Using wastes to replace scarce materials

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What do you do with a continuous flow of thousands of gallons of water that contains valuable plant nutrients from potato processing? Recycle and use it for irrigation water is what the J. R. Simplot Company is doing at their Caldwell, Idaho, plant where several thousand tons of potatoes are processed daily for nationwide distribution (*1*).

The unique system recycles waste water from the operation by using it to irrigate 1,000 acres of forage crops for feeding to company-owned cattle. The system provides almost total utilization of both waste water and solids and zero discharge of any surface water.

When the potato-processing plant began primary treatment operations in 1964, five reservoirs covering 30 acres were used to contain the water for treatment. When the ponds were overloaded with organic wastes, microbial activity produced anaerobic conditions and, at times, disagreeable odors. After treatment, the waste water was discharged into the nearby Boise River, adding to existing pollution problems.

Development of a land treatment and disposal system began as a pilot project in July 1968. A trial planting was made of various grasses and legumes to determine the species best adapted for year-round irrigation. Latar orchardgrass and creeping meadow foxtail were selected because of strong adaptability and superior forage quality. Other plants tested were tall wheatgrass, yellow sweetclover, strawberry clover, Alta fescue, reed canarygrass, and Lahontan alfalfa.

The soils on the disposal site were of the Moulton-Bram-Baldock association, consisting of somewhat poorly drained and moderately well drained fine sandy loams and silt loams on lowlands (Table 1) (*4*). The watertable was maintained at approximately 10 feet by a system of open drains.

In 1971, a "dry peel" potato process developed by USDA at Albany, California, was installed, which reduced water use from 6,500 gallons per minute to about 4,000 gallons per minute. In addition, the new process required less caustic soda for peeling the potatoes. In the "dry peel" process, potatoes are dipped in a hot caustic soda solution and then scrubbed and washed with a low volume of water. This peel material, stored in a pit silo, is too caustic for microbial fermentation. Raw ground potato waste is added. Rapid fermentation reduces the pH by producing organic acids and the waste material can then be fed to cattle. Removing the caustic soda from the processing waste effluent decreases the salinity hazard of the water, allowing it to be used to irrigate land without building up soil salinity.

In waste water pretreatment, the water passes through a 20-mesh screen to remove coarse solids. A primary clarifer and vacuum filter are used to remove the settleable solids. The water is then stored overnight in a holding reservoir so that irrigation can take place during the day. The 4,000 gallons per minute intermittent flow is equivalent to about 4,500 acre-feet of water per year.

The land improvement program has been extensive; 1,000 acres were leveled and seeded. The company realigned and improved 3-3/4 miles of open drains. They installed 4,200 feet of 20-inch and 5,000 feet of 18-inch irrigation pipeline and 25,000 feet of concrete ditch. Three tailwater recovery systems with ponds and relift pumps to deliver runoff water back into the delivery system were completed. Approximate cost of the total project was $1,500,000. One pipeline alone, to deliver water to a 350-acre tract of land, cost $100,000.

The company encountered frost damage to the ditch and canal linings during the winter of 1972-73. When the processing plant was closed for Christmas vacation and water removed from the irrigation system, the soil under the concrete linings froze and heaved severely, cracking the concrete. Subsequent investigations led to the design of linings with longitudinal expansion joints rather than conventional lateral joints.

A graded-border irrigation system was used. The fields were leveled carefully because ponding would have killed vegetation and caused objectionable odors.

A new field delivery system with buried

Table 1. Particle-size distribution and mechanical analysis of soil at two sites on J. R. Simplot farm.

	Depth (in)	Clay (%)	Sand (%)	Silt (%)	Soil Type
Site 1	0-12	14.9	50.9	34.2	Loam, Sandy Loam
	12-24	17.5	48.9	33.4	Loam
	24-36	13.0	43.9	43.1	Loam
	36-48	10.1	66.8	23.1	Sandy Loam
	48-52	41.4	33.6	24.0	Clay
	52-60	10.2	69.0	20.8	Silty Loam
Site 2	0-12	12.4	57.9	29.7	Sandy Loam
	12-24	Gravelly Sandy Loam			
	24-36	8.0	71.9	21.1	Sandy Loam
	36-48	3.5	86.9	9.6	Sand, Loamy Sand
	48-60	3.0	91.4	5.6	Sand

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Table 2. Forage analysis.

Harvest Date	NO_3 (ppm)	N (%)	Protein (%)
9/13/73	450	2.45	15.3
9/13/73	950	3.13	19.6
10/4/73	1,300	2.94	18.4
10/4/73	520	3.18	19.9
6/5/74	1,425	2.14	13.4
6/5/74	1,825	2.46	15.4

Table 3. Water composition, Simplot Company.

Item	Waste Water	Tile Drain
COD (ppm)	1,500	30
Total N (ppm)	39	0.8
Nitrate N (ppm)	0.7	0.3
EC (u Mhos)	1,325	840
Mg (meq/l)	1.3	1.2
Ca (meq/l)	2.1	2.9
Na (meq/l)	6.6	5.2
K (meq/l)	3.6	0.15
SAR	5.1	3.6
Total P (ppm)	13.2	0.15

mainline pipe and automatically timed and controlled outlet gates was installed in 1975 on a 27-acre field for testing.

Water is delivered from ditch to field by either outlet gates or 6-inch siphon tubes. The fields are irrigated every 6 to 8 days during the hot summer months with about a 4-inch application, averaging one-half inch per day. In winter, irrigation is less frequent and is rotated to apply an average of one-fourth inch of water per day. When the processing plant is closed for repairs or vacations during the peak summer water use season, the waste water supply is supplemented from the regular irrigation supply source. Supplementary irrigation water comes from the Boise River.

The average annual temperature is 50 to 52°F with extremes above 100°F in summer and near 0°F in winter. Annual precipitation is about 10 inches.

The unique combination of 75 to 80°F water temperature at the Clarifier and high nutrient quality of the effluent water results in six cuttings of grass. Eight tons per acre are harvested annually. This compares with the average hay yield in the area of 4 to 5 tons in three cuttings.

We estimate that 500 to 700 pounds of nitrogen per acre are applied annually through the waste water irrigation process when the total system is operating. The harvested forage contains from 14 to 20 percent protein (Table 2).

When grass is fertilized with large amounts of nitrogen, there is some danger of the nitrate concentration becoming high enough to be toxic to livestock. A value of 2,000 parts per million NO_3-N can be fatal to some animals. This value has become a point of reference at which mortality is likely to occur (*2*). Livestock can be conditioned to higher nitrate concentrations, but high nitrate feed should be diluted with other feeds having lower nitrate content such as grain concentrate and other supplements. The nitrate content of the forages grown on the land irrigated with potato waste water was lower than the lethal level indicated above.

Some of the fields are grazed in the early spring and late fall. The majority are chopped green and mixed with other rations, including the waste potatoes separated from the process water. This forage provides partial feed for 26,000 yearling steers.

Table 3 illustrates the effectiveness of the soil in cleaning up the waste water. Chemical oxygen demand (COD) reduction is practically 100 percent with passage of the water through the soil. The low chemical oxygen demand concentration in the drain water is probably background concentration that would be found under any cultivated field.

Micro-organisms decompose the organic wastes and mineralize the inorganic components, including nitrogen and phosphorus. Electrical conductivity (EC) in the drainage water is lower than that in the waste water. This is probably caused by dilution of the drainage water with water from the Boise River. The conductivity of the river water is lower than that of the waste water. Phosphorus concentration is reduced greatly as the water passes through the soil profile, but is still higher than would be expected.

Some relationship exists between the relatively high initial salt concentration in the soil and the movement of phosphorus through the soil. Calcium, magnesium, and potassium concentrations in the drainage water appear to be about what would be anticipated.

Only one major problem has developed outside of the general management problems inherent in running a huge project such as this one. Total salts have decreased sharply in the soil, but sodium has not decreased as rapidly as calcium and magnesium (*3*). To prevent development of undesirable sodium concentrations in the soil, gypsum will be applied to increase the rate of sodium leaching. Further efforts will also be made to prevent loss of sodium hydroxide in the "dry peel" process.

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