CALIFORNIA TURFGRASS CULTURE
FORMERLY, SOUTHERN CALIFORNIA TURFGRASS CULTURE

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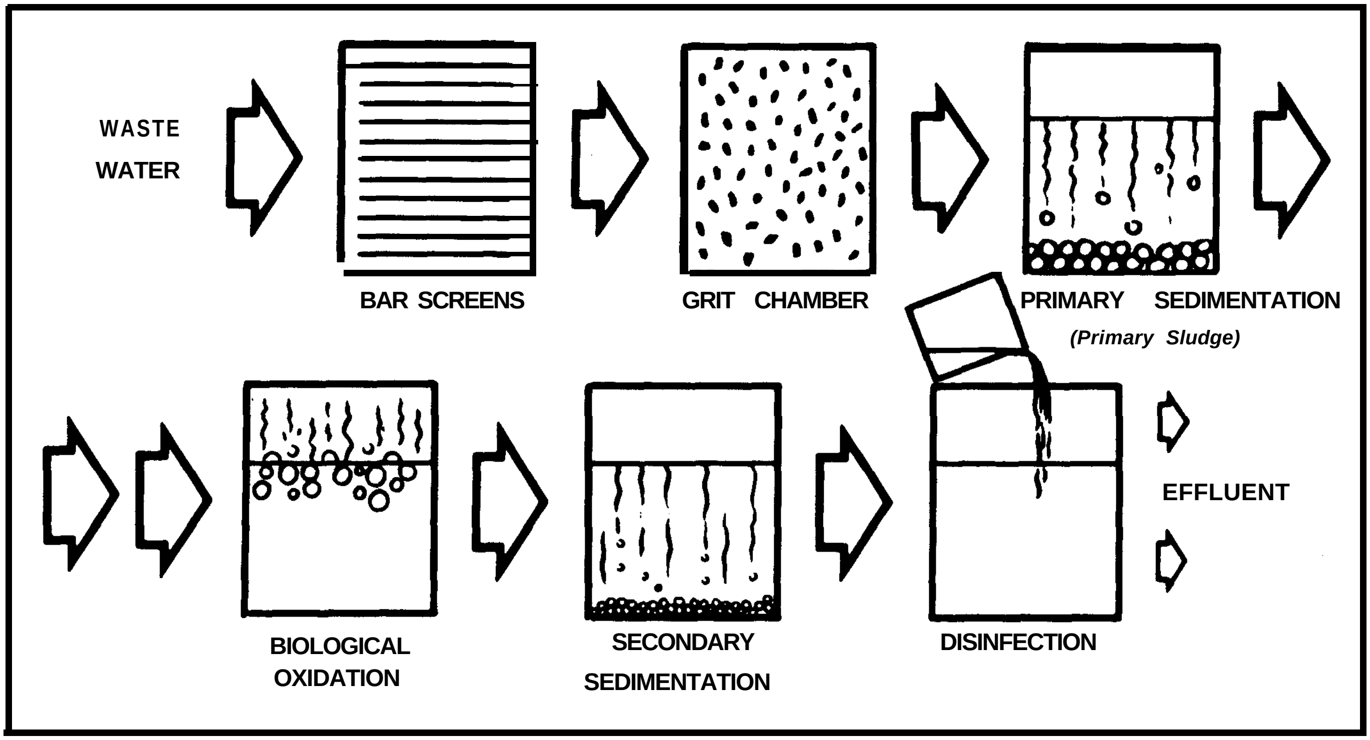
A THREE ARTICLE SERIES ON THE CHARACTERISTICS AND USE OF EFFLUENT WATER

The use of effluent water for irrigation is on the increase. The three articles that follow describe the characteristics of effluent water and factors to consider in its use. The flow diagram below illustrates the processes of ***water treatment prior to release for irrigation use.***



FLOW DIAGRAM OF PRIMARY AND SECONDARY SEWAGE TREATMENT

Sewage from most municipalities receives primary and secondary treatment before the waste water is discharged. Primary treatment consists of removal of large non-biodegradeable material and grit by the bar screens and grit chambers after which most of the organic solids are removed in settling or sedimentation tanks. This would complete the process except for chlorination to destroy microorganisms if primary treatment only were provided.

In secondary treatment, the primary effluent is further treated by aeration or biological oxidation and a second settling to remove additional solid materials before chlorination: the resulting effluent appears quite clear but still contains some organic material, various salts, nutrients, #articulates and varying amount of microorganisms.

Tertiary treatment, when provided, would remove most of those substances. Waste water irrigation if properly done provides the equivalent of tertiary treatment through the "living filter" system.

I. THE USE OF EFFLUENT WATER IN YOUR MANAGEMENT PROGRAM

- Characteristics of Effluent Water -

Wade L. Berry*

Water has been and is a limiting natural resource in southern California. The people of the Los Angeles basin have been forced to go to many distant areas at great effort and expense to secure additional water supplies for the continued growth of the basin. The Owens River, Colorado River and the Feather River are now major sources of water for the Los Angeles basin. Having gone to this large effort to obtain water, every effort should be made to conserve it and make the most efficient use of it. This should include multiple use or reuse of this water whenever possible.

The City of Los Angeles is dumping close to 320 Million Gallons per Day (M.G.D.) of wastewater into the ocean each day and the County Sanitation District about 350 M.G.D., making a total of about 700 M.G.D. or over 2000 acre feet of water lost to the basin each day. In comparison, in all of the basin there is presently only about 40 M.G.D. being renovated and reused and that is an amount equal to about 6% of that being discharged. Although some of the renovated water is being reused for irrigation and industrial purposes, most of it is being used for water basin recharge. This reuse is expected to be doubled in the next two years and by the year 2000 ten times this amount of water is expected to be reused.

The characteristic of a given effluent water is primarily dependent upon three major variables. These are the quality of the original water source, the type of use, and the renovation treatment. Because of this, the term effluent water by itself is not sufficient to describe the quality of an effluent water. The quality can range anywhere from almost pure water to water so grossly polluted that it is not a fit source of water for any use. However, most of the renovated water considered for reuse is pretty well defined in terms of the above variables. The original water source is of sufficient quality to be used for drinking water, the use generally is predominately urban domestic and the treatment is secondary involving both sedimentation and biological treatments.

The real question when considering the reuse of effluent water for irrigation is how the effluent water differs from the original water supply. There are three categories of characteristics that are of concern in rcusc: (1) Biological composition, (2) Organic composition, and (3) Inorganic salt. Although the biological composition of the effluent water is of great concern because of pathogenic bacteria and viruses, renovated waters are not released for irrigation without prior approval of the public health people. Renovated water should cause no public health problem after secondary treatment and disinfection, provided that the approved handling procedures are followed. The organic portion of the effluent water is generally of minimal consequence unless nitrogen is included in this fraction. The concentration of the organic fraction generally runs 25 mg/l, which is sufficiently low so it should not interfere with equipment use. The characteristic that is going to have the most influence on the use of effluent water for irrigation purposes is the added salt load which it picks up in use.

A general rule of thumb is that water going through one cycle of use picks up about 300 ppm Total Dissolved Salts (T.D.S.) of inorganic salts. If this is looked at as just a contribution to the total salt load of the irrigation water, then this is of importance only when the salt load from the original source is high. For example, if the original source was the Owens River (229 T.D.S.), then an additional salt load of 300 ppm will not be very important. However, if the original source is the Colorado River water, (800 T.D.S.), then the additonal 300 ppm could have a significant effect.

The 300 ppm of added T.D.S. is only part of the picture. Depending on the elemental composition of the added salt, both the specific effect and the magnitude of the effect can be vastly altered. The salt load of a typical urban effluent can be characterized as containing the following eight elements in approximately the following concentrations given as mg 1: Na-70, K-10, Ca-15, Mg-7, Cl-75, So,-30, Si-15, PO,-25, NH_4-20, NO, and NO,-1. This typical salt' load in terms of electrical conductivity, calculates out to 0.6 millimhos/cm, which would place it in a favorable salt range if it were the only source of salt. However, if the original source water has a significant salt load, then this added Ioad could become very important. It should be pointed out that normal secondary treatment will not remove soluble salts.

The sodium adsorption ratio (SAR) of this mixture of inorganic salts is 8.9. The SAR is an index of the effect of sodium in reducing soil permeability. This level of SAR indicates that a permeaability problem could arise if not watched. The salt load just described does not account for an extensive use of self recharging home water softeners. If their use is common, then the SAR would increase because of the increase in sodium and a permeability problem would be likely on any soil except coarse textured ones. Along with the sodium, the chloride is already high and if increased with the use of water softeners, it could cause leaf burn on chloride sensitive plants.

The concentration of the primary nutrients (N, P and K) in this typical effluent is low in terms of parts per million but continued use of such effluent water for irrigation at high rates could add a significant amount of fertilizer. Each acre inch of effluent water used in this example will add 4 lb. of nitrogen, 2.7 lb. of phosphorus and 2.3 lb. of potassium. Considering that approximately 40 acre inches of water are needed in this area to replace evapotranspiration losses, this level of effluent use would add 160 lb. of nitrogen, 108 lb. of phosphorus and 92 lb. of potassium each year. In most instances this would supply more phosphorus and potassium than presently being used and also most of the nitrogen for low use turf, but additional nitrogen would be needed, especially

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for high use turf. Therefore, the amount of fertilizer applied as part of the effluent must be accounted for when considering your total fertilizer requirements.

Effluent water also contains a wide array of elements in trace concentrations, all of which are potentially toxic if present, and available in large excess over the normal concentrations at which they are found in the soil. The chemical charactertics of many of these trace elements, especially the heavy metals, are such that they tend to be concentrated in the upper horizons of the soil. Thus, when effluent water is used for irrigation over long periods of time, the concentrations of these trace elements in the upper soil horizons can build up to potentially toxic concentration. The safety and suitability of effluent water for irrigation has to be judged not only on how it will affect our present crops or turf, but also on how it will affect the crops of our children.

Keeping in mind that presently used effluent is generally derived from domestic wastewater, there does not appear to be any major problem with trace elements for plant growth. If the wastewater came from heavy industrial areas or was combined with such wastewaters, then no such prediction could be made without a complete chemical analysis, and even then with no degree of certainty.

There are five trace elements in domestic effluent which could be present in amounts that could potentially be toxic and should be periodically monitored: Boron, Cadmium, Copper, Nickel and Zinc. Boron in many effluent waters will run between 0.5 and 1 ppm. When boron is in this concentration range, some boron sensitive plants may show some injury. Fortunately, boron is very mobile in the soil and does not tend to build up in the soil as a heavy metal but is leached through the soil profile. This could lead to another problem, that of contaminated ground water which will have to be considered in any overall plan for water reuse.

The other four potentially toxic trace elements are heaw metals which in some instances are high in do mestic wastewaters. However, a high concentration of zinc more often than not should be beneficial to turf. The National Academy of Sciences has recommended that for continuous use as irrigation water, effluent should contain no greater than 0.005 ppm of Cd 0.2 ppm of Cu, 0.5 ppm of Ni or 5.0 ppm of Zn. Most renovated domestic wastewaters will meet these standards. But, monitoring is essential to insure that this continues to be the case.

II. USING EFFLUENT WATER FOR IRRIGATION

*Victor B. Youngner**

The use of treated sewage effluent water for irrigation has been practiced for many years on a limited scale. Interest in this source of irrigation water is now on the increase and managers of many golf courses, parks and other facilities are considering its use. What are the reasons for this renewed interest? There are several answers depending upon one's point of view.

From the sanitary engineer's view it promises to be a safe method of waste disposal without polluting the environment. The conservationist and hydrologist see it as a means of water conservation and recharging ground water reservoirs that have been seriously depleted. The user or potential user sees it as a new source of less expensive irrigation water.

Until recently little research has been devoted to use of sewage effluent for irrigation. People were entering into the practice with little knowledge of the numerous ramifications and potential hazards in its use. The user must fully understand these as he has the ultimate responsibility for the proper and safe management of the system. If something goes wrong the blame will be directed to him. He must work closely with State and County Health Departments and the State and Regional Water Quality Control Boards from the earliest planning stages. These agencies have established specific regulations on waste water disposal that are becoming more strict with time.

Waster-water recycling by sprinkler irrigation is feasible because the vegetation and soil act as a living filter system. As the polluted water moves through the soil, numerous constituents are removed or destroyed by the plant roots, soil microorganisms, and the soil itself. Thus, by the time the water reaches deep water-bearing strata where it might be removed for reuse, it is again of drinking-water quality.

However, successful recycling of waste-water requires that the user or potential user keep a number of considerations always in mind. He must never forget the possible health hazards from biological and chemical constituents of the water. He must be certain that there is no runoff into surface waters and he must watch for possible plant toxicity: Above all, his irrigation system must be the best possible in design. Problems that may arise from faulty design when using high-quality water will be many times more seroius when using waste-water.

Trouble-free waste-water irrigation is possible only if many factors are evaluated and considered during planning and construction. First, of course, is the quality of the waste-water. Sewage effluents are not the same but will vary greatly depending upon the source. Usually water derived primarily from domestic use will be satisfactory. However, if the source includes many industries the quality may be too poor because of toxic substances, especially heavy metals such as copper, zinc, cadmium and mercury. Other important water quality considerations are total dissolved solids which will indicate the salinity hazard; sodium absorption ratio (SAR) which, if it is high, may indicate future soil structure and water infiltration problems; boron which is very toxic to many plants; and organic matter which can lead to plugging of sprinkler heads and valves. If the area to be irrigated is open to the public, odor must be considered.

A thorough soil survey of the area to be used is highly recommended. A shallow soil over rock or hardpan may

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cause inadequately purified water to move horizontally into surface waters or through rock fissures into ground waters. Infiltration rates and hydraulic conductivity of the soil must be determined so that water application rates can be adjusted to avoid surface runoff or ponding.

Lake Arrowhead Sanitation District Sewage Treatment plant. A typical small treatment plant providing primary and secondary treatment. Primary treatment to remove most of the sludge occurs in the structures in the foreground. Secondary treatment consisting of contact aeration and activated sludge takes place in the large tanks in the back.

Most sandy-loams are good as water will move into and through them at a sufficiently high rate while their exchange capacity and other characteristics will be such that good removal of dissolved and suspended constituenrs of the water will be accomplished. Sands and clays should be avoided if possible. Water will move too rapidly through sands and not rapidly enough through clays. If the water has a high SAR, clay soils may lose their structure in time and become very poor for plant growth or water purification.

Topography of the area must be such that there are no steep slopes which will lead to surface runoff. Nor should there be any depressions or pockets that will collect water on the surface. If there are ponds or streams in the area the sprinkler system must be designed so that absolutely no effluent water falls directly into them.

Depending upon the quality of the water, irrigation of all types of plants may not be equally desirable. In general, turfgrasses may be the best plants for this purpose. They take up large amounts of the nitrogen, phosphorous and potash found in the water. They will also accumulate large amounts of boron without showing toxicity symptoms. However, some turfgrasses are better than others. If salinity is expected to become a problem, salt tolerant grasses such as tall fescue, bermuda and St. Augustinegrass should be selected.

Manv ornamentals have a low tolerance to both salinitv and' boron. Selection of ornamentals, therefore, must be made with care. If plants of low tolerance must be used in some locations, a separate irrigation system using better water should be considered if at all possible.

If the "living filter" system is to work at its best on turfgrass, all clippings should be removed. If this is not done the substances taken up by the grass will be returned to the soil as clippings decompose and the necessary purification may not be accomplished.

Drift of irrigation water onto any crop in the area must be avoided. Health regulations relating to waste-water irrigation or contamination of crops are very specific and 'strict.

Finally, weather conditions must be considered. The direction and intensity of wind may determine the design of the irrigation system and the time of irrigation. Where projects are planned in areas of high rainfall, the user may be faced with the choice or irrigating during wet weather or storing the water in ponds for extended periods of time. Many contracts for waster-water require that the user accept a specified amount of water each day regardless of weather conditions. Temperature is another factor of importance. Will winter temperatures cause problems of frozen irrigation systems because the wastewater must be used each day? Will high summer temperatures produce high evaporation rates and an excessive accumulation of dissolved solids on plant and soil surfaces?

In summary, the potential user must thoroughly evaluate all aspects of waste-water irrigation in respect to his specific site and the quality of water available to him. The irrigation system must be designed and the site modefide as dictated by such study. In some cases the studv may indicate that irrigation with waste-water is not feasible or desirable at that location. The "living filter" approach to waster-water disposal is not necessarily universal in its application.

III.ADVANTAGES AND DISADVANTAGES OF USING EFFLUENT WATER IN PLANT MANAGEMENT

A. J. Woffinden*

Water management probably affects landscape management more than any other factor in the growing of plants. It would follow then that water quality would be a limiting factor in plant management. Since most effluent water is of a lower quality it is important that we use all the tricks and tools known to us.

Most effluent water is high in salts and it becomes necessary to apply extra water periodically in order to leach out accumulated salts which build up in some soils. Overwatering practice, however, must be minimized. Soil, water and tissue tests must be used to chart certain salts and undesirable elements which tend to build up in the soil. These tests must be analyzed to identify what effects this build up has on plants. Proper fertility prac-

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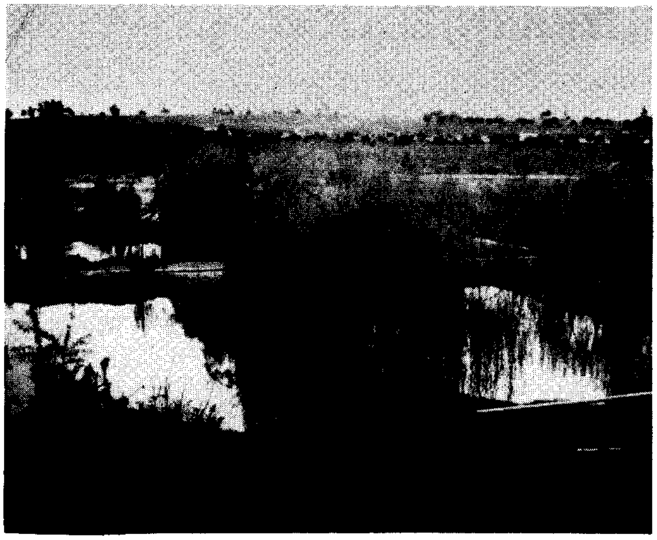
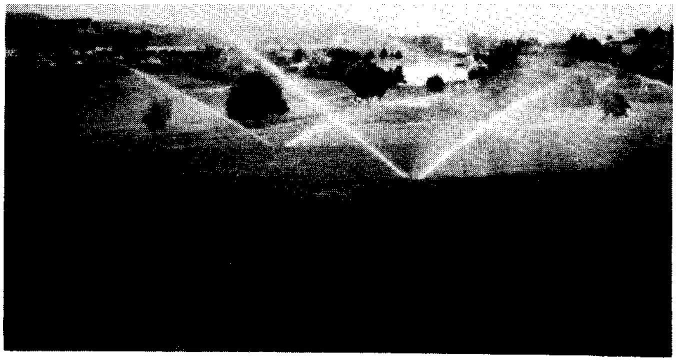


Waste water holding ponds at Leisure World.



Irrigation of a golf course with effluent water.

tices must be used to prevent problems in plant nutrition, color and vigor. Some effluent water may have a considerable amount of nitrogen, therefore, it is important that the amount per acre available be considered in the fertility program. Soil preparation is important where effluent water is to be used. A soil which drains well should be created whenever possible. A good example of this is in the construction of golf greens. Greens should be constructed to USGA specifications which allow for good percolation rates and internal drainage lines which allow for good internal drainage. Greens constructed in this manner show less salt accumulation than greens which have slower percolation rates due to clay soils in the mix and no internal drainage.

Analysis of water used to irrigate a golf course in Laguna Hills showed a TDS of 1100 ppm, an Ece of 1.6 and pH of 6.8 and Boren of 1.35 ppm. Fairway soil samples taken in August show an Ece of 5.0, a pH of 6.7, and a Boron content of 2.92 ppm.

Greens with a slight clay content with poor internal drainage showed an Ece of 4.0, a pH of 7.2, and a Boron of 1.88 ppm. Greens constructed with a good sand mix and good internal drainage showed an Ece of 1.2, a pH of 7.2, and a Boron of .98 ppm.

In reviewing these reports it becomes evident that water management is critical if grasses and other plants are to not only survive, but provide the use to which they are put. The reports for golf greens show a good reason for proper soil preparation and internal drainage.

When using effluent water it is important to choose plants which are more salt tolerant. Certain grasses and plants show the effects of induced iron chlorosis probably because of high phosphorous. This indicates that we need to apply another tool. This tool is the testing of fertilizer materials and different plant species. Tests made on the same golf course in Laguna Hills showed that a good response was obtained by adding Ferrous Amonium Sulfate to chlorotic Kentucky bluegrass. Various rates were applied and after one year of testing the results were analyzed and a program developed to take corrective action. At present, the same golf course is testing certain bentgrasses under putting green conditions.

These experimental grasses were chosen for their turf quality and ability to tolerate high salinity. It is important that all testing be done using good testing procedures. The University of California Cooperative Extension and South Coast Field Station personnel are the experts seting up and conducting these tests. It is important that such research be allowed long enough to gather significant data.

In California, the regional water quality control boards set certain controls on the use of effluent water and at present are administering these controls directly. The user is required by law to test and report these tests to the board. The user is limited to the amount of water he may use, the use of reclaimed water shall not cause a nuisance, it shall not cause pollution and it must at all times be maintained on property owned or controlled by the user.

Advantages of effluent water are: Low costs (about 1/3 the cost of domestic water). It is usually wetter due to detergents. Some effluent water has nitrogen which is available as a plant food. It is a good water conservation practice.

Some disadvantages are: It contains higher salts which increases salinity. It causes iron chlorosis. There is a possibilty of Boron excess. Irrigation lines, pumps, and storage facility may cost additional dollars because of special needs to filter, chlorinate, and control waste water. It is more corrosive to certain items such as glass, wood and other non metallic substances.

When all advantages and disadvantages are considered the two big items which speak in favor of using effluent water are the relative low costs and the conservation of a precious commodity.

EFFICIENCY OF FERTILIZER INJECTION

Albert W. Marsh*

The general purposes of injecting fertilizers in irrigation water are to achieve a greater efficiency, reduce costs, and improve performance. These purposes would be met by saving labor used in application of fertilizers, reducing the amount of fertilizer that would need to be applied, improving the timing of application of fertilizers since there is no restriction on when they can be applied, and by improving the distribution of fertilizer over the entire area. The question that remains to be answered is whether or not these objectives will be achieved. The answer to these questions depends upon the methods used for the injection and the efficiency of the irrigation system that will be used to apply the fertilizers.

The method of irrigation that can be used for fertilizer injection is limited to permanent or solid set sprinklers and drip irrigation systems. Surface irrigation and portable sprinkler systems seldom provide the uniformity of distribution required to obtain a satisfactory fertilizer application.

To obtain satisfactory injection of fertilizer material through irrigation water the materials must be in a liquid form or fully dissolved in water before being introduced into the fertilizer injector. Fertilizers that will not dissolve satisfactorily cannot be applied in this manner.

Two types of injectors can be used. One is the power injector where an injection pump is powered by an external source which can be either electric or gasoline or by a water power source coming from the pressure of water in the irrigation system. Power injectors have the advantage of providing a more positive closely regulated form of injection and are able to inject materials of constant concentration until the required amount has been injected. Another form of injector is that using the water displacement principle in which the inlet and outlet pipes from the injector are connected to the main line at two points having different water pressures. This causes water to flow through the injector gradually displacing the fertilizer it contains. The method is satisfactory where changes in concentration during the injection are not objectionable. The material becomes gradually diluted until it has all been discharged.

Efficiency of fertilizer injection is dependent mainly upon the uniformity of water distribution by the irrigation system. Recent sprinkler and drip irrigation systems can have a relatively high uniformity of distribution but this is not always the case. It is therefore important to determine the uniformity of distribution of the irrigation system before launching on a fertilizer injection program.

The uniformity of distribution of water from the irrigation system can be tested by placing a number of cans under the operating sprinklers or drippers and measuring the amount of water caught in a unit time. When the amounts of water caught in the different cans are compared mathematically, a figure representing the uniformity of distribution can be obtained. It is called the coefficient of uniformity. Coefficient of uniformity of reasonably well designed sprinkler irrigation systems will range from 70 to 90%. Some systems have coefficients below 70%. Probably sprinkler systems having coefficients greater than 80% are the only ones that should be considered for fertilizer injection. Experiments that we have conducted demonstrate that the uniformity of distribution of the dissolved chemicals is about the same as the uniformity of the distribution of the water. Therefore, an irrigation system unable to distribute water with a high uniformity will similarly be unable to distribute the fertilizer with a high uniformity.

A further analysis of the data obtained from uniformity studies reveals that distribution by injection through a sprinkler system having a coefficient of uniformity of 80% would require a total application of almost 1.4 pounds of fertilizer to the entire area in order to obtain at least one pound of fertilizer to 90% of the area. Some of that 90% would receive much more than one pound or even much more than 1.4 pounds. The 10% would receive less than one pound. If the coefficient of uniformity of the system is 90% only 1.15 pounds of fertilizer would have to be applied to the entire area in order to obtain at least one pound to 90% of the area. The importance of an irrigation system having a high uniformity of distribution as measured by the coefficient of uniformity is very evident.

Success depends not only upon having a good irrigation system to distribute water and therefore the injected fertilizer with a fair degree of uniformity but it also depends upon the proper management of this system during the irrigation in which injection is occurring. With many irrgation systems that may have a reasonably good coefficient of uniformity the application rate may be greater than the ability of the soil to absorb at all times. In this case there would be runoff and the uniformity of distribution would deteriorate sadly. All runoff must be strictly avoided during fertilizer injection and this may sometimes require an intermittent application-some now, some later. Another management technique to obtain a more uniform application of fertilizer over the entire season is to use smaller and more frequent applications. Since vagaries of distribution are sometimes caused by external factors other than the mechanics of the irrigation system, particularly winds that might blow in a random fashion, the non-uniformity of distribution at any one time may be a random matter and not occur in exactly the same fashion with every irrigation. Therefore, the more frequent application of smaller amounts of rertilizer would tend to provide a better distribution.

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ALLOCATING RESOURCES FOR GOLF COURSE MAINTENANCE

With increased play and more rigid turf requirements by golfers, increasing costs, and restricted budgets, golf course turfgrass management is becoming increasingly complex. A new University of California Cooperative Extension publication now available at county farm and home advisor offices can help golf course managers cope with these problems. Titled "Allocating Resources for Golf Course Maintenance" (MA-73, 3/74), this economic analysis was written by Dr. W. W. Wood, Jr., Extension Economist at UC Riverside, and John Van Dam, Los Angeles County farm advisor.

The authors present one method for allocating scarce resources in an orderly and planned system. It is based on a hypothetical 18-hole, par 72 golf course, typical of Southern California. The course is defined, tasks specified, and data on performance synthesized from observations, time and motion studies, and discussions with many individuals in the golf and turfgrass management field.

A building-block approach is used with each identified task specified in terms of labor, equipment, and material requirements. The various tasks are summarized on a time flow chart in order to develop a weekly labor requirement profile for a year. The labor requirement profile helps to identify specific periods of high and low labor requirements so that management can properly plan appropriate labor schedules.

SLOW-RELEASE NITROGEN FERTILIZER MAY REDUCE RATE OF THATCH ACCUMULATION

Application of a slow-release form of nitrogen to bermudagrass at a level which preserves the eye appeal of the grass yet avoids excessive plant growth may reduce the rate of thatch accumulation.

This suggestion comes from results of a field experiment conducted at Texas A&M University. The purpose of the study was to determine the effects of fertility, fungicides, and clippings on thatch accumulation in a Tifgreen bermudagrass putting green.

Results of the study showed that thatch accumulation in the Tifgreen bermudagrass turf was increased by a high rate of nitrogen compared with a low rate of nitrogen over a six-month growing period. Nitrogen source also influenced the rate of thatch accumulation. At each rate of nitrogen, plots fertilized with the activated sewage sludge accumulated less thatch than those fertilized with ammonium sulfate. Potassium applications had no influence on thatch accumulation. Fungicide treatments (Fore, Tersan 0 M) decreased thatch accumulation and increased microbial activity; these treatments may have inhibited plant growth, according to the researchers.

The best quality putting surface was maintained on plots receiving the high rate of activated sewage sludge and the fungicide treatments according to the study results. These plots, according to the researchers, provided an attractive, smooth surface that did not scalp after mowing. Further research, they add, is needed with fungicides or plant growth regulators to determine their usefulness in controlling thatch.

("Thatch Accumulation in Bermudagrass Turf in Relation to Management," Agronomy Journal, By V. H. Meinhold, R. L. Duble, R. W. Weaver, and E. C. Holt, Vol. 65, Sept.-Oct. 1973.)

ACTIVATED CHARCOAL APPLICATIONS ON KERB-TREATED POA ANNUA

Each year golf course turfgrass managers in the Southnest and Southeast must make a tough weed control decision. They use bermudagrass for permanent cover and overseed with cool season grasses during the fall to provide winter color and acceptable playing surfaces during its dormancy. If they apply a pre-emergence herbicide too soon, poor overall annual bluegrass control results. Later application dates may interfere with anticipated overseeding dates due to residual toxicity. Results of research may point the way out of this problem.

Kerb has been shown to be effective for pre-emergence and post-emergence control of annual bluegrass in bermudagrass. University of Florida researchers have demonstrated that the herbicidal properties of Kerb can be nullified by activated charcoal when applied immediately after the herbicide. Now they report that annual bluegrass can absorb a lethal dose of Kerb through short-term exposure to the herbicide and doesn't have to be continuously exposed until death.

Plots of Tifgreen-328 bermudagrass infested with annual bluegrass were used in the study. Treatments included plots receiving no Kerb or charcoal, Kerb only, and Kerb plus applications of 2.5 or 5.0 pounds of charcoal per 1,000 square feet immediately, two weeks, four weeks, or six weeks after subjected to the herbicide. All of the Kerb treatments were at a rate of one pound active ingredient per acre.

The Florida researchers report that no definite effects were observed in the annual bluegrass until four weeks after Kerb application. At that time, slight yellowing of the bluegrass was noticeable when visually compared with absolute checks and Kerb plots which had been deactivated with charcoal at the zero- and two-week time periods.

There was a drastic change, according to the researchers, when the plots were rated six weeks after Kerb application. Plots receiving the herbicide plus an immediate application of charcoal and the absolute check were unchanged and stil contained 20 live annual bluegrass plants. However, all but a few of the marked bluegrass plants were dead in the Kerb checks and in Kerbtreated plots receiving applications of charcoal two, four, and six weeks after Kerb treatments.

No differences were observed throughout the entire experiment between the two rates of charcoal used.

"These results," the researchers say, "indicate that

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established *Poa annua* is capable of absorbing a lethal dose of Kerb through short-term exposure rather than having to be continuously exposed until death." They add that work is currently under way to determine the minimum exposure time required to kill annual bluegrass with Kerb.

("The Black Eraser Part II," by H. G. Meyers and C. M. Sligh, *Florida Turf,* Vol. 7, No. 3, January 1974.)

MAINTAINING TURFGRASS IN SHADE

Maintaining high-quality turf in shaded areas is a common and major problem for almost all turfgrass managers. It is estimated that 20 percent of the turf in the U.S. is subject to some degree of shade.

Turfgrass managers should keep in mind the harmful effects of shade as well as the available shade-tolerant species which can minimize this problem.

Generally speaking, shade can cause the following adverse effects on turfgrass health and growth:

(1) reduced light intensity, resulting in a depletion in carbohydrate reserves and undesirable plant characteristics such as thinner leaves and reductions in shoot density, shoot and root growth and tillering;

(2) increased disease development caused by prolonged dews, decreased wind movement, increased relative humidity, and a more delicate leaf structure;

(3) more succulent leaf tissue which makes turfgrass more susceptible to injury from wear and environmental stress.

Shade-adapted species can do much to minimize a turfgrass manager's shade problems. Turfgrass with good relative shade adaptation include red fescue (dry shade), rough bluegrass (wet shade), Nugget and A-34 Kentucky bluegrass and St. Augustinegrass. Those with fair shade adaptation include colonial bentgrass, creeping bentgrass, tall fescue, and perennial ryegrass. Turfgrasses which do poorly in shade include Kentucky bluegrass while bermudagrass is extremely poor.

Alterations in cultural practices also can play an important role in solving the shade problem. Mowing height should be raised 1/4- to 1/2-inch above normal to provide more leaf area for absorption of what scant light is available. Raising the mowing height also will help to offset the appearance of thin turf. Avoid keeping the soil surface wet, which enhances disease activity and development of shallow tree feeder roots.

Avoid excessive nitrogen applications. They favor shoot growth over root growth and place a further stress on carbohydrate reserves. Because increased tissue succulence will decrease turfgrass wear tolerance, direct traffic around shaded areas. Fungicides may be necessary, especially to control powdery mildew. Bentgrasses in shade should be placed on a fungicidal disease prevention program.

Finally, remember that no turfgrass species will be suitable under extreme shade. If you can't provide a turfgrass suitable for shade or modify your cultural practices or the shade environment, consider establishing shade-tolerant ground covers.

("Maintaining Turfgrass in Shade," The Golf Superintendent, September-October 1974, by Dr. James F. Wilkinson.)

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