WATER SUPPLY FOR AGRICULTURE, AQUACULTURE, AND FISHERIES

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Keywords: agriculture, aquaculture, fisheries, water quality guidelines, rain, precipitation, irrigation, floodwater, groundwater, wastewater, salinity, water temperature, pH, carbon dioxide, dissolved oxygen (DO), ammonia, oil, heavy metals, organic chlorine compounds, nitrogen, phosphorous, eutrophication, endocrine disrupters

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Summary

Water for agriculture, aquaculture and fisheries must be available in large quantities and good quality to achieve and maintain harvests.

Rain is the most useful source of water for agriculture but its use is often restricted to regions with sufficient precipitation. Irrigation is widely used in low precipitation areas, and utilizes rain, floodwater, groundwater and treated wastewater. There have been a number of different water quality guidelines related to irrigation. SAR (sodium adsorption ratio), EC (electrical conductivity), total dissolved solids, Na, Cl, B, NO_3-N, HCO_3^-, pH and others are recommended in the USA. Also in Canada, water quality guidelines are recommended for total coliform, fecal coliform and six pesticides. For the agricultural use of treated wastewater, WHO guidelines recommend levels for intestinal nematode and faecal coliforms.

It is important to maintain the water quality in aquaculture, for stable and increased production. Water for aquacultural use is often polluted by microorganisms or chemicals flows into rivers, lakes, ground water and sea water from domestic and industrial waste. Aquatic organisms such as fish and shellfish are affected by water temperature, pH, carbon dioxide (CO_2), DO (dissolved oxygen), ammonia and others. Water quality guidelines for aquaculture in Japan apply to BOD, COD, T-P (total phosphorous), T-N (total nitrogen), DO, SS (suspended solids), coliforms in rivers lakes, and sea water. As regards water for fisheries, pollution of sea water by industrial chemicals such as oil, metals, organic chlorinated compounds, nitrogen and phosphorous, endocrine disruptors and others affect fish and shellfish, mainly in populous coastal areas. Water quality guidelines for fisheries in Japan apply to COD, nitrogen and phosphorous, DO, pH, and SS.

1. Introduction

Water is very important not just for drinking but industrial activity. Agricultural, aquacultural and fisheries use of water is also important. It is necessary to have large amounts of good quality water to achieve and maintain harvests. There are water quality standards or guidelines for these purposes. This chapter describes water sources and water quality for agriculture, aquaculture and fisheries, and water quality guidelines for each use.

2. Water for agricultural use

A large quantity of water is necessary for producing crops such as rice and wheat, as well as vegetables or fruits. For example, the water needed for crops amounts to 1000 to 3000m^3 per ton of cereal harvested. Put another way, it takes 1-3 tons of water to grow 1 kg of rice. Agriculture is a primary industry and has a close connection with the natural environment. The cultivation of plants needs soil, water (rain water), air temperature and sunshine. Currently, about 3600km^3 of freshwater is withdrawn for human use every year. In all regions except Europe and North America, agriculture is by far the biggest user of water, accounting worldwide for about 69% of all withdrawals, with domestic use amounting to about 10% and industry using some 21%. Water for agricultural use contains rain, river, and pond water and irrigation depends on regional conditions.

2.1. Rainfall

Rain is the most useful source of water for agriculture. However, annual precipitation or rainy seasons differ greatly between regions, affecting the water cycle in each region and influencing the use of agricultural water. Currently, average precipitation in the world is about 1000mm annually. The average precipitation in the world from 1971 to 2000 is shown in Figure 1. South-east Asia, Central Africa, South and Central America and Oceania had above average precipitation. More than 3000 mm annual precipitation are founded only Oceania region, such as Micronesia (4591 mm), Palau (3735 mm), Guinea (3622 mm) and the Marshall islands (3328 mm). Precipitation in most European areas was 500 to 1000 mm per year. On the other hand, regions of low precipitation include Central Asia, the Middle and Near East, Northern Africa, western North

America, and central Australia. These areas sometimes have a water shortage. Countries with less than 100 mm of rain per year are Egypt, Mauritania, Bahrain, Oman, China and Peru. Notably, only 0.7 mm of rain was registered at Aswan in Egypt, and 3.5 mm at Lima in Peru during 30 years annually average precipitation. Areas low in rain need irrigation for the sustainable use of natural resources and increased agricultural productivity and diversification.

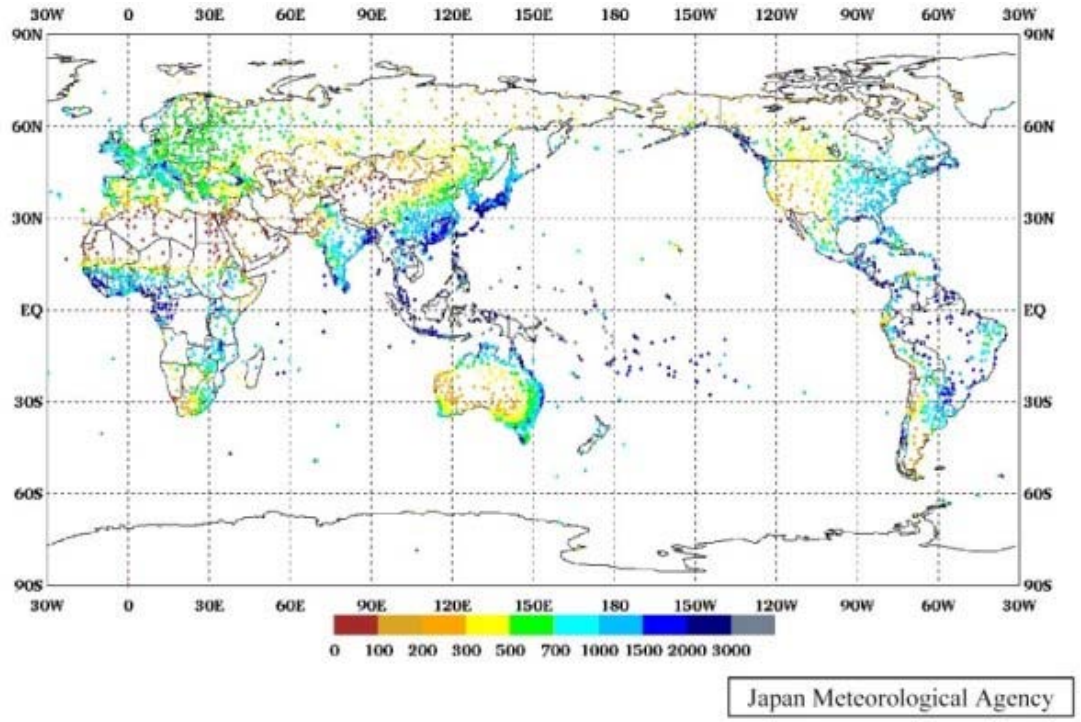

Figure 1. Average precipitation in the world

2.2. Irrigation

Agriculture and irrigation have affected the rise and fall of many great civilizations. Without agriculture, our way of living would cease to exist as it does today. Without irrigation, we would not have agriculture. Irrigation is the act of moving water from one place to another and is used in farming to water crops.

While much can be done to increase crop yields mainly in rain-fed agriculture, most attention is currently focused on irrigated agriculture, which relies mainly on water that runs into rivers or is stored in aquifers. As the map shows in Figure 2, water shortage areas with low levels of precipitation such as Central Asia, the Middle and Near East, Northern Africa, and North America show high levels of diffusion of irrigation.

The rate of irrigation was about 100% in Egypt and Kuwait. Many developing countries rely heavily on irrigation. In an FAO analysis of 93 developing countries, it was found that 18 of them use irrigated agriculture on more than 40% of their cultivated land; an additional 18 countries irrigate between 20 and 40% of their cultivated area. However, high precipitation areas of Africa showed only 5 to 10% irrigation.

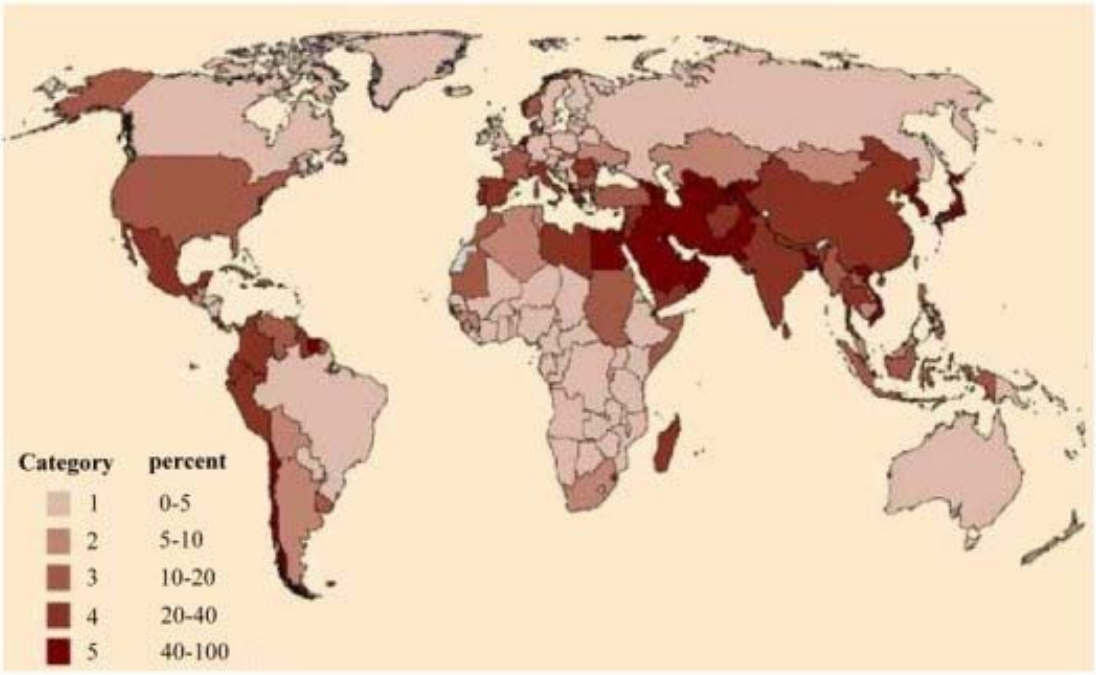

Figure 2. Area equipped for irrigation as a percentage of cultivated land.(FAO: 1998)

2.3. Source of water for irrigation

Irrigation is widely used mainly in low precipitation areas, to ensure the required water resource. Water sources for irrigation include rain, floodwater, groundwater and recycled wastewater.

Rainwater

Irrigation with rain water which is distributed from remote areas with high precipitation is used in regions with low precipitation. For example, Israel, California (USA) and Australia use large-scale water pull systems.

Floodwater

Floodwater harvesting comprises a system with catchments being many square kilometers in size, from which runoff water flows through a major “wadi” flow (bed of an ephemeral stream or river). The water is forced to infiltrate and the wetted area can be used for agriculture or pasture improvement. Floodwater farming has been practiced in the desert areas of the Middle and Near East, and middle North America. However, traditional floodwater farming methods are used less frequently today in many areas. As a high risk system, floodwater farming is no longer competitive with conventional irrigation agriculture.

Groundwater

Groundwater has been used in arid regions since ancient times. The Middle and Near East and China often collect groundwater for irrigation. This method utilizes vertical

holes and tunnels running horizontally to collect underground water. Other collection methods include dams cutting off the flow of rivers, and collecting rainwater that has permeated underground. Furthermore, water from aquifers is distributed using pumps. For example, the Ogallala aquifer located in the central part of America used groundwater from a 100 to 200m deep well. In general, groundwater is distributed using big sprinklers.

Waste water

There has been increasing interest in the reuse of wastewater in agriculture over the last few decades, due mainly to increased demand for freshwater. The use of wastewater in agriculture is becoming more important due to increasing water scarcity in dry climatic regions of the world. Reducing the pollution loads of water used by farms, industries and urban areas would enable much more of it to be reused in irrigation. There are enormous potential benefits to be had from the use of wastewater for irrigation. The fertilizer value of the effluent is almost as important as the water itself. Typical concentrations of nutrients in treated wastewater effluent from conventional sewage treatment are: nitrogen 50mg L^{-1}, phosphorus 10mg L^{-1} and potassium 30 mg L^{-1}. In addition, other valuable micronutrients and organic matter contained in the effluent would provide additional benefits. Wastewater is used extensively for irrigation in certain countries, e.g. 67% of total effluent in Israel, 25% in India and 24% in South Africa is reused for irrigation through direct planning, though unplanned reuse is considerably greater.

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Biographical Sketch

Yoshiteru Tsuchiya is a Lecturer in the Faculty of Engineering of Kogakuin University, where he has been in his present post since 2000. He obtained a Bachelor Degree in Meiji Pharmaceutical College in 1964. He worked for the Department of Environmental Health in Tokyo Metropolitan Research Laboratory of Public Health until 2000. In the meantime, he obtained a Ph.D in Pharmaceutical Sciences from Tokyo University. From 2002 to 2003, he worked for the Yokohama National University Cooperative Research and Development Center as Visiting Professor. He has written and edited books on risk assessment and management of waters. He has been the author or co-author of approximately 70 research articles. He is a member of the Japan Society on Water Environment, Pharmaceutical Society of Japan, Japan Society for Environmental Chemistry, Japan Society of Endocrine Disrupter Research, and International Water Association.(IWA)