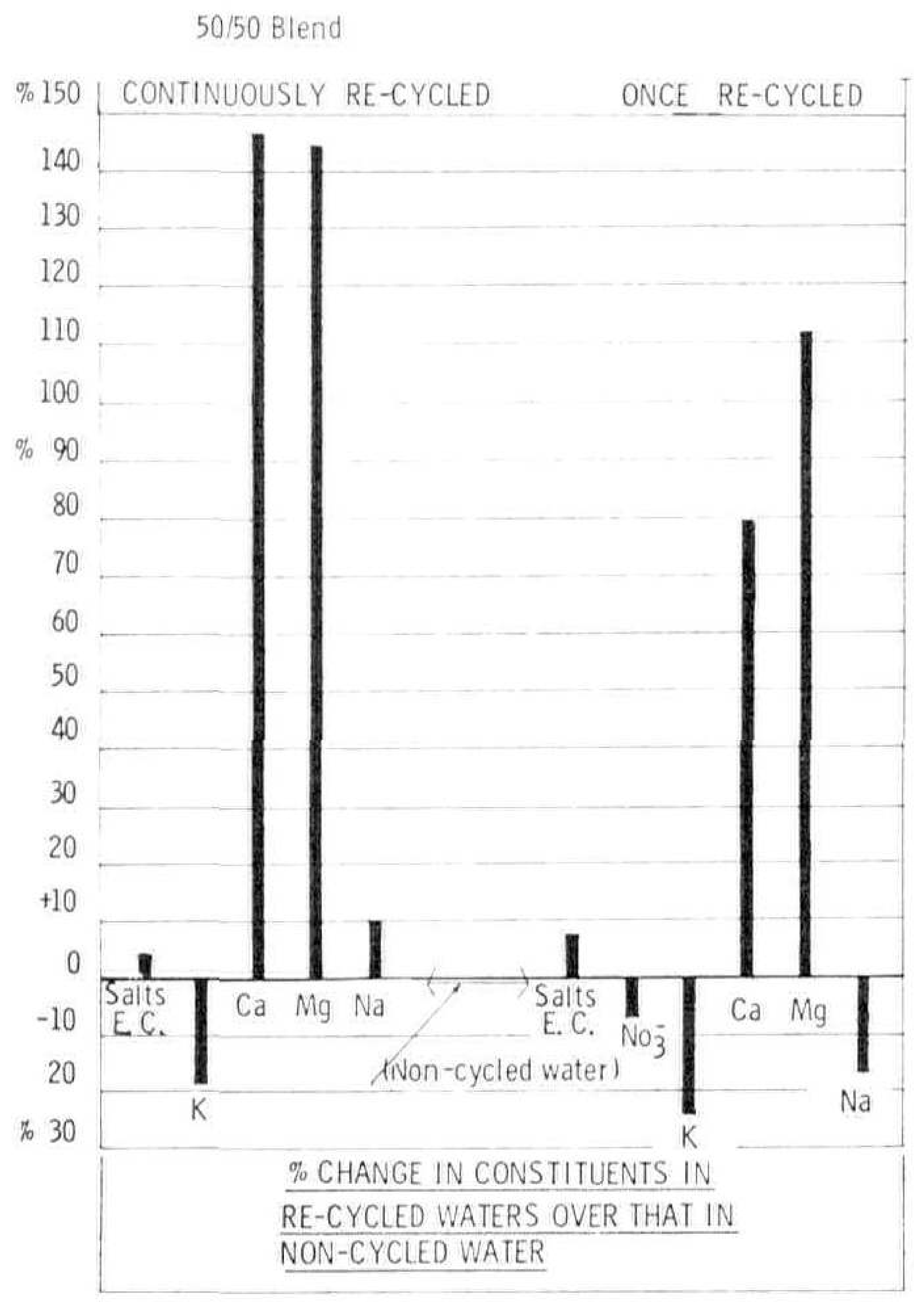

Figure 2. Changes in constituents of re-cycled water.

RESULTS OF RE-CYCLING EXPERIMENTS

In 1973 we set up an experiment to test the response of 24 species and cultivars of container grown ornamental plants to re-cycled, non-filtered, run-off water. In this experiment we examined the plant response and the changes in the soil constituents as a consequence of re-cycling. The average response was about 97% of the check. Table 2 lists 16 of the species tested and the percent growth — relative to the check — irrigated with fortified, non-cycled water. The remaining 8 species were not measured for growth; however, they followed similar trends, i.e., their growth was about 90 to 97% of the plants grown in non-cycled water.

Table 2. Plant Growth in Response to Type of Irrigation Water

Plant	Once Re-cycled Gutter*	Non-Cycled Hydrant
	Relative % yield	% yield
Berberis atropurpurea	96	100
Buxus microphylla var. *japonica*	89	100
Cedrus deodara	150	100
Chamaecyparis pisifera 'Boulevard' ('Cyano-viridis')	80	100
Cupressus sempervirens 'Glauca'	93	100
Euonymus japonica 'Silver King'	107	100
Juniper chinensis 'Keteleeri'	98	100
'Kaizuka' *Juniper chinensis* ('Torulosa') (1 gallon)	115	100
'Kaizuka' *Juniper chinensis* ('Torulosa' (5 gallon)	90	100
Ligustrum japonicum 'Lusterleaf' ('Texanum')	97	100
Mahonia aquifolium 'Compacta'	98	100
Pyracantha 'Victory' (1 gallon)	98	100
Pyracantha 'Victory' (5 gallon)	96	100
Thuja orientalis 'Aurea Nana'	105	100
Viburnum tinus 'Robustum'	55	100
Abelia grandiflora	78	100

*The yield is the mean of both re-cycled beds.

Table 3. Salinity Trends as TDS[1] of Re-cycled Water

Re-cycling Sequence	TDS of Run-off Water (7% Increase[2] in TDS/cycling)	TDS of Make-up Water	Mean TDS of 50/50 Blend or Applied Reservoir Water
0	—	934	934
1	999	934	967
2	1035	934	984
3	1053	934	993
4	1063	934	998
5	1068	934	1001
6	1071	934	1003
7	1073	934	1004
8	1074	934	1004
9	1074	934	1004
10	1074	934	1004

[1]Total dissolved solids.

[2]The 7% increase is added to the TDS of the applied irrigation water. TDS calculated from conductivity by taking 2/3 of E.C. as mhos x 10^{-6}.

Based on a mean 7% increase in salinity of the water for *each* cycling as determined by our experiments, theoretically it is impossible to increase salinity beyond 7.5% of the original water after the 7th cycling of a water blend of 50% fresh fortified water and 50% re-cycled water. (See Table 3) On a 75/25 blend of re-cycled/fresh fortified water, resp., equilibrium is not reached until the 18th cycle at which point the water is 26% higher in salinity than the original fortified fresh water. The success of a recycling program therefore is dictated by: (1) the original salinity of the fortified water; and (2) the proportion of blend on each cycling. It will be interesting to see in actuality, the point at which equilibrium is reached with our new treatment facility.

WHAT PROBLEMS WILL PESTICIDES POSE?

The majority of the herbicides, insecticides and fungicides will adsorb on the colloidal fraction in the run-off water. The colloidal fraction is then removed by filtration together with the adsorbed pesticides. In addition, there is biological and physical degradation of these products. Fortunately, solubility of most pesticides is very low.

REGULATORY AGENCIES INVOLVED

Five separate governmental agencies and three divisions of the County Engineers were involved in processing of permits. If we had to file an Environmental Impact Report we would have encountered the Regional Planning Commission, and all branches of the county including Police, Fire and the Museum of Natural History. Additional cost for such a report would be about $2,500 and a delay of about 6 months.

The governmental agencies involved in processing permits were:

1. California Water Resources Control Board — Water Quality Division.
2. County of Los Angeles Department of County Engineers
   a. Building and Safety Division
   b. Drainage Division
   c. Project Planning and Pollution Control Division
3. Los Angeles County Flood Control District
4. Los Angeles County Sanitation District
5. Los Angeles County Road Department

Any nurseryman contemplating re-cycling needs to examine all parameters peculiar to his situation by competent authorities. In addition, before embarking on re-cycling, he should run some experiments with plant response under his conditions.

It is inevitable that more restrictions on run-off water will be forthcoming and it is only a matter of time when many nurserymen will be approached in this regard.

MODERATOR TOKUJI FURUTA: I have the pleasure of introducing the last speaker, who happens to be myself. So we will just turn the slides on and get started.

IRRIGATION OF ORNAMENTALS

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Present day concern for our environment has had many profitable benefits for the environmental horticultural community. Plants of all types are used indoors and out-of-doors, not as mere decoration or objet d'art, but as a subject to create moods within our surroundings, moods to soothe and refresh our inner self.

Present day concern for our environment has necessitated that we examine our ways as producers. Degradation of the environment in the name of profit or growth is no longer acceptable. Utilization of all resources in an inefficient manner is not acceptable. Painful though the process may be, it is necessary to adapt to the present day real world. As some have stated, we, who are the prime providers of better environments through the use of living plants, certainly should not contribute towards the degradation of that same environment.

Efficient and effective use of water for the production of container-grown ornamental plants is a many-faceted opportunity. Some claim that to replenish the water withdrawn from the soil, all that is needed is to uniformly spread the water over the area where the plants are growing, and to do this with the least cost of capital investment and labor. This disregards efficient use of resources. This disregards possible degradation of the environment. The situation is complex, and is subject to many constraints.

Let us examine some of the facets of efficient and effective use. To be efficient, one must distribute water to the plants with the least waste of water, labor and capital — all considered together. To be effective, one must apply the water on a schedule and in the amount necessary to maintain desirable plant growth. To be efficient, the water must be applied only inside many containers. Efficient and effective use of water then requires the need