THE CONSERVATION AND BENEFICIAL USE OF WATER
Under the General Topic of
Physical and Economic Trends in Beneficial Uses of Water

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Introduction

Conservation and beneficial use are synonymous terms although this may not be immediately apparent. Beneficial use is defined in the dictionary as a use which is advantageous, profitable, or directed toward a good end. Conservation is defined as preserving, protecting, or keeping in safe or entire state. Common usage in the natural resources field has extended the definition of conservation to mean protection against waste. Since waste can hardly be defined as a beneficial use, the basic principles defining the beneficial use of water should coincide with the basic principles of water conservation. There may be some disagreement concerning the definition of waste.

Some of us have been guilty of using a double standard, based on personal interests, in defining water waste. Irrigated agriculture has been a favorite whipping boy in the water resource field and has been accused of wholesale waste of vast quantities of water. These accusations are based on calculations which assume that any water diverted or pumped for irrigation which is not specifically required by the crop plants is waste. We might examine domestic water use in the same light. Studies have been made which indicate that the minimum essential amount of water required for domestic purposes is 20 gallons per capita per day. Reports of the Senate Select Committee state that average domestic use in the United States is approximately 60 gallons per capita per day. If we apply the same criteria to domestic water use that have been applied to irrigation water use, we can say that two-thirds of the water used for domestic purposes is not essential and can be classified as waste. This latter statement will be disputed on the grounds that the water used, although not absolutely essential, is being used beneficially and is not being wasted. The same argument can be made regarding irrigation. Most disagreement will relate to defining the amount of water which can be used above that which is absolutely essential before the increased use can be defined as waste. Regardless of all other considerations, it should be clear that the same basic beneficial use criteria should be applied to all water use, whether it be industrial, domestic, agricultural, or recreational.

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Water Supply Problems

Means of obtaining higher degrees of beneficial use have, for many years, been of concern to numerous individuals working in the water supply field. The general public has more recently begun to be concerned with water supply problems by virtue of being bombarded with stories, statements, and advertisements which imply that the United States is in imminent danger of catastrophic shortage. The situation is confused by occasional statements which imply that there is no national water supply problem at all. The reason for these conflicting statements is quite simply the fact that although we do have many local water supply problems, the United States as a whole is not in any real danger of running out of water. There are certain areas which are short of water. Thirty-four percent of the land area of the United States is classified as arid or semi-arid. The water supply problem in these regions is compounded by the fact that low precipitation is accompanied by low runoff percentages. Less than 10 percent of the already low precipitation in the Colorado River Basin appears as runoff in the Colorado River System. There are, however, water supply problems facing other regions where rainfall is high. There are water supply problems on the lower reaches of the Mississippi River in the state of Louisiana where annual rainfall is approximately 55 inches and the entire flow of the Mississippi River would seem to be available. Water supply problems are not necessarily related to available rainfall but are related instead to the management and use of the supplies that are available.

A universally proposed solution to water supply problems is the development of new water supplies. These are proposed in several different ways. One approach is the design and construction of conventional water diversion, storage, and distribution projects which are based on thoroughly tested principles and methods. Development of new water supplies has also been proposed through an approach which might be classified as the hopefully pending scientific breakthrough. These proposals usually relate to the modification of weather to increase rainfall or to the low-cost removal of salt from sea water. These latter approaches have had great popular appeal and the public, not recognizing the nature of the scientific and engineering problems involved, has perhaps expected too much too soon. At the present time, no scientific breakthroughs have occurred and our hopes for the development of completely new water supplies must at the moment depend upon the conventional approaches.

Essentially new water supplies can also be obtained by water conservation. There are many opportunities for reducing the present loss of water on forest and range lands, in agricultural use, and in municipal and industrial use. Although these opportunities have always existed, water conservation has been an unpopular subject and has received little national attention. This is because of the understandable reluctance of any and all water users to admit that they may be wasting some water. Increased attention to water supply problems is rapidly reversing this attitude, and it is now becoming evident that water conservation will soon play a major role in the solution of our water supply problems.

Opportunities for Water Conservation

Forest and range lands occupy over one-half of the land area of the United States. Non-beneficial evaporation and transpiration from these lands represent tremendous quantities of potentially available water, particularly in arid and semi-arid regions. On an average basis for the United States, approximately two-thirds of the precipitation never reaches the stream channels but returns directly to the atmosphere through evaporation from soil and plant surfaces. There are many opportunities for recovering a considerable portion of this water. A summary of studies conducted throughout the world indicates that, on the average, runoff does not occur from brush or forest covered lands until precipitation exceeds 16 inches annually. Average runoff from grassed areas is about nine-tenths of the precipitation in excess of 11 inches. This indicates that runoff from areas with precipitation in excess of 11 inches can be increased by replacing brush with grass. Vegetation management is an extremely complicated subject, and the successful implementation of this practice will require the development of a vast amount of new information concerning watershed hydrology and plant-soil-water relationships.

Conservation of precipitation can also be obtained by the treatment of selected areas to increase rainfall runoff. The potential value of this practice, which is called water harvesting, can be illustrated by pointing out that 1 inch of rain produces 5.6 gallons of water per square yard. Ten inches of rain on 1 square yard will fill a 50-gallon barrel with 6 gallons left over. Rainfall in New Mexico averages 84 gallons per square yard. Average rainfall for the continental United States is 170 gallons per square yard. It becomes obvious that a relatively small area of waterproofed soil can produce large volumes of water. Recent research indicates that water harvesting areas can be constructed for an annual cost of 2 cents per square yard. This means that in a 10-inch annual rainfall area water can be produced for 36 cents per thousand gallons. Continued research should lower costs to the point where water can be produced in the state of New Mexico for an average cost of 45 dollars per acre-foot or less. Water harvesting areas can be constructed above existing reservoirs or ground-water recharge areas to take advantage of existing distribution systems. They can also be constructed in any size, shape, or color to avoid scenic damage and can utilize lands which have little or no value for domestic animals, recreation, or wildlife.

Present knowledge indicates that any useful reduction in agricultural water use must relate primarily to irrigation. Evaporation losses from large reservoirs, chargeable in part to irrigated agriculture as well as to hydroelectric and urban water uses, are estimated to total about 12 million acre-feet per year. Attempts to reduce these losses by use of monomolecular films have not been encouraging. There appears to be a good possibility, however, that monomolecular films may be utilized to reduce the estimated 3,400,000 acre feet of evaporation which occurs from stock ponds and small lakes in the 17 Western States. Conveyance losses from canals in the 17 Western States total approximately 20 million acre feet annually. This loss will be reduced through the development of economical canal linings and seepage reducing treatments. Water losses incurred in the application of irrigation water to fields totals approximately 30 million acre feet annually. This loss occurs largely because the irrigator has not been provided with the information or equipment required for efficient water application. This loss can be greatly reduced through the development of improved methods for the design of farm irrigation systems, practical and reliable methods for measuring soil moisture and scheduling irrigations, and practical devices for automatically controlling, measuring, and applying irrigation water.

The possibility of reducing domestic water use has been mentioned. This use will not be decreased if water is distributed solely on ability to pay, as is sometimes proposed. It would seem that factors other than ability to pay must be considered where portions of the national economy are artifically controlled. Regardless of arguments on this point, domestic water use can be reduced if necessary. There is also room for conserving some of the water presently used by municipal public agencies for washing streets and watering parks at an average national rate of 25 gallons per capita per day. There is little question but that industrial water use can and will be lowered as the situation demands. Industry is considerably more susceptible to economic and regulatory pressures than are municipalities and agriculture; and for this reason, industry has already made great strides in modifying various processes to use less water or to use water of lower quality. Little information is available concerning opportunities for water conservation in the field of recreation. Recreation should not be exempt from the general responsibility for maximum beneficial use of water supplies. Means for producing the maximum amount of fish, game, water sports, and other recreational products with minimum loss of water for other users must be of concern.

Water supply problems associated with urban water use, which includes domestic, industrial, and public use, now relate primarily to pollution. It has been stated that only about 2 percent of the water diverted for urban use is consumptively used. About 98 percent of the water withdrawn for urban use is reported as returned to the streams or lakes. It should be recognized that pollution is sometimes so severe that the cost of purifying the water is greater than the cost of developing completely new supplies. Such polluted water must then be considered to have been completely consumed, since it is unfit for other uses. Moreover, upstream water withdrawals are limited by the necessity for leaving enough water in the rivers to dilute upstream pollutants so that there may be some downstream use. Considerable attention is being paid to reclaiming sewage effluents, and rapid progress in this field can be safely predicted. Many of the sewage pollutants are potentially useful substances which can be used for a number of purposes including the production of energy or food for animals.

Problems in Water Conservation

Although mankind has used, handled, and studied water for many thousands of years, progress in the field of water conservation is seriously hindered by the many things we do not know about water. We do know the arrangement of hydrogen and oxygen atoms in water molecules, and we do know the molecular structure of bulk water and ice. We do not know how water molecules are arranged when they are in close proximity to soil particles. Because of this, we do not know exactly how water moves through soil. This problem may not bother us too much in designing filter beds for water treatment, but it bothers us considerably when we try to measure and predict such things as the infiltration of water into soil or the evaporation of water from soil. We do not have sufficient knowledge about the physical state and dynamic behavior of water in plants, and this causes some trouble in determining the actual requirements and use of water by plants. We do not know very much about the physical properties and dynamic behavior of water flowing in thin sheets over rough, porous surfaces. This knowledge is needed for progress in irrigation, soil erosion, and water supply hydrology. There are other things we do not know about water and its physical behavior.

Accurate measurement is necessary for the efficient planning, development, and management of water supplies. Our present accuracy in water measurement leaves much to be desired. Precipitation data are inadequate in many regions of the United States because of physical and financial problems involved in the use of present measurement techniques. Measuring, tracing, and predicting the movement of water into and through soil is now largely qualitative rather than quantitative. Evaporation from water, soil, and plant surfaces cannot be directly measured in the field. These measurements are required for many purposes including the determination of potential versus present yield of water from a watershed. Existing methods for measuring the flow of water in pipes and channels are inadequate. Flow measurement in natural streams is often only an intelligent approximation rather than an accurate measurement. Flow in large pipes and artificial channels is measured with limited accuracy because of the difficulty of calibrating large measuring structures in place. The problem may be emphasized by pointing out that most water measuring devices used today are copies or minor modifications of devices designed more than 50 years ago. Accuracy which was good enough when water was plentiful is not good enough today.

Water conservation is materially influenced by legal decisions on water rights. This complicated and argumentative subject will only be acknowledged and will not be discussed except to point out that sound legal decisions must be based on sound information. Here again the basic problem relates to the development of better information so that legal decisions can be based on proven facts rather than beliefs or opinions.

The attitudes and knowledge of the ultimate user, the so-called average citizen, will often determine whether or not we are to achieve the optimum beneficial use of our water supplies. It is unfortunate that the average citizen does not usually appreciate his personal concern with water supply management until water stops coming out of the faucets at home. This is not because he is not interested but because he has not been properly presented with the facts. Perhaps this is a job for the Madison Avenue advertising firms, but I doubt it. I believe that is a job which must be recognized and accepted as a collateral responsibility of all agencies, groups and individuals working with water resources. Among other things, we need a water conservation counterpart of that famous forest conservationist, Smoky Bear. The average citizen will support the water supply programs, projects, and research if he understands the need for them. We must pay more attention to informing this average citizen, for the problems will not be solved without his support.

Outlook

An impartial evaluation of the evidence at hand indicates that the United States, as a nation, will not suffer any catastrophic shortages of water. Estimates which have predicted such shortages have erred in several ways.

1. These estimates have assumed that our presently luxurious use of water will continue and that in some instances water will be used with less efficiency than it is today. This assumption will certainly be wrong if serious water shortages develop. Although little effort has been directed toward increasing water use efficiency by municipalities, agriculture, and industry, much greater efficiency can be achieved through the application of existing knowledge.

2. These estimates have made no allowance for research progress in the fields of water supply development and management. Research and development now underway is gradually revolutionizing these fields. Although our research on water is not well publicized and does not appear as glamorous as space technology, our scientists and engineers are quite competent and are doing some amazing work. The principles and techniques of sonics, nuclear physics, physical chemistry, electronics, surface chemistry, plant physiology, micrometeorology, hydrodynamics, analogs and high speed computors are being skillfully applied to solve problems as complex as anything encountered in space technology. Radically new materials and machines are being developed by industry to help solve our construction and maintenance problems. We can be certain that this work will not only increase the efficiency in use of existing water supplies but will permit us to develop new sources of supply.

3. A major source of water supply which has received too little attention is the precipitation which is now lost to non-beneficial evaporation and transpiration. Calculations of maximum available water supplies have been based on the national average streamflow of about 1,200 billion gallons per day. These calculations assume that we can do nothing about the 3,000 billion gallons per day lost to evaporation. We can and will capture part of this water by means of vegetation management and water harvesting. How much we capture will depend upon seriousness of our need for additional water.

Summary

Conservation and beneficial use of water are both based on the same principle - the reduction of waste in the use of our water resources. Although there may be differences of opinion concerning the definition of waste, there is no doubt that present water use efficiency can be increased by all users. There does not seem to be any reason to expect a disastrous national water supply problem. Application of the principles of conservation and beneficial use and the application of new knowledge to develop new water supplies can solve any foreseeable water supply problems. Catastrophic water supply problems can develop only if the people responsible for water supply development sit on their hands and do nothing. This will never happen.