SPRINKLER IRRIGATION OF POTATO PROCESSING WASTE WATER FOR TREATMENT AND DISPOSAL ON LAND[1]

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INTRODUCTION

Potato processing and other food industries discharge large volumes of waste water generally characterized by high chemical oxygen demand (COD), large amounts of suspended solids, and various inorganic constituents including nitrogen and phosphorus (1, 2, 3). Applying these waste waters to agricultural land may (a) promote crop growth, (b) conserve water and nutrients otherwise wasted, (c) provide economic treatment of waste waters, and (d) decrease the pollution load on surface water supplies. (4) Wilcox (5) recommended using a variety of industrial effluents for agricultural irrigation and indicated that waste waters from paper pulp, potato and other food processing effluents generally are well suited for land disposal.

Sprinkler irrigation with cannery and food processing waste water has been practiced in the United States for several years (6, 7, 8) and in Europe potato wastes have been disposed on land for over 100 years (9). Sprinkler irrigation was first used for waste disposal in the United States in 1947 and has expanded widely since that time. While sprinkler irrigation with waste water is expanding, there are limitations and restrictions that should be imposed on its use. Drake and Bier (10) indicated that (a) organic matter may accumulate on plants and provide a suitable environment for fungi and other harmful growths, (b) prolonged irrigation of a particular field may deteriorate the soil structure, (c) roots of plants may rot if soaked too often, and (d) plant diseases may spread from the processed products to the crops being irrigated. Nevertheless, sprinkler irrigating with food processing waste water is usually practical, simple in concept, straightforward in operation, and with careful planning and control adaptable to various soil conditions and terrain.

CHARACTERIZATION OF WASTE WATER

The chemical characteristics of the waste water depends to some extent on the chemical characteristics of the source water. Water for most processing plants is pumped from wells. Processing plants vary greatly in processing capacity and in the amount of water used. Some of the smaller processing plants use from 0.2 to 0.5 million gallons per day (mgd) while the larger plants may use as much as 7 to 8 mgd. Organic loading of

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SOIL LOADING FACTORS

Hydraulic Loading

There are two approaches for determining hydraulic loading of the soil. One is to apply water to meet the demand of crops being grown based on the evapotranspiration plus a leaching fraction to prevent salt accumulation in the root zone. In southern Idaho an average of 0.25 inch per day for six warm months and 1.0 inch per month for the six colder months closely approximates evapotranspiration. A second approach is to apply as much water as will infiltrate the soil. If this approach is adopted, it is necessary to program drying periods into the management system to allow for infiltration rate restoration. Continually inundated soils lose their infiltration capacity, become anaerobic, and emit highly objectionable odors. Drying restores the infiltration capacity and eliminates odors. Hydraulic loading will seldom be the major limiting factor in designing a system for treatment and disposal of potato processing waste water.

Organic Loading

A rule of thumb figure often used in designing systems for organic loading of waste treatment fields is 100 lbs COD per acre per day for long season treatment. This loading has worked satisfactorily over a wide range of soil and climatic conditions but is by no means the maximum organic loading that a soil can accomodate. In laboratory experiments with waste cooking oils, Smith (3) found that with high loading under ideal conditions in a Portneuf silt loam soil up to 6000 lbs oil per acre could decompose in 1 week. Potato wastes should decompose as rapidly as cooking oil in the field. Therefore, under field conditions organic matter decomposition will not be a major limiting factor in designing a system for treatment and disposal of potato processing waste water.

Nutrient Loading

Nitrogen

Most of the nitrogen found in potato processing waste water is in the organic form, with generally less than 1 ppm found as nitrate. Nitrate is the form of nitrogen usually considered to be most likely to pollute groundwater but the absence of nitrate in the waste water does not eliminate the problem because organic matter decomposition by micro-organisms changes the form of many organic compounds and an end product of aerobic decomposition is nitrate. It is, therefore, desirable to consider nearly all of the nitrogen in the waste water as potentially nitrate. If 100 inches of average waste water (50 ppm total N) is applied to an acre of land, 1130 lbs of nitrogen will be applied. If waste water contains 100 ppm total N at the same application rate more than 1 ton of nitrogen could be applied per acre. Nitrogen is probably the first limiting factor in designing a system for treatment and disposal of potato processing waste water on land.

Forage grown on potato waste water treatment fields receiving large amounts of organic nitrogen will have a higher than normal protein concentration.

fertilized system, phosphorus uptake would increase, and the hay may contain twice as much phosphorus as indicated with a maximum of approximately 60 lbs phosphorus removed per acre per year. This will result in a highly enriched soil system that could lead to nutrient imbalances involving trace element deficiencies. A better approach would be to apply less water so that less phosphorus would be applied. Some scientists think that 100 lbs phosphorus per acre per year is a maximum application. Phosphorus should be considered as a limiting factor in designing a system for treatment and disposal of potato processing waste water on land. Although phosphorus is not generally considered to leach in soils and to pollute groundwater, with long-term fertilization using organic phosphorus at high levels other undesirable results may occur.

Potassium

Applying 100 inches of water containing 50 to 150 ppm potassium would apply approximately 1100 to 3400 lbs potassium per acre. Few, if any, crops will utilize this much potassium, but there have been no indications that excess potassium in the soil will create problems and potassium has not been considered to be a pollution hazard, except as it contributes to the salt content of the soil. Potassium application can probably be accepted at whatever level it occurs in the waste treatment system and will reach an equilibrium concentration in the soil with the water applied.

Heavy Metals

Potato processing waste water does not normally contain heavy metals or other materials that would be damaging to soil or toxic to animals or humans. Galvanized or copper plumbing could contribute low concentrations of zinc and copper under some conditions.

Management of the Irrigation Systems

Land Preparation

The design for sprinkler irrigation with potato processing waste water should include land preparation and shaping. With data on soil types and infiltration usually obtained from the Soil Conservation Service, irrigation systems can probably be designed to apply water at rates to avoid runoff. Fields should be shaped to contain runoff if it should occur, either with diking, leveling, or other means. Runoff from the treatment area must be completely avoided and retention facilities designed to handle rainfall as well as waste water sprinkled on the land and ice and snow melt accumulation. In some locations, auxilliary pumping systems may be necessary to return runoff to the land. A requirement frequently imposed by regulatory agencies on these installations is peripheral dikes to retain a storm or plant effluent for a certain processing time period.

from this source have been minimal. Possibly diseases may be transmitted to potatoes by sprinkling potato wastes and, therefore, growing potatoes on the waste treatment field may not be desirable.

Soil Fertility Maintenance

Although major nutrients in potato waste water applied are mostly in the organic form and an availability factor should be applied in calculating the fertilizer value of the wastes. Organic matter decomposes in soil fairly rapidly but the decomposition rate depends upon the nature of the organic matter. Mineralization of several plant nutrients takes place during organic matter decomposition, for example, the proteins in organic matter are converted to ammonium and then to nitrite and to nitrate by microorganisms (12). While protein nitrogen is not generally available to plants, ammonium and nitrate nitrogen are utilizable. Therefore, when organic wastes are the sole source of fertilizer nitrogen, the organic matter decomposition rate determines the nitrogen availability rate to the growing crop. Reports from the Netherlands, where potato processing waste water has been used for irrigating agricultural lands for over 100 years, indicate that the nitrogen in potato waste water is approximately 50% as effective for growing crops as fertilizer nitrogen.

Not all nitrate that is produced by microorganisms in decomposing organic matter is used by plants or leached into the groundwater as is the case with most of the nitrate in aerobic systems. The leaching loss is an important consideration in waste water treatment and disposal because of the rather large amount of water and nitrogen involved. If nitrate is leached into the groundwater, it poses a potential health hazard, therefore, precautions must be taken to prevent leaching of nitrogen compounds. In systems where energy is present and oxygen is limiting, denitrification can take place. In locations where a water table is near the soil surface, soil oxygen is limited. From 85 to 99% of the organic matter in potato processing waste water is oxidized in the surface 12 to 24 inch layers of soil. The small amount of the remaining organic fraction leaches into the soil providing the energy for prolific microorganism growth. With limited aeration, the microorganisms decomposing the remaining organic matter, utilize the oxygen from nitrate releasing the nitrogen back to the atmosphere as nitrogen gas and eliminating the groundwater pollution problem. This condition may also develop to some extent with slightly excessive irrigation in areas with no close groundwater table.

IRRIGATION EQUIPMENT

Sprinkler systems for distributing potato processing waste water should be designed similar to agricultural irrigation systems to uniformly distribute the waste water. Some present systems were designed with solid set systems more widely spaced than required to achieve uniform distribution. This results in a very ragged looking field with extremely nonuniform water distribution and inefficient land use. Some waste treatment field operators have commented that irrigation type equipment with optimum spacing would be too expensive. Of course, with proper spacing, less land would be irrigated with the present equipment but apparently the environmental agencies calculate loading on the basis of total acreage with very little consideration for water distribution.

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