TECHNICAL NOTES

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

ROOM 101, 1405 SOUTH HARRISON ROAD
EAST LANSING, MICHIGAN 48823

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Agronomy #3

SUBJECT: Disposal of Industrial Waste Water by Irrigation

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TO: All Offices

FROM: Palmer G. Skalland, State Resource Conservationist

This technical note is adapted from a paper prepared by Agronomist Richard H. Drullinger and presented at the SCS Midwest Agronomy Workshop at Bay City, Michigan, October 18-22, 1971.

C. W. Thornthwaite Associates of Elmer, New Jersey, who have been designing waste disposal systems on land since the early 50's, say land disposal (which they call "Natural Filtration") is a practical approach to any disposal problem involving waste water polluted by biodegradable material, by material which can be made biodegradable through pretreatment, or by inert inorganic substances.

UTILIZATION OR DISPOSAL

Right now there are two groups interested: those who want to utilize wastes through growing crops, and those who want to dispose of wastes on the land. Utilizing wastes implies turning them into something of value. Disposal, as we will use it here, simply means using the land to get rid of all the waste we can. Since the two aims are entirely different in application, we will consider them separately.

Also, wastes may be in solid or liquid form. Most of our firsthand knowledge on this subject is in the field of waste water disposal or utilization. Solid waste disposal will be referred to only briefly.

UTILIZING WASTES THROUGH GROWING CROPS

Waste water can be used for irrigation of growing crops. Most of the techniques we already know. Because this is <u>waste</u> water though, one of the byproducts of manufacturing, canning, freezing, or other industrial process, it can have vastly different qualities from normal irrigation water or liquid livestock or municipal waste system effluents.

Existing irrigation guides can tell us how much water needs to be applied to a particular crop at any one time for optimum growth. These guides can tell us how fast water can be applied for the specific condition of soil and vegetative cover. We can also determine how frequently we need to reapply it.

Monitoring the waste water quality can show what else besides H_2O is being applied. Tests must be run for nitrates, phosphates, calcium, sodium, and other dissolved salts. We must also know the amount and kind of undissolved solids that may be going out with the waste water, for we are concerned with its effect on soil sealing, or vegetation smothering.

We also are concerned with the ratio of carbon to nitrogen. It is possible to apply several tons of dissolved N per acre per year and yet have crops suffer from N starvation if large amounts of carbonaceous solids are applied along with it.

While not the same thing, the BOD (biochemical oxygen demand) loading is the usual way of expressing the degradable substances in the waste water. The system handling effluent of high BOD is limited by the oxidation reduction capacity of the microorganisms. However, BOD measurements do not tell the whole story. Systems handling a waste containing a high percentage of sugars will accept a higher BOD loading per acre than systems handling starchy or fibrous materials. The carbon-nitrogen ratio may be a better measure for the agronomist's purpose than is BOD.

Monitoring should analyze also the industrial process for any additions of possibly toxic materials such as caustic soda or the heavy metals, lead, arsenic, zinc, nickel, or mercury. These heavy metals as well as certain pesticides that break down very slowly may build up to toxic proportions in the soil after years of additions of waste material. Disease organisms, too, may need to be monitored though industrial waste water is not as likely to carry them to growing crops as is municipal sewage.

Knowing how much water to apply to a given crop and what it contains in the way of elements useful as plant food or as soil amendments, such as lime, we can then calculate (a) how much fertility benefit we can expect from the waste and (b) what amount of supplemental fertilizer is needed for optimum crop performance.

When we have the water amount and quality matched to the needs of the crop, we can concentrate on the delivery and distribution system--whether it is sprinkler irrigation, flooding, or corrugation irrigation. The engineers can help with these details as well as determine whether the system should be direct application from the processing plant or if holding ponds are needed. There apparently is no advantage to the crop either way as long as adequate filtration takes place at the plant to screen out solids that might plug distribution systems or cause residue problems on soil or crops. A good screening system is generally more suitable than settling ponds.

Along with the distribution system, the producer must determine how he is going to rotate the application to different fields. The processor and the producer must work out how they are going to handle the waste water when they cannot irrigate because of surplus natural moisture, crop harvest operations, or possibly during freezing weather.

Because of these latter problems most of the systems studied here in Michigan have either given up or bypassed utilization and have gone directly to waste water disposal.

Utilization through a growing crop offers (a) a possibility of financial return from a product which otherwise one must pay to get rid of, and (b) the removal, by cropping, of plant nutrients such as nitrogen and phosphorus that might otherwise become pollutants of either ground water or surface runoff. Then, too, application of waste water in amounts metered to good crop growth is unlikely to be in excessive amounts that would result in polluting ground or runoff water.

DISPOSAL OF WASTE WATER

In spite of the possibilities for irrigation with waste water, most industries in our experience prefer to just get rid of the water without worrying about any possible production from it. Their reasons are good. They do not want to be concerned about timing operations to the needs of a crop. Nor do they want to spread the waste over any more acres than necessary. Thus it becomes a question of how fast can we get rid of the waste water and how many acres will it take?

Guidelines for maximum application are sketchy at present. Rate per hour varies, depending on soil infiltration rates and existing vegetative cover, from 1 inch down to $\frac{1}{4}$ inch or less. The total amount that can be applied at one time and the frequency of reapplication also are geared to soil and vegetation. Under Michigan conditions a sandy soil with quackgrass cover has taken 2 inches of waste water per week for years without apparent deterioration of either soil or vegetation. Reed canarygrass on a loamy sand has taken between 4 and 7 inches per week during the growing season without apparent damage to the vegetation. However, some runoff and occasional odor occurred under this high an application. Where water concentrated or where application was greater than 7 inches per week, vegetation was killed completely or grasses were replaced by the smartweeds (Polygonum pensylvanicum and P. coccineum). These observations would tend to bear out the conclusions of Dr. Louis Kardos and his associates in the Penn State Studies that irrigation with 2 inches of waste treatment plant effluent per week is a safe figure, and under certain conditions one might go to 4 inches per week.

The total yearly amount of water that can be applied depends in part on whether application in seasonal or year around. Freezing ground in winter creates problems of disposal but many companies and the Penn State researchers have overcome these difficulties.

16

Maximum application of water may be limited, too, by the quality of the water. Water percolating to ground water levels should not contain more than 10 ppm of nitrates, for example. Between what a growing crop of corn or good grass hay could remove and what will be denitrified and returned harmlessly to the air, Dr. L. R. Webber, Professor of Soil Science, University of Guelph, Ontario, Canada, estimates that about 300 lbs. per acre of nitrogen as organic wastes can be applied to corn or hay on a well drained loam or finer-textured soil without increasing ground water nitrate levels. Exactly how much can be added where vegetation is not harvested is still a matter of speculation.

Again referring to the Penn State Study, the researchers there reported that P and K equilibrate at the 1-foot level in the soil. Nitrate N, Ca, Mg, Na, and Cl equilibrate at the 4-foot level. Organic N (including ammonium N) still trails off at the 6th foot. Equilibria represent the balance between inputs and removals by adsorption, chemical precipitation, ionic exchange, biochemical transformation, biological absorption (especially by vegetation), and physical filtration.

Those levels of equilibria are bound to be influenced by soil texture, kind of vegetation, and many other factors. Much more research is needed before we have concise answers to what the soil can handle.

A look at some of the existing systems that have been in operation for a number of years provides some answers to what is working and what are some of the problems.

Gerber Products Company, Stokley Van Camp Food, Inc., Musselman Fruit Products, Welch Foods, Inc., and the A. F. Murch Company are all fruit and vegetable processors whose waste-water disposal systems we have studied. The Celotex Corporation at L'Anse, Michigan, disposing of insulation board mill effluent by land irrigation, and Seabrook Farms Company, Inc., food processors in New Jersey, are other large operations on which we have information.*

Seabrook Farms has used irrigation sprinkler disposal since 1950, Gerber and Welch since 1953. All the others have at least 5 years' experience except Celotex, which started its system in late 1967. Quantities of waste water being disposed of range from 500,000 gallons per day for Celotex and the smaller fruit processors to a maximum of 12 million gallons per day for Seabrook Farms. Seabrook's annual average, however, is 4½ million gal/day. These industries are applying from 75 inches to more than 150 inches of waste water per acre annually. That is in addition to natural rainfall averaging about 27 to 32 inches per year.

*Trade and company names are used solely to provide specific information. Their mention does not constitute a guarantee or recommendation of the product or company over other comparable products or companies that are not named.

The systems that result in good condition of soil and vegetation, without objectionable odors or direct runoff, are on permeable, naturally well-drained soils. They are applying not more than 2 to 4 inches per week of waste water on good grass cover--quackgrass (Agropyron repens), tall fescue (Festuca arundinacea) or reed canarygrass (Phalaris arundinacea). The grasses are named here in the order of their abilities to stand increasing wetness.

Unfortunately both systems that had operated for years in woodland had applied excessive amounts of water that resulted in drowning out the woody vegetation, which was replaced by smartweed and common reed (Phragmites communis).

Another problem associated with excessive application or uneven distribution of waste water is odor resulting from anerobic conditions in a soil saturated with effluent that contains organic wastes. Methane and hydrogen sulfide smells are sometimes encountered in such cases. No odor problems are noted under applications of 2 to 4" per week that provide for alternate wetting and drying cycles together with adequate screening to remove many of the suspended solids. Satisfactory operations existed where suspended solids from fruit washing varied from 200 to 3,000 ppm of suspended solids and 800 to 3,000 ppm of BOD during the season.

18

Unfortunately the operations which resulted in odors or killed-out vegetation had no knowledge or records of the quality of their waste water or the amount actually applied per acre.

Improper filtration or certain additions during processing can cause problems of soil sealing, soil structural changes, or vegetative kill. Common among these additives is caustic soda, used sometimes in vegetable peeling processes and often for cleaning evaporators or other equipment. Since excessive sodium can cause a drastic reduction in the soil's infiltration rate as well as other detrimental effects, users must be warned to plan other means of disposal of wastes containing caustic soda.

Some of the solids filtered out of the fruit and vegetable processing plants are fed to livestock. Many are buried in a sanitary landfill operation. Some solids such as cherry pits have many uses and many yet to be discovered, I am sure. One company dries and burns them for fuel, saying, "There is nearly enough heat in the pits to completely process the cherries." To a similar company, 80 miles away, cherry pits are a real waste disposal problem. They give away what they can for horticultural mulching material (for which they are excellent) and bury tons of them. Sixty miles in the other direction, newspapers recently carried articles on the many uses being developed for cherry pits: from oils for cosmetics to soil conditioners and from cracked shells to prevent skidding on icy pavements to pit-shell flour used in plastics and as a binder for plywood.

All of which shows there is much yet to be learned about solid and liquid waste disposal though we do have knowledge now that can make a real contribution to the environment.

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