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COVER – Experiments in dune fixation using Saccharurn Aegyptacum under the supervision of a United Nations Food and Agriculture Organization (FAO) forestry expert are shown in the foreground. In the background previous experiments conducted in 1951-52 by private enterprise failed because insufficient quantities were employed. The scene is near Tripoli, Libya. Photo courtesy of FAO.

Editorial

Water and Man

All the rivers run into the sea,
yet the sea is not full;
Unto the place from whence the rivers come,
Thither they return again. — Ecclesiastes 1:7

Water, said the Greek philosopher Pindar, as early as the fifth century B.C., is the best of all things. It may perhaps be an overstatement, but it is certainly not surprising, especially when it is considered that it has been one of the most precious commodities throughout man's recorded history. Water makes life - human, animal or plant - in the biosphere possible, and without it, life and civilisation can not develop or survive. Wars have been fought in the past over the availability of water, and even now relations between several countries are strained due to disputes over management of shared water resources.

Because of the important role water plays in human survival, it has always been a subject of great interest, and the entire history of mankind can be written in terms of its need for water. From the very beginning, man realized that water is essential for the satisfaction of basic human needs, and hence early civilisations flourished on lands made fertile by major rivers: Tigris and Euphrates in Mesopotamia, Nile in Egypt, Indus in India, and Huang-Ho in China. As early as 3000 B.C., the Egyptians had already developed intricate water resources networks, especially irrigation systems. The historian, Herodotus, provides a vivid description of these early Egyptian water development works, and he was so impressed by the role of the River Nile in the country's survival that he called Egypt "the gift of the Nile.".

The importance of water can be further amplified by the fact that the Greek philosopher, Empedocles of Agrigemtum (490-430 B.C.), considered water to be one of the four primary elements or roots *(rhizomata)* from which all the materials of the world were constituted. The other three basic elements were air, fire and earth; the last two in the present day can be interpreted as energy and land. One can thus argue that such a concept was the forerunner of the molecular theory of materials, and water was considered to be so important that it was accepted as one of the fundamental building blocks of nature. Even great philosophers like Plato and Aristotle accepted this concept of water as a fundamental element, with only minor modifications.

The magnitude and complexity of water resources development and management problems in the early days were not complex. Population was small, per capita demand was low and water was plentiful. When there were water-related problems like droughts or floods, man simply migrated to a better location. Pollution loads were low, mainly of an organic nature, and water courses assimilated whatever load that entered without serious deterioration of water quality. Thus, right from the beginning man tended to treat water as a gift from God - a "free" resource - and his birthright to use and squander as he saw fit. This freewheeling concept, until recent times, did not pose serious management problems. Hence, until the early twentieth century, the demand for water, its efficiency of use and its quality were generally secondary issues.

This scenario started to change in the developed countries with the advent of the Industrial Revolution. Workers from agricultural sectors in rural areas started to migrate to urban centres, attracted by burgeoning industrial employment. One of its undesirable side-effects was the development of centres of dense population. As the industries in the cities developed, more workers migrated from the rural areas, which in turn attracted more industries, and this created a somewhat vicious circle.

Industries were often unfortunately located in close proximity to water bodies because of the ease with which waste products could be discharged to the receiving waters at no direct economic cost. Furthermore, cities discharged their sewage into the water bodies without much treatment, thus compounding the problem. Even today, some major cities like Montreal, Canada, discharge sewage to nearby watercourses without even primary treatment. Such developments contributed to growing water pollution near centres of dense population. In medieval Paris, the streets were often like open sewers, but the River Seine was clean, and one could see fish swimming in the clear water. Times have now changed. Today the streets of Paris are clean, but the Seine is murky and gray, and one would indeed be fortunate to see any fish.

The situation in developing countries was somewhat different. From a global perspective, the water situation can be visualised within two extremes. At one extreme are the highly urbanised cities of advanced industrialised countries, where the vast majority of population have inhouse connections and sewerage services, backed by adequate infrastructure and institutional arrangements, having access to adequate financing, high level technology and necessary service personnel. At the other extreme is the rural sector of developing countries, having no service of any kind for either potable water or excreta disposal. Herein lies a major development dilemma, the rich get richer, the poor, poorer. In many urban centres, if one can afford the capital costs, clean piped water could be cheap enough for the rich to fill their swimming pools, while the poor may have to pay two or three times as much, per unit quantity of water, to buy by the bucket from a tanker. Even then, these urban poor may be luckier than their rural counterparts, who get their water, often contaminated, from whatever sources they can.

There is no doubt that the total amount of water available globally, if used efficiently, can meet vastly higher human needs. Current estimates indicate that the total volume of water on earth is 1.4×10^9 km^3, 97.3 per cent of which is ocean water, and, therefore cannot be used by man except for fisheries and navigation. Only 2.7 per cent is fresh water, 77.2 per cent of which is stored in polar ice-caps and glaciers, 22.4 per cent as ground water and soil moisture (about two-third lies deeper than 750 metres below the surface), 0.35 per cent in lakes and swamps, 0.04 per cent in the atmosphere and less than 0.01 per cent is in streams. In other words, nearly *90* per cent of fresh water is stored in ice-caps, glaciers and as deep ground water, and as such is not easily accessible. For all practical purposes, it is surface water in rivers, streams and lakes, amounting to less than half of 1 per cent of available freshwater, that constitutes the basic available supply for man, even though ground water has been heavily developed in certain parts of the world.

While reasonably accurate estimates of the total volume of water in the earth is available, information on its quality leaves much to be desired. Thus, with very few exceptions, even approximate continental or global assessments of the different water quality parameters are not known. Nor is much known about the magnitude and type of organic wastes from municipalities and industry that are entering water courses, and rapidly constituting growing hazard to human health and environment. Even in a major advanced industrialized country, like the United States, according to the 1976 report of its National Commission on Water Quality, 92 per cent of suspended solids, 37 per cent of biochemical oxygen demand and 98 per cent of the coliform bacteria will still remain uncontrolled in natural surface water, *even* when all discharges from point sources have been eliminated. This is largely due to agricultural activities. Currently there are no general measurements of volumes of synthetic organic compounds and heavy metals reaching water courses, and eventually the oceans.

Toxic chemicals and heavy metals are serious hazards to environmental health. They are gradually dispersed to ecosystems, other than the one intended, by evaporation and subsequent precipitation, or by drainage waters. For example, it has been estimated that England receives nearly 36 metric tons of chlorinated hydrocarbon as fallout per year. Such dispersal mechanisms mean that the toxic substances can be detected in areas far away from the points of application. Thus, significant quantities of pesticides, including DDT and its derivatives, have been found in animals in Antarctica, like penguins and their eggs, skua and fish, even though there is no agriculture, no insect life and no use of pesticides.

Water plays an important part as a medium through which toxic chemicals are dispersed to the ecosystems by selective concentration, as they pass relatively unchanged through successive levels of food chains and food webs. For example, in Lake Michigan, the concentration of DDT in lake sediments was 0.0085 ppm. Invertebrate primary consumers concentrated this to 0.41 ppm, their fish predators to 3 to 8 ppm, and the herring gulls predatory on the fish had levels no less than 3,177 ppm. This means the level of concentration increased by nearly 374,000 times between the lake seaiments and the gulls.

The effect of such selective concentration means that the toxic effects of chemicals are more readily noticeable in top carnivores. Thus, discharge of mercury in the Minimata Bay, Japan, increased the mercury content of fish to dangerous levels, so much so that the fishermen who depended on fish as a major source of food, suffered heavily from mercury poisoning. Currently, this form of disease is often known as Minimata, and in addition to Japan, severe mercury poisoning, under similar circumstances, have been noted in Canada, especially among Indians having fish as their staple diet.

In addition to the above environmental health implications, the quality of water available has direct relations to human health. Use of potable water will undoubtedly reduce health hazards like cholera, typhoid, infectious hepatitis and bacillary dysentery. It would further reduce human contacts with vectors of water-borne diseases like schistosomiasis, trypanosomiasis, and guinea worm. Some have estimated that the Gambian sleeping sickness can be reduced by 80 per cent by good water development schemes. While this figure may be somewhat optimistic, there is no doubt that the provision of potable water will significantly reduce the incidence of the dreaded sleeping sickness disease by reducing the exposure of human beings to Tsetse flies during the water collection journey. Similarly, guinea worm infection, which currently affects some 48 million people, chiefly in the Indian sub-continent and West Africa, can also be reduced. Currently, water and health situation, on a global basis, has been estimated as follows:

- Gastro-enteritis, 400 million cases every year;
- Schistosomiasis, 200 million cases every year;
- Filariasis, 200 million cases every year;
- Malaria, 160 million cases every year; and
- Onchocerciasis, 20-40 million cases every year

These statistics clearly indicate that the health and economic costs of water-related diseases are considerable, and much of such costs can be reduced by rational water resources development and management. Availability of potable water in rural communities would eliminate the water collection journey, mainly of women and children of developing countries, who currently spend up to five hours every day collecting the family water requirements. Such chores take up to 12 per cent of daytime calorie needs of most carriers in non-dry areas, and up to 25 per cent or more in mountainous regions. Since women are not traditionally the most well-nourished members of the family, elimination of the water collection journey, by the availability of potable water closer to home, has not only implications in terms of reduced disease propagation, but also in terms of nutrition, a fact often overlooked by planners and politicians. Furthermore, the time freed can be used for learning and productive work.

There is no doubt that the total amount of water available globally, if distributed equally can meet much higher demands. The problem, however, is that water is not equitably distributed either in space or in time. In some parts of the world, there may be too much water and floods could be a perennial problem, whereas in other parts, especially in arid regions, there may not be enough water to sustain all water-related activities throughout the year. Thus, in areas of both water abundance and shortage, it is important to institute appropriate water resources and development and management policies so as to alleviate the problems of floods and droughts and to ensure in the process that adequate water of the right quantity and quality is available on a long-term sustaining basis. Such policies would include implementation of rational conservation plans and pollution control strategies, so that deterioration of water quality can be prevented, thus ensuring that the total stock of available water is usable for different purposes.

If the earlier general assessment of world-wide conditions is considered in conjunction with the following factors, the urgency of immediate rational water development and management becomes apparent.

It took nearly a million years for the first billion people to appear on earth, but the next billion is due in only another 15 years. The world population is expected to reach 6.5 billion by the year 2000. The basic human needs of the additional 2.5 billion people have to be satisfied in slightly over 3 decades. Basic human needs may be considered to be food, clothing and shelter, and public services provided by and for the community at large, such as safe drinking water, sanitation, public transport, and minimum health services. Satisfaction of basic human needs for the additional 2.5 billion people means more water to supply these goods and services.

According to the World Health Organization, 1,200 million people, or 30 per cent of the present world population, lack safe drinking water, and 1,400 million people have no sanitary waste disposal facilities. Lack of proper excreta disposal has an immediate impact on water quality, especially in areas where safe water is in short supply. It contaminates the water sources, and thus contributes to spread of diseases. Currently some 5 million people die every year from such water-borne diseases as cholera, typhoid, diarrhea, dysentery, malaria and intestinal worm infections.

Unplanned industrial expansion and population pressures in large urban areas are straining available water supply. As urban areas grow, more water becomes necessary and simultaneously more waste is being generated, some of which is disposed of in watercourses, thus degrading water quality. In other words, more and more water becomes necessary, but at the same time the quality of the available supply is being degraded.

The daily water demand for a human being varies between 1.5 and 20 litres, depending on climate and physical activity. The daily per capita in-house water use varies from 3 to 700 litres. A ten-year study in Singapore indicates that as domestic water use goes up, disease rates go down. It concluded that 90 litres of high quality water seemed to be the "social minimum" for prevention of water-borne diseases.

Agriculture is the greatest user of water, accounting for some 80 per cent of all consumption: the comparable figure for the United States is slightly above 40 per cent. It takes approximately 1,000 tons of water to grow one ton of grain and 2,000 tons to grow one ton of rice. In addition, animal husbandry and fisheries require abundant water.

In 1975, according to the Food and Agricultural Organization, the total area irrigated in the world amounted to 223 million hectares, of which 93 million hectares was in developing countries. Some 15 per cent of the world's cropland is irrigated, yielding from 30 to 40 per cent of all agricultural production. The amount of water used by irrigated crops is nearly 1,300,000 million cubic metres, but because of losses in storage, conveyance and use, the total amount used increases to almost 3,000,000 million cubic metres.

By 1990, it is estimated that the total area irrigated in the world would increase to 223 million hectares, of which 119 million hectares would be in developing countries. Expanding and maintaining irrigated areas to 1990 is going to be a challenging task, and its magnitude can be judged by the following requirements for the developing market economy countries only:

22.5 million hectares of new irrigation;
45 million hectares of irrigation improvement;
78.2 million hectares of drainage improvement, including 52.4 million hectares on irrigated land;
438,000 million m^3 of additional water; and
$97,800 million of investment at 1975 prices.

Increased agricultural activities in marginal areas have often overexploited water availability. In many areas, more groundwater is being withdrawn than can be replenished naturally, thus contributing to major management problems.

Industry is a heavy user of water. In the United States, industrial water demands account for nearly 40 per cent of the total water requirements, and five major industrial groups — food and kindred products, pulp and paper, chemicals, petroleum, coal products and primary metals — account for slightly more than 85 per cent of total industrial requirements. However, nearly 60 to 80 per cent of water required for industrial processing is for cooling and need not be of a high quality.

Irrational use of water is contributing to the loss of productive soil due to waterlogging, salination, alkalinization and erosion. On a global scale, at least 200 to 300 thousand hectares of irrigated land is lost every year due to salinization and waterlogging. In Nubariya area of Egypt, water level is increasing at the rate of one mm every day. Current estimates indicate that 20 to 25 million hectares of land that is saline at present was fertile and productive at one time.

Water conservation practices have not received adequate attention so far. The efficiency of use of irrigation water is still low in most countries, and losses of up to 70 to 80 per cent are not exactly uncommon. Overwatering is often endemic, and it is virtually certain that most current estimates of water needs for irrigation are grossly overstated to account for this loss. Similarly in the industrial sector, many products can be manufactured with significantly less water than currently being used. For example, water requirements to manufacture one ton of paperboard vary from 62,000 to 376,000 litres, the higher figure being over six times the lower one. In some urban centres of developing countries, as much as 50 per cent of all the water stored and conveyed is being lost due to leakage.

These and other aspects of water resources development affect different countries in different ways, and all go to prove that *rational management of water resources can no longer be considered as only desirable, it is now an absolute must.* But the overall tasks must be viewed in a wider context. Management of water is essential, but the fundamental question that must be asked is for what? Not for itself, but for those who inhabit this "only one earth", and to provide a better quality of life to those segments of society who have not had the opportunity for hundreds of years. In the case of water, as in that of energy or any other resource issues which confront the world today, the problems must be viewed in the wider context of rational use of natural resource for the achievement of a sustainable development process, as envisioned by the New International Economic Order proclaimed by the United Nations.

This may pose an important question: will enough water be available for future developments in the world? Some have already suggested that water, rather than land, will be the major constraint for increasing world food production during the final years of this century. Two comments can be made about such statements. First, the majority of such statements come from people who have no special expertise on water, and thus it becomes comparitively easy to make such rash forecasts. Secondly, such concepts are basically neo-

Malthusian, and like other similar concepts, it has been discarded by serious scholars.

To conclude, the major problem in the area of water resources is not one of a Malthusian spectre of impending scarcity, but one of instituting more rational and better management practices. Water resources of different regions for which adequate data are not available have to be assessed, and based on such assessments, long-term development and management plans have to be established. Water and land should not appear as constraints in the overall planning process of a country, rather realistic development and production targets should be matched to their availability. What is urgently needed is the formulation of long-term development policies, on a sustaining basis, that reflect changing water supply and demand patterns, consistent with efficient use, and better understanding of the social and environmental implications so that adverse impacts can be minimized. In fact, it can be successfully argued that the time has come when the emphasis should shift to comprehensive land and water planning, treating land and water as an integrated and interacting unit, rather than water planning *per se.*

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