Irrigation and Fertilization with Wastewater

Idaho researchers present an economically-palatable method of controlling water pollution— by preventing the entry into our streams of the $18.00 worth of nutrients in each acre-foot of secondary treatment plant effluent produced.

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MALODOROUS RIVERS, encumbered with drifting islands of blue-green algae and slime, oily, rainbow-hued water surfaces, and waste and litter are conditions that man must face for today and even more so for tomorrow if present waste disposal practices are continued. Only man can produce the huge quanitites of synthetic materials that resist natural decay. If the resulting alteration of man's environment is to be corrected, the carefully balanced forces of nature must be restored in order to allow the efficient decay processes of nature to catch up to the pollution load supplied by man. The increased demands being placed upon our water resources by the expansion of population and industry, and the increased problems of waste disposal and water pollution, are massive evidence that our lakes and streams can no longer dilute the quantities of effluent emptied into these bodies to levels acceptable for all users.

Some of the most dramatic evidence for man's ability to overcome the diluting abilities of a major watercourse is apparent along the course of the Snake River as it traverses the State of Idaho from its headwaters in the Tetons of western Wyoming.

A Multiple-Use Resource

The Snake River in southern Idaho is one of the major natural resources of that portion of the State. Though the stream is put to many uses, irrigated agriculture receives maximum benefits from it. In the broad basin of the Snake and its tributaries almost 3.4 million acres of agricultural land are irrigated with surface water withdrawn largely from the main stem of the Snake. The total demand for irrigation water varies between 15 and 20 million acre-feet per agricultural season.

Domestic and industrial users of ground and surface water resources presently demand over 360 million gallons of water a day. It is projected that by the year 2020 the joint municipal-industrial requirement will increase to 1,140 million gallons per day. In addition, the water users in the basin are becoming increasingly concentrated in the major service areas of the basin.

The river is also a resource for the generation of hydroelectric power and for navigation. Development of impoundments for storage, power production, and navigation has resulted in a highly regulated river basin. There were 80 storage structures either existing, under construction, or authorized as of 1970. The total existing storage is in excess of 9.6 million acre-feet, with 11.6 million acre-feet available upon completion of structures under construction or authorized for construction. The existing capacity of the hydroelectric power structures presently operating is a total of 1,894,300 kilowatts. The total power capacity, including dams under construction or authorized, is 3,689,300 kilowatts. Some 20 power and multi-purpose dams are presently operating, under construction, or authorized for construction. Of these, 4 will be utilized to provide slack-water navigation for barge traffic to the Lewiston-Clarkston complex, linking these cities with ports on the lower Columbia River.

The Snake is also a significant fisheries resource. In the Columbia River system some 61% of the anadromous fish passing McNary Dam on the Columbia River enter the Snake system each year. Hydroelectric projects have precluded the entry of these fish into the upper reaches of the Snake.

Recreation in the Snake River Basin is an important source of income to Idaho business. For the State as a whole in 1968, tourism was the third leading income producer, ranking behind agriculture and manufacturing. Estimated recreation days spent by both in-state and out-of-state recreationists or tourists averaged 1.6 million on publicly administered reservoirs which offer boating and swimming opportunities. The U.S. Fish and Wildlife Service has estimated that the anadromous fishery resource of the lower basin is primarily responsible for approximately 2.7 million angler days of sport fishing each year. Another important source of recreation is the migratory waterfowl hunting available in season in the basin.

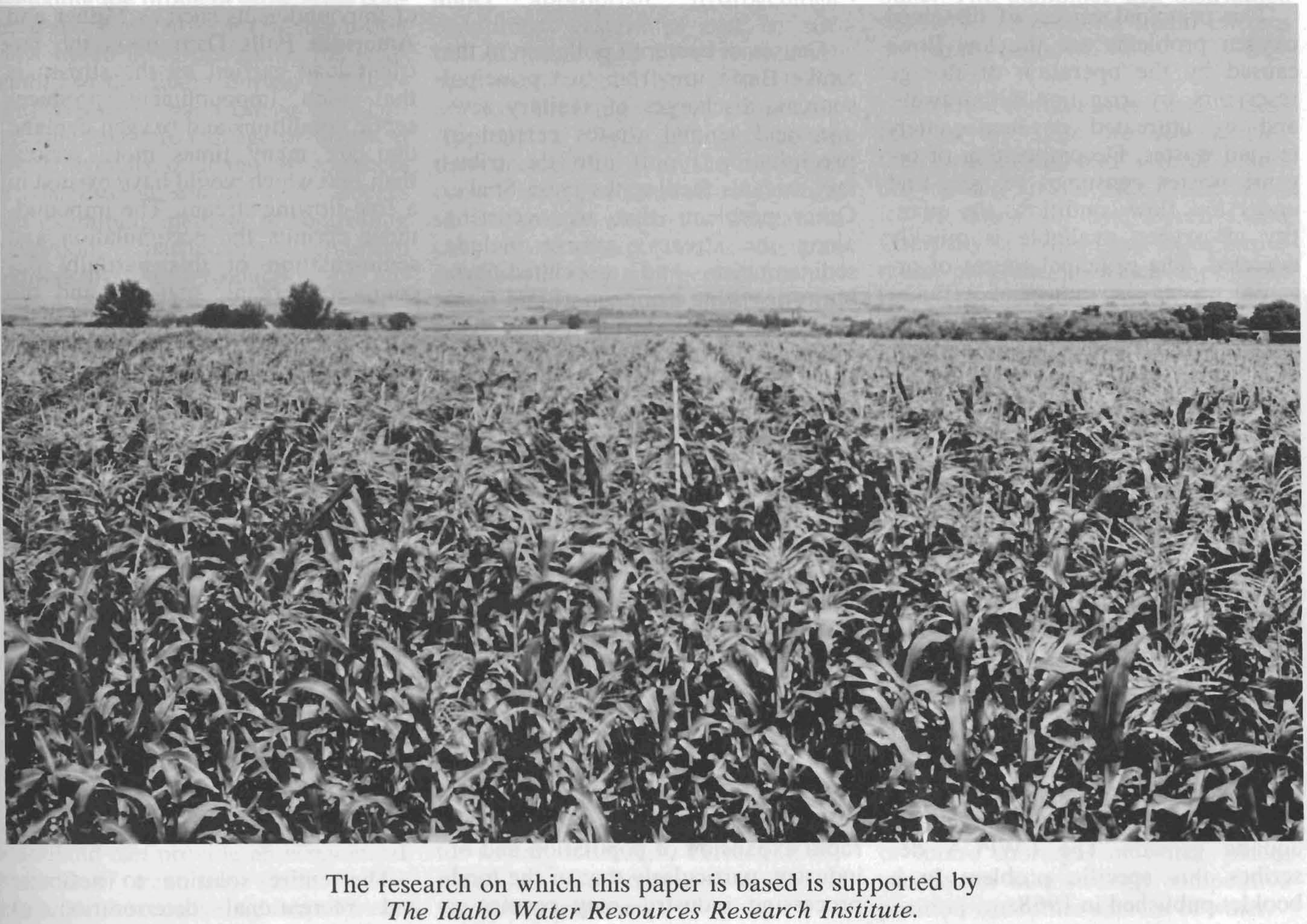
Several agencies, both public and private, estimate that tourism and recreation expenditures may outrank both agriculture and manufacturing as the major income producing activity for the residents of Idaho by 1986. Tourism income is growing between 9 and 12% each year, while manufacturing is increasing by 5% annually and agriculture by less than 5%. Idaho's water resources figure prominently in the total tourism and recreation picture. These figures lend emphasis to the importance of maintaining this valuable resource for the continued profit and pleasure of its beneficiaries.

Causes and Consequences of Pollution

It is most surprising that this stream course should be experiencing problems with pollution when one considers the seemingly favorable situation in existence within the State. One of the larger states in the Union (13th), Idaho has one of the lowest

This aerial view of the fields shows the corrugates which are used to help spread the canning factory wastewater.

The eight-foot-high stick in the middle of the corn field shows what irrigating with canning factory wastewater can do.



The research on which this paper is based is supported by
The Idaho Water Resources Research Institute.

population densities, with an average of 8.4 people per square mile residing within the State. Nevertheless, the Department of the Interior's Federal Water Pollution Control Administration (FWPCA) has documented water quality problems of a very serious nature along the river. Serious fish kills from dissolved oxygen depletion have occurred along the stream. Without expensive treatment, some communities are no longer able to utilize surface water from the stream for their domestic water supply because of taste, odor, and bacterial contamination. Recreationists have abandoned certain areas because of the disagreeable appearance of aquatic growths and because of bacterial contamination. Irrigators have suffered inconvenience when these masses of aquatic vegetation have interfered with water transmission. Thermal pollution has also affected the fishery when occasional high water temperatures in the lower Snake have prevented the migration of salmon up the system for several weeks, in some cases delaying the fish in their spawning run to the degree that these fish die before they have reached the spawning beds.

The principal causes of dissolved oxygen problems are the low flows caused by the operation of storage reservoirs, by irrigation withdrawals, and by untreated or inadequately treated wastes. Decomposition of organic wastes consumes oxygen, and under low flow conditions the quantity of oxygen available is quickly depleted. The principal source of organic wastes is industrial effluent from food processing industries along the stream, but domestic and agricultural wastewater also is a significant source of organic material.

Excessive aquatic growths are related to the high concentrations of the basic nutrients— nitrogen and phosphorus— in the Snake system. Phosphate concentrations rise steadily through the upper basin, then increase abruptly at the head of American Falls Reservoir, where the Portneuf River joins the Snake. In addition, natural phosphate levels, irrigation return flows, municipal wastes, animal wastes, and the decay of aquatic biota all contribute to the nutrient balance which stimulates aquatic growth. The FWPCA describes this specific problem in a booklet published in 1968:

"Perhaps the most characteristic water quality problem of the Snake River Basin is the excessive aquatic growths which detract from the beauty of the streams, clog irrigation canals, and eventually die, creating sludge deposits and oxygen demands. Thick blooms of algae make the waters of the upper and central basins a characteristic opaque green. Floating rafts of algae are prevalent on the surface of the Snake and form clinging slimes where they adhere to rocks and banks. As these growths die and decay, they release nutrients for new growths and become a principal source of oxygen demand in the basin."

Another factor compounding the problem is the system of impoundments on the Snake River. When a free-flowing stream is changed into a series of pools, the aquatic environment becomes more susceptible to algae and other plant productivity. Temperature, stratification, and detention time all serve to increase biological productivity. It is this same series of impoundments which has produced the problems of warming of the water and the resulting thermal pollution.

Causes of bacterial pollution in the Snake Basin are from two principal sources, discharges of sanitary sewage, and animal wastes carried in precipitation runoff into the tributary streams feeding the main Snake. Other problems that are occurring along the stream's course include sedimentation and associated turbidity resulting from runoff and from irrigation returns during the summer, the presence of toxins including acid waste discharges to the Portneuf River, and pesticide concentrations.

Some persons question whether or not the Snake River is worth saving. The costs involved in providing primary and secondary treatment for domestic and industrial wastewater are nearly prohibitive. By 1972, Federal statutes established under the Federal Water Pollution Act of 1965 will force cities to comply with water quality standards advocated by the Federal Water Pollution Control Administration. But just meeting the water quality standards of the FWPCA may not be sufficient. The rapid expansion of population and of industry, particularly that of the food processing industry, may require a third stage of treatment to augment the first two stages; the nutrient content of the large volumes of secondary effluent may create nuisance growths of aquatic plants even in the absence of other water quality problems.

An alternative to the costs embodied in such a three-stage treatment process would be to follow practices many eastern cities and states have been forced to adopt, that of writing off the Snake River as a multiple-use stream, allowing it to degenerate, and concentrating on saving the still unpolluted rivers of Idaho. This drastic step is not necessary yet, and it is felt that the costs of avoiding such a circumstance can be justified simply by citing the increased emphasis Americans are placing on the recreational and aesthetic value of waterways.

The pollution problem in the Snake River Basin is a consequence of several factors working together to complement one another. An example is that of the depletion of dissolved oxygen. Adding biochemical oxygen demand (BOD) to the stream from industrial and domestic wastewater is a serious matter from the standpoint of pollution and depletion of dissolved oxygen. But the impact of impoundments such as Milner and American Falls Dam upon the nutrient load carried by the stream is that such impoundment produces septic conditions and oxygen demand that are many times more serious than that which would have existed in a free-flowing stream. The impoundment permits the accumulation and sedimentation of this partially decomposed organic material and the corresponding hastened extinction of the reservoir. The increased growth of algae and other aquatic biota are a consequence of the warming of the relatively still reservoir water from solar heating. The concentration of slime and other aesthetically unpleasant matter on the surface and along the shores of the reservoir is another by-product. Under free-flowing conditions the river would enjoy a greater self-regenerating or self-cleansing action, especially during the period of annual high-water. This regeneration would facilitate the more efficient removal of the nutrient load by the current, thus prohibiting the compounding of the pollutants.

The entire solution to aesthetic and recreational deterioration of such a resource will require measures much broader than that simply of controlling the sources of nutrient enrichment of this water body. For example, the control of nutrient input will not significantly aid in effecting a solution to the problem of thermal pollution arising from impoundment. In addition, controlling the input of nutrients from domestic and industrial sources will do little to alleviate the problem of turbidity and pesticides in the river. However, the problem of domestic and industrial nutrient enrichment and its control must still be viewed as one of the most important goals we must strive to achieve before multipurpose uses become limited.

Solution Proposed by University of Idaho Researchers

The need for control of sources of domestic and industrial pollution is well recognized. However, the costs for such control via customary means of wastewater processing and treatment are substantial. The State of Idaho is concerned with determining means of achieving just such control, and it is by no means sitting by and watching the problem grow. This concern has resulted in the inauguration of a statewide effort, under the leadership of the Idaho Bureau of Mines and Geology, the College of Engineering, and the College of Mines at the University of Idaho. Researchers in the Bureau and the two Colleges are examining methods of controlling pollution, particularly pollution caused by the introduction of nutrients into lakes and streams.

So far the most promising possibility for preventing the entry of nutrient-rich wastewater into these waters is crop irrigation or surface application of domestic and industrial wastewater for renovation by the soil system. The wastewater from more than 400 cities in the United States is already being used in this manner. It has been well documented that irrigation or surface application of high nutrient wastewater under appropriate hydrogeologic conditions will yield a level of treatment or renovation equivalent to that obtained with the tertiary or third stage of treatment mentioned earlier. Surface application to crops, pasture, or woodland can provide an economical method of treatment which is less costly than extensive, advanced treatment of domestic and industrial wastewater. Irrigation with wastewater will result in increased crop production from fertilizer value contained in the effluent, an increase in the supply of irrigation water available for agricultural irrigation, and will renovate the wastewater by lowering nutrient content. Biochemical oxygen demand (BOD) in the wastewater is reduced and removal of some of the dissolved solids from industrial wastewater is realized. Removal of bacteria from the wastewater also occurs. In addition, such irrigation or surface spreading onto a soil system often will result in recharge to ground water of a portion of the effluent, with minimum threat to the continued quality of that resource.

Much specific information is now available on the benefits of such a practice of irrigation with wastewater. The fertilizer value (nitrogen, phosphorus and potassium) of domestic effluent has been estimated at about $18 per acre-foot; however, this figure can vary significantly.

It has been demonstrated also that under appropriate hydrogeologic conditions wastewater can be sufficiently renovated by a porous soil medium to meet U.S. Public Health Service drinking water standards. Appropriate hydrogeologic conditions include the presence of an unconsolidated porous medium (such as sand) through which the wastewater can move an appreciable distance (which will vary with geologic conditions) before entering a stream or water supply; the absence of surficial, jointed rocks through which the wastewater might move without appreciable adsorption of dissolved solids by the porous medium is required; a water table depth of at least five feet is advisable. Hydrogeologic conditions less than optimal will result in less than optimal renovation of the wastewater, in which case care must be taken during application if water supply sources are located near the disposal area. Only rarely will a given hydrogeologic environment not renovate wastewater to the equivalent of secondary (biological) treatment. In many cases renovation of wastewater by vegetation and the geologic column can be substituted for tertiary treatment. Terrestrial disposal has also been used in lieu of secondary treatment.

The initial effort by the Idaho researchers consisted of a survey of the State to determine the geographic distribution and quantities of effluent produced. At this stage emphasis was placed on municipal effluent. The degree of treatment was determined as a part of the survey. Subsequently, information on the production of industrial wastes, particularly canning, potato processing and meat processing wastes, was obtained. On the basis of this information, those areas where terrestrial reuse of wastewater seemed appropriate were delineated. These areas were then checked to see whether hydrogeologic conditions therein were appropriate for the safe reuse of wastewater. Factors such as type of soil, thickness of soil, depth to bedrock and depth to the water table received particular attention. The results of the investigation were published in 1969 as Idaho Bureau of Mines and Geology Pamphlet 143 entitled, "Feasibility of the Reuse of Wastewater for Fertilization, Irrigation and Ground Water Recharge in Idaho." The pamphlet discusses the type of wastewater produced and the hydrogeologic conditions present on an area by area basis throughout the State. The pamphlet was distributed widely to responsible Idaho citizens on a gratis basis.

Several communities and industries in the State are now reusing their wastewater and several others are looking further into the economics of doing so. The Green Giant Company near Buhl has an extensive reuse program in which the Idaho researchers are cooperating to determine precisely the fate of the materials contained therein. The wastewater from the sewage treatment plants of the cities of Buhl, Jerome and Mountain Home are also being reused. Blackfoot is having the advisability of reuse investigated further by a consulting engineering firm.

The researchers at the University of Idaho hope that Idaho's efforts in this regard will set a precedent which other states will follow. Wastewater reuse is one of the few economical means of preventing the entry into our streams of the $18.00 worth of nutrients in each acre-foot of secondary treatment plant effluent produced. This fact, combined with predictions of future shortages of water, places wastewater in a strongly competitive position with other sources of water.